social sciences

MDPI

Article

Real-Time Military Security Index Calculation Model Using Big Data Analytics: The Case of South Korea

Hee-Jae Jeon and Moon-Gul Lee *

Department of Defense Science, Korea National Defense University, Nonsan 33021, Republic of Korea
* Correspondence: bomblee@korea.kr

Abstract: The recent advent of the New Cold War and rapid changes in global situation are increasing the need for quick and accurate geopolitical risk measurement through quantitative analysis. This study intends to present a new military-security index, a method of measuring military-geopolitical risk using big data analysis. In this regard, South Korea, one of the countries with the highest level of geopolitical risk in the world, was analyzed and quantified by analyzing direct provocations and threats from neighboring countries. The data used include the results of quantifying provocation cases in neighboring countries according to time, frequency, and intensity, the results of analyzing news keywords related to military-security issues in neighboring countries, and real-time terrorism and cybersecurity-risk measurements. Based on this, a model that enables relatively accurate and timely analysis and prediction by indexing and time-series geopolitical risks is presented.

Keywords: geopolitical risk; security; data analysis; big data; index; Korean Peninsula

Citation: Jeon, Hee-Jae, and Moon-Gul Lee. 2022. Real-Time Military Security Index Calculation Model Using Big Data Analytics: The Case of South Korea. *Social Sciences* 11: 572. https://doi.org/10.3390/socsci11120572

Academic Editor: Patrick James

Received: 1 September 2022
Accepted: 1 December 2022
Published: 6 December 2022

1. Introduction

Recently, the security situation on the Korean Peninsula has changed more rapidly than ever. There are various factors behind this change, including the New Cold War caused by the US–China hegemony struggle. After the end of the US–Soviet Cold War, countries around the world enjoyed a long period of peace, including active trade and exchange as part of the global network. However, China's economic rise and the challenge of US hegemony under Xi Jinping have led to new confrontations, starting with the US–China trade war. In addition, Russia's armed invasion of Ukraine has caused significant global divisions. This change can be more clearly seen in the announcement of the new strategic 12-year plan adopted by NATO, the Western world's leading military organization, at the 2022 Madrid Summit. In this announcement, NATO defined China and Russia as direct security threats, in contrast to their characterization of China and Russia as cooperative partners in the previous announcement (NATO 2022). The new Cold War structure between Russia, China, and Western forces heralds a major change in military and foreign policy on the Korean Peninsula.

Amid this New Cold War, rapid changes in the security landscape of Northeast Asia, which is considered a flash point, have also been observed.

The inter-Korean conflict has continued into 2022, involving a series of provocations and the possibility of a seventh nuclear test. The Yoon Suk-yeol administration (2022~), which is determined to strongly counter North Korea's provocations, is planning to impose sanctions on the North by forming diplomatic and security ties with hardliners who led strong policies against the North during the Lee Myung-Bak administration (2008~2013). Meanwhile, the Biden administration is also expected to put strong pressure on the new US ambassador to South Korea, classified as a hardliner on North Korea, with the nickname, "The Grim Reaper of North Korea," which is likely to worsen inter-Korean relations.

Korea–China relations indicate that the US–China tightrope diplomacy of the Moon Jae-In administration (2017~2022) is leaning toward the US due to the emergence of the

Yoon Seok-yeol administration and the New-Cold-War situation. This can be seen from the new government's willingness to rebuild the Korea–US alliance and strengthen the comprehensive strategic alliance and its policy stance to set the Korea–US alliance as a focus on foreign and security policies amid US–China competition. In addition, China criticized the president's attendance at the NATO summit, saying it would "damage the diplomatic independence of Asia and worsen relations with China." (Hankyung 2022). In addition, the recent rapid increase in anti-Chinese sentiment in Korea over issues, such as the Terminal High Altitude Area Defense (THAAD) retaliation, COVID-19 and fine dust, the Northeast Project and history recognition, and the Hanbok and Kimchi controversy, is believed to show another possibility of worsening relations (Chung 2022).

Uncertainty is growing around not only relations with China but also future relations between Korea and Russia. After Russia's armed invasion of Ukraine, the Korean government is participating in economic and financial sanctions against Russia in participation with the international community, such as the US and Europe, and is providing military supplies for non-lethal purposes to Ukraine. Accordingly, Russia designated and criticized Korea as an unfriendly country, and threatened it by daily invading the Korea Air Defense Identification Zone (KADIZ) through military aircraft. According to the Russian International Affairs Council (RIAC), a Russian think tank, there are even strong opinions about dismantling the 15-year strategic partnership between South Korea and Russia, reviving military-technology aid, or building a Russian military base in North Korea (RIAC 2022).

The Yoon Suk-yeol administration hopes to see a turning point in improving Korea–Japan relations based on a military and diplomatic consensus about North Korea's nuclear weapons and the need to address China through military and security cooperation between South Korea, the US, and Japan. Meanwhile, Japan has begun to recover its past momentum with a common nationalization movement represented by the Self-Defense Forces (SDF)'s rearmament, which is actively supported by the US under the pretext of checking China. Furthermore, Abe's assassination sparked a wave of condolences for the Japanese people, with support for the Liberal Democratic Party and a return of far-right politics reflected in the upper-house election, leading conservative parties to win more seats. Despite the atmosphere of improving relations between Korea and Japan, the rise of Japan's far-right forces and the rearmament of the SDF may spark a new security threat.

If the South Korea–US alliance, the additional deployment of the THAAD, the joining of the Quadrilateral Security Dialogue (Quad), and the three-party security cooperation are embodied by the Yoon Suk-yeol administration as a presidential pledge, the situation in the region may result in a solid confrontation between Korea, the United States, and Japan and North Korea, China, and Russia, further heightening the security crisis in Northeast Asia (Yoon 2022).

The recent rapid change in the security situation in Northeast Asia increases the need for timely and objective evaluation of geopolitical crisis.

Due to the security realities of the Republic of Korea, the world's only divided and truce nation, many attempts have been made in the past to index the geopolitical crisis of the Korean peninsula as a concept of peace index. On the other hand, in judging the crisis, the majority of cases dealt only with inter-Korean relations. Due to the limitations of qualitative measurement, such as collection through people, expert questionnaires, and evaluations, it is limited to quarterly, semi-annual, and annual publications. There is a limit that it does not reflect the cyber security and the risk of terrorism from home and abroad. In particular, in terms of timeliness, the general public does not have a security index that can directly experience the degree of geopolitical crisis, except for the security crisis that is encountered through news articles. This raises the need to develop quantitative indicators that can measure not only the situations in North Korea but also those in China, Japan, and Russia, in relation to timely and new threats.

The development of measurement indicators satisfying these conditions can be an alternative to addressing the public's anxiety about the foreign-security situation and can also be used as an auxiliary indicator in the commander's decision on military policy for-

mulation and security issues. In particular, it is expected that it will contribute to the elimination of national-security insensitivity that has become accustomed to the long-standing confrontation with North Korea.

In this study, first of all, the scope of military-security measurement is set and the results are derived based on the data obtained through military data and newspapers that can be used for the most objective and rapid measurement of the set range. Based on the quantitative results analyzed in a time series through statistical analysis techniques, such as scientific methodology in international relations research, the effectiveness was discussed and explained through a comparison with the cases of military-security conflicts on the Korean peninsula. In this process, the values constituting the index are divided into provocative acts, threats, and other threats, and they are combined to complement the shortcomings of each component. The study focuses on solving a range of quantitative, timely, and measurement problems mentioned above.

2. Scope and Method of Research

2.1. Range of Military Security Measurement

In the narrow sense of geopolitics, geographical characteristics are defined by academics regarding the relationship between countries and the struggle for world domination (Foster 2006). The term geopolitics, universally used, is used to encompass political factors as well as geographical characteristics in a broader sense. In this study, geopolitical risks are defined as threats, practical actions, and side effects that can affect international relations from a military perspective, such as war and terrorism.

With the development of geopolitical study, quantification for evaluating and predicting geopolitical risks in countries or specific areas has been studied for a long time and has been developed for various purposes. For example, the financial industry can be selected in areas that are most sensitive to geopolitical risks. The geopolitical crisis in the financial industry is a factor that has a great impact on the movement of the stock market and the direction of investment in real time. Since it is directly related to investment revenue, entrepreneurs, market participants, banks, and securities, companies have continued their efforts to measure and predict the economic effects of a security crisis. Meanwhile, attempts to measure security in academic or military aspects have also been steadily developed. This study aimed to measure geopolitical risks in military aspects, focusing on academic purposes, and it was judged that it is possible to express them by measuring the relevant sectors through the definition of military security.

