# Investor trading behavior around the time of geopolitical risk events: evidence from South Korea

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**Abstract**

How do investors trade before and after geopolitical risk events? The South Korean stock market gives an interesting testing ground because the nuclear weapons testing and military aggressions by its belligerent neighbor, North Korea, are exogenous. Moreover, as North Korea has transitioned from a state without nuclear weapons to one with substantial nuclear capabilities, investors have revised their beliefs about the level of geopolitical risk with each testing. Using microstructure data of South Korean stock market from 1999 to 2012, we find a permanent negative abnormal return of -1.59% in the South Korean market (and -0.88% for the US market) for nuclear weapons testing, but only transitory response to military aggressions. Moreover, we find a significant increase in abnormal short selling volume *before* the events from non-resident foreign institutions of the countries having diplomatic relations with North Korea.

Key words: Geopolitical Risk, political insider trading, North Korea, nuclear weapons, military aggression, short selling, individual investors, institutional investors, foreign investors

JEL classification: G10; G14; G15; H56

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## Ⅰ. Introduction

Geopolitical security is one of the bare necessities to have a well-functioning financial market. In this paper, we study the investor behavior before and after geopolitical risk events caused by North Korea (NK, hereafter). Though many researchers document significant investor responses to political events in various international settings, one of the most important issues is that a shock in geopolitics may be a function of the financial markets of the countries involved, especially due to the globalized capital markets. South Korea (SK, hereafter) gives us an interesting testing ground. While SK has grown rapidly to become the world's 15$^{th}$ largest economy, its long-time source of geopolitical risk has been North Korea – nicknamed the "hermit kingdom" – that has been ruled by a communist dictatorship dynasty with almost complete insulation from global capital markets for more than half a century (Acemoglu and Robinson, 2012).

NK has been drawing much attention from the world for a long time with its belligerent rhetoric against the US and SK. The reckless brinkmanship of NK – and accordingly, the tension level – has grown worse since the late 1990s due to the country's constant endeavor to establish the capability of producing nuclear weapons and long range missiles (LRMs, hereafter), to secure its regime from both outside and inside forces. The uncertainty surrounding the Korean peninsula grew after the death of "Dear Leader," Kim Jong-Il in late 2011. With the succession of the new dictator, Kim Jong Un, who is barely thirty years old, NK escalated the tensions in the region by proclaiming that it would attack SK and even the US with its newly tested LRMs, carrying its own nuclear warheads. As a result, in the spring of 2013, some heavy weight multinationals operating in SK, such as General Motors, and some foreign embassies, began to draw up serious contingency plans for their employees and compatriots living in SK (Choe, 2013). The New York Times (2013) quoted Mr. Coyner of the American Chamber of Commerce in SK: "[NK's threat] is a very interesting, sophisticated economic attack on SK," because the nuclear threat of NK negatively affects SK's stock market and business.

Why should economists care about this paper? First, preventing the proliferation of nuclear weapons to 'rouge states' has been a primary concern of national security of the US and the capitalist countries. However, there has been no study that systematically assessed the economic impact of having an enemy state with nuclear weapons. This is the first study to estimate the economic magnitude of stock market response to having an enemy state

transitioning from a country without nuclear weapon to the one with significant nuclear capability[2].

Second, a recent report by the Center for Risk Institute of Cambridge University argues that a potential war between China and Japan would drag down the world economy into a recession of more than four years (Wallace, Hartley, Bowman, Coburn, and Ruffle, 2013).[3] The combined size of the economies of the countries around NK is now greater than that of the economy of the European Union. A potential (nuclear) war on the Korean peninsula could not only cause unprecedented human casualties but also devastate the world economy on a massive scale. Among the neighboring countries China has been the closest and the most powerful ally of NK, and it is almost the only effective communication channel to the NK leaders. In an untabulated event study, we find that the SK stock market index increases by 1.69% (t-stat=1.66, N=14, event window: [0,2] trading days) when China works as an intermediary in multiparty talks to solve problems on the Korean peninsula. Meanwhile, Japan and SK have been important strategic allies to the US since the Korean War. Recently, the geopolitical tensions between China and Japan drastically increased due to their territorial disputes over Diaoyudao/Senkaku Islands (see map in Appendix B), to the point of the Japanese Prime Minister addressing it as "a similar situation to Britain and Germany before World War I" (Rachman, 2014). Therefore, a war on the Korean peninsula could easily propagate itself to become a much larger scale military conflict between China and Japan with the US.

Third, we study the foreign short sellers' behavior before NK's aggressions that are plagued with information asymmetry. If some of the investors are better informed about NK's forthcoming military actions that generate negative price response, they could take advantage of their private information by short selling Korean stocks before the action of NK. We identify the channel of information using the KRX microstructure data that identifies the nationality of the foreign traders. We find that foreign investors of the countries that have

[2] Due to diplomatic concern among the countries involved, we cannot use the word "having nuclear weapon" in this paper.

[3] A possible sudden implosion of the NK regime with its nuclear weapons is another source of risk because of the high likelihood of sale of these weapons to terrorists or unwanted states, not to speak of the potential influx of millions of refugees into China and SK. Ian Bremmer, head of the geopolitical risk consulting company the Eurasia Group, pointed out at the Davos World Economic Forum in 2014 that an implosion of NK would be a very serious problem in East Asia, because Kim Jung Un "has not given any confidence to believe that he knows how to run a (nuclear) totalitarian country (Wiesenthal, 2014)." In addition, recently, Falletti (2014) pointed out that the obsolescence of NK's nuclear power plants poses even more serious environmental risks than that from "Chernobyl" upon neighboring countries.

diplomatic relations with NK short sell Korean stock significantly more before the NK's aggressions. Whether short sellers are better informed (Asquith, Pathak, and Ritter, 2005; Boehmer, Jones, and Zhang, 2008) or better skilled information processors (Engelberg, Reed, and Ringenberg, 2012) has been debated widely in the literature. Our evidence adds to the view that international short sellers are better informed to the extent that the information is about geopolitical risk.

North Korean military threats have been "credible," because the country's track record of military aggression includes the full-scale war in 1950 that involved major superpowers such as the US, the Soviet Union, and China, the assassination of the SK First Lady in 1974, the killing of 17 SK cabinet members during a diplomatic visit to Myanmar in 1983, and the shelling of Yeonpyeong Island in 2010. Additionally, the unpredictable nature of North Korean attacks enables us to identify the exogenous shock in geopolitical risks.

Some readers may argue that the long history of stand-off between NK and SK with the presence of the US army on SK soil implies that NK would not wage a full-scale war. As has been widely reported (McLeod, 2013), most South Koreans take the military threat of NK as "business as usual." Consequently, any NK attacks will not trigger any permanent stock price responses. The empirical evidence in the literature is mixed. Nam (2002) documents insignificant price responses to NK attacks, but Ahn, Chay and, Jeon (2010), Gerlach and Yook (2013), and Lee (2006) find negative price responses.

We believe that the conflicting results in the literature may be attributable to the method of classifying the events. Some of the military actions of NK may give different strategic meaning from the rest to SK, and thus may receive different degree of stock price response. Having an enemy with nuclear weapons (nukes, hereafter) and LRMs is a totally different state of nature in terms of geopolitical risk compared to having an enemy without them. During our sample period, NK has gradually transitioned from a country *without* nuclear weapons to a country *with* significant capabilities in both nukes and LRMs (Lee, 2013; and UPI, 2013). Hence, to the extent that investors take the weapons testing as an event of updating their belief about NK's strengthened nuclear capability, the price response would be negative and *permanent*. In contrast, sudden military conflicts may be considered as "business as usual" which may only receive transitory price response.

Using Korean stock market data and the hand-collected data on nuclear-/LRM-related events and military aggression over the 1999~2012 period, we find supporting evidence for

our hypothesis. The series of tests of nuclear weapons and LRMs has resulted in a permanent and significant decrease in the stock market (KOSPI) index of -1.59%. This abnormal return translates into USD 17.6 billion or 1.56% of SK GDP as of the end of 2012.[4] Interestingly, the magnitude of the price response has diminished over time, suggesting that most of the learning of investors about the nuclear capabilities of NK took place before 2010. Since the US is NK's proclaimed major adversary, we also investigate the stock market response in the US and find a statistically significant abnormal return of -0.88% over a [-1,1] days window. The price response in the US became more negative after the NK began testing longer range missiles. In contrast to all of this, the investor response to major military attacks of NK is insignificant. This reconciles the recent puzzle in the literature. Our study reveals that nuclear testing has significant information content about the gradual change in the state of nature of a situation of dealing with a counterparty that has a nuclear capability.

If some investors are better informed than others about NK's forthcoming actions, the asymmetric information would widen the bid-ask spread. Specifically, some investors might have better access to information about NK, possibly through various international intelligence network inside and outside of SK as well as through diplomatic relations with NK. We are open to the possibility that SK is as foreign as any other country with respect to insider information on NK (as discussed in Section 2). We find that the bid-ask spread increases significantly *before* NK military actions. One might argue that this increase in bid-ask spread could also be explained by the distraction (Hirshleifer, Lim, Teoh, 2010) that NK causes to the SK market, as traders could be significantly disturbed by the geopolitical news or anticipation of the events. If so, however, the liquidity in the market should also dry up and the trading volume decrease significantly. However, we do not find supporting evidence for distraction hypothesis.

When some investors are better informed about forthcoming NK military aggression or nuclear testing, they could profit from their informational advantages by short selling stock. And since the SK microstructure data identifies short sales, we study the volumes of abnormal short selling surrounding NK nuclear weapons/LRM testing and acts of military aggression. Since the nationalities of foreign investors are also identified (247 of them), we group them into foreigners from countries that have diplomatic relations with NK (147

[4] According to the World Bank, SK GDP was USD 1,130 billion in 2012. The aggregate market cap of Korean stocks was meanwhile KRW 1,178 trillion as of 12/31/2012, which with a KRW/USD exchange rate of 1,062.87 translates to USD 1,108 billion.

countries) and those that do not (100 countries). We find that the volumes of abnormal short selling by non-resident foreign institutions from countries *with* diplomatic relations with NK, as well as those by domestic investors, increase significantly even five trading days before the events in question. Specifically, the institutions from UK and Germany are actively short selling Korean Index before the attacks. The result may be consistent with Kang, Kim, and Lee (2014), in which they find that the tone of British media has significant predictive power of NK's forthcoming actions. In contrast, we find no significant abnormal short selling from non-resident foreign institutions of countries *without* diplomatic relations with NK.

The rest of this paper is organized as follows. In section 2 we briefly review the literature. Section 3 then describes the collection of data, and the results are reported in Section 4. We conclude in Section 5. In technical appendix, we show our microstructure event study results to see the speed of real time investor response to geopolitical risk events and the trading behavior of individual investors at the minute of breakout of surprise attacks.

## II. Literature Review

Cutler, Poterba, and Summers (1989) document that major political events have relatively little impact on the US stock market. However, strands of literature have found significant impacts of political events on stock markets. Barro (1991), Mauro (1995) and Alesina et al. (1996) argue that political instability has a negative effect on economic growth. Ahn, Chay, and Jeon (2010) study the impacts of news about NK-SK relations based on 37 events and 46 Korean firms, and find that news about military attacks has negative impacts on the stock prices of firms having production facilities in Kaesong, a city in NK that was opened for economic cooperation projects between North and South Korea from 2000.

He, Nielsson, and Wang (2012) find that non-violent events of political tension between China and Taiwan result in a drop of -2% in the Taiwanese stock market index on the days of these events. They find that the abnormal returns are larger in magnitude if the firms are supporting the pro-independence party and if they are located within the range of missiles from China. Fisman, Hamao, and Wang (2012) study the market reaction to increased cultural aversion in Sino-Japanese relations. Abadie and Gardeazabal (2003) find significant negative economic impacts of guerrilla attacks in the Basque Country, Spain. Besley and Mueller (2012) study the political conflict in Northern Island, and find housing prices to be significantly affected by the chances of having military conflict and killings of people in the region, using a Markov switching model for switching from peace to conflict and vice versa.

Zussman and Zussman (2006) use a stock market event study to identify the impacts of political risk on stock prices from Israeli data. They find that investors react positively to assassinations of senior military leaders of Palestine, but negatively to assassinations of senior Palestinian political leaders. The reason for this contrast is because the killing of political leaders are counterproductive in terms of peace talks in the region and increased geopolitical risk. Rigobon and Sack (2004), Surowiecki (2004), Chen and Siems (2004), Wolfers and Zitzewitz (2009), Zussman and Zussman, and Nilsen (2008) find that financial markets are sensitive to political, diplomatic, and military developments. To the best of our knowledge, this is the first study in the literature to use microstructure data and short selling data to examine the behaviors of international traders and the real time impacts of geopolitical risk, especially surrounding Korean peninsula.

Gerlach and Yook (2014) [GY, hereafter] comes close to our paper in that both study the stock market impacts of NK aggression. However, our paper differs in several important dimensions. First, while GY work with 13 events in total, we study 74 events (10 tests of nuclear weapons or LRMs, 13 acts of military aggression, 21 rumors/reports about testing, 21 events of NK claims to test nuclear weapons in the near future, and nine military threats). These come from our exhaustive hand collection of 292 events associated with NK over the period of 1999~2012, including most of the diplomatic gestures of NK and surrounding countries. To the best of our knowledge, our collection of events is the largest in the literature on NK. Since nuclear weapons testing is preceded by either forewarnings by NK or rumors or reports from other countries, we capture these pre-warnings to see if investors respond significantly. Also, we investigate the stock price responses to NK military threats, and find that the threats generate significant negative responses. While GY studies the 53 largest stocks in SK, using daily stock return data, we work with all listed companies in SK using both microstructure and daily data.

Second, GY is about testing whether foreign investors destabilize the SK stock market at around the time of NK military aggression, in the vein of Choe, Kho, and Stulz (1999). Our interest is identifying the economic magnitudes of the impacts of change in the geopolitical risk level, specifically associated with NK's testing of nuclear weapons and LRMs. While GY treat both nuclear weapons testing and military aggression as the same group of events, we classify them into *different* groups because the former causes significant belief revisions in the perceived level of geopolitical risk while the latter does not.

Third, we investigate whether there is political insider trading associated with NK by looking at the short selling volume *before* surprise attacks. We forensically investigate the potential information leakages before events that may drive some investors to move ahead of their occurrence. While GY treat foreigners as a uniform group, we dissect the foreigners into various subgroups leveraging the unique feature of microstructure data we have, especially foreigners from the countries that have diplomatic relations with NK versus those from the countries that do not.

Poteshman (2006) is comparable to our study in that both papers attempt to look forensically at the behaviors of investors that have information advantages before geopolitical events. He finds abnormally high long positions of put options for the related airline stocks on the day before the 9/11 terrorist attack, a piece of evidence suggesting that the terrorists and their associates were profiting from their advance knowledge of the attack. Because we do not have option trading data, we look at the abnormal short selling volume by different nationalities of traders and find supporting evidence for potential political insider trading.

## III. Data

To make our study complete, we start by extensively collecting 292 events among all diplomatic and military interactions of NK involving SK, the US, and the multiparty talks during the sample period of 1999~2012. This is a union of 162 events of our own collection and 237 events compiled by the US website, Arms Control (www.armscontrol.org). For our own collection, we use the papers in the literature (Ahn, Chay, and Jeon, 2010; Gerlach and Yook, 2013; and Lee, 2006) and search through documents, such as the Defense Annals in SK, Google, and news articles of major media outlets, such as the Chosun Ilbo, the Dong-A Ilbo, the Hankyore, and the Joong-Ang Daily. We narrow our focus down to 74 events for this paper, and classify them into five groups: (1) tests of nuclear weapons (Nuke, hereafter) and LRMs (N=10); (2) military aggressions (N=13); (3) external rumors and reports about forthcoming NK Nuke/LRM testing; (4) NK declarations to test Nuke/LRM in the near future; and (5) NK military threats to bring "sea of fire" to SK. We classify the events of (1) NK beginning to restart its nuclear facilities and (2) NK withdrawing from the Non-Proliferation Treaty on January 10, 2003[5] in the first group, because, unlike NK's declarations of forthcoming Nuke testing, these events clearly signaled NK's intention to develop nuclear weapons and to move into a different state of nature permanently. The data on daily stock prices and the accounting information on public companies in South Korea are from FN Guide. The Korean microstructure data of 1999~2012 is from the KRX.

