System Dynamics as a Foreign Policy Tool to Resolve the North Korean Dilemma

Brendon Cagney[1] and Ernest Wong[2]

[1]Department of Systems Engineering
United States Military Academy
West Point, NY 10996, USA

[2]Army Cyber Institute
United States Military Academy
West Point, NY 10996, USA

Corresponding author's Email: ernest.wong@usma.edu

Author Note: Brendon J. Cagney recently graduated from the United States Military Academy at West Point and is serving as a Second Lieutenant in the US Army. Lieutenant Colonel Ernest Y. Wong is Chief of Staff at the Army Cyber Institute and serves as an Assistant Professor with the Department of Systems Engineering at West Point. The authors wish to thank Major Steven Song, Major Jillian Wisniewski, and Colonel Dan McCarthy for their feedback on the models used in this paper. An earlier version of this paper entitled "Leveraging System Dynamics with the North Korean Dilemma" was published and presented in the Donald R. Keith Memorial Capstone Conference at USMA in May of 2017. The views expressed in this paper are those of the authors and do not reflect official policy of the US Army, Department of Defense, or the US Government.

Abstract: Since its establishment as a nation-state after World War II, North Korea has undermined regional stability and has increased the threat to global security. The North Korean regime has shown time and time again that it will stop at nothing to maintain its power and portray itself as a strong and prosperous nation. Today the worry over North Korea extends well beyond its substantial conventional firepower—its asymmetric gains in chemical, biological, nuclear, and cyber warfare capabilities have given rise to a new set of complexities that frustrate international accord. Kim Jong-Un, North Korea's current Supreme Leader, has pressed vehemently against the challenges he perceives from adversaries, both foreign as well as domestic, in order to promote his nation's self-interest. As a consequence, the international community typically responds in kind with political and economic sanctions intended to curb further North Korean provocations. However, history has repeatedly shown how such sanctions serve as merely temporary measures that postpone continued advances in North Korea's military effectiveness. In this paper, the authors leverage system dynamics to better characterize the current situation in North Korea and attempt to provide useful insights into understanding why the Kim Jong-Un regime behaves in the way that it does. By doing so, the authors encourage policy makers to employ system dynamics as a foreign policy tool to come up with more effective ideas and solutions for dealing with today's North Korean dilemma.

Keywords: System Dynamics, North Korea, US Foreign Policy

1. Introduction

1.1 A History of Conflict with North Korea

North Korea began with a troubled history and continues to remain locked in a vicious cycle of militant actions that jeopardizes global stability and security. North Korea's origins as a nation-state began at the end of World War II in 1945, after US-led troops secured the southern part of the Korean peninsula while Soviet-led troops occupied the area north of the 38th parallel (Pruitt, 2013). Crafted by two US military officers on August 14, 1945, the line dividing Korea in half was merely intended to form temporary occupational zones (Fry, 2013). However, the emergence of the Cold War added considerable significance to the infamous 38th parallel, as both the US and the USSR wanted to strengthen their own influence on the peninsula. Distrust between the two former allies as well as the need to bolster their nascent foreign powers prevented both the US and USSR from deciding on a single unifying leader for all of Korea. As a result, the USSR selected Kim Il-Sung as the leader of the north, while the United Nations General Assembly, urged by the US, pushed for the inauguration of the Republic of Korea, free elections, and a constitutional framework in the south (Pruitt, 2013). As democratic principles espoused by the US slowly began to take shape in the south, in the north the communist government quickly set up a "Concentrated Guidance Campaign" that rounded up and executed citizens who failed to pledge fidelity to the new leadership which began to deify Kim

Il-Sung inside the minds of its faithful North Korean subjects. As a result of the purges and the resistance of those who did not accept the idea being ruled by a "God-king," approximately 800,000 Koreans fled to the south (Sholte, 2014).

Kim Il-Sung became obsessed with reunifying the Koreas under the rule of communism. With considerable military support from the USSR, North Korea prepared for war to unify the peninsula by force (Peck, 2016). By 1950, Kim Il-Sung had amassed enough offensive military capabilities, especially in its numerical superiority in armored tanks, mechanized vehicles, artillery, and combat aircraft, which permitted him to plan and execute a surprise invasion south. On June 25, 1950, North Korea initiated its attack and within just three days captured Seoul, the South's capital city. Upon learning of this military aggression, the United Nations (UN) Security Council voted to respond militarily, with sixteen nations providing troop support—with the overwhelming majority coming from the US (Sholte, 2014). The war started with the UN employing defensive tactics and after nearly a month of heavy fighting around the Pusan Perimeter that denied the North Korean military its final objective, President Truman and General Douglas MacArthur shifted to an offensive strategy after building enough forces for a counterattack. They aimed to liberate the entire peninsula of communist influence, and by October 1950, the UN forces actually were able to push the North Korean military to the Yalu River which bordered China. However, China threatened the US with a full-scale war if a cease-fire failed to materialize (History.com Staff, 2009). Between October and December of 1950, an estimated 250,000 to 300,000 Chinese soldiers slipped into Korea to resist MacArthur's advances, and as a result, the UN troops were forced to retreat from overwhelming Chinese counterattacks (Fehrenbach, 1963). On July 27, 1953, the UN agreed to a cease-fire with China and North Korea. However, to this day, North and South Korea have yet to sign a treaty that officially puts an end to the Korean War (Sholte, 2014).