Military-security concerns government policies that can protect the state from domestic and international military threats, usually focusing on protection from external rather than internal threats (Fry 2010). This can be seen primarily in two aspects: first, it is related to military power, which is the military attack and defense ability of the country and other countries; the other is related to the threat of the other country and its intention (Szpyra 2014).

On the other hand, today's security environment is very complex, and unlike the aspects of war in the past, there is a hybrid threat that breaks down the boundaries of traditional non-traditional conflicts. Future military-security threats will be characterized by the combination of traditional and irregular tactics, the dispersion of war planning and execution, and the innovative use of war technology by non-state actors (Hoffman 2009). In other words, today's war is a war in which "the lethality of state conflict with the fanatical and protracted fervor of irregular warfare" and "wars . . . in which Microsoft coexists with machetes and stealth technology is met by suicide bombers." (Gates 2009). Therefore, in order to measure military security, evaluation of hybrid threats, such as terrorism and cyber security, must be done in parallel.

For the quantification of military security according to the definition of military security, it will be possible to consider the degree of maintenance of military balance considering the geopolitical position in relation to the aspect of military power, measurement of external threats, and internal confusion.

The comparison of military power to represent military balance is excluded from this study based on real-time measurement because real-time evaluation and immediate feedback are limited in reality, and the survey was mainly focused on the method of calculating internal and external threats.

2.2. A Study on the Peace Index of Korean Peninsula

The most common way of indexing peace is to set up the concept of the upper area that constitutes the peaceful degree of the individual country, determine the indicator that can reflect it, and synthesize it. Examples include the Inter-Korean Integration Index, the Korean Peninsula Security Index, and the HRI Korean Peninsula Peace Index (Lee 2008).

The Inter-Korean Integration Index (IKII), published annually by the Seoul National University Institute for Peace and Unification Studies, is an evaluation and index of the degree of inter-Korean integration in economic, political, and social culture. The result value is measured based on objective indicators, such as statistics, structural relationships, and system construction stages, and subjective indicators, such as survey results, and 0 point means complete division and 1000 point means complete unity (Park 2015).

The Korean Peninsula Security Index (KPSI), which is published every quarter since 2007 by the Samsung Economic Research Institute, is a survey of 40 Korean peninsula experts from Korea, the United States, China, Japan, and Russia. The results of the survey are quantified and expressed as an index, which shows that more than 50 points are positive.

The HRI Korean Peninsula Peace Index (HRI KPPI), which is published every quarter since 2009 by the Hyundai Economic Research Institute, is an index calculated by combining surveys and trend data for unification and security experts, such as representatives of inter-Korean economic cooperation. It is evaluated as a value between 0 and 100 points.

On the other hand, as part of the quantitative-peace-index-calculation method, the method of adding weights to the cumulative frequency of event data rather than the peace-index calculation method through index synthesis is partially related to the military-security-index-calculation method of this study, so it will be explained in the theoretical background.

2.3. Theoretical Background of Quantitative Military Security Analysis

The most representative way to measure geopolitical risk through quantitative methods involves collecting events that have occurred and using them to measure risk. The collection of these events is mostly based on the concept that individual geopolitical events shape international relationships, and most of them are reported in news articles, which collect information about events the most accurately and efficiently (Lee and Jeong 2020). Event-based measurement method is mainly composed of three methods: COPDAB project, WEIS project, and GPR index.

In addition, the Terrorism Risk Model used in terrorism research was applied to measure military security to improve the disadvantages of existing methods.

2.3.1. Conflict and Peace Data Bank Project

The Conflict and Peace Data Bank (COPDAB) database of Azar (1980), which is the most established and widely used method, uses news articles reported in the media among 135 events that took place in countries, international organizations, and non-governmental organizations from 1948 to 1978. COPDAB collects and classifies news reports from multiple media sources into 15 types of events: one neutral event, seven positive events (cooperation) and seven negative events (dispute) (Reuveny and Kang 1996). In Korea, COPDAB has been used to measure the geopolitical crisis on the Korean peninsula. The Korea Peace Index (KOPI) of Hanyang University's Asia-Pacific Research Center was created to measure the degree of friendship between the two Koreas (Han 2006).

2.3.2. World Event/Interaction Survey Project

McClelland (1999)'s World Event/Interaction Survey (WEIS) project is also widely used. From 1966 to 1978, 243 countries, international organizations and non-governmental organizations were classified as news articles. The Kansas Event Data System (KEDS) project was developed to automatically classify events on a computer using the WEIS system. The events classified in WEIS project were finally calculated by applying Goldstein (1992)'s conflict-cooperation scale (27 positive events, 33 negative events, and one neutral event) (McClelland 1999; Goldstein 1992).

2.3.3. The Geopolitical Risk Index

The geopolitical risk (GPR) index of Caldara and Iacoviello (2022) is used to measure geopolitical crises through statistical methods at certain points rather than accumulating measurement results for individual events (Caldara and Iacoviello 2022), such as COPDAB or WEIS. This starts with the establishment of a positive- and negative-word dictionary that can determine the geopolitical crisis. It estimates geopolitical risk by measuring how many pre-built words appear at the time of publication for all articles of 10 international newspapers in the US (6), UK (3), and Canada (1), such as the Wall Street Journal (US) and the New York Times (US).

The Geopolitical Risk from North Korea (GPRNK) index measures the degree of crisis caused by North Korea using methods similar to the GPR. It used news reports from 18 domestic media companies. The GPRNK index differs from the GPR index in terms of word-dictionary construction, result value and calculation formula (Jung et al. 2021). The GPRNK-index method of calculation is as follows.

First, a search was conducted with the basic keyword 'North Korea', and the related word dictionary was constructed on four topics of military tension, sanctions, dialogue/consensus, and economic cooperation by analyzing news articles related to major geopolitical crisis situations. Thereafter, the return value is obtained through the following calculation formula:

$$X_{it} = \frac{N_{neg,it} - N_{pos,it}}{N_{it}} \quad (1)$$

In relation to X_{it}, N_{it} is the number of news articles related to North Korea issued at t time in i media, $N_{neg,it}$ is the number of geopolitical-negative articles, and $N_{pos,it}$ is the number of positive geopolitical articles. Thereafter, it changes into $\widetilde{X}_{it}$ so that X_{it} has only the positive value.

$$\widetilde{X}_{it} = \frac{1}{2} X_{it} + \sqrt{(X_{it}{}^2 + 0.1)} \quad (2)$$

Next, the standardized Y_{it} is calculated by dividing $\widetilde{X}_{it}$ into the standard deviation of $\widetilde{X}_{it}$ for 1995∼2016.

$$Y_{it} = \frac{\widetilde{X}}{\sigma_i} \quad (3)$$

Y_{it}, thespecially-calculated media is distributed to the number of media N to obtain Y_t.

$$Y_t = \frac{1}{N} \sum_{i=1}^{N} Y_{it} \quad (4)$$

Then, Y_t is standardized to $\overline{Y}$, which is the mean value of Y_t from 1995 to 2016. The mean value of 100 points and the *GPRNK* value is finally produced.

$$GPRNK_t = \frac{100 Y_t}{\overline{Y}} \quad (5)$$

2.3.4. Terrorism Risk Model

Another way to calculate geopolitical risks is to measure the risk level of a particular area based on the events (provocation cases) that have occurred. For example, the Terrorism Risk Model of Toure (2017) is a method of measuring the risk of terrorism in a specific area based on the time of occurrence of terrorist incidents and the frequency of occurrence at that time (Toure 2017). This is modeled as the risk increases at the time of the first incident and then decreases over time.

$$\text{Terrorism Risk Model (Enhanced Risk)} = 100 \sum_{i=t}^{\theta} \left(\frac{\lambda_t \left(\frac{1}{\sqrt{\theta - t + 1}} \right)}{\frac{1}{\sqrt{\theta - t + 1}}} \right) \quad (6)$$

where θ is the date of starting measurement, t is the date of ending measurement, and λ_i is the frequency of terrorist events at i point. To obtain a value of 0~100 points, this is standardized and the return value is produced.

This is a mechanism similar to the fact that the influence of events, such as provocations and threats between countries in international relations, is not temporary; instead, it leads to grudges, even though it has been developed as a method of measuring the risk associated with terrorism. In addition, it can be applied to geopolitical- crisis measurement because it has a common denominator that accounts for risk at a particular point.

The measurement methods examined so far have been used as individual indicators, but in this study, they were applied and used in combination to increase accuracy and compensate for some shortcomings.

3. The Military Security Index (MSI) Model and Method of Calculation

3.1. Military Security Index Research Model

In this study, a case-based risk-measurement method is calculated by applying and combining the Goldstein conflict-cooperation weight of the WEIS project and the Terrorism Risk Model, and the news keyword-based measurement method of the GPRNK index is improved to fit the military-security measurement. In addition, a new index, the MSI (Military Security Index), is developed to measure the military-security threat of Korea, including the recent threats of cyber security and terrorism.