[Insert Table 1 about here]

## IV. Results

### 1. Daily event study using KOSPI index returns

We first investigate the market level movements in response to the geopolitical risk events. For each category of event listed in the previous subsection, we compute the abnormal returns using the KOSPI index value. An abnormal return is defined as the index return on a trading day in the event window minus the expected daily index return (which is the average index return over the estimation window of [-130,-11] trading days). The results are shown in Table 2 below. The t-statistics using Boehmer, Musumeci, and Poulsen (1991)

[5] NK in fact declared its withdrawal from the NPT in 1993, but it joined back again in a year after having high level talks with the US. However, it then withdrew from the NPT for good in 2003.

are shown in every second row. Some readers may wonder if the results that we report here are merely attributable to short-run overreactions. Therefore, we run longer window event study in Figure 1, in which we start to accumulate the abnormal returns from [-1] trading day until the trading date on the horizontal axis. For the analysis in Figure 1, to steer clear of the effect of confounding events, we remove the observations if any NK-related events took place less than six days before the event being observed.

[Insert Table 2 about here]

[Insert Figure 1 about here]

Investors' responses to nuclear weapons or LRM testing are negative and significant (-1.59% with t-stat of -2.08) over a [-1,1] trading day window relative to the actual setting off of the weapons. This response does not seem to be an overreaction but permanent. In Panel A of Figure 2, we find the CAR[-1,7] to be -2.23% (t-stat=4.84). This confirms our hypothesis that the nuke/LRM testing by NK over the last decade has had significant information content that the level of geopolitical risk has changed significantly. Considering the fact that NK sometimes pre-warns the testing of nukes/LRMs, some readers may question whether the investor response to the actual tests should be insignificant if rational expectations are formed and if investors believe NK's words. If so, investors should respond significantly at either the advance warnings or the rumors about nuclear weapons testing. Our event study however reveals that this is not the case. Stock market participants do not seem to take the advance warnings of NK or the rumors from intelligence sources as informative. Only when the actual testing happens do we see significant investor responses.

The investor response to actual major military aggression by NK turns out to be not significant or an overreaction at best. The average CAR[0] is -1.23% (t-stat=1.88 with N=13), but as we look at the longer window event study in Figure 1, we see an immediate reversal on the next trading day. This confirms again our hypothesis that investors take military attacks by NK to be "business as usual."

In contrast, we find the stock market response to military threats by NK to be negative and significant. The cumulative abnormal return over a [-1,1] event window is -1.79%, with a t-stat of -3.28. However, since only two of these events are non-contaminated, we do not

make further inferences. For sure, these are events distinct from the advance warnings by NK of exploding nuclear weapons or launching LRMs for testing.

Our next question is whether the magnitude of investor response changes over time. If the transition from having a negotiation counterparty without nuclear weapons to one with nuclear weapons is finished, after a certain point, nuclear weapons testing would start to become business as usual and investors would no longer respond. And the magnitude of the investor response would thus shrink over time. Therefore, in Panel A of Figure 2, we show the CAR of each event of Nuke/LRM testing. We find that the investor response was the worst on December 22, 2002, the day when NK began to restart its nuclear facilities. As the testing of long-range missiles and nuclear weapons has continued, the direction of the CAR has been largely negative, while the magnitude has decreased slightly over time. Therefore, a significant part of the revision of beliefs seems to have taken place in the early stage. By the time NK launched its Daepodong 2 LRM on April 5, 2009, the market response was even slightly positive. When NK's recent LRM launch of December 12, 2012 succeeded, the market seemed to be responding as if there were no update needed in terms of the level of geopolitical risk, consistent with market efficiency (Fama, 1970).

[Insert Figure 2 about here]

**2. Daily event study using market index returns of US**

As long as the US is a proclaimed counterparty of NK in the nuclear arms negotiations, and as long as NK's LRMs are targeting the North American continent, the testing of nuclear weapons may indicate a significant increase in geopolitical risk for the US as well. Therefore, we run a short-run event study of the S&P500 index returns using the moving average method over a [-130,-11] trading day estimation window. We find that the ACAR[0,1] of the S&P500 return for NK nuclear weapons/LRM testing is -0.88% (t-stat=2.13), which means it is negative and significant at less than the 5% level. This result is robust when we use the value-weighted CRSP index (-0.85% with a t-stat of 1.93) and the equal-weighted CRSP index (-0.50% with a t-stat of 1.37). To save space, we do not tabulate them.

With the same logic as in the last subsection, we investigate the time series of investor responses in the US to the series of NK Nuke/LRM tests and show it in Panel B of Figure 2. We show the CAR[0,1] of US market index returns. For each incident we use three different indices: S&P500, value-weighted CRSP, and equal weighted CRSP. In contrast to what we

find in the Korean stock market, the US market began to respond significantly from March 10, 2003 (-3.2%: the day of a NK launch of a non-ballistic missile (still long-range)), and the magnitude of the negative response was similar on April 5, 2009 (the day of NK's launch of its LRM, Daepodong 2). The response is still negative in 2012. Interestingly, the US response is slightly *positive* on the days of the first and second nuclear weapon tests (October 9, 2006 and May 25, 2009), and what we can infer from this is that US investors began to take the geopolitical threat of NK very seriously as NK's LRM program advanced in terms of distance to reach closer to the US mainland. What this implies may be that the US would more readily take action against any greater nuclear/LRM threat, to protect its own territory. Again, the magnitude of responses to LKRM launches seems to have been diminishing since the Daepodong 2, indicating that most of the updating was done until 2009.

We also investigate the stock price responses in Japan and Hong Kong , using the Nikkei (Japan) and Hang Seng (Hong Kong) indexes downloaded from Yahoo!Finance. We again use the 120-trading day moving average over the estimation window of [-130,-11] trading days as the expected return, but do not find any significant abnormal returns (untabulated to save space). We plot the time series of CAR[0,1] for each Nuke/LRM test in Panel C. Because China and Hong Kong are not really targeted by NK, we do not find any significant pricing pattern in the Hong Kong market. The returns on the Nikkei index were the most negative on the day when NK launched non-ballistic missiles into the sea between Japan and the Korean peninsula on March 10, 2003. For Japan, as the range of NK's LRMs grew beyond Japanese territory and reached closer to the US, the stock price response became insignificant. This pattern might be attributable to two potential offsetting effects. On the one hand, the rise in geopolitical risk would reduce Japanese stock prices, just like in SK and the US. On the other hand, the increased risk from NK would trigger Japanese rearmament, which would spur production in military-related industries and in turn increase stock prices.

**Analysis of stock level responses in SK**

In Section 1 we investigated the market-wide response to various geopolitical risk events on the Korean peninsula. Even though the geopolitical news has macroeconomic impact, depending on the characteristics of the firm, the news may have different information content (Boyd, Hu, Jagannathan, 2005). For example, news about military aggression may have negative information content for the firms that have more business exposure to NK, but it may have positive information content for the firms that have business contracts with the

Defense Ministry. Therefore, in this section we study the cross-sectional variation in stock price responses among all 1,715 individual listed firms in SK using a multiple regression framework. We use the event day return as the dependent variable and the firm characteristics as explanatory variables or controls. Ever since 2000, the year of the first summit talk between SK and NK, as a symbol of economic cooperation between NK and SK, the two countries established a special economic zone in the territory of NK only 10 kilometers (6.2 miles) north of the DMZ (demilitarized zone), called the Kaesong Industrial Region (KIR, hereafter). There are 72 public firms with production plants located in KIR, and for this group of firms geopolitical tensions between NK and SK would negatively affect their production in terms of cash flow and risk.

For example, some of the free trade agreements that SK has entered into with different foreign countries take different stances in terms of recognizing products from the KIR as products of SK (or of NK), and these stances have changed depending upon the hawkishness of the SK ruling party. Therefore, the price competitiveness of these products has been affected by geopolitical tensions, which have naturally affected cash flows. In addition, every now and then NK has leveraged the SK workers in the KIR as a bargaining tool, for example expelling SK government officials in 2008. For SK employees working in the KIR, there has always been the worst case possibility of becoming hostages, which would cause tremendous costs to SK companies. NK eventually closed the KIR in 2013, at the peak of the tensions surrounding its nuclear testing. We therefore hypothesize that the stock price responses to military/diplomatic tension would be especially negative for companies with exposure in the KIR. In Appendix C we list these companies, and label their stocks "Econ coop stocks," meaning stocks of companies involved in economic cooperation with NK. We construct our list by combining the lists in Ahn, Chay, and Jeon (2010) and those used in Shinhan Bank and Korea Investment Securities Co.

There are also some companies that produce defense industry products, such as tanks and heavy machinery. We label their stocks "Defense stocks," and hypothesize that military tensions between North and South Korea may be good news for them because of the increased chance of selling more products to the Department of Defense. Ahn, Chay, and Jeon (2010) find that bad news in NK-SK relations results in positive responses of stocks in the defense industry. Our list of 41 "Defense" stocks is also given in Appendix C.

We control for foreign ownership, firm size (log of total assets), profitability (ROA: operating income before depreciation divided by assets), financial risk (leverage ratio), and information asymmetry (R&D margin: total R&D expenses divided by revenues). Given that

the geopolitical risk coming from NK is such an important factor in investing in SK, foreign investors might have chosen certain stocks in SK to minimize this geopolitical risk in the first place. Therefore, for a stock with high foreign ownership, the investor response to events of high tension between NK and SK should be less negative. Since we are investigating the cross-sectional variations among all stocks in the stock market, we use the raw returns instead of abnormal returns as our dependent variable. We control for industry fixed effects. Because we take repeated observations from the same companies for different events, we use clustered standard errors at the firm level. Our empirical model is as follows:

$$\text{Ret}[0] = \beta_1 1\{\text{Econ Coop}\} + \beta_2 1\{\text{Defense}\} + \gamma\text{Controls} + \text{industry FE} + \epsilon \ldots\ldots (1)$$

We run the regressions for each different group of events, and the results are shown in Table 3:

[Insert Table 3 about here]

First and foremost, we find that the stocks of companies involved in economic cooperation between NK and SK are hit hard by events of geopolitical tension such as nuclear weapons testing or announced plans by NK to test Nukes/LRMs. Contrary to our conjecture above, we do not find defense stocks to be significantly affected by geopolitical risk events. This may be because the increased tension does not materially increase the production of weapons for the arsenal or military facilities in SK. We also find some evidence of flight to quality when geopolitical tensions increase. Specifically, when nuclear testing is carried out by NK, (1) the returns on small stocks seem to be worse than those on large stocks, and (2) the returns on high leverage stocks seem worse than those on low leverage stocks. Firms with high foreign ownership seem to perform better when there are rumors or reports or NK announcements of plans for testing Nukes/LRMs. However, when military aggression takes place these firms seem to suffer more on the days of those events. Given that the investor response to NK military aggression ends up being an overreaction, it might be the case that some unsophisticated investors (presumably domestic individuals) in firms with high foreign ownership are overreacting by being overly conscious of foreign investors' potential selling pressures.

## 4. Analyzing bid-ask spreads

When a negative geopolitical event takes place, if the event is informative about the future cash flows and risks of South Korean firms, investors should revise their beliefs and reallocate their assets accordingly. If some investors have better information than others before geopolitical events, the adverse selection cost component of the bid-ask spread will increase. For example, when NK plans a surprise attack on SK territory, some investors may have better information through their professional or personal networks with the intelligence services. Some foreign investors may have better information if their countries have diplomatic relations with NK. In this subsection, therefore, we investigate the bid-ask spreads of stocks in SK related to events of NK Nuke/LRM testing and military aggression.

For each stock we first measure the effective spread for each transaction in a day. The effective spread is computed as the ask price minus the bid price divided by the midpoint between them. To avoid the noisiness of the market in the beginning and ending 30 minutes of the trading sessions, we take only the trades made during the time segment between 9:30 am and 2:30 pm (McInnish and Wood, 1992). For each stock on each trading day, we compute the average of the effective spread. Next, over the estimation window of [-40,-11] trading days, we estimate the mean of the daily average effective spreads. And then, for each trading day over the event window of [-5,5] trading days, we first compute the abnormal spread for each stock by subtracting the mean of its daily average effective spread from the daily average effective spread. Then we finally compute the mean of the abnormal spreads across all stocks. To obtain the standard errors, we run bootstrapping with 1,000 replications based on the sample. If the average abnormal effective spread is significantly different from zero with a statistical significance of 10% (|z-stat|>1.96), we represent it with a colored dot.

[Insert Figure 3 about here]

As predicted, we find that the daily average effective spread becomes abnormally high on the day of the event concerned, which may indicate either that the information asymmetry increases or the liquidity dries up. A more interesting finding is that the spread starts to increase significantly even four trading days before the outbreaks of military aggression and one day before Nuke/LRM tests. Before we jump to any conclusions about this, however, we first investigate the liquidity of the stocks to see if such increases in bid-ask spreads are attributable to the drying up of liquidity.

## 5. Daily abnormal volume event study

In this subsection we study how the daily trading volume changes at around the days of

the events. If the event is informative and the price change is permanent under market efficiency and a frictionless market where information is common knowledge, the price change will *not* be accompanied by a significant increase in trading volume (Milgrom and Stoke, 1982). However, if NK's testing of nuclear weapons and LRMs distracts investors (Hirshleifer, Lim, and Teoh, 2009), liquidity would dry up due to a lower trading volume, which would partly explain the increase in bid-ask spread in the previous subsection. On the other hand, if the event merely draws attention and triggers widespread disagreement among investors, the trading volume would rise significantly. We analyze the abnormal trading volume at the aggregate market level. Consistent with our return event study in Figure 1, we set up our estimation window to be [-130,-11] trading days and the event window [-1,20]. For each trading day we compute the abnormal trading volume by subtracting the average trading volume over the estimation window from the event day trading volume. And then, for the given event classes that are not confounded by other events from our exhaustive collection of 292 events, we compute bootstrap z-statistics by replicating 1,000 times. If the abnormal share turnover is significantly different, with an absolute value of z-statistic greater than 1.96, we indicate it with a box dot. The results are shown in Figure 4. We do find significant changes in liquidity in the stock market. Sixteen trading days after Nuke/LRM testing we detect significant declines in trading volume, but 16 days is too long to be linked to the events. For at least a handful of days around the day of an event, we do not see meaningful changes in trading volumes, making it hard for us to conclude that the increase in bid-ask spread find in the previous subsection is attributable to the liquidity issue. Rather, the results make it reasonable to attribute the bid-ask spread change to possible information asymmetry among investors caused by some investors having better information.

[Insert Figure 4 about here]

One possibility is that investors from countries having better diplomatic networks with NK are trading based upon their own private information. Some of these potential candidate investors may include foreigners of countries with diplomatic relations with NK and investors who have connections to various intelligence services. Other potential candidates are domestic individuals or institutions having better connections with intelligence services in various countries. When a trader has advance negative information about geopolitical risk, he/she has several ways of profiting from it. One is to take long positions on put options of the stocks of the country involved, as in Poteshman (2006). Unfortunately, we do not have the trading data of the option markets in SK. Another way of profiting is through the short selling of stocks or indices, which leads us to the next subsection.

## 6. Volumes of short selling around the time of NK events

The KRX data enables us to identify whether a sell order is a short sale or not, and whether an order is coming from individual or institutional investors. Further, it gives information about the nationalities of the traders and the kinds of institutional investors concerned, such as brokerages versus asset managers. It in addition identifies whether a trade is associated with program trading and of which kind, for example index arbitrage. For institutional details about short selling in the Korean market, please refer to Lee and Wang (2013).