Today, over 24 million North Koreans reside in relative darkness and isolation. When looking at the Korean peninsula at night from satellite imagery, North Korea stands in stark contrast to the lights that shine brightly across the major cities of China and South Korea which are connected to the rest of the global community via the Internet. North Koreans live in a caste system of 51 categories, and only the top castes enjoy suitable living conditions. Prison camps, similar to Nazi death camps, serve as societal rehabilitation centers intended to re-educate an estimated 150,000 to 200,000 North Koreans whom the regime has deemed as being disloyal and contaminated (Sholte, 2014). North Korea is currently controlled by Kim Jong-Un, the grandson of Kim Il-Sung. However, little is known of Kim Jong-Un because of the closed borders of the Hermit Kingdom. What is known is that he grew up while his father, Kim Jong-Il, ruled over North Korea. Many Korean experts did not think Kim Jong-Un was in the running for succeeding his father because of the existence of an older brother and older half-brother. Yet within a few months into his reign after his father's death in December of 2011, Kim Jong-Un conducted a satellite launch that many nations considered to be a test of an inter-continental ballistic missile that could target the US mainland. As a result, the UN Security Council imposed a new round of economic sanctions on the rogue nation (Profile: Kiim Jong-Un, North Korea's Supreme Commander, 2016).

Unfortunately, in spite of such repeated punitive measures imposed on the nation, the North Korean regime has continued to provoke international condemnation and frustrate the UN, especially with advancements in North Korea's asymmetric military capabilities. Since October 2006, North Korea has conducted five nuclear tests—the most recent being a detonation of an estimated 10-kiloton warhead in September of 2016 (Hunt, Kwon, & Hanna, 2016). North Korea's offensive cyber program has also caused serious concerns for globally connected world. North Korea is credited with the cyberattack on Sony Pictures in 2014 (Orr, 2015) and is thought to have committed a cyber heist of nearly $81 million from the Bangladesh central bank in 2016 (Arnold, 2016). To further solidify his rule, Kim Jong-Un is also thought to have orchestrated and ordered the 2017 assassination of his half-brother in a Malaysia airport using VX nerve agent (Bondarenko, 2017).

The international community has failed to come up with lasting measures that dissuade and deter the North Korea regime from continuing to threaten global peace and stability. Along with its nuclear tests and extensive hacking programs, North Korea has built a considerable conventional military force that has more soldiers, artillery pieces, battle tanks, and submarines than South Korea (Browne, 2016). It also has stockpiles of chemical munitions and has amassed one of the world's largest biological weapons arsenal (Kaplan, 2006). China, arguably its sole remaining ally, does not approve of North Korea's hostile overtures and has opposed its nuclear program from the beginning (Bandow, 2017). Perhaps an even more worrisome dilemma the international community must deal with is collapse within North Korea itself—if the North Korean regime should unexpectedly fall, this would likely trigger a civil war within the north at best, or perhaps possibly initiate the release of nuclear weapons at worst. In this paper, the authors encourage those who wish to better understand and model the complexities of North Korean to leverage system dynamics as a foreign policy tool. Furthermore, the authors demonstrate how system dynamics can be used to propose more effective options to help the international community resolve the North Korean dilemma.

1.2 System Dynamics as a Foreign Policy Tool

System dynamics started with philosophers, scientists, and management experts advocating for a systematic way of thinking in order to describe the complexities of the world (Sterman, 2000). This process is intended to enhance the understanding of complex systems by attempting to describe problems through their connections to their environment. This

analytical technique is more effective when it involves interdisciplinary research because of the many different domains typically associated with real-world systems and problems. Although this process originated as a way to mathematically model complex structures, John Sterman, one of the leading experts on system dynamics, emphasizes that the tool can be applied to human behavior, physical systems, and technical systems, while also drawing on social and technical sciences (2000).