The MSI index uses three main types of data, as shown in Figure 1. The first is scoring based on provocation, which corresponds to 60 out of 100 points; the score was calculated based on the provocation cases (actual provocation) from four countries around the Korean Peninsula (North Korea, China, Japan, and Russia) and the news-keyword search results related to the provocation. Among them, the base of provocation cases (*MSI_case*) is 40 points; the results of the news-keyword search related to provocation (MSI_news_{ac}) accounts for 20 points. Second, in the case of scoring based on provocation threats (MSI_news_{th}), it corresponds to 20 out of 100 points. The score was calculated based on the search results of news keywords related to the provocation threat. Finally, scores for other threats are calculated based on the degree of cybersecurity (*MSI_cyb*) and terrorist (*MSI_ter*) threats in Korea. Each is designed to account for a total of 20 points with 10 points each. The MSI value can be calculated by summing up all five values mentioned above.

$$MSI = \overbrace{\boxed{MSI\_case + MSI\_news_{ac}}}^{\text{provocation}} + \overbrace{\boxed{MSI\_news_{th}}}^{\text{threat}} + \overbrace{\boxed{MSI\_cby + MSI\_ter}}^{\text{other threat}} \quad (7)$$

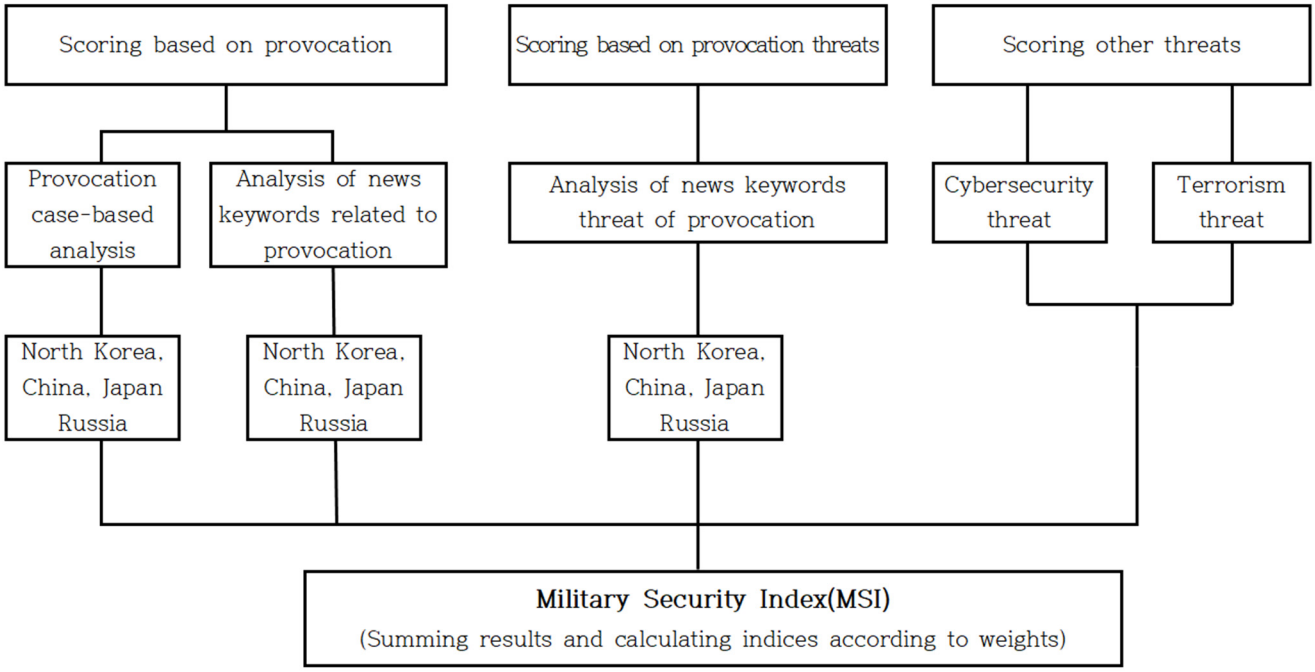

Figure 1. Military Security Index research model.

3.2. Military Security Index Method of Calculation

3.2.1. Provocation Case-Based Analysis Method of Calculation

The provocation case-based analysis (*MSI_case*) is modeled based on two prerequisites. This means that the more time has passed since the time of the incident related to the military security threat, the more the influence of the incident at this time is continuously reduced, and the more recent events are, the more influential (time factor) and the higher the frequency of the incident at that time, the higher the risk (frequency factor) (Lee 2008). The calculation formula included events and weights that occurred between Korea and neighboring countries for t days,

$$MSI\_case = \sum_j \sum_t \sum_b \frac{a_{btj} \times s_{btj}}{2\sqrt{t+1}} \quad (8)$$

where b represents four neighboring countries (North Korea, China, Russia, and Japan) in relation to Korea, and t refers to the period before t days (calculated based on 365 days in this study) based on the date of the incident. j is the sequence of events that occurred t days ago in relation to country b, and a is a binary variable representing the jth event that occurred t days ago in country b. s represents weighting for the type of event; to add objectivity of the event coefficient, only the score for negative events was selected from Goldstein (1992)'s conflict-cooperation scale (Goldstein 1992) used in the WEIS project (see Table 1).

The peace indexes developed in the past were modeled to accept the positive events between countries as a signal that conflicts are being resolved, and thus, offsetting negative events, which is a part of the diplomatic process. However, from the perspective of measuring the military crisis, it would be more objective to consider only the negative behaviors and intentions of the other country. In the case of North Korea, it is easy to find cases of armed provocations, such as preemptive raids while promoting fake peace at the forefront and alleviating the South Korea's security concerns through a covert peace offensive using two-sided tactics. Similarly, other countries have maintained friendly economic exchange, but they do not hesitate to engage in military actions, such as military invasion.

Table 1. Goldstein Scale for WEIS Project (Goldstein 1992).

Category Number	Type of Event	Weighted Value
223	Military attack; clash; assault	10.0
211	Seize position or possession	9.2
222	Nonmilitary destruction/injury	8.7
221	Noninjury destructive action	8.3
182	Armed-force mobilization, exercise, display; military buildup	7.6
195	Break diplomatic relations	7.0
173	Threat with force specified	7.0
174	Ultimatum; threat with negative sanction and time limit	6.9
172	Threat with specific negative nonmilitary sanction	5.8
193	Reduce or cut off aid or assistance; act to punish/deprive	5.6
181	Nonmilitary demonstration, walk out on	5.2
201	Order person or personnel out of country	5.0
202	Expel organization or group	4.9
150	Issue order or command, insist, demand compliance	4.9
171	Threat without a specific negative sanction stated	4.4
212	Detain or arrest person(s)	4.4
192	Reduce routine international activity; recall officials	4.1
112	Refuse; oppose; refuse to allow	4.0
111	Turn down proposal; reject protest, demand, threat	4.0
194	Halt negotiation	3.8
122	Denounce; denigrate; abuse	3.4
160	Give warning	3.0
132	Issue formal complaint or protest	2.4
121	Charge; criticize; blame; disapprove	2.2

At this time, to set the upper limit value of *MSI_case*, a scaling process was performed, and 40 points were determined as the upper limit value. This value assumes that provocations with an *s*-weight of 10 points occur continuously every day for 7 days in 2 of the 4 countries, and if stronger provocations and conflicts occur, they are considered to be the worst situation, close to full-scale war between countries.

3.2.2. News Keyword Base Score Calculation Method

News media is the fastest and most accurate means of disseminating information through various forms of media, including information about security-related issues. There are several characteristics of news media to consider when analyzing data sourced from news reports. First, the more important and urgent the contents of a story, the more frequently and widely it is reported. In addition, news report titles tend to include keywords that that allow readers to intuitively understand the contents of the report.

On the other hand, there are also disadvantages. The first is that sensitive issues, such as security, are not immediately reported at the time of the actual incident. The Ministry of National Defense and Ministry of Unification in Korea, which deal with security-related issues, control the release of information for security and other reasons or limit reporting to a certain period of time through embargo. The second is the political tendency of the media. Reporting may differ depending on the so-called conservative and progressive characteristics of the media, and in severe cases, events may be distorted, excessively biased, or not reported at all.

The news-keyword search method (MSI_news_{ac}), which is the second score-calculation method based on provocation, is a score of the proportion of the news titles that contain keywords related to direct provocation in neighboring countries. As a tool for analyzing news, Big Kinds (n.d.), a news-analysis service created by the Korea Press Foundation, was used. Big Kinds has built an integrated DB that collects more than 70 million news articles in real time for 54 representative media companies in Korea and provides a classification and analysis environment according to media type, theme, event, and accident.