For foreign investors placing orders, the KRX data not only identifies whether they are individuals or institutional, but also whether they are resident or non-resident foreigners and what their nationalities are. While non-resident foreign individual investors are not active in short selling SK stocks, resident foreign individuals sometimes are. Also, when foreign institutions short sell Korean stocks, their non-resident counterparts offshore (headquarter) typically execute the transactions. We therefore focus on the short selling behaviors of resident foreign individual investors (RFInd) and non-resident foreign institutions (NRFInst). Moreover, because we conjecture that the behavior of foreign investors may be a function of the diplomatic relations of their home countries with NK, due to the potential information flow, we split the sample into foreigners from countries with diplomatic relations with NK (147 countries including China, Sweden, and Singapore) and from those without (100 countries including the US, Japan, and offshore South Korean citizens having permanent residency in foreign countries). We obtain the list of countries that have diplomatic relations with NK from the National Committee on North Korea's webpage (http://www.ncnk.org/), and Google searching.

We first set our estimation window to be [-40,-11] trading days before the event, and our event window to be [-5,5] trading days. For each stock we carry out the following process, for individual investors and institutional investors separately: We first calculate the short turnover, which is the short selling volume divided by the number of shares outstanding on a trading day. Next, over the estimation window, we compute the daily average short turnover of the stock. Then, on each trading day of the event window, we compute the abnormal short turnover, which is the actual minus the expected (average) short turnover. We then take the average abnormal short turnover across all stocks and across the series of events in the same category of event.

$$Short\ Turnover_{itckp} = \frac{Short\ Volume_{itg}}{Shares\ outstanding_{itg}} \ldots\ldots\ldots\ldots (2)$$

$$Average\ Abnormal\ Short\ Turnover_{tkp} = \frac{1}{I}\sum_{i=1}^{I}\left[Short\ Turnover_{itg} - \overline{Short\ Turnover_{ig}}\right] \ldots\ldots\ldots (3)$$

where $i$ is a subscript for each stock in the Korean market, $g$ is a subscript for the investor sub-group, and $t$ is a subscript for the trading day. The event window is [-5,-1] trading days, and $\overline{Short\ Turnover_{ig}}$ is computed over the estimation window of [-40,-11] trading days. Figure 5 shows the average abnormal short turnover around the day of NK nuclear/LRM testing, and Figure 6 the average abnormal short turnover around the day of NK acts of military aggression. We bootstrap 1,000 times to obtain the standard error, and represent it with a colored dot when the average abnormal short turnover is statistically significant at the 5% level.

[Insert Figure 5 & 6 about here]

For the trading days before both groups of events we detect significant abnormal short selling volume coming from domestic individual investors and domestic institutions. We do not have hard evidence as to whether some of these investors may have had better information from NK or been more sensitive to expectations of forthcoming actions by NK. When we look at the behaviors of foreign investors before Nuke/LRM tests in Panel C of Figure 5, an interesting pattern arises. Non-resident foreign institutions from countries that have diplomatic relations with NK show a spike one day before the Nuke/LRM testing. The spike is not statistically significant, but the economic magnitude is large compared to the movements of domestic institutions. This suggests that some countries in the group with diplomatic relations with NK are disproportionately short selling greatly, while the rest are not involved in short sales. The graph also shows that non-resident foreign institutions from countries without diplomatic relations with NK are not short selling any more significantly than before.

When we look at the behaviors of foreign investors before military attacks, in Panel C of Figure 6, another interesting pattern appears. Non-resident foreign institutions from

countries having diplomatic relations with NK significantly short sell more than two days before the attacks. Recall that acts of military aggression bring an abnormal return of about -1.23% (t-stat=1.88) on the day of the event. The spike in short turnover is both statistically and economically significant. Interestingly, again, the graph shows that non-resident foreign institutions from countries without diplomatic relations with NK do not short sell any more significantly than before. These pieces of evidence may suggest that some investors placing orders in countries with diplomatic relations with NK are leveraging their informational advantages by short selling of stocks in advance. And we therefore delve deeper in the next subsection, and investigate which countries' institutions are short selling significantly more over this pre-event window utilizing the country codes.

**7. Short selling volume around the time of NK events by nationality**

We conduct the same short turnover event study as in the previous subsection, focusing on the nationalities of the institutions involved. For the sake of fairness we show the results for both countries with and without diplomatic relations with NK. Panel A of Figure 7 shows the abnormal short turnover before NK testing of nuclear weapons or LRMs of non-resident foreign institutions from countries having no diplomatic relations with NK. We do not find any statistically significant spike for this group. Some readers may suspect that these short sellers are those operating in the usual suspect tax haven destinations, such as the Cayman Islands. But the Cayman Islands turn out to have no diplomatic relations with NK, and do not seem to generate any significant spike in short turnover. Panels B and C of Figure 7 show the abnormal short turnover of non-resident foreign institutions of countries having diplomatic relations with NK. We find that German (Swiss) institutions short sell significantly more from three (two) days before the NK testing of nuclear weapons or LRMs.

Figure 8 shows the abnormal short turnover before NK acts of military aggression, in accordance with the nationalities of the foreign institutions involved. Panel A again shows the abnormal short selling activities of institutions from countries without diplomatic relations with NK, and Panels B and C those of institutions whose countries do have diplomatic relations with NK. We see a huge spike in short selling coming from UK institutions three and two days before the military aggression, while not finding any significant increase in short volumes from other countries. These results might suggest that some institutions, such as hedge funds, working in (or close to) London, Berlin or Zurich may be trading based on their informational advantages related to NK. These cities, obviously, are ones that have

North Korean embassies. According to Jason (2012), UK hosts more than fair share of pro-NK organizations, such as Korean Friendship Association (KFA).

Some readers may argue that these short sales may be mechanically associated with program trading such as index arbitrage. When the index futures value is lower than the spot index, institutions may short sell the spot index, which would increase the short selling volume. Institutions from these countries may be more sophisticated and more capable of doing this than those from the rest of the world. However, we are working with an abnormal short turnover that is benchmarked against the average over the estimation window or prior 30 trading days. Moreover, it is difficult to believe that institutions from the UK, Switzerland, and Germany are any more sophisticated than those from France, Japan, or the US. We nevertheless take a conservative stance, and investigate the abnormal short selling behavior by the kind of investor and the purpose involved, all of which are identifiable in the KRX microstructure data.

[Insert Figure 7 & 8 about here]

**8. Short selling volumes, by kind of investor and purpose of trading**

Boehmer, Jones, and Zhang (2008) find that short sales of individual stocks carried out by institutional investors under non-program trading are the most informative. In our setting, however, the insider information is about macro-level geopolitical risk that is applicable to the whole market of SK. One could possibly therefore profit sufficiently through short selling the market index either in the form of index arbitrage or index non-arbitrage. Korean microstructure data identifies the kinds of institutions that have placed the orders: brokerage houses, insurance companies, asset managers, private equity, banks, pension funds, government/municipal/international organizations, and other firms. It also shows what kinds of program trading the trades originate from: general trading, index arbitrage, stock arbitrage, ETF arbitrage, KDR (Korean Depository Receipt) arbitrage, stock/index hedging, ELW hedging, futures hedging, ETF hedging, OTC derivatives hedging, index non-arbitrage, etc. We compute the average abnormal short turnover by the stock, trading day, the kind of institution, and the kind of trade in the following manner:

$$Short\ Turnover_{itckp} = \frac{Short\ Volume_{itckp}}{Shares\ outstanding_{itckp}} \ldots\ldots\ldots (4)$$

$$Average\ Abnormal\ Short\ Turnover_{tkp}$$

$$= \frac{1}{I}\sum_{i=1}^{I}\left[Short\ Turnover_{itckp} - \overline{Short\ Turnover}_{ickp}\right] \ldots\ldots\ldots (5)$$

where *i* is a subscript for each stock in the Korean market, *c* a subscript for the country, *t* a subscript for the trading day, *k* a subscript for the kind of institutional investor, and *p* a subscript for the program trading code. The event window is [-5,-1] trading days, and $\overline{Short\ Turnover}_{ickp}$ is computed over the estimation window of [-40,-11] trading days. We plot the average abnormal short turnovers in Figure 9. We use a bootstrapped standard error by replicating 1,000 times. If the average abnormal short turnover is significantly different from zero at a 5% significance level, we display it with colored dots. Based on the results in the previous subsection, we focus only on the three countries that showed significant abnormal short turnovers: Germany, Switzerland and the UK. Since some readers might wonder if the pattern we report is spuriously driven by events that took place on SK trading holidays, we focus only on those that occurred on SK trading days. The results are robust when we include all of the events that occurred on non-trading days (two from each group of events).

[Insert Figure 9 about here]

We find that German banks short sell the SK index significantly more before Nuke/LRM tests. This short selling is associated with index non-arbitrage, which means that the institutions are (actively) short selling at least 15 of the components of the KOSPI index. We detect a similar pattern for Swiss banks on trading day -1, but it is not statistically significant. When we look at the short selling behavior of British institutions before NK surprise military attacks, we find intensive movements. First, "other firms" short sell significantly more in conjunction with index arbitrage. This might be more passive short selling driven by computer programs that link the spot and the futures/options markets. Second, brokerage firms and asset managers (presumably hedge funds) short sell significantly more three to one days before surprise attacks. Again, just like in the case of German banks before Nuke/LRM testing, these transactions are associated with index non-arbitrage, indicative of active short selling of the index. All in all, it seems that some banks placing short sale orders in Germany and some asset managers and brokerage houses placing short sale orders in Britain have moved ahead to profit from their informational advantages related to NK.

## 9. Short selling volumes of domestic institutions

[Insert Figure 10 & 11 about here]

In this subsection we analyze the short selling behaviors of domestic institutions before NK actions. The short selling volume itself is in the first place an order of magnitude smaller than that of foreign institutions, and this may be attributable to the concerns of the institutions to avoid triggering any unnecessary attention of the regulators given the negative connotations associated with short selling. Therefore, the results could be more noisy than informative. With this caveat, we find that asset managers short sell significantly more in conjunction with index arbitrage one day before nuke/LRM tests (Panel B). Brokerage houses also short sell more in conjunction with ETF hedging. Before surprise military attacks by NK, we detect significant spikes in ETF arbitrage (or ETF hedging) related to short sales by brokerage houses. All of these sales are attributable to passive program trading strategies. We find that brokerage houses short sell the market index significantly more in forms unrelated to index arbitrage, which is more active short selling. However, in contrast to what we find about asset managers of the UK or banks in Germany, the abnormal short volume reverses as the date approaches the event day.

## 10. Volume of short selling by domestic individuals

When we look at the short turnover of individual investors we cannot break it down in accordance with the program trading patterns because, with the exception of a small number of day traders, individual investors are by definition not so sophisticated as to use computer-based program trading. We therefore dissect the types of individual traders from a different angle, which is their method of placing orders. The microstructure data identifies which media the traders used to place their orders: local branches, land line telephones, wireless communication tools, home trading systems, and others. Panel A of Figure 12 shows the abnormal short turnover of domestic individuals by medium of order placing prior to NK Nuke/LRM tests. We find that none of the abnormal short turnover is statistically significant, even though it is generally trending upward until day -1. When we analyze the volume of abnormal short selling of domestic individual investors before NK military attacks, we find a significant spike three trading days before the event for the group of individuals placing their orders at local branches. Still, just as what we reported for index short selling by domestic institutions unrelated to index arbitrage, there is a significant spike downward as we draw closer to the event day.

[Insert Figure 12 about here]

## V. Conclusion

The South Korean stock market enables us to identify the impacts of changes in geopolitical risk because of the transitioning by its belligerent communist neighbor beyond its northern border from a country without to a country with substantial capabilities in nuclear weapons and LRMs (Lee, 2013; and UPI, 2013). Moreover, NK's testing of weapons has been exogenous to the financial market of SK, and has been unpredictable due to NK's secretive nature. We find not only a 1.59% permanent decrease in the SK stock market index, but also a 0.88% decline in the US stock market at around the days of NK testing of nukes/LRMs. While the magnitude of the investor response in SK has diminished since 2009, that of the investor response in the US remains non-trivial especially as NK's LRM tests prove to be able to reach closer to the US mainland. We interpret from this that US investors take the threat of NK seriously now.

We also find significant information asymmetry among investors *before* the actual testing of nuclear weapons and LRMs or launches of surprise military attacks, which lead to significant increases in bid-ask spreads without changes in liquidity. In addition, we document a significant difference in short selling volume between the investors with better access to information of NK and those without. The information channel that we identify is diplomatic relations between NK and the home countries of the foreign institutions placing orders from outside SK. Specifically, we find that some asset managers in the UK and some banks in Germany are short selling abnormally more in the form of index short selling unlinked to index arbitrage. This result may imply a kind of geopolitical insider trading. Given the heavy US sanctions against financial institutions dealing with NK, it is in the absence of account level identification of traders difficult to conjecture that these short sellers are financing tools for the NK regime. Our contribution to the literature is that this is the first paper to use microstructure/short selling data in a geopolitical risk study of finance and to identify potential insider trading based on geopolitical information.

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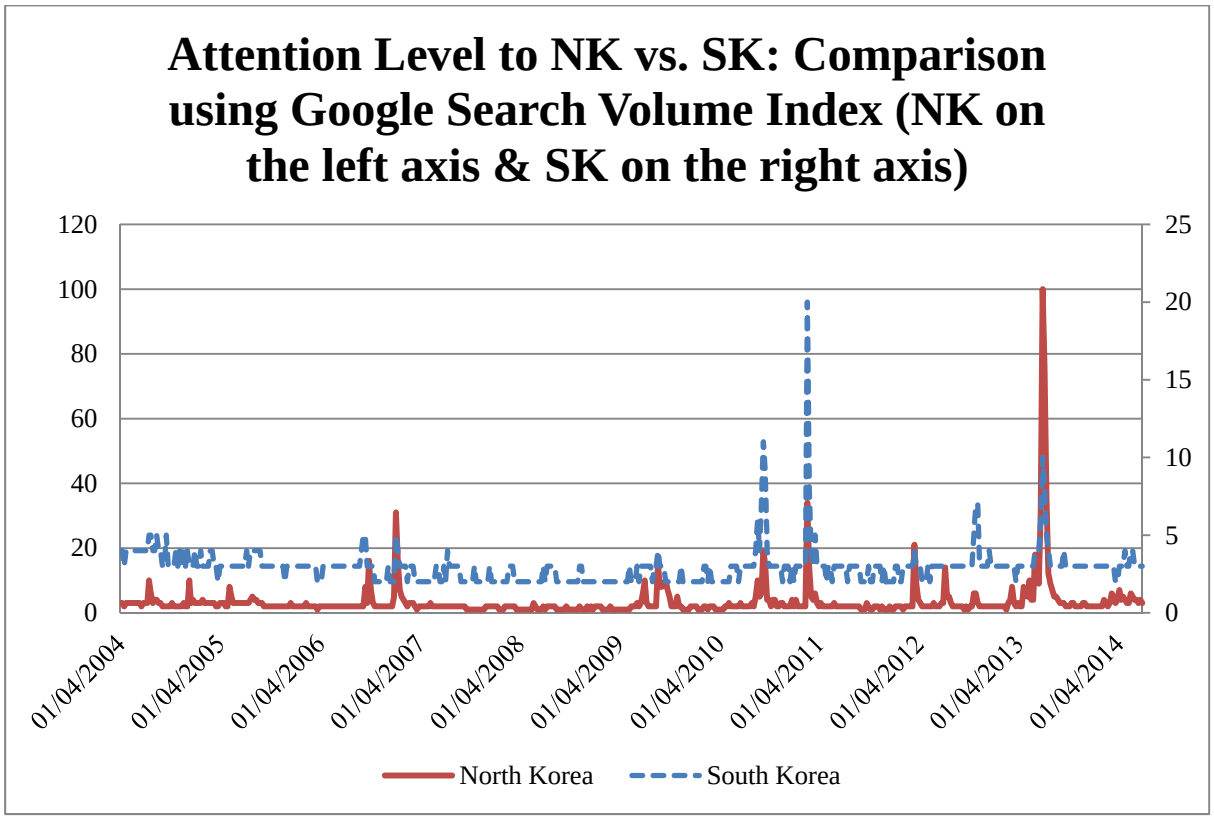
**Appendix A. Comparing levels of attention to NK and to SK using Google Search Volume Index**