The five steps of the system dynamics modeling process provide a roadmap for using the tool for modeling a problem. The first phase is the problem articulation phase, where the boundaries of the project are selected. The second phase is the dynamic hypothesis, where the initial predictions are stated. The third phase is the formulation phase, which involves making the model and setting up the parameters. The fourth phase is testing, which is running a model through various simulations and specifications. The fifth and last phase is policy formulation and evaluation, which involves making future recommendations from the results (Sterman, 2000). This paper walks through the modeling steps of phases 1 and 2, and it concludes with future recommendations and work. The authors believe this paper will introduce and acquaint readers on the viability of employing system dynamics on complex real-world problems. Ultimately, the authors hope that this paper will encourage further multi-disciplinary research that helps the international community resolve the North Korean dilemma once and for all.

2. Problem Articulation

2.1 Key Variables

Concerning the North Korea dilemma, there exist an unlimited number of variables that one can think of in describing North Korea's relationship to the rest of the world. In the first phase of the system dynamics modeling process, the very first step is to identify the system's most important variables (Sterman, 2000). These key variables serve help to identify the most important factors and relationships in the system. In this paper, the authors identify a handful of key variables that adequately characterize the North Korean dilemma. The first is North Korean power, and the second is the likeliness of North Korea attacking the US or South Korea. The likelihood of a new round of international sanctions is also an important variable, for it directly relates toward countering the power of North Korea. North Korea's probability of conducting an additional nuclear test serves as important variable in describing one of the most critical problems the international community has with North Korea. China's support is another important variable concerning the North Korean dilemma, since the North relies on China not only as an ally but for economic trade as well. Kim Jong-Un's power is an important factor, as is the US' willingness to assert its power. Lastly, the amount of dissenters within North Korea and the amount of North Korean loyalists are both important factors. Clearly, there are an infinite number of additional variables that impact the North Korean dilemma, but the authors select these as most critical for building a system dynamics model that improves overall understanding of the problem.

2.2 Reference Modes

Reference modes are a valuable system dynamics tool. They translate the descriptions of variables into a graphical interpretation using time as a reference mode to better visualize incremental and sequential changes in the system (Sterman, 2000). In this section of the paper, the authors select the key variable of China's support to North Korea for analysis. Ever since China sent its military forces in support of the North during the Korean War, China has been North Korea's most significant ally (History.com Staff, 2009). Figure 1 highlights the growth in trade from 2000 to 2010 between the two nations. China is one of the only remaining nations to support North Korea with economic and energy assistance even after the North's continued nuclear tests. Although they remain allies, China has also made declarations against the North Korean nuclear program. Regarding the peninsula, the Chinese government is greatly concerned about averting a resumption of a full-scale conflict and North Korea's nuclear program which both cause difficulties for China (Albert & Xu, 2017).

In spite of international pressures on China to exert more of its influence against further North Korean provocations, China does also desire a denuclearized North Korea and has declared commitments to decrease trade with the Kim Jong-Un regime. Figure 2 shows variations in the potential trade volume over the next 3 years between the two countries depending on North Korea's willingness to denuclearize. The difference between a conservative trade estimate and the baseline projection of a nuclearized North Korea is over $10 billion per year by 2020, and approximately $30 billion in cumulative trade from 2017 to 2020 (Snyder, 2013).

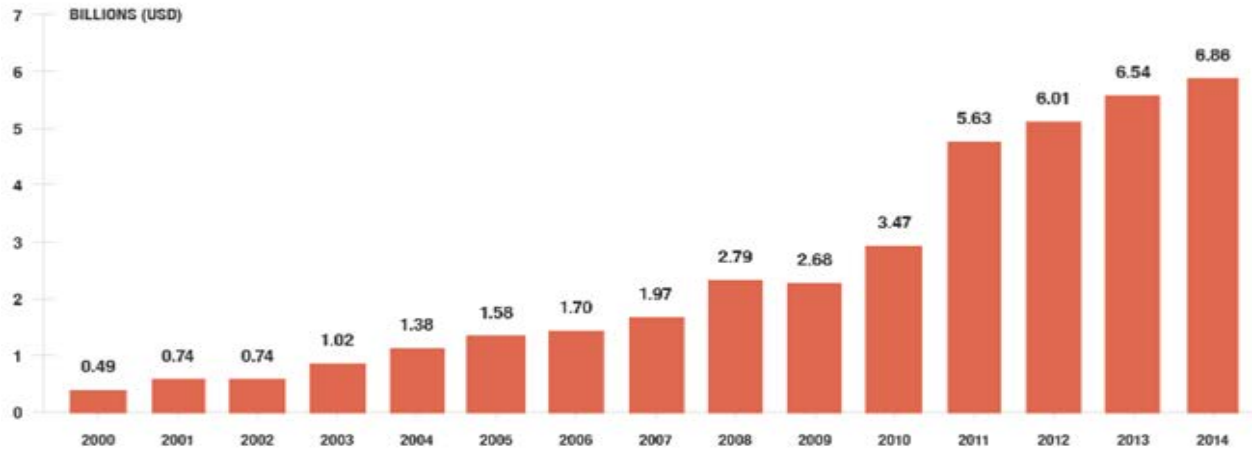

Figure 1: Historical China and North Korea Trade Volume (Albert & Xu, 2017)