In this study, 18 newspapers and broadcasters representing Korean media were selected by referring to the press-media selection process of the GPRNK index (Jung et al. 2021). Among the top 20 newspapers based on the reading rate (Korea Press Foundation 2021), 15 newspapers were selected in consideration of political tendencies after excluding sports newspapers and local newspapers. Of the 15 selected newspapers, 10 were daily newspapers, 5 were economic newspapers, and the remaining 3 were broadcasters, diversifying the media. The media used between news-keyword searches is shown in Table 2.

Table 2. Medias used for searching Keywords (Caldara and Iacoviello 2022).

Newspapers(10)	Chosun-Ilbo, Dong-a Ilbo, Joong-ang Ilbo, Kyunghyang shinmun, Kookmin Ilbo, Munhwa Ilbo, Seoul Shinmun, Segye Ilbo, Hankyoreh, Hankook Ilbo
Economic Newspaper(5)	Maeil Business Newspaper, Money Today, Seoul Gyeongje, Hankook Gyeongje, Herald Economy
Broadcasting Companies(3)	KBS, MBC, SBS

In addition, to limit unnecessary searches, the subjects of news articles were limited to politics, economics, and society. In the search-keyword selection process, first, search terms referring to the names of neighboring countries and their armies were selected as default keywords. Then, the words to be included and excluded were classified by analyzing related news-article titles. Through this process, keywords related to provocative acts are summarized, as shown in Table 3.

Table 3. Provocation act-based Keywords (translated into English).

Category	**Included Words**	**Excluded Words**
Default keywords	(North Korea) OR (北) OR (People's Army)	
	(China) OR (中) OR (People's Liberation Army)	
	(Russia) OR (Ru 軍) OR (RU Miliary)	
	(Japan) OR (日) OR (the Self-Defense Forces)	
Act of provocation	(KADIZ) OR (Military Aircraft) OR (Air Defense) OR (Intrusion) OR (Fighter Jet) OR (Airspace) OR (Provocation) OR (Infringement) OR (Nuclear Weapon) OR (Nuclear Warhead) OR (Nuclear) OR (Skirmish) OR (Opening of a War) OR (Shoot Down) OR (Dead shot) OR (Attack) OR (War) OR (Invasion) OR (Offensive) OR (Sinking) OR (Shot) OR (Shelling) OR (Local War) OR (Launch) OR (Occupation) OR (Bombing)	(Drama) OR (Semiconductor) OR (Film) OR (Book) OR (Commemoration) OR (Memorial) OR (Game) OR (Publishes) OR (Real Estate) OR (Gamers) OR (Writer) OR (Tax) OR (Sports) OR (Soccer) OR (Baseball) OR (Investment)
Search Keywords (Korean)		
Category	**Included words**	**Excluded words**
Default keywords	(북한) OR (北) OR (인민군)	
	(중국) OR (中) OR (인민해방군)	
	(러시아) OR (러軍) OR (러군)	
	(일본) OR (日) OR (자위대)	

Table 3. *Cont.*

Category	Included words	Excluded words
Act of provocation	(KADIZ) OR (카디즈) OR (군용기) OR (방공) OR (침입) OR (전투기) OR (영공) OR (도발) OR (침범) OR (핵무기) OR (핵탄두) OR (핵) OR (교전) OR (개전) OR (격추) OR (사살) OR (공격) OR (전쟁) OR (침공) OR (공세) OR (침몰) OR (피격) OR (포격) OR (국지전) OR (발사) OR (침략) OR (점거) OR (폭격)	(드라마) OR (반도체) OR (영화) OR (도서) OR (기념) OR (추모) OR (게임) OR (발간) OR (부동산) OR (게이머) OR (작가) OR (세금) OR (스포츠) OR (축구) OR (야구) OR (굴기) OR (투자)

The provocation-threat score (MSI_news_{th}) is calculated in the same way as the news-keyword search for provocations from neighboring countries; Table 4 shows the same keyword-selection process. Meanwhile, to prevent overlapping search results, keywords already searched for were added to the excluded words.

Table 4. Provocation threat-based Keywords (translated into English).

Category	Included Words	Excluded Words
Default keywords	(North Korea) OR (北) OR (People's Army)	
	(China) OR (中) OR (People's Liberation Army)	
	(Russia) OR (Ru 軍) OR (RU Miliary)	
	(Japan) OR (日) OR (the Self-Defense Forces)	
Threat of Pprovocation	(Military) OR (Training) OR (Actual battle) OR (Flaunting) OR (Augmentation) OR (Warning) OR (Threat) OR (Tension) OR (Disobeying) OR (Blaming) OR (Arms) OR (Ambition) OR (Conflict) OR (Rebellion) OR (Sanction) OR (Impromptu) OR (Crisis) OR (Radar)	(Drama) OR (Semiconductor) OR (Film) OR (Book) OR (Commemoration) OR (Memorial) OR (Game) OR (Publishes) OR (Real Estate) OR (Gamers) OR (Writer) OR (Tax) OR (Sports) OR (Soccer) OR (Baseball) OR (Investment) + All Included words in Act of Provocation
Search Keywords (Korean)		
Category	**Included words**	**Excluded words**
Default keywords	(북한) OR (北) OR (인민군)	
	(중국) OR (中) OR (인민해방군)	
	(러시아) OR (러軍) OR (러군)	
	(일본) OR (日) OR (자위대)	
Threat of provocation	(군사) OR (훈련) OR (실전) OR (과시) OR (증강) OR (경고) OR (위협) OR (긴장) OR (불복) OR (비난) OR (군비) OR (야욕) OR (분쟁) OR (보복) OR (반발) OR (제재) OR (일촉즉발) OR (위기) OR (레이더)	(드라마) OR (반도체) OR (영화) OR (도서) OR (기념) OR (추모) OR (게임) OR (발간) OR (부동산) OR (게이머) OR (작가) OR (세금) OR (스포츠) OR (축구) OR (야구) OR (굴기) OR (투자) + All included words in Act of Provoca tion

Since MSI_news_{ac} and MSI_news_{th} values use the same calculation method, we will explain the calculation formula with MSI_news. Meanwhile, in utilizing the search results,

the value X_{bt} calculated by calculating the ratio of news articles related to military-security threats to the total number of news articles related to neighboring countries is as follows.

$$X_{bt} = \frac{N_{b,t,sec}}{N_{b,t,all} + \overline{N}_{b,all}} \quad (9)$$

where N is an index meaning the number of news articles, $N_{b,t,all}$ is the number of all news published at time t (date) in relation to country b, and $N_{b,t,sec}$ is the number of news publications related to security threats published at time t in relation to country b. $\overline{N}_{b,all}$ is the average value of all news related to country b per day for '10~'21 years and plays a role in correcting the excessively high X_{bt} value due to the small absolute number of articles in countries, such as Russia.

$$Y_{bt} = \frac{K_b \times X_{bt}}{\sigma_b} \quad (10)$$

where K_b used rank reciprocal weight as a coefficient meaning weight for each country, and the rank was given in the order of North Korea (0.48) > China (0.24) > Japan (0.16) > Russia (0.12) based on the average value of *MSI_case* for each country for '10~'21 years. Then, the largest Y_t value of '10~'21, which is added by multiplying the weights by country, was set to 4 quartiles (16 points), and the *MSI_news* value was calculated by applying a margin to the upper limit value.

$$MSI\_news_t = \frac{16 \sum_b Y_{bt}}{max(\sum_b Y_{bt})} \quad (11)$$

3.2.3. Other Threat Based Score Calculation Method

In addition to the traditional-security threats centered on combat and engagement, the recent global-security situation has rapidly increased the influence of non-traditional security threats, such as terrorism, cyberattacks, hacking, and cyber-psychological warfare (Song et al. 2020). These methods are being used more extensively in modern warfare because they minimize the exposure of the attacker, do not require a large-scale military force, conceal the intention of the act, and achieve its purpose. The category of non-traditional security threats may include threats or economic pressures caused by viruses, such as COVID-19, but this study considers only the risk of cyber security and terrorism, which are related to military security.

The first of the other threat-based score calculation methods is the evaluation of cyber security threats (*MSI_cyb*), which utilizes cyber-crisis alarms, a system that evaluates cyber threat levels in real time and issues alarms at the Korea National Cyber Security Center (National Inteligence Service n.d.). The cyber-crisis alert evaluates and ranks situations that could affect national cybersecurity in four stages: attention (blue), caution (yellow), alert (orange), and serious (red). In the case of a red stage, give 10 points and subtract 3 points as the step is lowered, and 1 point is given when it is at the blue stage. The second is the evaluation of terrorist threats (*MSI_ter*), which uses a domestic-terrorism alert that issues an alert by evaluating the risk and timing of internal and external terrorism in real time by the Terrorism Information Center. Domestic-terrorism alerts are also ranked into four stages of attention (blue), caution (yellow), alert (orange) and serious (red) (National Inteligence Service n.d.), and the method of giving scores is also the same.