## Appendix B. Map of East Asia (Source: Google Maps)

## Appendix C. List of "Economic cooperation" and "Defense" stocks

"Economic cooperation" stocks are the South Korean companies that have production facilities in Kaesong Industrial Region (KIR), which is 10 kilometers (6.2 miles) north into the territory of North Korea. Defense stocks are the South Korean companies that supplies materials to Department of Defense. We constructed the list by combining the list of Ahn, Chay, and Jeon (2010) and the lists used by Shinhan Bank and Korea Investment Securities Co.

| Name Econ Coop stocks | Name Econ Coop stocks | Name of Defense stocks |
|---|---|---|
| DS Steel | Acebed | DMS |
| GS Construction | NK CO.,LTD. | HRS |
| KT | Woowon Infra | MDSTechnologyCo.,Ltd. |
| LS Industrial Systems | Ehwa Technologies Information | S&T Motiv |
| LG International | In The F | S&T Dynamics |
| GAON CABLE CO.,LTD | INZI CONTROLS CO.,LTD | S&T Holdings |
| Kunng Nong | Ilshin Stone | STX Engine |
| KyeongWon Industry Inc | Iljin Electric | YTN |
| KwangMyung Electric | JAHWA ELECTRONICS CO.,LTD | Kanglim |
| Geumhwa PSC | Jaeyoung Solutec | Kisan telecom |
| NamKwang | Cheryong | Kia |
| Namhae Chemical | Cheryong Electric | Deayang |
| Greencross | CHEIL INDUSTRIES INC | Daewoo Shipbuilding & Marine Engineering |
| Daelim | Chobi | KOREAN AIR LINES CO.,LTD |
| Daewoo International Corporation | Goodpeople | Doosan Infracore |
| Daewon Cable | KOLON CORPORATION | Theallmedibio |
| Dongbu CNI | TAEKWANG INDUSTRIAL CO.,LTD | lumens |
| Dongbu HITEK | PAN-PACIFIC CO.,LTD | Victec |
| Tongyang | Halim | Samsung Heavy Industries |
| Tong Yang Moolsan | HISTEEL CO., LTD | Samsung Techwin |
| Dong Yang Steel Pipe | KOREA ELECTRIC TERMINAL CO.,LTD | Samyung ENC |
| Romanson | Korea Electric Power Corporation | Speco |
| LOTTE CONFECTIONERY CO.,LTD | KOREA ELECTRIC POWER CORPORATION | SatrecInitiativeCo.,Ltd. |
| Lotte Tour | HANSSEM CO.,LTD. | Ace Technologies Corp. |
| MANIKER CO.,LTD | Hyundai Engineering & Construction | Welcron |
| MIJU STEEL MFG.CO.,LTD. | Hyundai Corporation | Withus Co., Ltd. |
| Bosung Power | Hyundai Merchant Marine Company Limited | EM Korea |
| BnB Sungwon Co.,Ltd. | Hyundai Elevator | Firstec |
| Vitzrosys | Hundai Steel Company | PEOUNGHWA IND |
| Vitzrotech | Haein | Formetal |
| Sambu | Hyosung | POONGSAN CORPORATION |
| Samsung C&T | | Poongsan Holdings |
| Samsung Fine Chemicals | | Korea Aerospace Industries |
| Samchuly Bicycle | | HANYANG ENG CO.,LTD |
| Seondo Electric | | Hanil Forging |
| Sungbo Chemical | | Hanjin Heavy Industries |
| Semyung Electronic | | Hanjin Heavy Industries&Construction Holdings |
| Shinwon | | Hanwha |
| CN Plus | | Hyundai-wia |
| Asia Agricultural Machinery | | Hyundai Heavy Industries |
| Emerson Pacific | | Huneed |

**Table 1. Classification of events**

To make our study complete, we start by extensively collecting 292 events among all diplomatic and military interactions of NK involving SK, the US, and the multiparty talks during the sample period of 1999~2012. This is a union of 162 events of our own collection and 237 events compiled by the US website, Arms Control (www.armscontrol.org). For our own collection, we use the papers in the literature (Ahn, Chay, and Jeon, 2010; Gerlach and Yook, 2013; and Lee, 2006) and search through documents, such as the Defense Annals in SK, Google, and news articles of major media outlets, such as the Chosun Ilbo, the Dong-A Ilbo, the Hankyore, and the Joong-Ang Daily. We narrow our focus down to 74 events

| | date of breakout | Event |
|---|---|---|
| Nuke/ICBM | | |
| 1 | 12/22/2002 | NK stopped the CCTV on their nuclear facilities, and they removed the cover of nuclear fuel |
| 2 | 01/10/2003 | NK gets out of NPT |
| 3 | 02/24/2003 | NK tests long range missles in the East Sea |
| 4 | 03/10/2003 | NK launches non-ballistic missiles |
| 5 | 07/05/2006 | Daepodong 2 test launching |
| 6 | 10/09/2006 | First nuclear testing of NK |
| 7 | 04/05/2009 | Launching Daepodong 2 new version |
| 8 | 05/25/2009 | 2nd nuclear testing |
| 9 | 04/13/2012 | NK fails in launching a rocket or a potential prototype of ICBM |
| 10 | 12/12/2012 | NK succeeds in sending a long-range rocket carrying a satellite into orbit |
| Military aggression | | |
| 1 | 06/08/1999 | The first battle of Yeonpyeong |
| 2 | 11/27/2001 | North and South Korean forces exchange fire |
| 3 | 06/29/2002 | The second battle of Yeonpyeong |
| 4 | 01/14/2003 | ROK and NK soldiers exchange machine gun fire |
| 5 | 07/17/2003 | North and South Korean forces exchange fire at the DMZ |
| 6 | 08/27/2003 | KPA soldiers fire rounds that strike a UNC guardpost. |
| 7 | 07/31/2006 | North and South Korean forces exchange fire near Yanggu |
| 8 | 08/06/2007 | KPA soldiers and 12th Infantry Division troops exchange fire. |
| 9 | 11/10/2009 | Battle of Daecheong |
| 10 | 01/27/2010 | Around thirty NK artillery shells shot into the NK's coastal waters. |
| 11 | 03/26/2010 | The South Korean patrol ship Cheonan is sunk near the South Korean-NK maritime border. |
| 12 | 08/09/2010 | NK artillery shells into the NK's coastal waters |
| 13 | 11/23/2010 | NK fires artillery rounds at the SK island of Yeonpyeong, 200 of which hit the island killing civilians and soldiers |
| Rumor report of Nuke/ICBM (21 events) | | |
| | 02/03/1999 | CIA reports capability of NK to launch ICBC Taepodong to Alaska in the near future |
| NK claimed Nuke/ICBM (21 events) | | |
| | 02/10/2005 | NK declares it has nurlear weapons and stops participating in 6 party talks |
| Military Threat (9 events) | | |
| | 02/27/2011 | NK threatens to turn Seoul into a “sea of fire” in response to the Key Resolve exercises, planned long in advance |

**Table 2. Short-run event study: KOSPI index returns using 120-trading day moving average of KOSPI index return as expected return.**

An abnormal return is defined as the daily KOSPI index return minus the average return over the estimation window of [-130,-11] trading days. Cross sectional t-statistics are reported in every second line.

| Expected return: | | 120-day moving average | | | | |
|---|---|---|---|---|---|---|
| Event group | N | [0] | [0,1] | [0,2] | [-1,0] | [-1,1] |
| Nuke/ICBM Testing | 10 | -0.73% | -1.02% | **-1.57%** | **-1.29%** | **-1.59%** |
| | | -1.41 | -1.30 | **-1.86** | **-2.17** | **-2.08** |
| NK claimed Nuke ICBM missile launching | 21 | 0.00% | 0.29% | 0.09% | 0.18% | 0.47% |
| | | 0.00 | 0.58 | 0.20 | 0.38 | 0.76 |
| Rumor Report about Nuke ICBM missile of NK | 21 | 0.05% | 0.62% | 0.43% | -0.07% | 0.51% |
| | | 0.11 | 1.06 | 0.65 | -0.11 | 0.63 |
| Military aggression of NK to SK | 13 | -0.29% | **-1.23%** | -0.79% | 1.00% | 0.01% |
| | | -1.05 | **-1.88** | -1.22 | 1.30 | 0.01 |
| Military threat of NK to SK | 9 | **-0.41%** | **-0.68%** | -0.17% | **-1.52%** | **-1.79%** |
| | | **-1.95** | **-1.70** | -0.30 | **-3.87** | **-3.28** |

**Table 3. Regression analysis of stock returns on days of NK actions (non-contaminated events only)**

Dependent variable is the raw returns of individual stocks on event day. We use all the stocks listed in SK market (KOSPI and KOSDAQ). To steer clear of the effect of confounding events, we remove the observations if any of the 292 NK-related events took place less than six days before the event being observed. 1{Econ coop stock} is a dummy variable that is one if the company has production facilities in Kaesong Industrial Region (KIR) that was established as a symbol of economic cooperation between North and South Koreas in 2000. 1{Defense stock} is a dummy variable that is one if the company has exposure to military supplier business. ROA is operating income before depreciation divided by assets, R&D margin is total R&D expenses divided by revenues. Industry fixed effects is based on the industry classification code provided by FN Guide. Standard errors are clustered at the firm level. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

| Dependent variable: Return [0] | | | | | |
|---|---|---|---|---|---|
| | [1] NK action of Nuke ICBM missile launching | [2] NK claimed Nuke ICBM missile launching | [3] Rumor Report about Nuke ICBM missile of NK | [4] Military aggression of NK to SK | [5] Military threat of NK to SK |
| 1{Econ coop stock} | -0.007 *** | -0.004 *** | 0 | -0.001 | 0.002 |
| | (-2.62) | (-4.24) | (-0.12) | (-0.48) | (0.57) |
| 1{Defense stock} | -0.004 | 0.003 | 0 | 0.001 | 0.003 |
| | (-0.70) | (1.34) | (0.14) | (0.34) | (1.08) |
| Foreign ownership | -0.009 | 0.007 * | 0.006 * | -0.013 *** | -0.008 |
| | (-1.54) | (1.89) | (1.69) | (-3.44) | (-0.98) |
| ln(Total Assets) | 0.004 *** | 0 | 0.001 *** | 0 | -0.001 |
| | (6.66) | (-0.48) | (4.10) | (0.06) | (-0.98) |
| ROA | -0.008 | -0.003 | -0.009 ** | 0.003 | 0.007 |
| | (-1.12) | (-0.55) | (-2.05) | (0.56) | (0.76) |
| Leverage Ratio | -0.008 ** | -0.007 ** | -0.003 | 0.004 | -0.003 |
| | (-2.00) | (-2.47) | (-1.21) | (1.20) | (-0.77) |
| R&D Margin | 0 | -0.003 | 0.004 | 0.018 ** | -0.01 |
| | (-0.00) | (-0.32) | (0.48) | (2.01) | (-0.67) |
| constant | -0.068 *** | 0.002 | -0.02 *** | -0.003 | 0.008 |
| | (-6.96) | (0.32) | (-3.67) | (-0.44) | (0.78) |
| Industry FE | Yes | Yes | Yes | Yes | Yes |
| N | 5225 | 13834 | 14250 | 5882 | 2691 |
| Adj.R2 | 0.014 | 0.002 | 0.004 | 0.008 | 0.021 |

**Figure 1. Event study of military and diplomatic actions involving North Korea (for non-contaminated observations only)**

An abnormal return is defined as the daily KOSPI index return minus the average return over the estimation window of [-130,-11] trading days. We accumulate the abnormal returns from one trading day before the first date of the event's being reported, and then keep accumulating until the trading day shown on the horizontal axis. If the average cumulative abnormal return is significant at the 10% level or less, we indicate it with box dots. The t-statistic is constructed using Boehmer, Musumeci, and Poulsen (1991), to control for event-induced volatility. To steer clear of the effect of confounding events, we remove the observations if any of the 292 NK-related events took place less than six days before the event being observed.

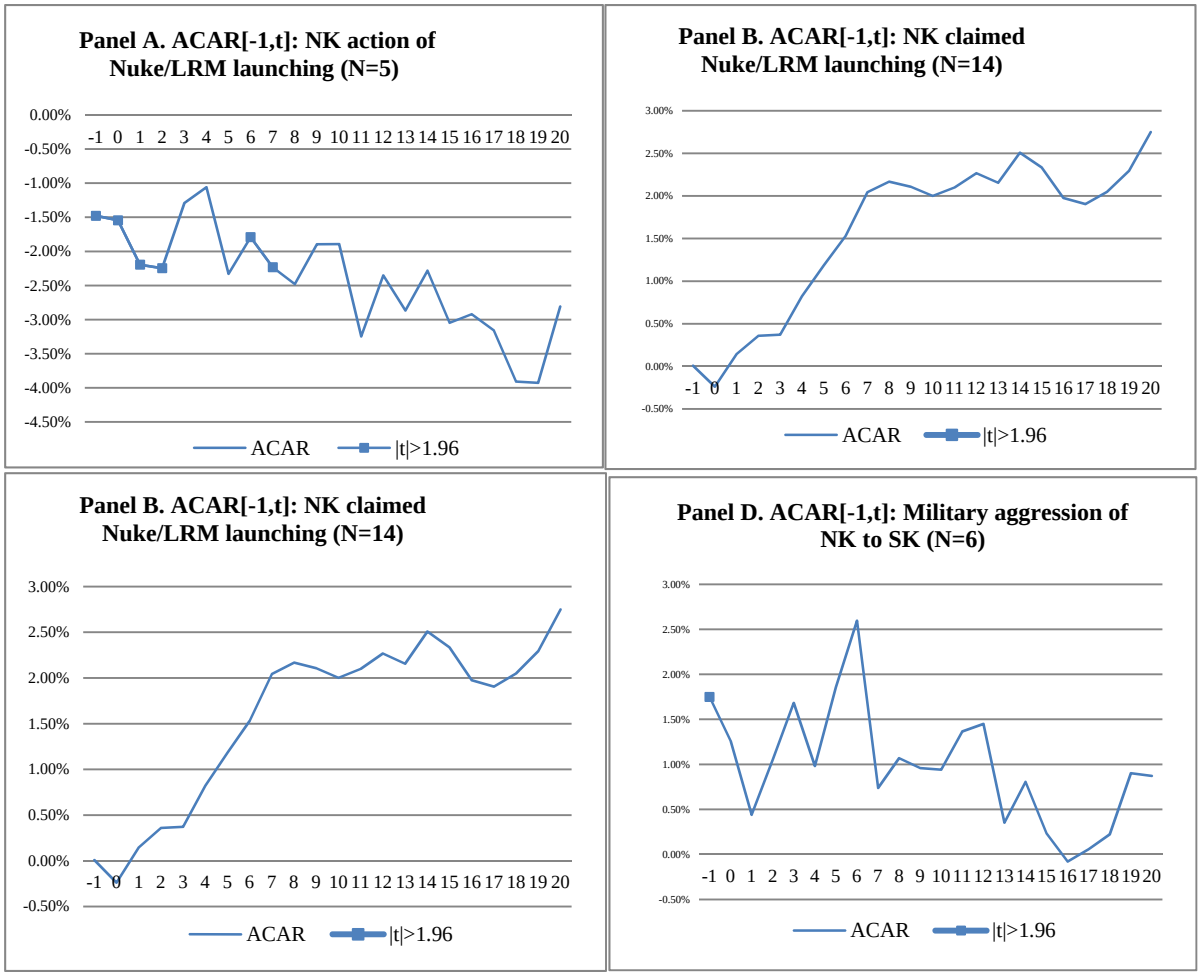


**Figure 2. Stock market responses to NK nuke/LRM testing in different countries over time**

The dates on the horizontal axis are the first trading days after the occurrences of events, and so may differ slightly from the dates in Tables 1.