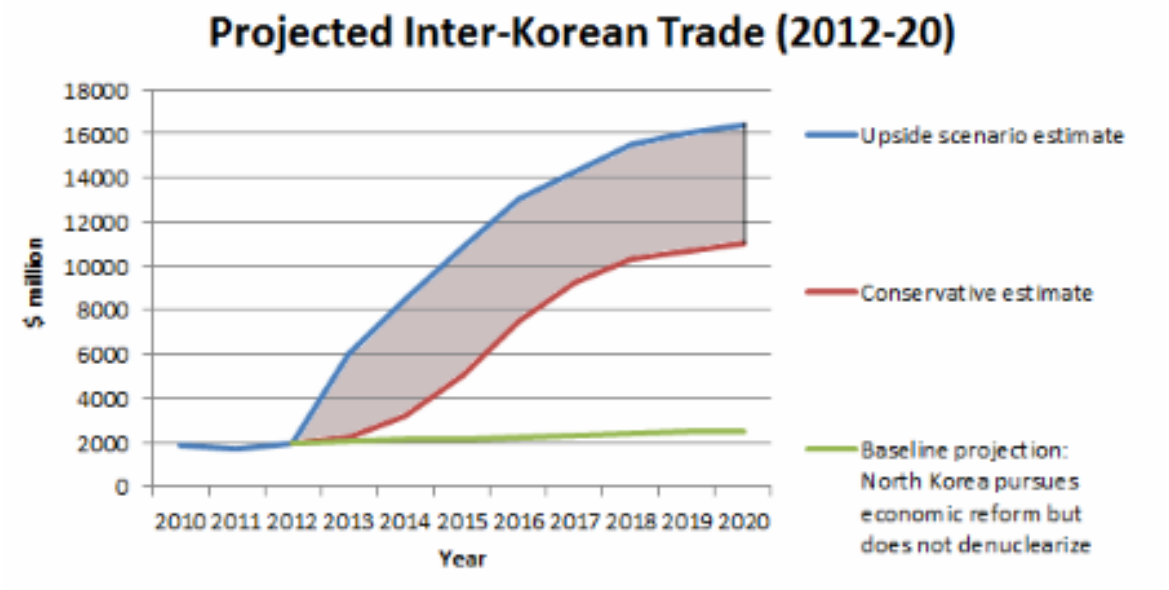

Figure 2: Scenarios for Future China and North Korea Trade (Snyder, 2013)

This economic analysis is merely one reference mode that foreign policy makers can use to make better sense of the North Korean dilemma. Each identified key variable can also be further analyzed to examine current and projected future behavior that can have an important role in the dynamics surrounding North Korea. What is important to highlight for the analysis in this paper is that the relationship between North Korea and China plays an integral part in describing the North Korean dilemma.

3. Dynamic Hypothesis Testing

The purpose of dynamic hypothesis testing is to model the system as a whole in an effort to see how key variables interact with one another. This involves generating an initial hypothesis as well as mapping. Mapping involves developing visualizations of causal structures based on initial hypotheses (Sterman, 2000). In this paper, the mapping will be used to show the key relationships that define the North Korean dilemma.

3.1 Causal Loop Diagrams

A causal loop diagram is a mapping technique that captures feedback dependency. The arrows in a diagram indicate a causal relationship. If an arrow is pointed from variable A to variable B, variable B would be dependent on variable B. Positive or negative signs reside at the tip of each arrow. A positive sign indicates a positive effect (variable B increases when variable A increases). A negative sign indicates a negative effect (variable B decreases when variable A increases). In a causal loop diagram, the polarity is calculated by multiplying the signs together. If the value is positive, the system contains reinforcing (R) or positive feedback. If the value is negative, the system contains balancing (B) or negative feedback (Sterman, 2000).