4. Model Research Results and Implications

4.1. '15 Military Security Index

To confirm the results of the model, the results of each score-calculation method were presented on a cumulative-bar graph based on the '15 year when the DMZ-wooden-box-mine provocation occurred. The red box in the graph is displayed to emphasize the characteristic values of each output value.

4.1.1. Provocation Case-Based Score Calculation Result

The *MSI_case* results in Figure 2 show that the *MSI_case* value has risen sharply from the shelling of the western front on 20 August, when the conflict between the two Koreas began to intensify after the North's wooden-box mine was detonated on approximately 4 August. Looking at the unique values other than North Korea, it can be seen that the invasion of the KADIZ by Russian military aircraft occurred on 20 March, and in May and November, the value rose due to the military tension between Korea and Japan.

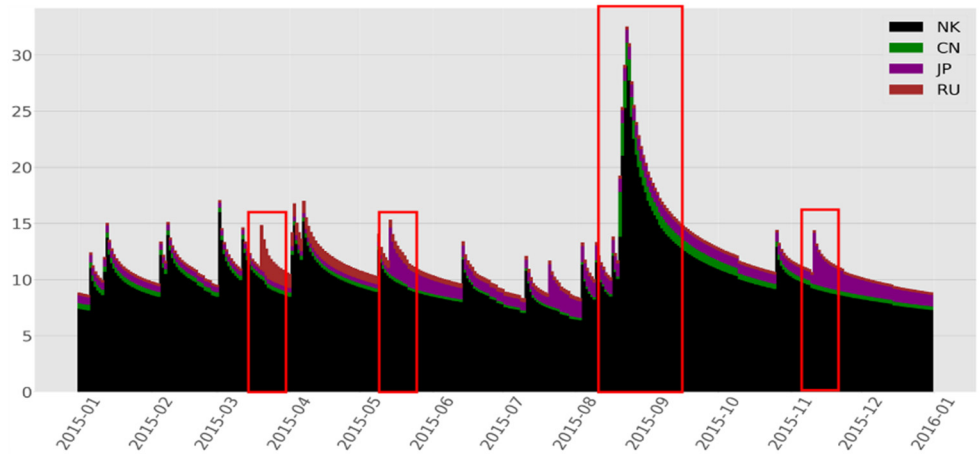

Figure 2. Provocation case-based results (*MSI_case*).

4.1.2. Provocation News Keyword-Based Score Calculation Results

In the MSI_news_{ac} of Figure 3, a high score was observed once in September in addition to the provocation of North Korea in August. This suggested a nuclear test and long-range rocket launch in North Korea on 15 September, and warned that the nuclear facility would be operated normally, and the US confirmed that there were many reports of military-security threats, such as the possibility of cyber provocation by North Korea.

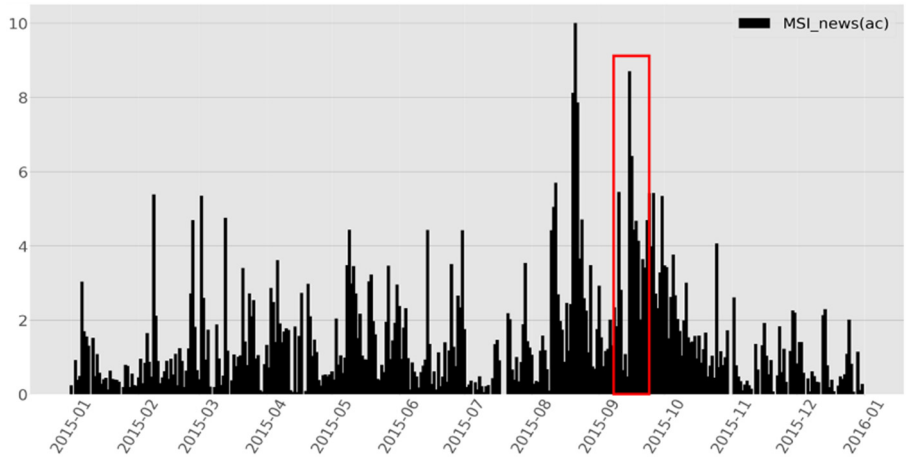

Figure 3. Keywords related to provocation-based results (MSI_news_{ac}).

4.1.3. Scores Calculated Based on Provocation

Looking at the results of the provocation-based score calculation, it was observed that the *MSI_case* and MSI_news_{ac} values rise simultaneously as most provocation actions occur and related news reports are published in real time. On the other hand, it was confirmed that there were strong warnings and criticisms between countries related to the provocation in the case where the value rose only by changing the MSI_news_{ac} value, even though no provocation occurred. Excluding the two previously mentioned high-score values, the

points that soared in Figure 4 were caused by North Korea's fourth nuclear test (January), drone invasion (January), and eight missile launches (February to June). On the other hand, changes in the results were observed in the three Korea–US joint drills (February, March, and August) and the defense training (October).

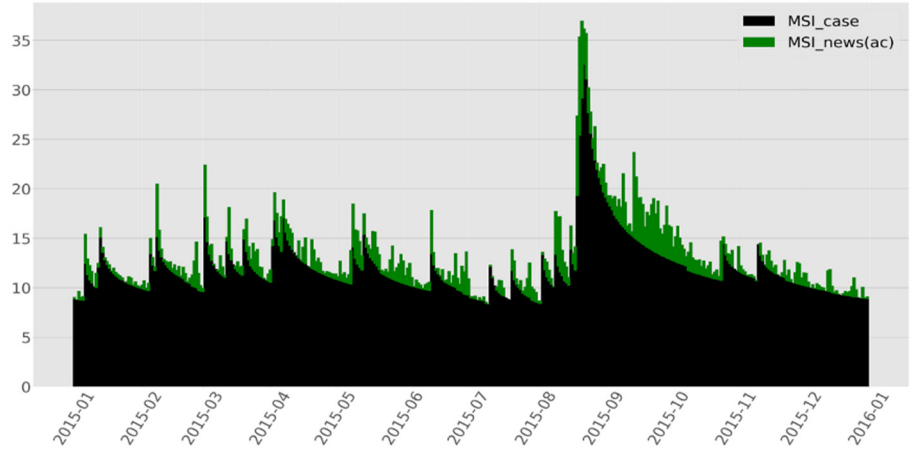

Figure 4. Provocation-based results (*MSI_case*+*MSI_news*$_{ac}$).

4.1.4. Provocation Threat News Keyword-Based Score Calculation Results

In the *MSI_news*$_{th}$ value in Figure 5, high values were observed in May, September, and December. On 18 May, US Secretary of State John Kerry visited Seoul to deliver a message that he would "never give in to threats from North Korea," and South Korea's National Intelligence Service (NIS) also announced that North Korea's chief, Hyun Young-chol, had been purged. In addition, former President Park Geun-hye, in an official statement, urged North Korea to cease provocations, and many news related to security threats were reported in a day. On 30 September, there was a backlash from North Korea about the creation of a missile-strike unit in South Korea, leading to fierce criticism from the North after former President Park Geun-hye (2013~2017) mentioned North Korea's suspension of provocation and unification in his keynote address at the UN General Assembly. On 9 December, there was a protest by the North-Korean side due to US sanctions against them, and the results of the US announcement of the construction of the North Korean submarine and the failure of the submarine-launched ballistic missile (SLBM) were reported.

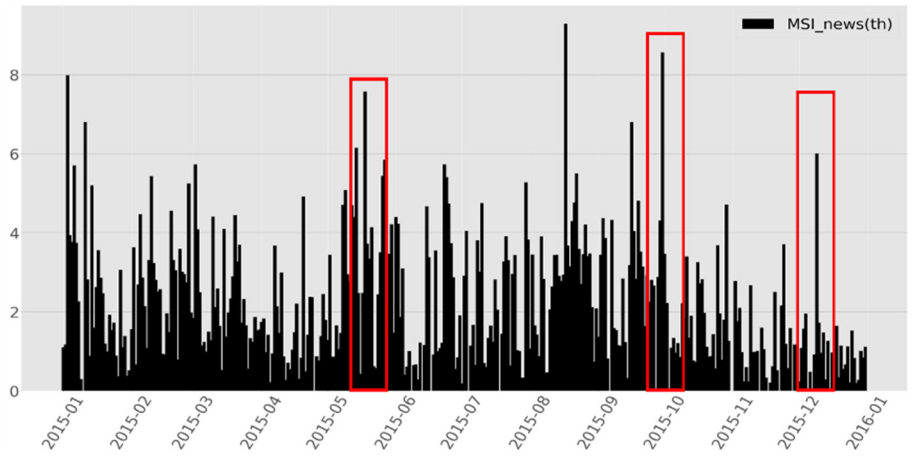

Figure 5. Keywords related to threat-based results (*MSI_news*$_{th}$).