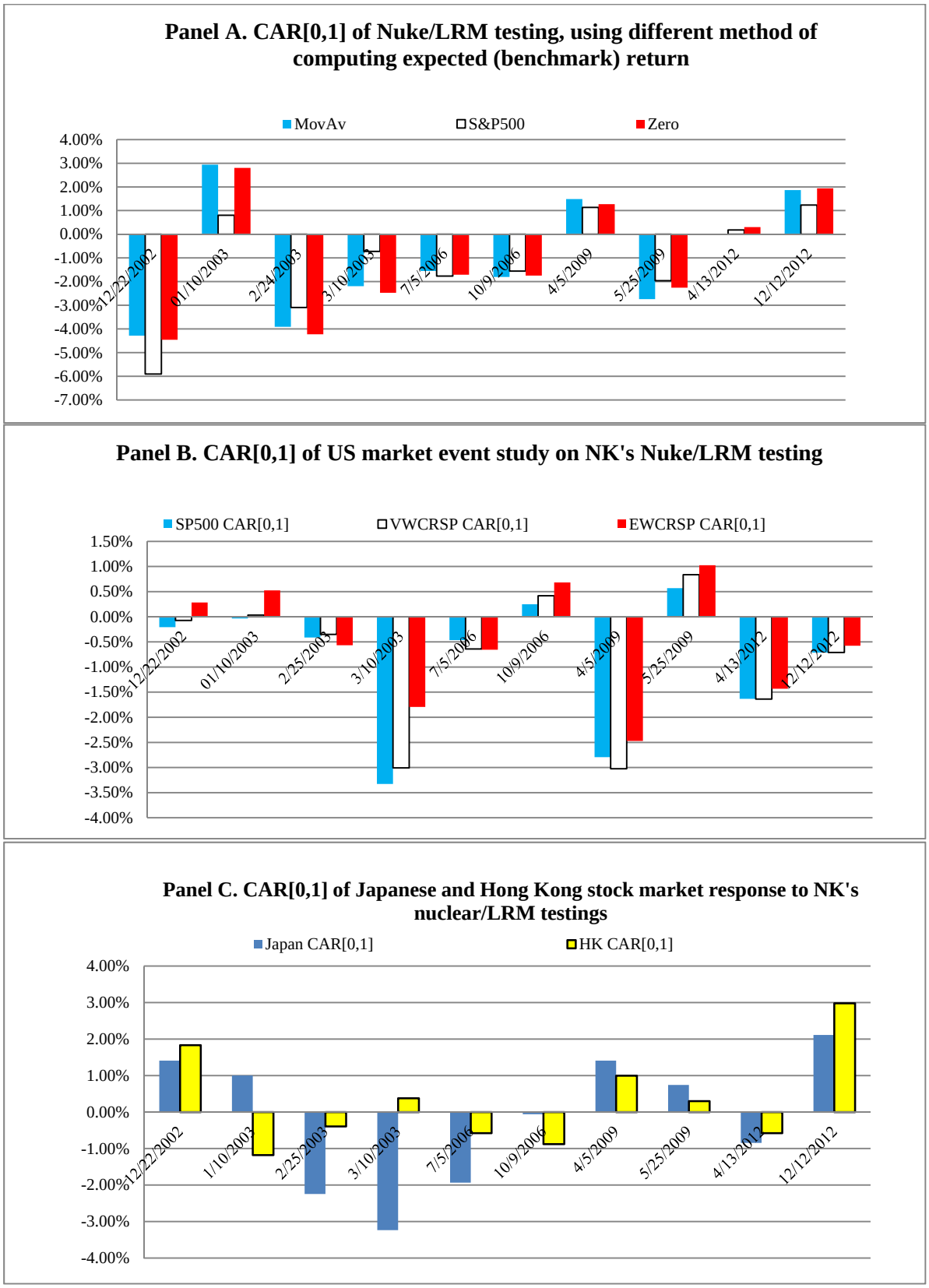


**Figure 3. Time series of average abnormal bid-ask spreads during geopolitical risk events**

For each stock we first measure the effective spread for each transaction in a day. The effective spread is computed as the ask price minus the bid price divided by the midpoint between them. To avoid the noisiness of the market in the beginning and ending 30 minutes of the trading sessions, we only take the trades made during the time segment between 9:30 am and 2:30 pm. For each stock on each trading day, we compute the average of the effective spread. Then over the estimation window of [-40,-11] trading day, we estimate the mean of the daily average effectives spread. Then for each trading day over the event window of [-5,5] trading day, for each stock we first compute the abnormal spread by subtracting the mean of the daily average effective spread, then we compute the mean of the abnormal spread across all the stocks. If the average abnormal effective spread is significantly different from zero with the statistical significance of 10% (|z-stat|>1.96) we represent it with a color dot. Z-statistic is obtained through bootstrapping with 1,000 replications. The results are robust when we represent (|z-stat|>2.58).

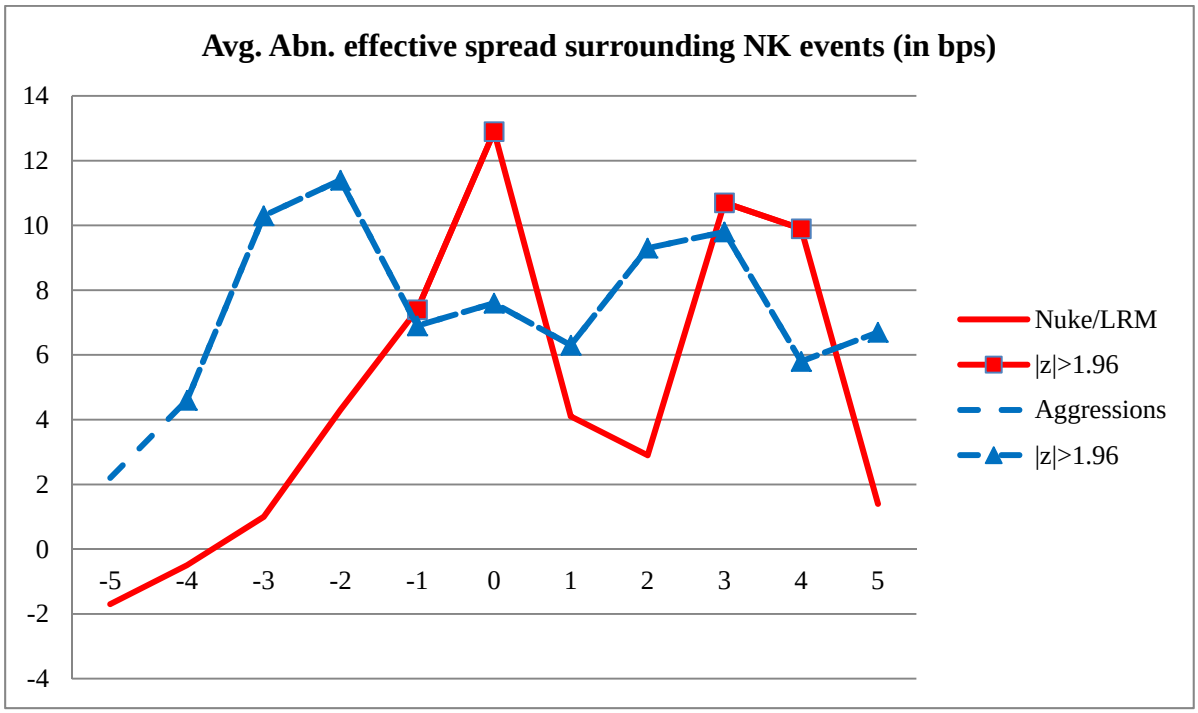


**Figure 4. Abnormal trading volume analysis**

We set up our estimation window to be [-130,-11] trading days and event window to be [-1,20]. For each trading day we compute the abnormal trading volume by subtracting the average trading volume over the estimation window from the event day trading volume. Then for the given event class that are not confounded by other events from our collection of 292 events, we compute a bootstrap z-statistic by replicating 1,000 times. If the abnormal share turnover is significantly different with the absolute value of z-statistics greater than 1.96, we present it with a box dot.

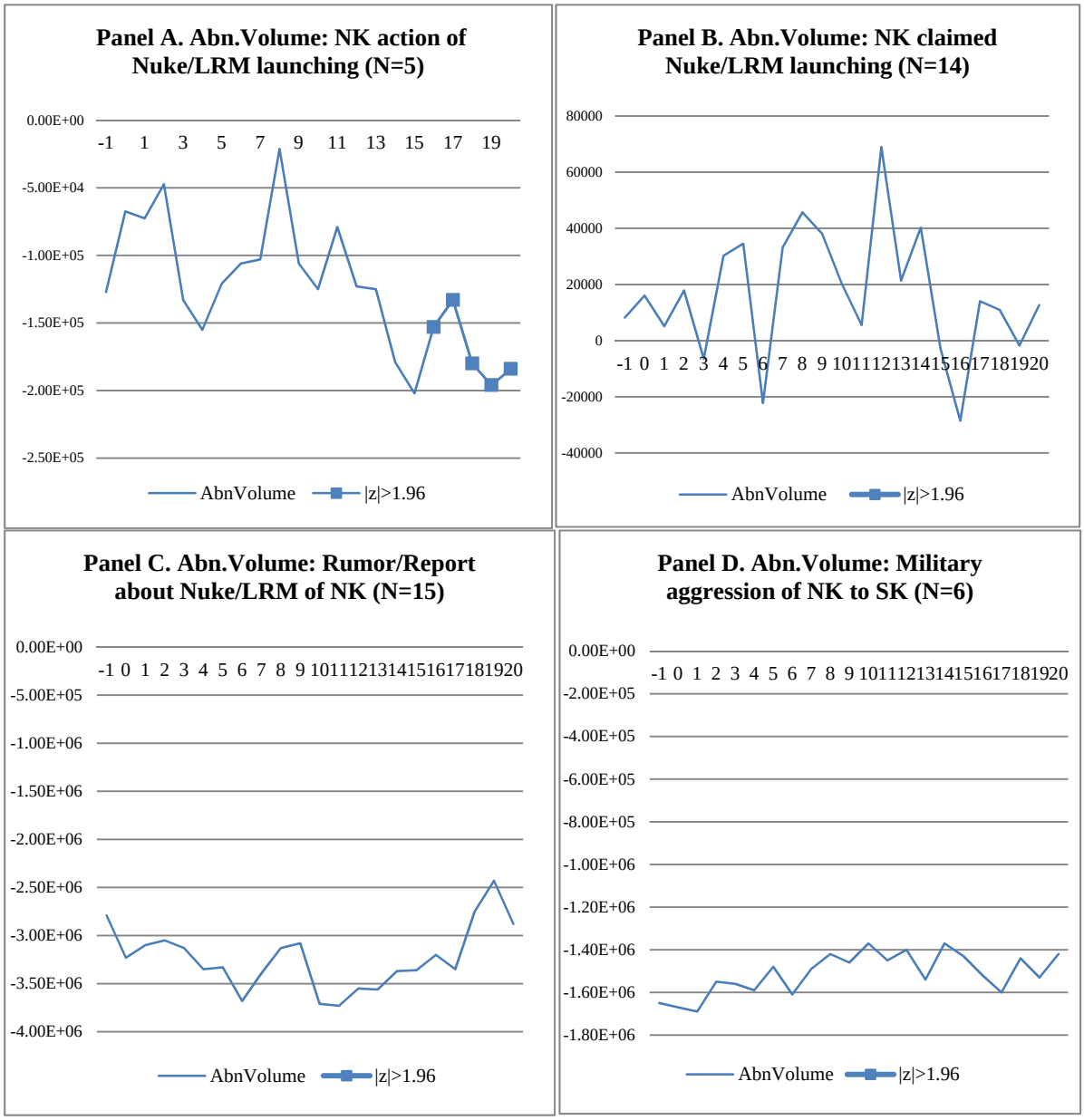


**Figure 5. Volumes of abnormal short selling surrounding NK Nuke/LRM tests**

Short turnover is calculated as the short selling volume divided by total shares outstanding, which we then multiply by 1,000,000 for better readability. Therefore, the unit on the vertical axis is 1/100 basis point. The horizontal axis shows the trading days relative to the event.We first set our estimation window to be [-40,-11] trading days before the event, and the event window to be [-5,5] trading days. We first set our estimation window to be [-40,-11] trading days before the event, and our event window to be [-5,5] trading days. For each stock we carry out the following process, for individual investors and institutional investors separately: We first calculate the short turnover, which is the short selling volume divided by the number of shares outstanding on a trading day. Next, over the estimation window, we compute the daily average short turnover of the stock. Then, on each trading day of the event window, we compute the abnormal short turnover, which is the actual minus the expected (average) short turnover. We then take the average abnormal short turnover across all stocks and across the series of events in the same category of event. We bootstrap 1,000 times to obtain the standard error, and represent it with a colored dot when the average abnormal short turnover is statistically significant at the 5% level.