Figure 3 shows an example of a positive reinforcing feedback loop. As North Korea's power increases, North Korea's likeliness to attack increases as well, and as North Korea's likeliness to attack increases, North Korea's power increases. At the same time, as North Korea's power decreases, North Korea's likeliness to attack decreases. This is an extremely dangerous predicament because North Korea could potentially increase its power exponentially while at the same time increasing in its likelihood of attack (Kaplan, 2006). In order to mitigate the threat and decrease the potential for attack, the US and allied nations must consider policy actions that impede the North Korea regime from increasing its power. The future behavior of North Korea's likeliness to attack will increase with the growth of its power.

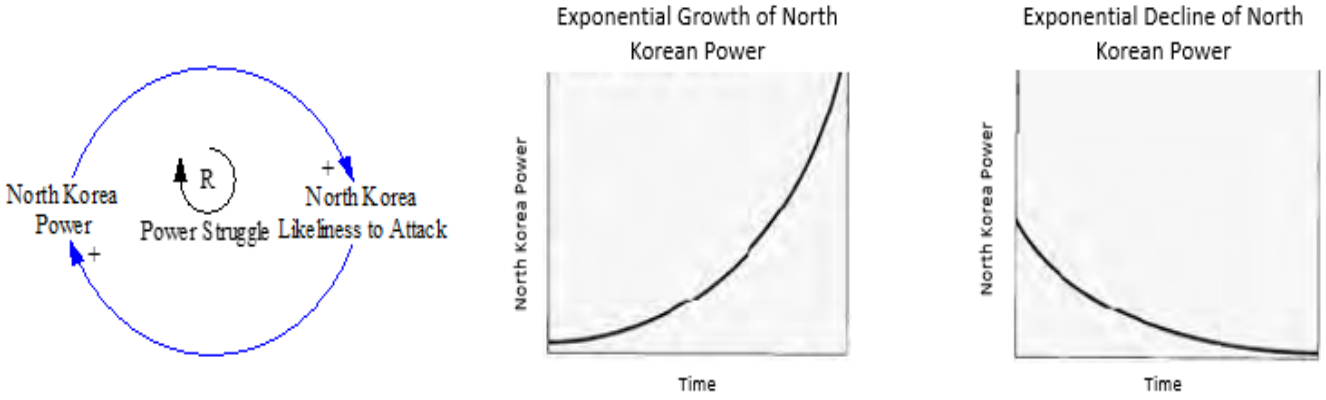

Figure 3: Positive Reinforcing Feedback Loop Resulting in Exponential Growth/Decline in Power (Sterman, 2000)

On the other hand, Figure 4 displays a balancing feedback loop. As the US becomes more willing to assert power in the form of economic sanctions or military threats, North Korea becomes more inclined to decrease further nuclear tests. However, as North Korea decreases nuclear testing, the need for additional US sanctions and military threats decrease as well. The introduction of the two lines on these arrows represent time delays, which cause corrective actions to continue even after the initial activities occur in time (Sterman, 2000). The result of this causal loop diagram is an oscillating line in which the measured variable increases and decreases over a span of time. Because the feedback loop is balancing, North Korea's nuclear tests increase and decrease as time progresses depending on the level of military threats and economic sanctions it has at a certain point in time. Certain sanctions, for instance, make it harder for North Korea to assemble the materials and resources needed to create a hydrogen bomb, but as it finds ways to thwart international sanctions, North Korea finds a way to initiate and complete a nuclear test (Moon & Park, 2016). Accordingly, this balancing feedback loop suggests that an effective way to stymie future North Korea nuclear tests is to apply constant and consistent external pressure.

Figure 5 provides a more complex feedback model that describes Kim Jong-Un's power, which involves both a reinforcing and balancing loop. The balancing loop models Kim Jong-Un's power positively affecting the US' willingness to assert power which, in turn, positively affects North Korea's instability. As a result, this negatively affects China's support to the US actions, positively affecting North Korea's economy, and finally positively affecting Kim Jong-Un's power. The reinforcing loop involves Kim Jong-Un's power positively affecting the willingness for the US to assert power, since the US would want to place in check a rise in the regime's power. Willingness for the US to assert power positively affects North Korea's instability, for North Korea would not be in a secure power position. Finally, as North Korea's instability goes up, Kim Jong-Un's power would go up as well because he is able to feed off of the instability as a power assertion for more North Korean military capabilities.

