

# Quantitatively Modified Two-level Game Theory and Its Application to Reality: Modified Two-Level Game Theory and the Possibility of Its Application to the North East Asian International Affairs

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**Abstract.** Recently, the world begins to comprehend the importance of Northeast Asia, particularly in such inconstant international situations, considering its geopolitical factors, surrounded by world powers such as the United States, China, Russia, and Japan. It is then evident that there will be frequent conflicts between involved countries. This calls for the detailed analysis of present circumstances. Therefore, this study presents a method of investigating complex international relations, based on the modified Two-Level Game Theory, which is quantified by adding our analytic tool to the existing hypothesis. In order to prove the utility of this devised tool, our study offers cases of application of the theory to recent instances, including the war threats of North Korea.

**Keywords.** Quantitatively modified two-level game theory, Application to diplomatic strategy, Northeast Asian international politics

## 1 Introduction

The status of Northeast Asian countries, whose geopolitical importance is becoming more significant, is rising rapidly and international conflicts between such nations are occurring frequently. Game Theory has been one of the theories to explain these conflicts. However, in the case of the existing Two-Level Game Theory, the degree of investigation was limited to the 'qualitative' standard, being unable to provide exact analysis of circumstances. Accordingly, this study added the concept of quantifying analytic standard generated from the Traditional Game Theory to the existing hypothesis of Two-Level Game Theory, and changed some hypotheses in order to suit the diplomatic status quo of Northeast Asia. This theory demonstrated its usefulness by taking part in analyzing the war threats of North Korea since 2013.

## 2 Quantitatively Modified Two-Level Game Theory

### 2.1 Major Hypotheses of Quantitatively Modified Two-Level Game Theory

- H1 Diplomatic strategy of every state participating in the negotiation can be numerically assessed by "Firmness Index ( $F$ )" whose range is between -1 and 1. If  $F$  exceeds that range, the maximum or minimum value is used instead.
- H2 When a state participating in the negotiation is governed under the essential democracy, 0.2 points is subtracted from its  $F$ . On the other hand, when a state participating in the negotiation is governed under the one-man dictatorship, 0.4 points is added to its  $F$ , while 0.1 points is added to its  $F$  when it is governed by one-party dictatorship.
- H3 When one country's consensus is biased toward the extremism, 0.3 points is added to its  $F$ . Moreover, when there was military conflicts within 5 years from the time of negotiation, 0.2 points is added to  $F$  of the country that got preemptive strike.
- H4 0.3 points is added to  $F$  of the country with superior military power.
- H5 0.3 points is added to  $F$  of the relatively isolated participating state.
- H6 0.5 points is deducted from  $F$  of both countries in relation of close alliance.
- H7 There is one-to-one correspondence relationship between  $F$  calculated based on hypotheses H1~H6 and win-sets size in international negotiation, which could be quantitatively assessed by "Win-sets Size Index ( $W$ ).". Specific relationship is illustrated in Figure 1.
- H8  $W$  calculated based on H7 is deducted (or magnified) by 10 percent when one country chooses hardline (moderate) diplomatic strategy.
- H9 Every strategy of participating countries in negotiation can be categorized into either hardline or moderate strategy.

### 2.2 Relationship between Firmness Index ( $F$ ) and Win-Sets Size Index ( $W$ )

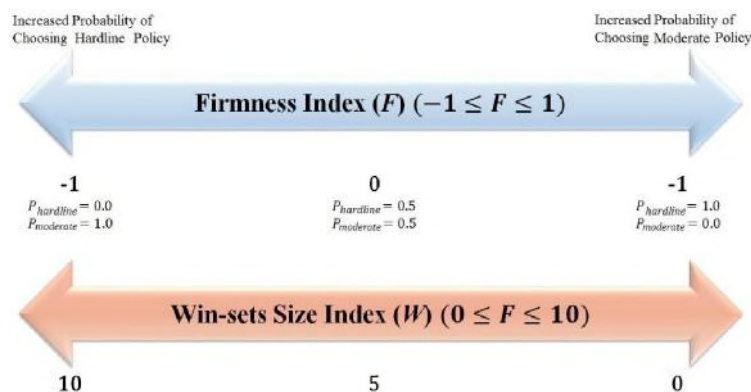


Fig. 1. Relationship between Firmness Index ( $F$ ) and Win-Sets Size Index ( $W$ )

### 2.3 Expectancy Function

x	The probability of choosing hard line strategy ( )		
	W when choosing hardline strategy		W when choosing moderate strategy

## 3 Applications to Reality

– North Korea throwing war threats toward South Korea since 2013

### 3.1 Abstract of Negotiation Conditions

**Table 1.** Firmness Index (*F*) of negotiating countries and Basic Win-sets Size Index

	South Korea – North Korea		U.S. – North Korea		China – North Korea	
	South Korea	North Korea	United States	North Korea	China	North Korea
F	0 <sup>[1]</sup>	1 <sup>[2]</sup>	0.5 <sup>[3]</sup>	1 <sup>[4]</sup>	-0.1 <sup>[5]</sup>	0.5 <sup>[6]</sup>
W	5.0	0	2.5	0.0	6.0	2.5

