

Costs and Dynamics of War
: System Dynamics approached to
Maritime Disputes in the South China Sea

By
Warakan Supinajaroen

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System Dynamics Group,
Faculty of Social Sciences
University of Bergen

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I have learnt a lot along the way of System Dynamics modeling. Now I understand that a model is modeling. Thus a model in this thesis is not finished but the time is.

ABSTRACT

“Maritime sovereignty disputes in the South China Sea (SCS) are complex issues of growing concern over regional and global stability. Significant possibility of high resolution conflict as an arms race has been accumulated. It may lead the region to a war in the future.

China, as the most powerful nation in the disputes, is expected to be a key player influencing the situation. Several scholars have proposed solutions for China to resolve the disputes by peaceful way. Most of them pointed out the way of cooperation and various advantages of solution without war.

This thesis reverses the trend of previous works by making scenarios of potential war in the SCS. System Dynamics methodology is used as a tool of study together with National Power principle as frame of considerations. The result draws paradigms of war in SCS which can be a conclusion for China to avoid potential war in SCS”

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LIST OF MAIN ABBREVIATIONS

DOD	Department of Defense
SCS	South China Sea
SD	System Dynamics
MO	Military Operation
NP	National Power

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CHAPTER 1 INTRODUCTION

Maritime sovereignty disputes in the South China Sea (SCS)¹ are complex issues of growing concern over regional and global stability. Definitely, the disputes are underlying with miscellaneous interest such crude oil, natural gas, fishery resources etc. (Herberg 2004; Rosenberg 2010) Ten littoral nations have claimed their right over many parts of SCS for centuries. Among the disputes, cases between China and six members of Association of South East Asian Nations (ASEAN)² including Brunei, Indonesia, Malaysia, The Philippines and Vietnam, are the most concerned according to asymmetric power. Furthermore, SCS is considered as an important strategic area for world's economic and security. (Kivimäki 2002; Rosenberg 2005; Shaihua 2006; Rosenberg 2010) Particularly the United State (U.S.) defines SCS as its area of interest as well. (Gallagher 1994; Ruscheinski 2002; Beukel 2010)

China, as the most powerful nation in the disputations, seems to be a key player influencing the future of SCS. But it always acts like what Deng Xiaoping, former president of China, said for decades that *"since we can't solve the South China Sea issue, we can leave it to the next generation which will be smarter."* (Xiaokun and Ting 2010) Such attitude came along with rejections to solve the disputes by the mutual benefit of all disputant nations. Consequently, significant possibilities of high resolution conflict as an arms race³ have been accumulated. And it may lead the region to military conflicts in the future (Klare 1993; Kivimäki 2002; Herberg 2004; Santolan 2011)

Should war be a national strategy for China to achieve its goal in SCS? An answer might be "Yes", since war is unavoidable, when politics could not solve the problems (Arnold 1994; Henderson 2003; Anderson 2007). Besides, strategically, war is an implementation of National Power (NP) elements⁴ to pursuit national goal(s). The use of military power is war (Armitage and Joseph 2007; Bartholomees 2010). However, war is the answer that nobody wants it happen.

Several scholars have proposed solutions for the disputant nations to prevent potential war in SCS. For example, Tønnesson (1999; 2003; 2006), Rosenberg (2005) suggest a solution by the United Nation Convention Law on Sea (UNCLOS) or Herberg (2004) , David(2007; 2010) Tønnesson(1999) suggest cooperation over sovereignty focusing on join development in the dispute areas and gaining benefit together. Most of them are in trend that point out

advantages of avoiding a war. In other words, they try to explain various good points of peace for preventing war.

This thesis reverses the trend of previous works by examining “If China starts a war in SCS”. In doing this, System Dynamics (SD) methodology is implemented with National Power principle to examine the potential war in SCS aiming to *(1) build a generic model of potential war in SCS, (2) simulate potential SCS war scenarios in term of cost benefit, and (3) point out how the misperception of war might affect to China’s strategy systematically.*

Simulation results draw paradigms of war in SCS and distinct dynamics of war which might be ignored. There are two distinctions of this thesis. First, this thesis applies SD and war which seems to be another issue which has no one done it before. Second, the thesis points out perceptions that people always ignore about previous war to potential war.