4.1.5. Other Threat-Based Score Calculation Result

Figure 6 is the result of other threat-based score calculations that show *MSI_cyb* and *MSI_ter*. As the Gwangju Summer Universiade, an international competition, was held for

6.30–7.3 days, it can be seen that the domestic terrorism alert, blue → orange level, rose sequentially.

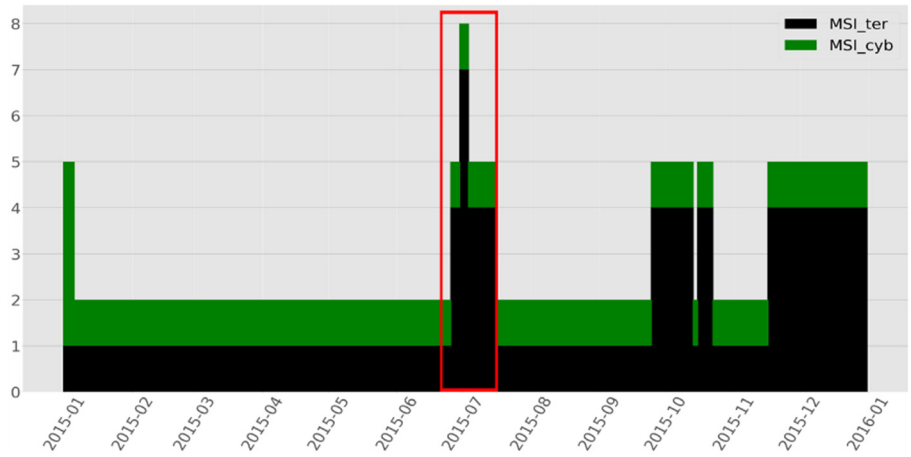

Figure 6. Terrorism and cybersecurity risk-based results (*MSI_ter+MSI_cyb*).

4.1.6. '15 Military Security Index Results

Figure 7 is the result of calculating the '15 MSI index by summarizing the five result values, including the *MSI_case* value.

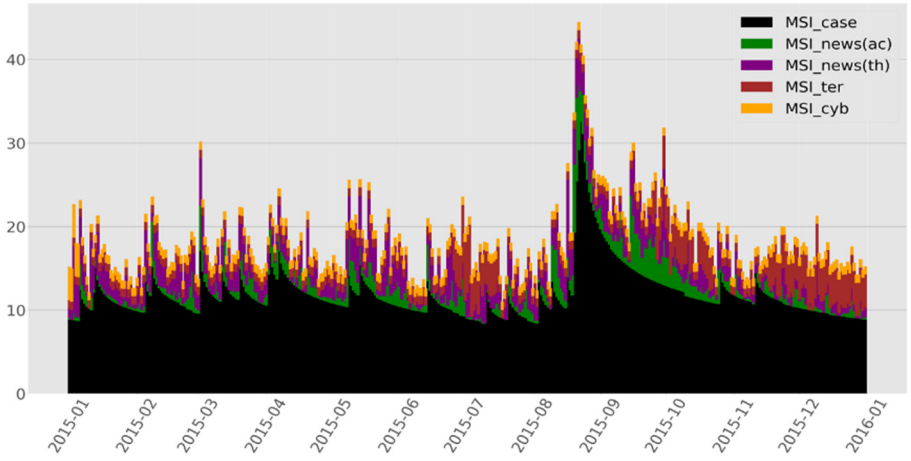

Figure 7. Military Security Index ('15).

4.2. '10~'21 Military Security Index Results and Risk Classification

Looking at the MSI value of '10∼'21 years in Figure 8, it can be observed that there were four rapid increases in the index and that the index remained relatively high for '16~'18 years, unlike other periods. First, in '10, high values were observed due to the shelling of Yeonpyeong Island. In February and March of 2013, North Korea's third nuclear test was followed by two sanctions against the UN and the US, two joint exercises and North Korea's missile launches. In '19, seven consecutive missile launches continued in a month after the US sanctions on North Korea on 13 July, and ROK-US joint training and arrest of direct spies were conducted. From February 2016 to September 2017, the conflict with North Korea and China was very deep, and during this period, North Korea performed 37 missile launches and two nuclear tests, and made remarks about hitting the President's office (Cheong Wa Dae) and Seoul. In response, the US and the UN have imposed sanctions on North Korea 11 times. Meanwhile, it was confirmed that South Korea's announcement of the deployment of THAAD in July 2016 created a significant confrontation between South Korea and China.

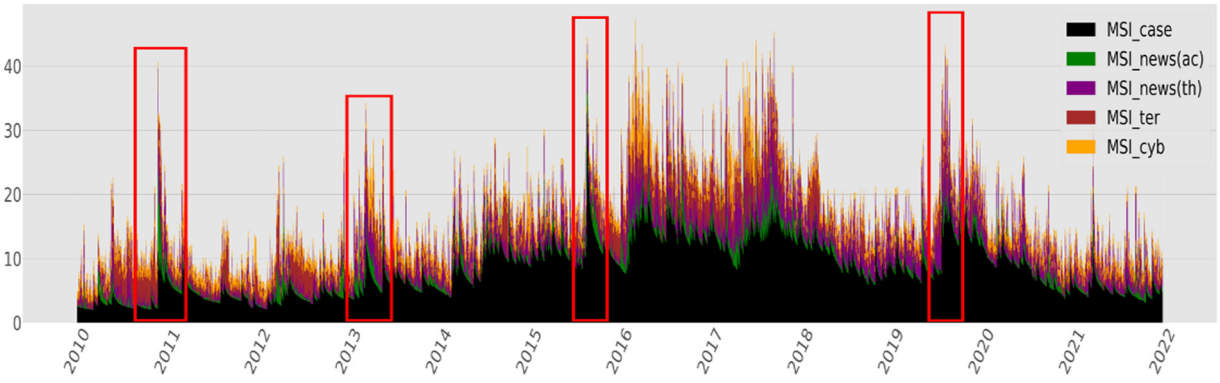

Figure 8. Military Security Index ('10~'21).

In this regard, as a result of calculating the MSI value for '10∼'21 years, the value exceeding 40 points was only 26 days out of the total 4,383 days, which was about 0.6%. The value between 30 and 40 points was 206 days, about 5%, and the value between 20 and 30 points was 904 days, accounting for about 20%. The value between 10 and 20 points was 2134, which is about 50% and accounts for the largest proportion. The value of less than 10 points was 1113 days, which is equivalent to 25% of the total.

Based on this distribution, the degree of risk for each section is indicated so that the current state can be simply checked and the risk can be easily expressed. An MSI value exceeding 40 points is defined as serious (red); 30–40 points, 20–30 points, and 10–20 points are classified into alert (orange), caution (yellow) and attention (green), respectively. Normal (blue) is 10 points or less.

4.3. Military Security Index by Country in '10~'21

The results of the military security index by country are summed up by *MSI_case*, MSI_news_{ac}, and MSI_news_{th}. The red box in the graph is displayed to emphasize the characteristic values of each output value.

The result of North Korea (Figure 9) shows a graph form similar to the overall *MSI* result value. This confirms based on statistics that North Korea is the country that has been the most provocative and threatening to Korea.

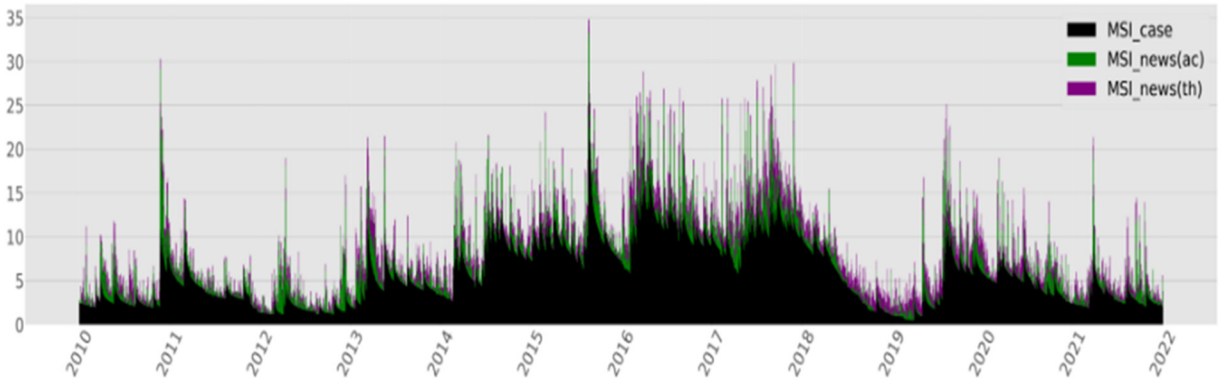

Figure 9. Military Security Index of North Korea ('10∼'21).