### 3.2 Analysis based on quantitatively modified Two-Level Game Theory

**Table 2.** Negotiation complexion between South Korea and North Korea defined by modified Two Level Game Theory

	<b>Negotiation Strategy - North Korea</b>
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- [1]  $F = 0(\text{Initial Value}) - 0.2(\text{H2-Application of Democracy}) + 0.2(\text{H3-ROKS Cheonan sinking and Bombardment of Yeonpyeong of 2010}) = 0$
- [2]  $F = 0(\text{Initial Value}) + 0.4(\text{H2-One-man Dictatorship}) + 0.3(\text{H3-Jucheism}) + 0.3(\text{H4-Asymmetric Power}) + 0.3(\text{H5-International Alliance}) = 1.3$ . Since this value surpasses the maximum range of *F*, the maximum value of 1 is given.
- [3]  $F = 0(\text{Initial Value}) - 0.2(\text{H2-Application of Democracy}) + 0.3(\text{H4-Military Superiority}) = 0.1$
- [4]  $F = 0(\text{Initial Value}) + 0.4(\text{H2-One-man Dictatorship}) + 0.3(\text{H3-Jucheism}) + 0.3(\text{H5-International Isolation}) = 1.0$
- [5]  $F = 0(\text{Initial Value}) + 0.1(\text{H2-One-party Dictatorship}) + 0.3(\text{H4-Military superiority}) - 0.5(\text{H6-Traditional Alliance}) = -0.1$
- [6]  $F = 0(\text{Initial Value}) + 0.4(\text{H2-One-man dictatorship}) + 0.3(\text{H3-Jucheism}) + 0.3(\text{H5-International Isolation}) - 0.5(\text{H6-Traditional Alliance}) = 0.5$

		Hardline Policy	Moderate Policy
Negotiation Strategy - South Korea	Hardline Policy	(4.5, 0.0)	(4.5, 1.0)
	Moderate Policy	(5.5, 0.0)	(5.5, 1.0)

**Table 3.** Negotiation complexion between United State and North Korea defined by modified Two Level Game Theory

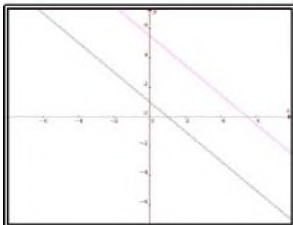
$(W_{United States}, W_{North Korea})$		Negotiation Strategy - North Korea	
		Hardline Policy	Moderate Policy
Negotiation Strategy - United States	Hardline Policy	(2.25, 0)	(2.25, 1.0)
	Moderate Policy	(2.75, 0)	(2.75, 1.0)

**Table 4.** Negotiation complexion between China and North Korea defined by modified Two Level Game Theory

$(W_{China}, W_{North Korea})$		Negotiation Strategy - North Korea	
		Hardline Policy	Moderate Policy
Negotiation Strategy - China	Hardline Policy	(5.40, 2.25)	(5.40, 2.75)
	Moderate Policy	(6.60, 2.25)	(6.60, 2.75)

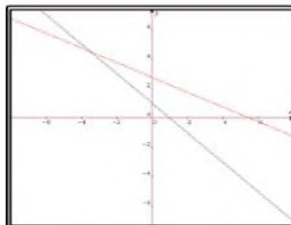
**Graph 1** Graph regarding negotiation between South and North Korea

<b>Pink</b>	Expectancy function of South Korea $(f(x) = 5.5 - x)$
<b>Black</b>	Expectancy function of North Korea $(g(x) = 1 - x)$



**Graph 2** Graph regarding negotiation between U.S. and North Korea

<b>Red</b>	Expectancy function of United States $(f(x) = 2.75 - 0.5x)$
<b>Black</b>	Expectancy function of North Korea $(g(x) = 1 - x)$



**Graph 3** Graph regarding negotiation between China and North Korea

<b>Yellow</b>	Expectancy function of China $(f(x) = 6.6 - 1.2x)$
<b>Blue</b>	Expectancy function of North Korea $(g(x) = 2.75 - 0.5x)$



Table 5. Quantified result of diplomatic strategies based on <Graph 1>~<Graph 3>[7]

Graph 1			Graph 2			Graph 3		
	X	W		x	W		x	W
South Korea	0.4	5.10	United States	1.0	2.25	China	0.6	5.88
North Korea	1.0	0.00	North Korea	1.0	0.00	North Korea	1.0	2.25
Subtraction	.	5.10	Subtraction	.	2.25	Subtraction	.	3.63

## 4 Conclusion

From the above case, it is predictable that each country would adopt a more moderate policy in order to reactivate negotiation afterwards. This is because persistence of hard line policies makes negotiation almost impossible. Extending this concept, it can be inferred that each nation would reduce  $W$  difference from another participating country between other countries by increasing the size of  $W$  and adopt moderate policy in order to get the opportunity of negotiation. Still, hard line policies of some countries might be based on judgement that increasing the size of  $W$  will bring adverse effect of enlarging difference between other countries and negotiation will come at the expense of own interests. Since numerical value used in this analysis is based on limited amount of reference, above analysis could have margins of error. However, if given value based on professional reference and data, the applicability of this theory will be infinite.

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[7] The probability of choosing hardline policy 'x' of each participating country is the result of calculation based on analysis on media reports of January, 2015.