The report is organized from introduction in this chapter. Literature reviews are discussed in Chapter 2. After that, in Chapter 3, problem definition is described and reference modes are formulated. In Chapter 4, hypothesis and model will be explained. The details about boundary, variable and relationship between structures in the model are shown as well. Chapter 5, the model validation method and validation result will be presented to make the model justifiable. Chapter 6, all scenarios are shown and be discussed. In the discussion, some more topics related to the mimicked war will be criticized. The last chapter, Chapter 6, the study will be concluded and future researches are suggested.

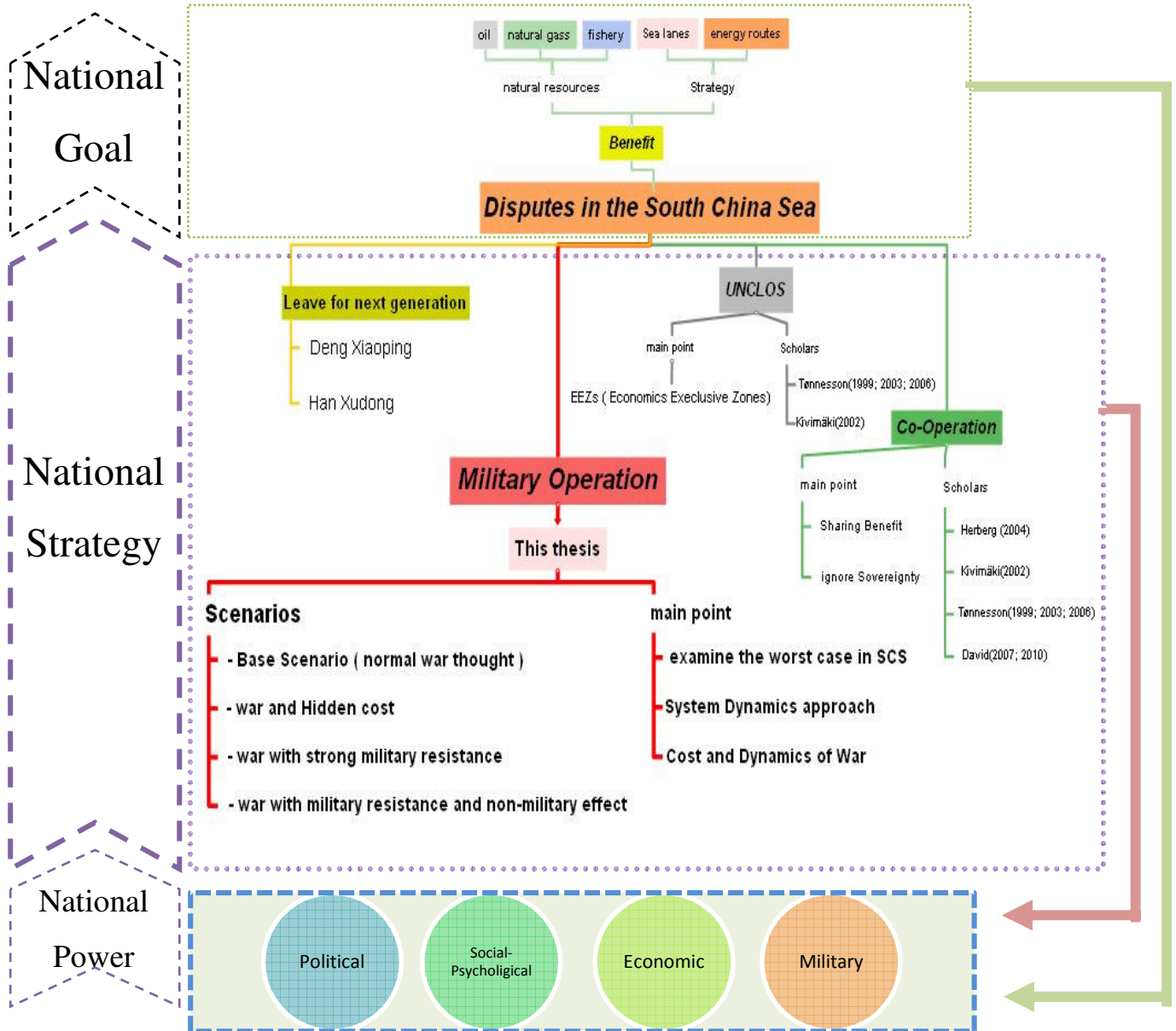


Figure 1: Mind Map Diagram presents concepts and ideas of the thesis

CHAPTER 2 LITERATURE REVIEW

This thesis relates to three issues such as the South China Sea disputes, War and System Dynamics. This chapter, surveyed literatures are contributed to this thesis are presented.

South China Sea Dispute and contexture

Background

The South China Sea (SCS) is a part of the Pacific Ocean, covering the area from the Singapore and Malacca Straits to the Strait of Taiwan of around 3,500,000 square kilometers. The sea plays various important roles for littoral nations by providing natural resources, food and energy. The estimated crude oil is at about 213 billion barrels and estimated more than 2,000 Tcf (Trillion Cubic Feet) of natural gas resources. Furthermore, as one of the biggest sea lanes in the world, 50 percent of the world's supertanker traffic passes through the SCS yearly (Kivimäki 2002; Rosenberg 2005; Shaihua 2006; Globalsecurity.org 2010; Rosenberg 2010).



However, the future of the SCS is still unstable, according to the maritime sovereignty disputes over the SCS among the littoral nations.

Tønnesson(1999; 2003; 2006), Kivimäki(2002), Beckman(2010)have drawn SCS disputes which are all around the area of SCS, the most intensive disputes are between China and five

ASEAN members named Brunei, Malaysia, Philippines, Indonesia and Vietnam. Each nation has been trying to claim sovereignty over the disputes according to huge benefit in term of maritime, geopolitics, economic and strategy. Such conditions make a low progress to end the SCS dispute. Together with interventions from 3rd parties like the U.S. who define SCS as a core interest (Gallagher 1994; Kivimäki 2002; Beukel 2010).

Concerns over SCS