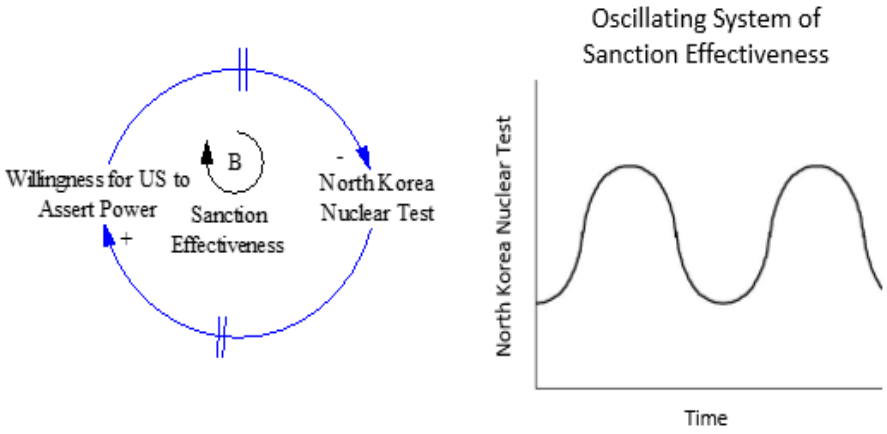

Figure 4: Balancing Feedback Loop Resulting in Oscillation (Sterman, 2000)

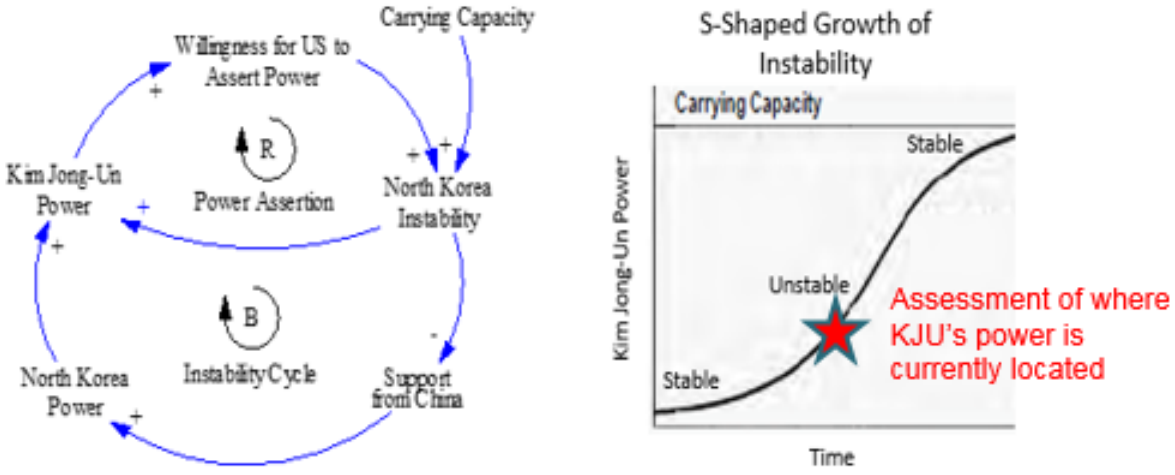

Figure 5: Balancing and Reinforcing Loop Resulting in S-Shaped Growth (Sterman, 2000)

Overall, there exists an s-shaped curve describing how Kim Jong-Un's power directly impacts stability for the region. At the start of the curve—when Kim Jong-Un first became the North Korean ruler—his power was at the lowest point, and the overall stability for the region was actually fairly stable as the new regime focused on securing internal control within North Korea. This is represented by the reinforcing loop and the exponentially increasing portion of the graph in Figure 5. The middle of the s-shaped curve highlights a tipping point where Kim Jong-Un solidifies control over his own people and flexes North Korea's military strength externally towards foreign adversaries. This inflection point indicates where Kim Jong-Un gains the highest rate of change in power for his regime, and up until this period of time the reinforcing feedback loop holds greater impact over the balancing feedback loop. After the inflection point, the international community responds more forcefully to North Korean military provocations, and this is where the balancing feedback loop begins to exert more influence over the reinforcing feedback loop resulting in the greatest degree of instability for peace and security (Sterman, 2000). Interestingly, the s-shaped curve does also reveal that if Kim Jong-Un is able to truly secure complete power over North Korea and truly convince the world of the futility in fighting against North Korea's military might, stability in the region does improve. However, the authors assess that Kim Jong-Un's current struggles for control and power has not yet reached this tipping point—as a result, North Korean provocations continue to spark global unrest and security concerns throughout the world. The authors also assert that in order to restore the region to greater levels of stability, the best courses of action would be to reduce the regime's power rather than to allow Kim Jong-Un to consolidate even greater power. Although modeling this problem with system dynamics does show how a competing set of foreign policy directives can be implemented to achieve eventual peace and stability for the two Koreas, the authors believe that the risks in conducting activities that lead to even greater instability

for the region will likely lead to a resumption of conflict on the peninsula that will engulf other nations embroiled in the North Korean dilemma.