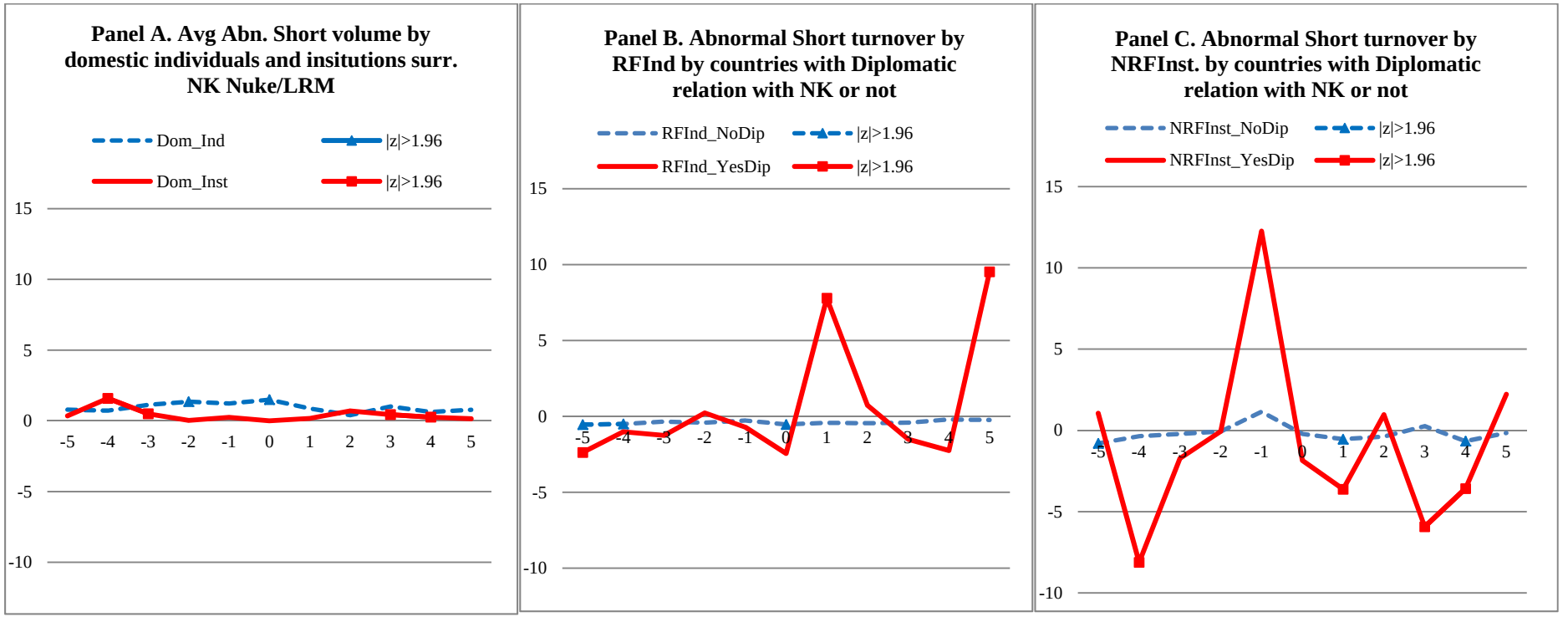
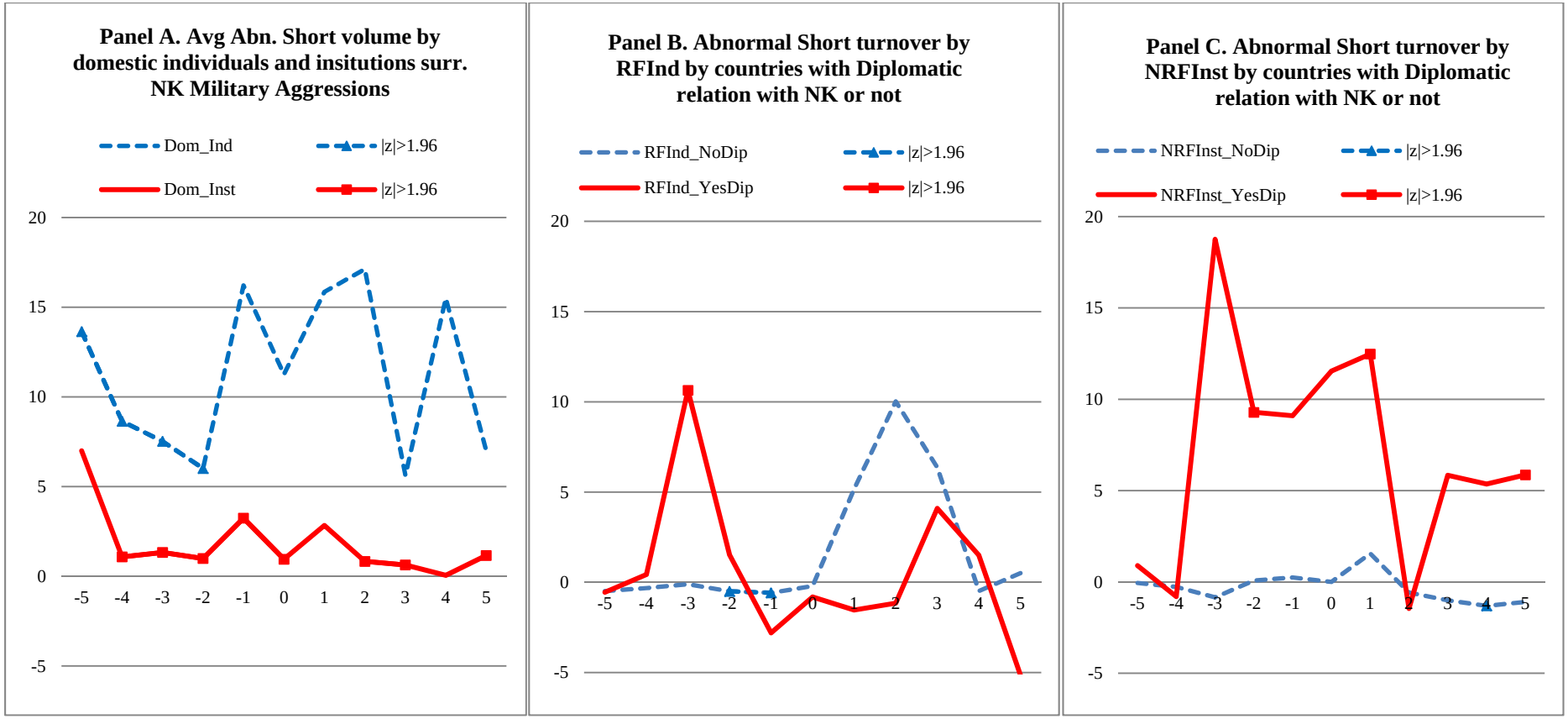
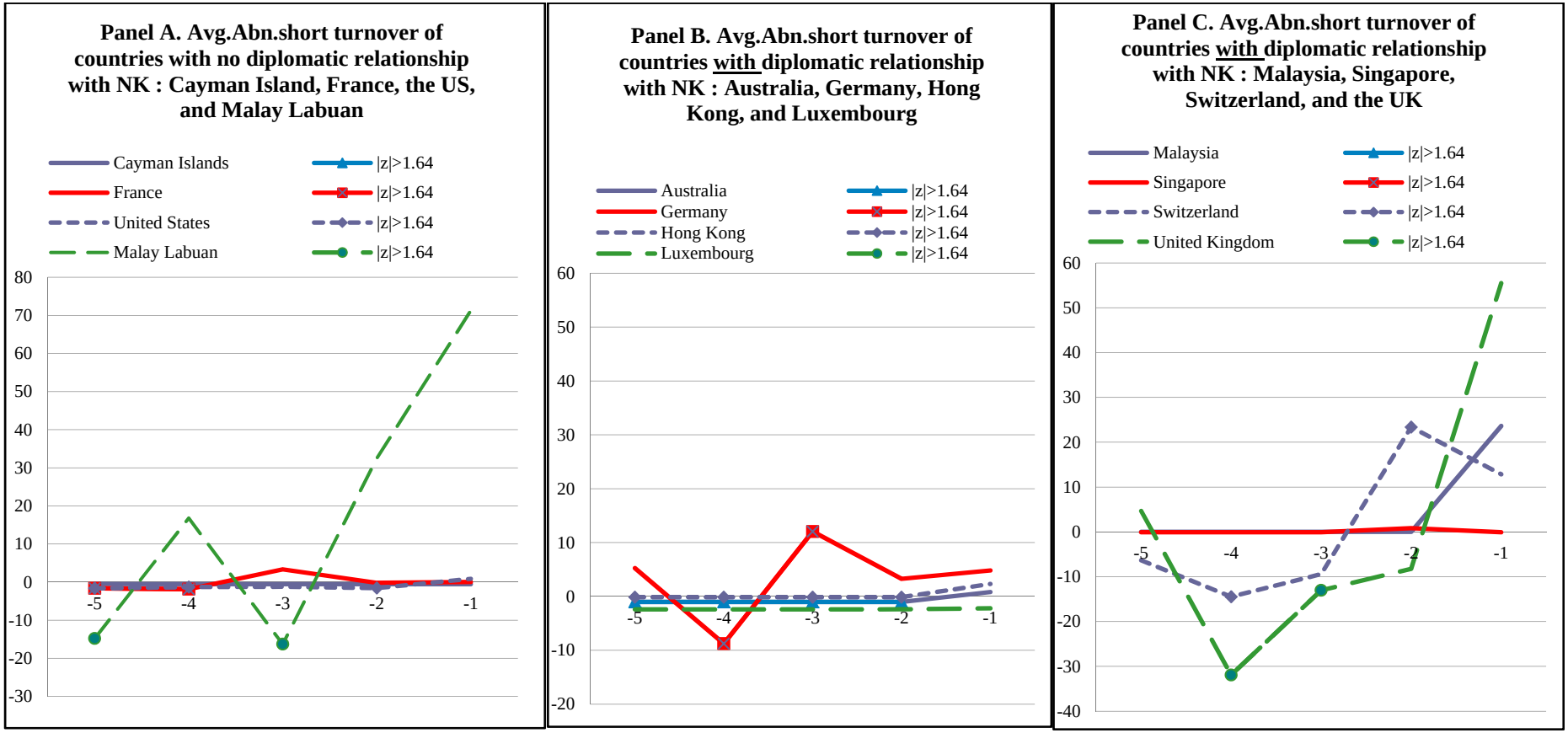


**Figure 6. Volumes of abnormal short selling surrounding NK acts of military aggression**



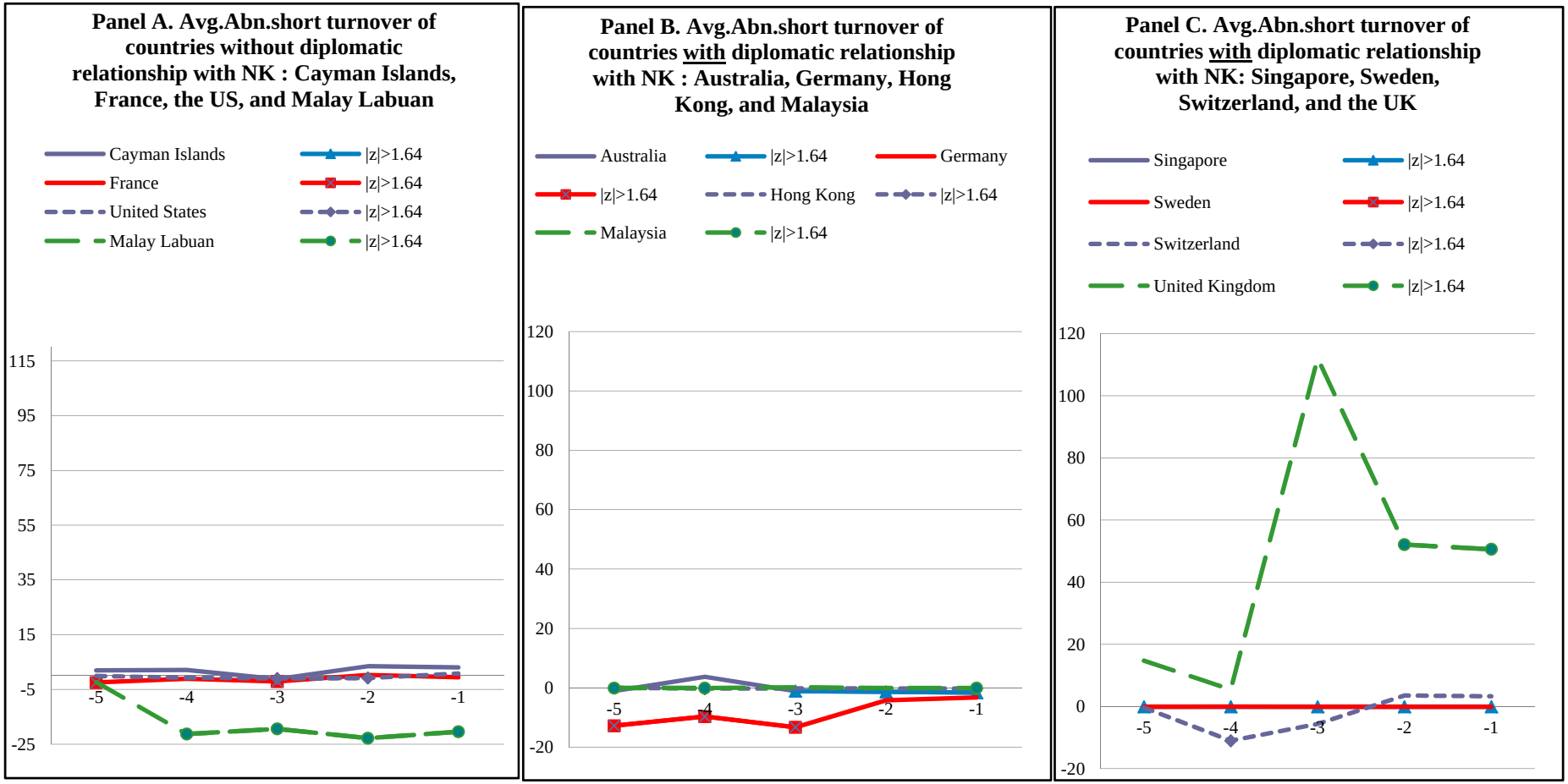

For the captions, please refer to Figure 5. The unit on the vertical axis is 1/100 basis points. The horizontal axis shows the trading days relative to the event.

**Figure 7. Average abnormal short turnovers of stocks by non-resident foreign institutions before NK Nuke/LRM testing**



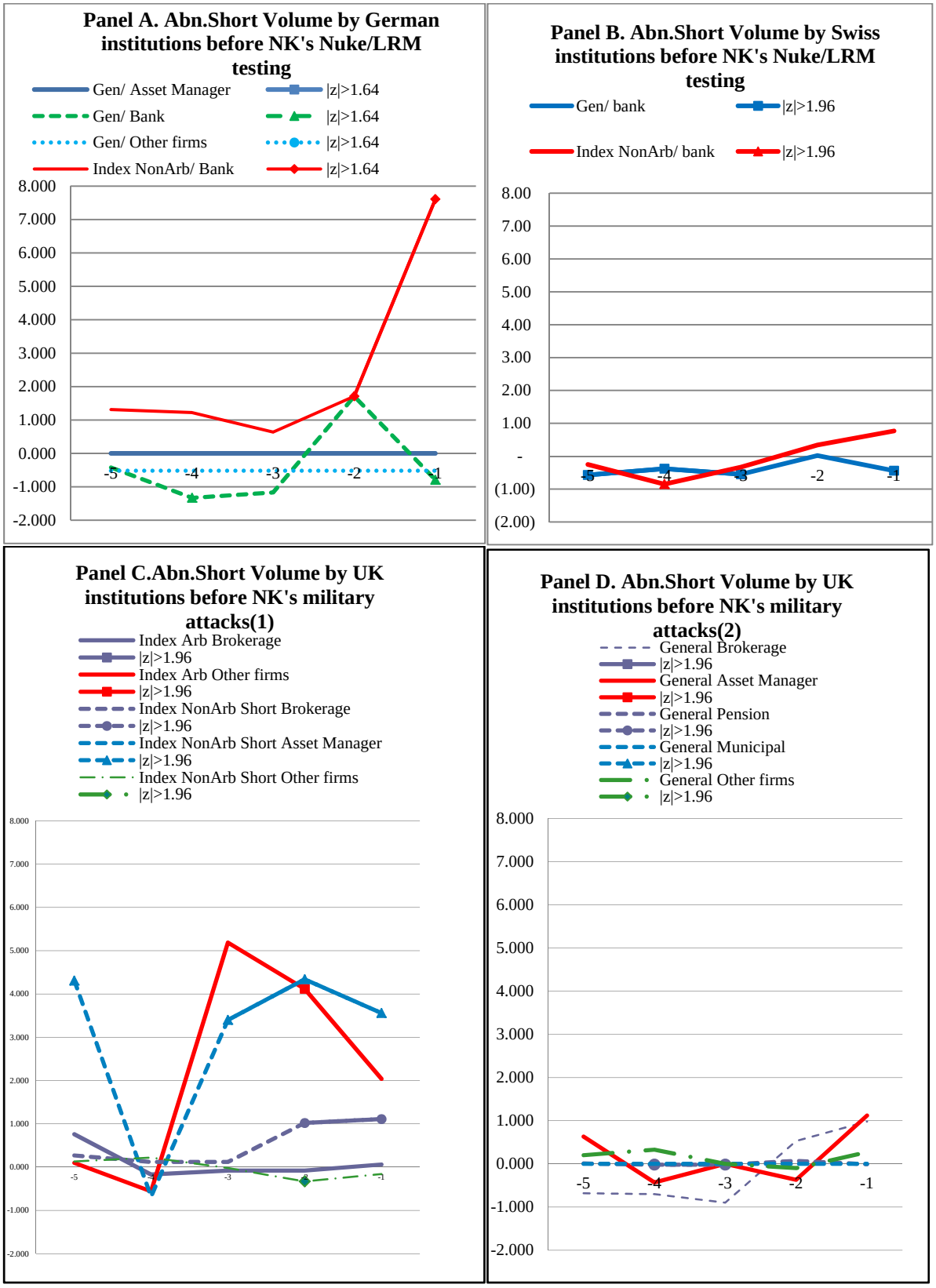

For the captions, please refer to Figure 5. The unit on the vertical axis is 1/100 basis points. The horizontal axis shows the trading days relative to the event.