As shown in Figure 10, China has been showing a high conflict pattern since '16, which is interpreted as indicative of a nervous battle between the two countries related to the THAAD deployment. There was an immediate invasion of the KADIZ after the Chinese first warned of the consequences of THAAD deployment in January. Every time there was an issue related to the deployment of THAAD, large-scale drills and military aircraft violations continued. In particular, after allowing additional THAAD deployment in September 2017, it was confirmed that the conflict continued by regularizing armed protests, such as

invading KADIZ, through military aircraft about once every 1.5 months on average from December 2017.

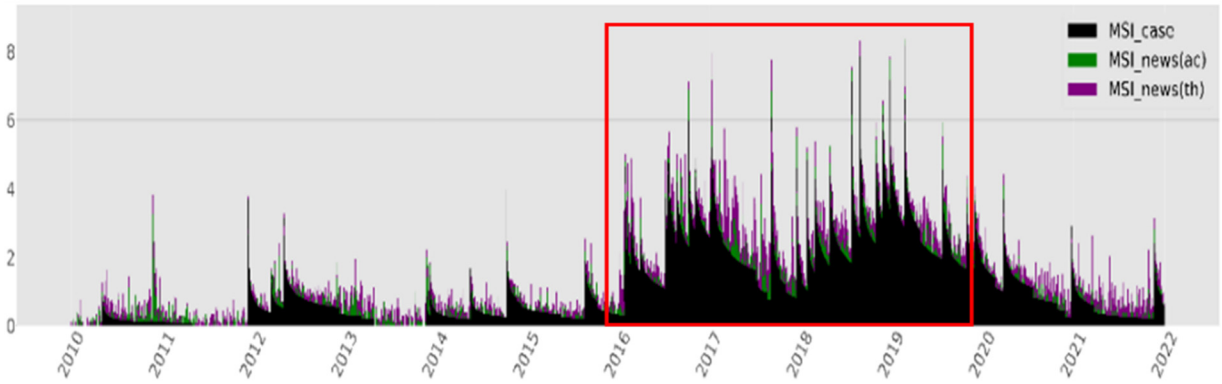

Figure 10. Military Security Index of China ('10∼'21).

The result of conflict with Japan (Figure 11) is mostly conflict related to Dokdo. Therefore, it was confirmed that the areas where *MSI* rose were the implementation of Dokdo defense training in Korea and the criticism and warning of Japan. On the other hand, a fairly high result was observed once in 2019, due to the low-air threat flight incident of the Japanese maritime-patrol plane, which began after Japan protested against Korea's Dokdo defense drill in December of 2018. At that time, a patrol plane belonging to the Japanese Maritime Self-Defense Force flew close to Korea's Gwanggaeto Great Ship at an altitude of 150 m, and three more low-threatening flights were made over the next month. As a result, mutual criticism and demands for apology at the Ministry of National Defense were pouring in, and the conflict between Korea and Japan reached its peak because it was linked to the end of GSOMIA (General Security of Military Information Agreement) in August and additional Dokdo defense drills.

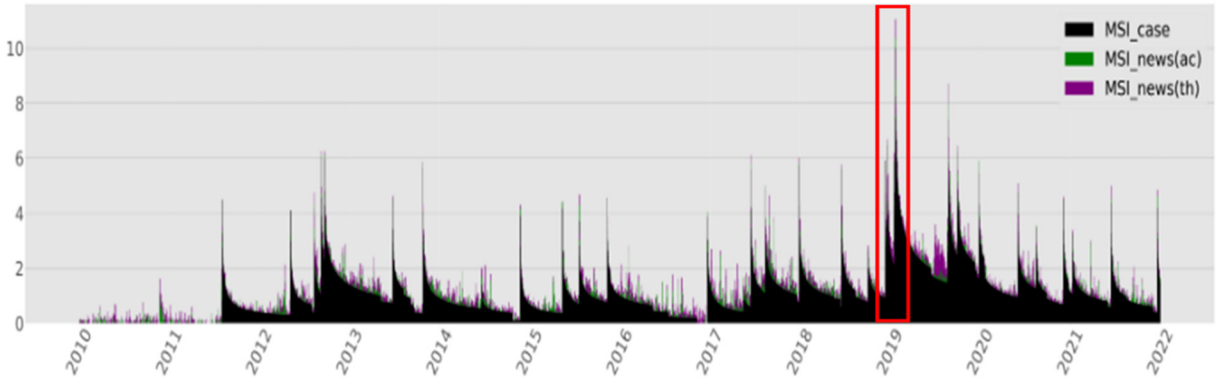

Figure 11. Military Security Index of Japan ('10∼'21).

As shown in Figure 12, intermittent increases in *MSI* are observed because Russia has been conducting intermittent invasions under the pretense of not recognizing KADIZ, which has been on the rise since 2019, while invading with Chinese military aircraft in the name of military training.

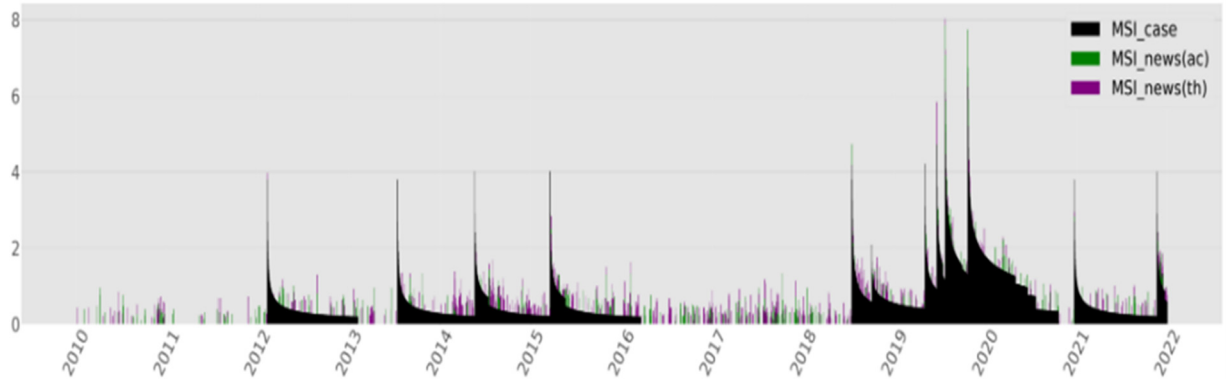

Figure 12. Military Security Index of Russia ('10∼'21).

While the overall *MSI* was useful in identifying the degree of overall military crisis at a glance, there was a limit to grasping the flow to individual countries. Therefore, the limitations could be resolved by separately examining the *MSI* by country (Figure 13). Moreover, it was possible to grasp which country's provocation proportion was high at that time when examining the result of summing up *MSI* by country.

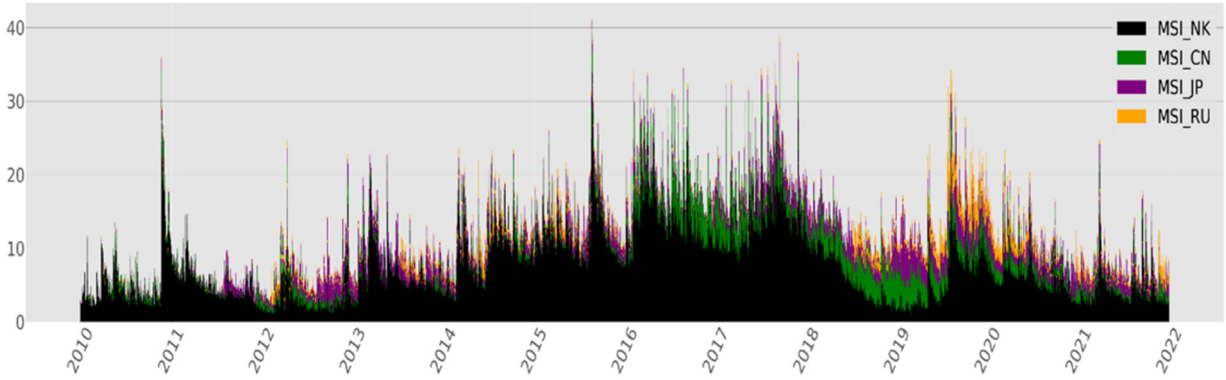

Figure 13. Total Military Security Index by Country ('10∼'21).