3.2 Stock and Flow Diagram

A stock and flow diagram is another effective tool that one can use to model a causal loop diagram with even greater fidelity. For this type of visual model, the squares in the diagram represent quantifiable stocks of resources key to the dynamic modeling, the straight lines represent the flow of those resources between key tasks, the valves on the straight lines represent the pressure points where one can speed up or slow down the flow of resources, and the arrows represent causal relationships (Sterman, 2000). Figure 6 updates the previous causal loop diagrams previously modeling in this paper with the addition of a number of key stocks and flows.

The system starts with a birth rate connected to a new susceptible population of North Koreans that are either supporting Kim Jong-Un and his government or that part of the population susceptible to defecting. The first flow from the susceptible population is the conformity rate, which results in a stock consisting of the conformed population. This population is supportive of Kim Jong-Un, and this population stock increases Kim Jong-Un's power. Kim Jong-Un's level of power then adjusts through the progression of those key variables identified earlier for the causal loop diagrams in Figures 3 to 5. As the conformed population rises, the conforming rate rises as well since it positively affects Kim Jong-Un's power. The second important flow from the susceptible population is the dissatisfaction rate, or the rate of people that are unhappy with the current regime. This ends with a stock labeled as the dissatisfied population. The dissatisfied population has two options: it can transform through a revolutionary rate into the revolutionary population stock which has the potential to rebel against the ruling order, or can become part of the dissatisfied population stock that progresses through the departure rate, becomes part of the defector population stock, and then finally leaves the system via defection. Figure 6 shows the overall stock and flow diagram that represents the North Korean people, and this model helps to convey how those in the lower castes and most dissatisfied with the regime can potentially organize into a revolt or popular movement against Kim Jong-Un (Sholte, 2014).

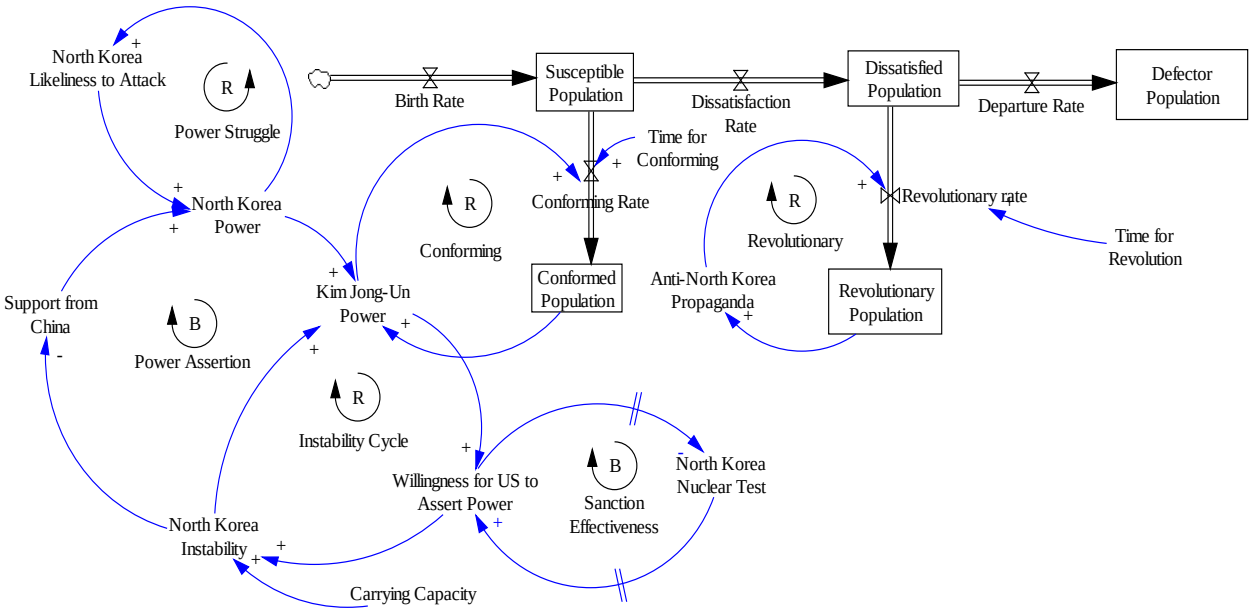

Figure 6: Stock and Flow Diagram of North Korean Dilemma (Sterman, 2000)