**Figure 8. Average abnormal short turnovers of stocks by non-resident foreign institutions before NK acts of military aggression**




For the captions, please refer to Figure 5. The unit on the vertical axis is 1/100 basis points. The horizontal axis shows the trading days relative to the event.

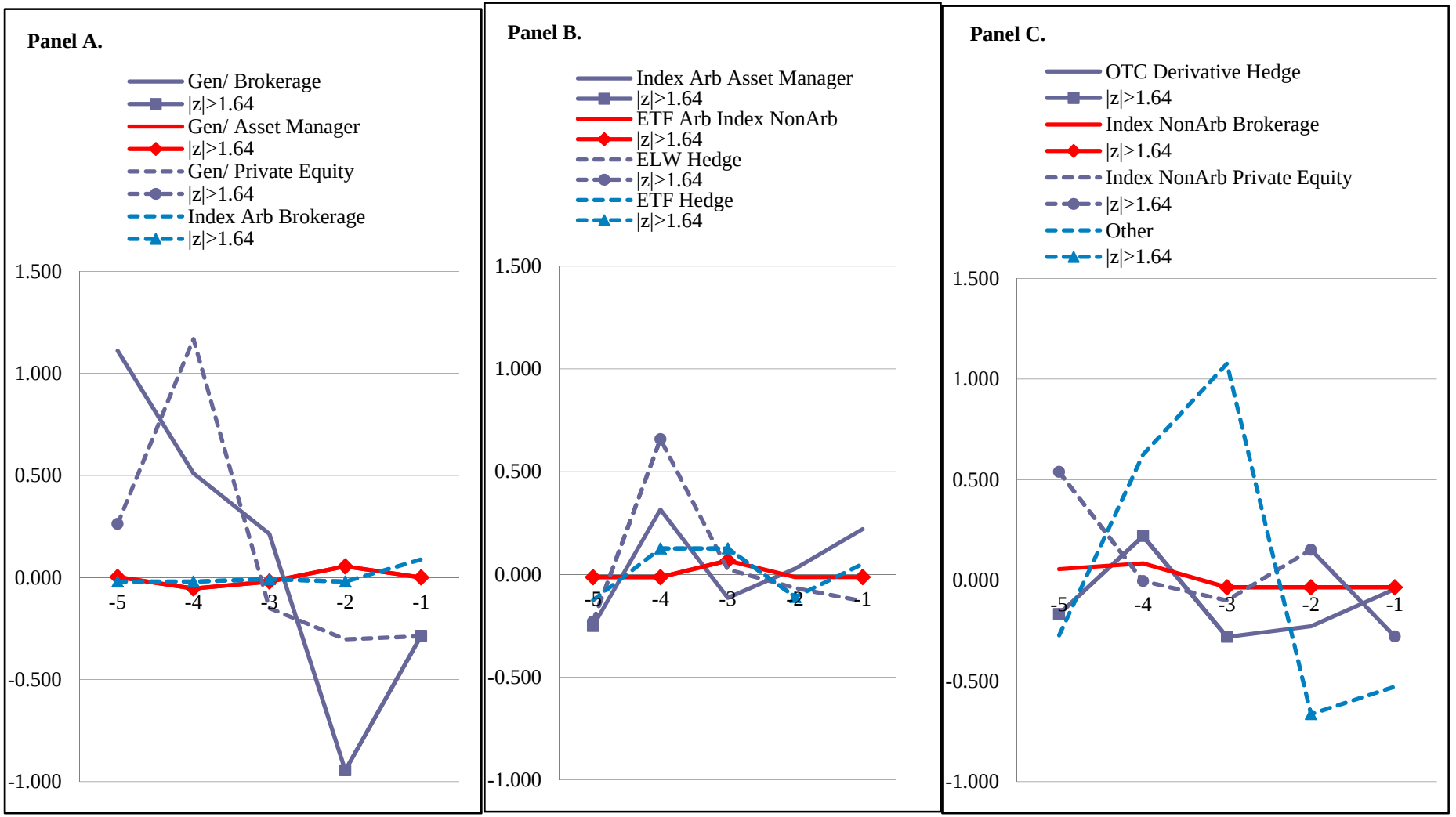
**Figure 9. Abnormal short turnovers, by kind of investor and purpose of trading**




In Panel A, the z-statistics of Index Non-arbitrage by banks on day -2 and day -1 are 1.7 and 1.77, respectively. In Panel C, all of the colored dots in this panel are, in fact, statistically significant at the 1% level, with z-statistics greater than 2.58. For the captions, please refer to

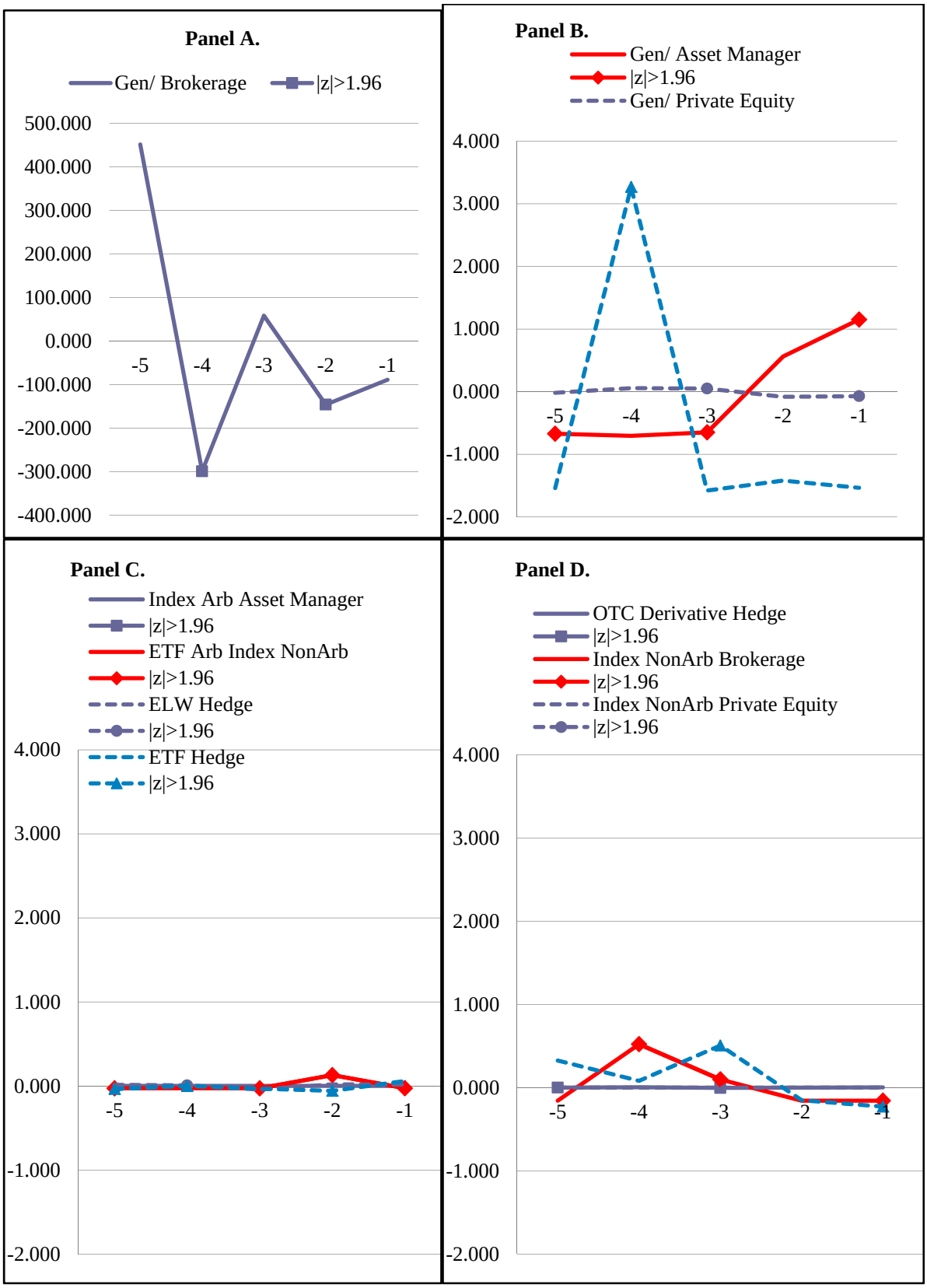
Figure 5. The unit on the vertical axis is 1/100 basis points. The horizontal axis shows the trading days relative to the event. "Gen/" indicates general trading.

**Figure 10. Abnormal short turnovers of domestic institutions before Nuke/LRM tests, by kind of investor and purpose of trading**



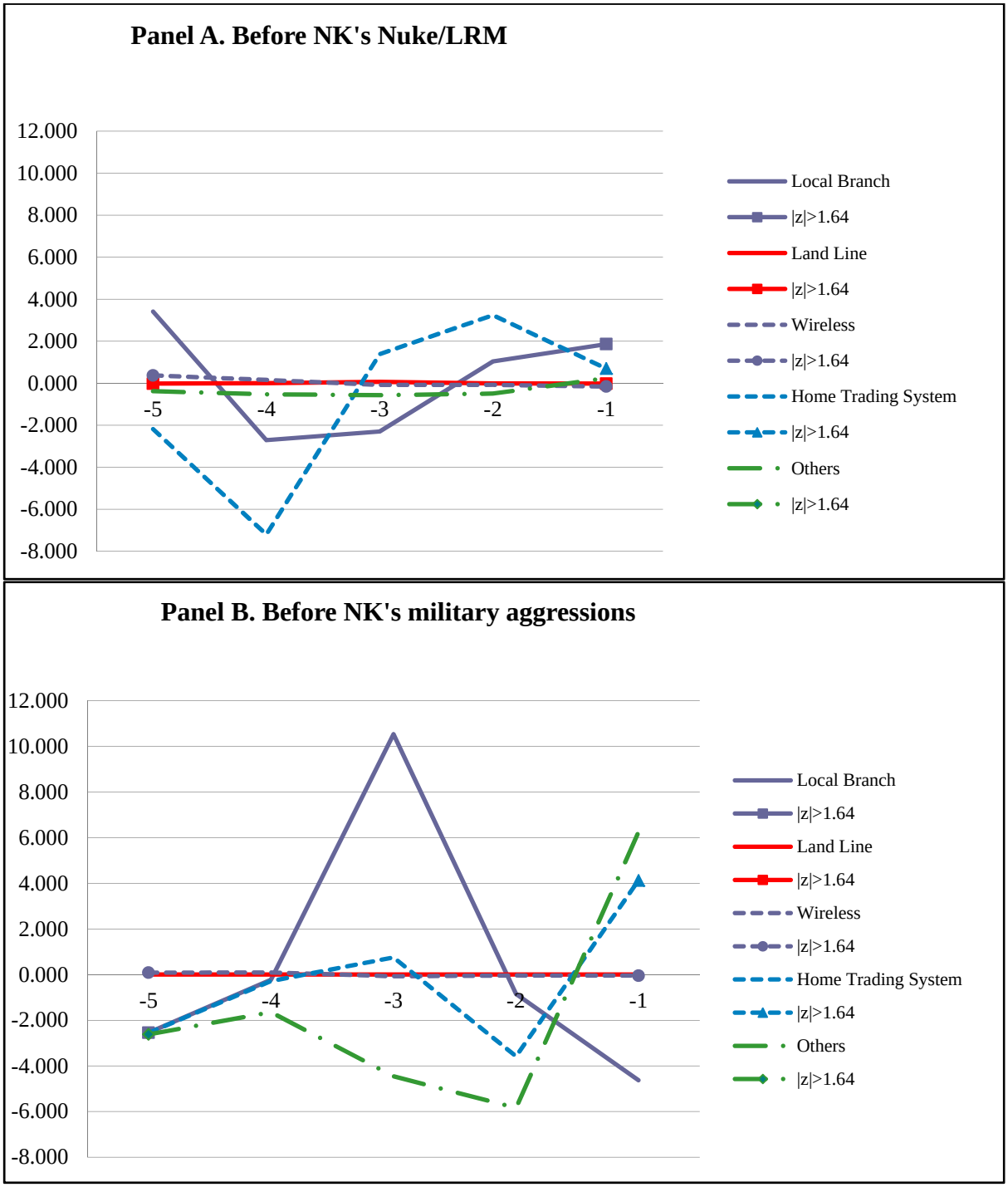

The unit on the vertical axis is 1/100 basis points. The horizontal axis shows the trading days relative to the event.

**Figure 11. Abnormal short turnovers of domestic institutions before the acts of military aggression, by kind of investor and purpose of trading**




The unit on the vertical axis is 1/100 basis points. The horizontal axis shows the trading days relative to the event. “Gen/” indicates general trading.

**Figure 12. Abnormal short turnovers by domestic individuals, by order placing medium**




The unit on the vertical axis is 1/100 basis points. The horizontal axis shows the trading days relative to the event.

## Technical Appendix

### 1. Microstructure event study

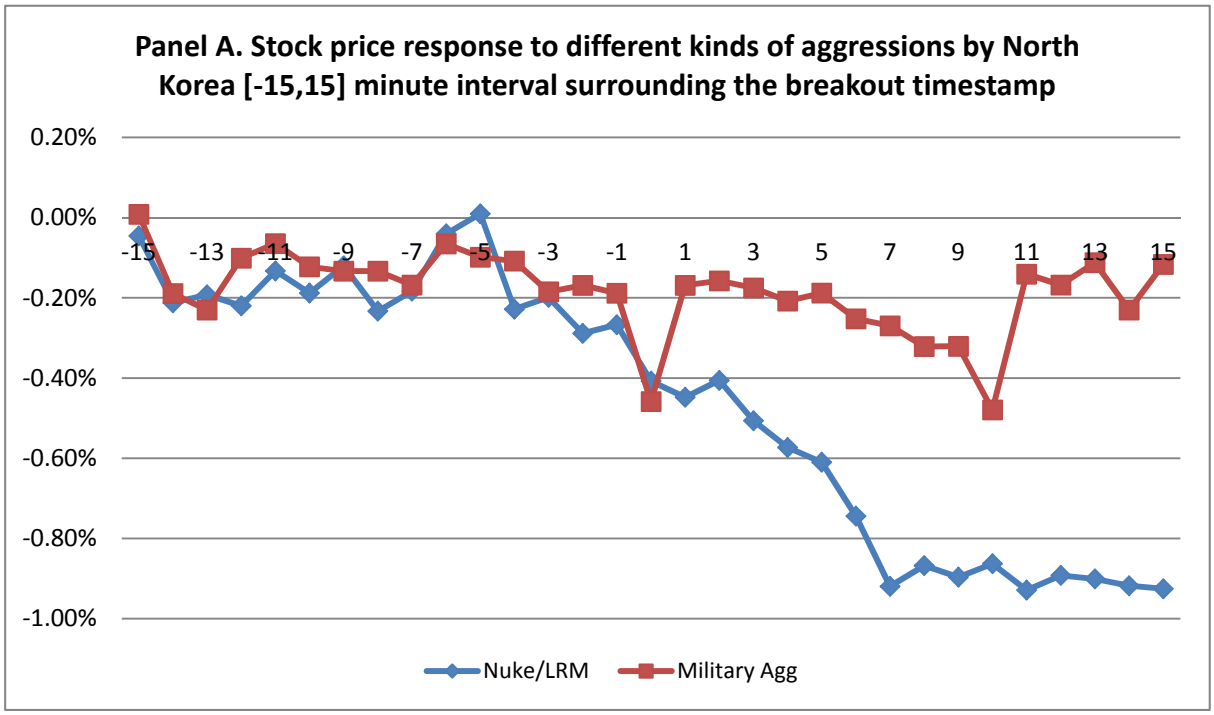
In this section, we examine how quickly the events are priced and who trades first by using microstructure data. Busse and Green (2002) document that it takes about seven minutes for a negative earnings surprise to be priced in the US market. We understand that the SK stock market may be less efficient than that of the US, and the kind of news concerned is also different. It seems, therefore, worth investigating how fast investors respond to geopolitically negative news such as of nuclear weapons testing, because the events may give profound information about the fundamentals of the business environment of companies listed in Korea. Again, we focus on NK's testing of nukes/LRMs and acts of military aggression.