5. Conclusions and Future Work

5.1. Summary of Contribution

This study is based on the argument that a new quantitative indicator is needed to measure the security threat in a timely manner in the military aspect as the military tension in Northeast Asia increases more than ever due to the Ukrainian war and the new Cold War.

Therefore, based on the provocation cases of neighboring countries, real-time data related to actions and threats and cyber-terror threats were analyzed to construct a military-security-index calculation model to measure military-security threats.

The model is calculated by summing up the five values of *MSI_case* based on cases, MSI_news_{ac} calculated through news articles related to provocation, MSI_news_{th} calculated through news articles related to provocation threats, *MSI_cyb*, real-time cyber-security risks, and *MSI_ter*, real-time terrorism risks. In the case of *MSI_case*, MSI_news_{ac}, and MSI_news_{th}, the values of neighboring countries are calculated, respectively.

Then, the values calculated through the results of the study were visualized, and the cases with unusual values were classified and compared with the actual security threats cases in 2015 and 2010–2021. First of all, in the case of 2015, the validity of each component value was established by confirming the specific values of each component value constituting the military-security index, and the validity of the entire model was established by confirming whether the data of 2010–2021 match the actual security-threat cases among the countries.

This study is meaningful in that it attempts to measure the degree of comprehensive security crisis on the Korean peninsula scientifically and time-series. First of all, it is the first attempt to measure the national-security risk (*MSI_case*) based on the provocation case, and even if it is closed to the public or limited to reporting through embargo for a certain period of time, military organizations and intelligence agencies are designed to fill out the case in a timely manner. In addition, it is possible to derive more reliable results by applying the Goldstein scale of the WEIS project to distinguish the severity by case.

In addition, unlike the existing peace index, it is a new type of quantitative indicator that reflects not only North Korea but also China, Japan, and Russia, including timely and hybrid threats, such as terrorism and cyber security.

In particular, when the calculated military-security index for each neighboring country is visualized separately, it is easy to judge the degree of conflict with the country in each period, and it is also possible to confirm which country is most prominent at a certain time.

5.2. Future Work

In this study, the *MSI_news* value was calculated based on the weight of specific words at a specific time for news-article analysis. In this regard, it is judged that more sophisticated results can be obtained than the word dictionary in this study if the study is conducted based on more cases when constructing a dictionary of provocative acts and threats related to the calculation of *MSI_news* value. In addition, it is judged that more reliable news-article analysis will be possible if prominent English-language daily newspapers are included in addition to domestic daily newspapers and broadcasting media.

Among other threats, the Cyber Crisis Alert of the National Cyber Security Center and the Domestic Terrorism Alert of the Terrorism Information Center were used. In addition, systematic research on data that can be additionally reflected will be needed in consideration of the increasing importance of the enemy's gray-zone strategy and hybrid- threat response.

In addition, additional research should be conducted to change the weight of each component in the composition of the military-security index.

As with other security-related analyses, in order for the Military Security Index to be used as a true military-security-risk-measurement model, continuous data accumulation based on this study must be premised. The accumulated data will enable empirical analysis related to provocations from neighboring countries, and analysis of patterns that may appear in the index will also be possible.

Finally, through this study, it is hoped that the military security-related index will be more systematically developed, which is the foundation for improving an index that can be easily encountered and accepted by people, as with the daily-fine-dust index.

Author Contributions: Conceptualization, M.-G.L.; methodology, H.-J.J.; validation, H.-J.J., investigation, H.-J.J.; writing-original draft preparation, H.-J.J.; writing-review and editing, M.-G.L.; visualization, H.-J.J.; project administration, M.-G.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data are not publicly available due to Korean military security.

Conflicts of Interest: The authors declare no conflict of interest.

References

Azar, Edward E. 1980. The Conflict and Peace Data Bank (COPDAB) Project. *Journal of Conflict Resolution* 24: 143–52. [CrossRef]
Big Kinds. n.d. Available online: http://www.bigkinds.or.kr (accessed on 22 June 2022).
Caldara, Dario, and Matteo Iacoviello. 2022. Measuring Geopolitical Risk. *American Economic Review* 112: 1196–200. [CrossRef]
Chung, Jaeheung. 2022. *The Yoon Suk-Yeol Administration's Policy towards China: Challenges and Tasks*. Seoul: The Sejong Institute, vol. 349, pp. 3–4.
Foster, John Bellamy. 2006. The New Geopolitics of Empire. *Monthly Review* 57: 1–2. [CrossRef] [PubMed]

Fry, Scott A. 2010. *Depratment of Defense Dictionary of Military and Associated Terms*, As amended Through April 2010. 419p.
Gates, Robert M. 2009. A Balanced Strategy: Reprogramming the Pentagon for a New Age. *Foreign Affairs* 88: 1–4.
Goldstein, Joshua S. 1992. A Conflict Cooperation Scale for WEIS Events Data. *The Journal of Conflict Resolution* 36: 375–77. [CrossRef]
Han, Hongyul. 2006. *Relation-Level Stability Index and Its Application: Korea and Four Major Countries(U.S., Japan, China, and Russia)*. Daejeon: Naional Research Foundation of Korea, pp. 1–5.
Hankyung. 2022. Available online: http://hankyung.com/international/article/202206281059Y (accessed on 22 June 2022).
Hoffman, Frank G. 2009. *Hybrid Threats: Reconceptualizing the Evolving Character of ModernConflict*. Strategic Forum. Washington, DC: Institute for National Strategic Studies, National Defense University, vol. 240, p. 5.
Jung, SeungHo, Jongmin Lee, and Seohyun Lee. 2021. *The Impact of Geopolitical Risk on Stock Returns: Evidence from Inter-Korea Geopolitics*. Bank of Korea WP 2021-10. Seoul: Bank of Korea, pp. 6–12.
Korea Press Foundation. 2021. Available online: https://www.kpf.or.kr/front/board/boardContentsView.do?board_id=246&contents_id=722a9cbd0ea442e49e1c75d3522899d1 (accessed on 22 October 2022).
Lee, Sungwoo. 2008. *Research on World Peace Index*. Seogwipo-si: Jeju Peace Institute, pp. 22–24.
Lee, Seongwoo, and Seonghui Jeong. 2020. *Time-Series Analyses for Inter-Korean Relations with GDELT Data Set*. Suwon: Gyeonggi Research Institute, pp. 24–30.
McClelland, Charles. 1999. *World Event/Interaction Survvey (WEIS) Project, 1966–1979*. Ann Arbor: Inter-university Consortium for Political and Social Research, pp. 1–3.
National Inteligence Service. n.d.a. Available online: https://www.nis.go.kr:4016/AF/1_7_1_1/list.do (accessed on 22 June 2022).
National Inteligence Service. n.d.b. Available online: https://www.nis.go.kr:4016/AF/1_6_1_1/list.do (accessed on 22 June 2022).
NATO. 2022. NATO 2022 Strategic Concept. Paper presented at Heads of State and Governmentat the NATO Summit in Madrid, Madrid, Spain, June 29–30; pp. 4–5.
Park, Suksam. 2015. *A Study of Inter-Korean Integration Index(IKII): Structural Characteristics and Enhancing Practical Utilization*. Unification and Peace. Seoul: The Institute for Peace and Unification Studies of Seoul National University, vol. 7, pp. 43–46.
Reuveny, Rafael, and Heejoon Kang. 1996. International Conflict and Cooperation: Splicing COPDAB and WEIS Series. *International Studies Quarterly* 40: 281–305. [CrossRef]
RIAC. 2022. Available online: https://russiancouncil.ru/en/analytics-and-comments/analytics/at-a-standstill-russian-south-korean-relations/?sphrase_id=94424142 (accessed on 22 June 2022).
Song, Taeeun, Jongin Lim, Haewon Jun, and Yoosik Kang. 2020. *Against Hybrid-threats Recent European Response*. IFANS Analysis of Major International Problems. Seoul: The Institute of Foreign Affairs and National Security, vol. 31, pp. 1–8.
Szpyra, Ryszard. 2014. Military Security within the Framework of Security Studies: Research Results. *Connections* 13: 59–82. [CrossRef]
Toure, Ibrahim. 2017. Real Time Big Data Analytics for Predicting Terrorist Incidents. Ph.D. thesis, University of Maryland Baltimore County, Baltimore, MD, USA.
Yoon, Changyong. 2022. A Retrospective of the International Situation in 2021 and Prospects for 2022. *Studies of Security Strategy for the Korea* 8: 10–23.