4. Conclusions

It is important to note that the Korean War has not ended because no formal peace treaty exists on the Korean peninsula. While a fragile ceasefire has endured for over six decades, the 1953 Armistice Agreement remains tenuous. Furthermore, North Korean provocations through its conventional military as well as its asymmetric warfighting capabilities have repeatedly stymied reconciliation and hopes for eventual peace between the two Koreas. This paper leverages system

dynamics and its many tools to help better explain key relationships that define the continuing conflict on the Korean peninsula, and encourages foreign policy experts to explore its use to come up with even better options for dealing effectively with the Kim Jong-Un regime. Admittedly, this paper provides a very simplistic view of the dilemma the international community faces in its dealings with North Korea. However, the main intent of this paper is to demonstrate how fairly straight-forward system dynamics can be in helping to model, understand, and formulate better solutions for dealing with such a complex problem that is North Korea. It is through the articulation of the problem, the identification of key variables, and the tools of mapping that the authors believe the international community can develop more consistent policies that can promote better decision-making against North Korean provocations. Finally, the authors encourage additional research into this topic, especially with regards to simulation and testing analysis using more quantifiable inputs in order to analyze the individual effect of all identified key variables. Through such analysis, the authors believe that policy makers will be able to come up with better solutions to help resolve the North Korean dilemma.

5. Acknowledgement

Parts of this paper were previously published and presented in the Donald R. Keith Memorial Capstone Conference at USMA in May of 2017.

6. References

Albert, E., & Xu, B. (2017). The China-North Korea Relationship. Retrieved from Council on Foreign Relations: http://www.cfr.org/china/china-north-korea-relationship/p11097

Arnold, C. (2016). North Korea Linked To $81 Million Bangladesh Bank Heist. Retrieved from NPR: http://www.npr.org/sections/thetwo-way/2016/05/27/479760450/north-korea-linked-to-81-million-bangladesh-bank-heist

Bandow, D. (2017). China Is Doing What It Has to in North Korea. Retrieved from Foreign Policy: http://foreignpolicy.com/2017/02/07/china-is-doing-what-it-has-to-in-north-korea/

Bondarenko, V. (2017). Kim Jong Un's Half Brother Was Assassinated - Here's What We Know So Far. Retrieved from Business Insider: http://www.businessinsider.com/kim-jong-un-half-brother-assassinated-kim-jong-nam-2017-2

Browne, R. (2016). U.S. General: Conflict with North Korea Would Be Akin to World War II. Retrieved from CNN: http://www.cnn.com/2016/02/23/politics/north-korea-wmd/

Fehrenbach, T. R. (1963). *This Kind of War: The Classic Korean War History*. Washington, D.C.: First Brassey's Edition.

Fry, M. (2013, August). National Geographic, Korea, and the 38th Parallel. Retrieved from National Geographic: http://news.nationalgeographic.com/news/2013/08/130805-korean-war-dmz-armistice-38-parallel-geography/

History.com Staff (2009). Korean War. Retrieved from http://www.history.com/topics/korean-war

Hunt, K., Kwon, K., & Hanna, J. (2016). North Korea Claims Successful Test of Nuclear Warhead. Retrieved from CNN: http://www.cnn.com/2016/09/08/asia/north-korea-seismic-activity/

Kaplan, R. D. (2006, October). When North Korea Falls. Retrieved from The Atlantic: https://www.theatlantic.com/magazine/archive/2006/10/when-north-korea-falls/305228/

Moon, K. H., & Park, P. (2016, March). Are Sanctions Enough to Deal with North Korea? Retrieved from Brookings: https://www.brookings.edu/blog/order-from-chaos/2016/03/02/are-sanctions-enough-to-deal-with-north-korea/

Orr, B. (2015, January). Why the U.S. Was Sure North Korea Hacked Sony. Retrieved from CBS: http://www.cbsnews.com/news/why-the-u-s-government-was-sure-north-korea-hacked-sony/

Peck, M. (2016, May). The Day North Korea Defeated the U.S. Army. Retrieved from National Interest: http://nationalinterest.org/feature/the-day-north-korea-defeated-the-us-army-16094

Profile: Kiim Jong-Un, North Korea's Supreme Commander. (2016, January 6). Retrieved from BBC: http://www.bbc.com/news/world-asia-pacific-11388628

Pruitt, S. (2013, April). What You Need to Know About North Korea. Retrieved from History: http://www.history.com/news/what-you-need-to-know-about-north-korea

Sholte, S. (2014). North Korea Under Communism 1948-2014. Retrieved from Victims of Communism: http://victimsofcommunism.org/north-korea-under-communism-1948-2014/

Snyder, S. A. (2013, November). The Economic Costs of North Korean Nuclear Development. Retrieved from Council on Foreign Relations: http://blogs.cfr.org/asia/2013/11/25/the-economic-costs-of-north-korean-nuclear-development/

Sterman, J. D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston: Irwin/Mcgraw-Hill.