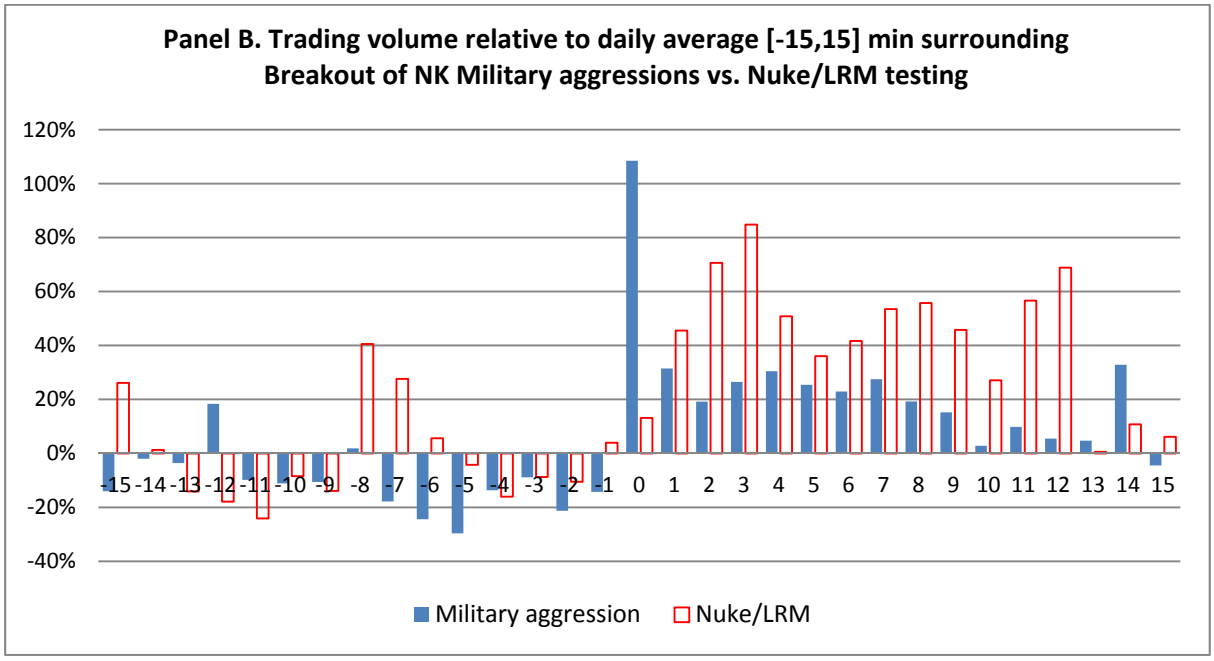
We first collect the time stamps of the first media reporting of the events, and the time stamps of the event occurrences. Among the ten events of Nuke/LRM testing and 13 events of military aggression, we are able to find time stamps for eight and eleven events respectively. Among these, 12 took place during trading hours (five Nuke/LRM tests and seven acts of military aggression). Based on the millisecond trade data of the SK stock markets, we construct the minute-by-minute price data using the price closest to the end of the minute as the price at the end of the minute. When there was no trade in a given minute, we take the previous minute's price as that of the current minute in a recursive manner. Since this is a very short horizon event study, we use the raw return over each one-minute interval. Panel A of Figure 12 shows the event study surrounding the minute of event occurrence, irrespective of the first minute of reporting. We find that it takes about seven minutes for the market to reflect the geopolitical news in the price, a speed comparable to the finding in Busse and Green (2002). What is interesting is that the price starts to move downward even

four minutes before the actual testing. For NK acts of military aggression, we find a significant negative spike at the minute of their initiation, with some noisy drift over the subsequent minutes. As time passes the price drifts back to the original level of the spike, with some noise. It is plausible that some investors who have the information of the breakout of military conflict trade immediately, while the others trade belatedly or do not even care about the event. Since we find statistically significant price movements for nuclear testing and military aggression, we further analyze the trading volumes by the minute for these two groups of events.

For every minute of the event date, we estimate the average trading volume for each stock. Then, for the event window of [-15,15] minutes centered at the minute of event occurrence, we compute the abnormal trading volume of each stock by dividing the trading volume of each minute by the average trading volume. We then take the cross-sectional average. The results are shown in Panel B of Figure 12, which indicates that investors trade 100% more than average at the minute of occurrence of an act of military aggression. In contrast, the abnormal trading volume gradually increases after the minute of nuclear/LRM testing, peaking at the third minute after occurrence. It might be that, for the surprise military attacks by NK, the SK investors trading closer to the places of conflict have more rapid access to the news and their perceptions of risk are much greater than those of investors trading at branches far from the places of military conflict. In contrast, because NK's nuclear testing takes place in its own territory, it takes about three minutes for the information to be diffused to investors and for them to trade significantly more.

**Figure TA1. Microstructure event study of geopolitical event news**



## 2. Who trades more at the minute of military aggression?

In this subsection we use multiple regressions to better understand who trades at the very minute of the outbreak of military aggression. In an ideal world, where information is available to all market participants simultaneously, the geographical proximity of traders to the place of outbreak should not matter. Empirically speaking, working with SK data may bias us against finding the result because the sheer size of its land mass is only one percent that of the US. However, one interesting feature of the Korean microstructure data is that it identifies the local branch of the brokerage house at which each order originates. Given that almost all local branches carry the names of the towns in which they operate, we hand collect the latitudes and longitudes of more than 3,500 local branches of the brokerage houses in Korea through Google Maps or Naver Maps, as in Kim and Jung (2014). We in addition collect the coordinates of the locations of the military conflicts. We then compute the distance between a local branch and the area of conflict as follows:

Distance=

$$\frac{6371\pi}{180}\sqrt{\left(\text{Latitude diff}\right)^2+\cos\left(\frac{\text{Lat1+Lat2}}{2}*\frac{\pi}{180}\right)\left(\text{Longitude diff}\right)^2} \ldots\ldots\ldots\ldots (TA1)$$

We next regress the trading volume of the branch at the minute of event occurrence for each stock on the geographical distance and other controls, such as firm characteristics. Because we conjecture that it is individual investors who trade more sensitively to the outbreak of military conflict, we of course do the studies for the individual investor sample and the institutional investor sample separately for a contrast. Also, since the Korean microstructure data identifies whether a trade is initiated by a buy or a sell order, we use the sell and buy volumes and order imbalances (buy-sell) separately. If the buy and sell volumes

increase equally then we will not be able to detect any increase in order imbalance even though the trading volume goes up. In addition, we exclude the local branches in the Seoul metropolitan area, which are shown as the first three rows in Appendix TA1. Nearly two-thirds of the local branches of brokerage houses are located in this area, which happens to be close to NK, and thus if we include this area, one might argue that the result is simply a spurious correlation caused by the fact that more trading volume comes from the densely populated area.

Our empirical model for analyzing the trading volume at the minute of event occurrence is as follows:

$$\text{Volume}_{i,b,t} = \beta_1 \text{Distance}_{b,t} + \beta_2 \text{Latitude of HQ}_i + \beta_3 1\{\text{Econ cooperation}\}_i + \beta_4 1\{\text{Defense stock}\}_i + \beta_5 \text{foreign ownership}_{i,t} + \beta_6 \#\text{shares outstanding}_{i,t} + \beta_7 1\text{yr daily volatility}_{i,t} + \beta_8 \ln(\text{total assets})_{i,t} + \beta_9 \text{ROA}_{i,t} + \beta_{10} \text{BEME}_{i,t} + \beta_{11} \text{leverage}_{i,t} + \text{industry FE} + \epsilon, \quad \text{(TA 2)}$$

where i is a subscript of the stock, b a subscript of the branch of the brokerage house, and t a subscript of the event. BEME is the book-to-market ratio, and the leverage ratio is the book value of interest-bearing debt divided by total assets. Since observations are repeated for the same firm and event date, standard errors are clustered at the firm level and day level as in Petersen (2009). Table 4 shows the results.

First and foremost, we find strong evidence that individual investors who place orders at branches located closer to the place of a military conflict trade significantly more at the minute of conflict outbreak. Individual and institutional investors do not seem to consider the distances of the headquarters of the firms from NK. Individual investors' selling volume is significantly less for defense stocks. Individual investors sell the stocks of small firms more.

Given that acts of military aggression only generate short run overreaction and reversal, these results seem to explain that the overreactions are primarily driven by individual investors living closer to the area of conflict.

**Table TA1. Regression of trading volume at minute of outbreak of NK military aggression**

Dependent variable is the trading volume (buy or sell) or order imbalance of each firm in Korean stock markets at a local branch at the minute of occurrence of NK military attack.

Distance is defined as $\frac{6371\pi}{180}\sqrt{\left(\text{Latitude diff}\right)^2 + \cos\left(\frac{\text{Lat1+Lat2}}{2} * \frac{\pi}{180}\right)\left(\text{Longitude diff}\right)^2}$. Latitude and longitude of the local branch of brokerage houses as well as those of the place of military conflict are obtained through searching in Google Maps and Naver Maps. 1{NK-SK Econ Coop} is a dummy variable that is one if the company has production facilities at Kaesong Industrial Region in NK. 1{Defense stock} is a dummy variable that is one if the company has business exposure in military supply industry. 1yr daily volatility is the standard deviation of the daily stock return over the one year period before the event. Industry fixed effects are controlled using the industry code from FN Guide, and standard errors are clustered at the firm level and day level as in Petersen (2009). *, **, and *** represent 10%, 5%, and 1% levels of statistical significance.

| Sample | Individual investors | | | Individual investors | | | Institutional investors | | |
|---|---|---|---|---|---|---|---|---|---|
| | brokerage branches excluding Metro-Seoul area * firms | | | brokerage branches including Metro-Seoul area * firms | | | brokerage branches * firms | | |
| Dependent variable | Sell volume | Buy Volume | Order imbalance | Sell volume | Buy Volume | Order imbalance | Sell volume | Buy Volume | Order imbalanc |
| Distance [branch-conflict] | -0.02 *** | -0.014 ** | 0.006 | -0.02 *** | -0.008 | 0.013 * | -0.005 | 0.025 ** | 0.03 * |
| | (-2.90) | (-2.04) | (0.75) | (-3.66) | (-0.96) | (1.93) | (-0.38) | (2.45) | (1.83) |
| Latitude of firm HQ | -1.86 | -2.937 | -1.077 | -1.027 | -2.027 | -1 | 1.666 | 0.765 | -0.901 |
| | (-1.58) | (-0.65) | (-0.29) | (-0.85) | (-0.72) | (-0.51) | (0.88) | (0.99) | (-0.48) |
| 1{NK-SK Econ Coop} | 2.424 | 0.695 | -1.729 | 1.74 | 1.644 | -0.096 | 2.218 | -1.89 | -4.108 |
| | (0.62) | (0.18) | (-0.38) | (0.64) | (0.63) | (-0.04) | (0.57) | (-0.75) | (-1.05) |
| 1{Defense stock} | -9.267 ** | -11.186 | -1.92 | -10.305 * | -13.476 | -3.17 | 1.522 | -1.904 | -3.426 |
| | (-1.98) | (-1.56) | (-0.56) | (-1.75) | (-1.38) | (-0.72) | (0.25) | (-0.79) | (-0.52) |
| Foreign ownership | -4.488 | -3.394 | 1.094 | 0.092 | 2.735 | 2.643 | -12.108 | -8.709 | 3.398 |
| | (-0.79) | (-0.34) | (0.14) | (0.01) | (0.31) | (0.56) | (-1.11) | (-0.57) | (0.19) |
| #shares outstanding | 0 *** | 0 *** | 0 | 0 *** | 0 *** | 0 | 0 | 0 *** | 0 |
| | (4.03) | (3.10) | (0.77) | (4.03) | (3.52) | (1.14) | (1.58) | (2.91) | (0.38) |
| 1yr daily volatility | 552.88 *** | 317.396 * | -235.484 | 570.732 *** | 397.637 ** | -173.096 | 485.672 ** | -383.683 *** | -869.356 *** |
| | (4.61) | (1.65) | (-1.32) | (4.93) | (2.56) | (-1.55) | (2.09) | (-3.61) | (-3.37) |
| ln(Total Assets) | -1.716 ** | -3.299 | -1.583 | -2.185 ** | -3.887 ** | -1.702 * | 0.833 | 0.346 | -0.488 |
| | (-2.01) | (-1.63) | (-1.07) | (-2.15) | (-2.12) | (-1.74) | (0.71) | (0.33) | (-0.33) |
| ROA | -10.875 | -21.919 ** | -11.044 | -17.596 ** | -21.633 *** | -4.037 | -27.202 | -16.266 | 10.935 |
| | (-1.63) | (-2.49) | (-1.42) | (-2.17) | (-2.72) | (-0.59) | (-1.42) | (-0.69) | (0.37) |
| BEME | 0 | -0.008 | -0.009 | -0.025 | -0.01 | 0.015 | -0.12 | 0.029 | 0.149 |
| | (0.01) | (-0.23) | (-0.18) | (-0.63) | (-0.38) | (0.64) | (-1.13) | (0.35) | (1.12) |
| leverage | -0.202 | 2.002 | 2.205 | -4.593 | -2.885 | 1.708 | -8.356 | -0.284 | 8.072 |
| | (-0.06) | (0.36) | (0.48) | (-1.10) | (-0.56) | (0.46) | (-1.14) | (-0.04) | (0.83) |
| constant | 91.943 * | 168.943 | 77 | 70.877 | 142.457 | 71.581 | -76.758 | -17.767 | 58.991 |
| | (1.96) | (0.85) | (0.47) | (1.51) | (1.18) | (0.86) | (-1.19) | (-0.50) | (0.87) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 648000 | 648000 | 648000 | 1550000 | 1550000 | 1550000 | 41835 | 41835 | 41835 |
| Adj.R2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Even though the acts of military aggression by NK, such as shelling certain small areas of SK, may not imply NK's intension of igniting an all-out war against SK, witnessing the fatal military attacks in neighboring towns would have strong effects on the risk perceptions of individual investors, so that they would try to liquidate their financial assets or reallocate their investments to safer assets. At the same time, some investors might interpret such an attack as a chance to buy a security at a cheaper price by providing liquidity, because of the perception that the geopolitical risk of the country as a whole does not change. This is precisely what we find. The individual investors living closer to the areas of military conflict are the ones that trade more. If the investors in the financial markets were exposed to the news of military attack at the same time without any time delay, we would not be able to see such significant differences. Our microstructure data of SK enables us to find that the geographical proximity to the related information does matter.

**Appendix TA1. Concentration of brokerage branches in Seoul metropolitan area**

| Area code | Area name | Frequency | Percentage |
|---|---|---|---|
| 2 | Seoul | 1727 | 47.04 |
| 31 | Gyeonggi-do | 529 | 14.41 |
| 32 | Incheon | 86 | 2.34 |
| 51 | Busan | 254 | 6.92 |
| 53 | Daegoo | 162 | 4.41 |
| 55 | Gyeongsangnam-do | 119 | 3.24 |
| 62 | Kwangjoo | 118 | 3.21 |
| 63 | Jeollabook-do | 97 | 2.64 |
| 42 | Daejeon | 96 | 2.62 |
| 54 | Gyeongsangbook-do | 89 | 2.42 |
| 61 | Jeollanam-do | 74 | 2.02 |
| 52 | Ulsan | 73 | 1.99 |
| 33 | Kangwondo | 72 | 1.96 |
| 43 | Choongcheongbook-do | 60 | 1.63 |
| 41 | Choongcheongnam-do | 58 | 1.58 |
| 64 | Jeju | 26 | 0.71 |
| 999 | Undetermined | 31 | 0.84 |