The disputes arouse concerns among the disputant nations and the world. The most concern is arms race in SCS (Klare 1993). A number of medias and scholars such as sinodefence.com(2006) Keneda(2006; 2011) Santolan(2011) Wong(2011) and Stockholm International Peace Research Institute or SIPRI (2010) observed about high military expenditure growth rate among ASIA Pacific nations, one of the reason is form the uncertainty in SCS.

Moreover, as the imbalance military power between China and other claimant nations (see. *Appendix I*) also makes concerns that China will use this advantage to solve the disputes. This opion corresponds to Shambaugh(2006; 2007) that China's military modernization is a step of preparation for its power in the region.

Bartholomees (2010) noticed that “...*Strategically, one fights war at sea to deny the enemy the economic advantages of the sea (sources of resources or lines of communication) and/or to secure those advantages for oneself...*”

Shidal (2000) criticized that the actions of China in SCS are not only about benefit in SCS but it point to enlarge power in the region. Moreover he noticed more that this is an interior issue of China that China military tries to distinct it importance among other sectors.

Recently, Santolan(2011) and The Singapore Institute of International Affairs (2011)reported that Philippine has deployed military personnel in SCS. And Vietnam has asked the U.S. to support its military capability.

With high growth rate in economics and population of the claimant nations increase the need of resources to support their growth, this situation may lead the region to high resolution conflict in the future (Klare 1993; Gallagher 1994; Shaihua 2006; Shaohua 2006; Santolan 2011).

Solutions

The disputant nations have been urged to end the disputes by the peace way. There have been a number of solotions introduced for them as well. From observations, there are two main types of solutions suggested.

First, base on international law; Tønnesson(1999; 2003; 2006), Kivimäki(2002) contemplated about the United Nations Convention on the Law of the Sea (UNCLOS)⁵ which should be the powerful tool of resolving the disputes. By UNCLOS, the length of 200 nautical miles will be an Exclusive Economic Zone (EEZ)⁶ for the littoral nations. However, there are many unclear issues in term of law interpretation especially EEZ's details of nation. Moreover, some claimant nations are still reticent to UNCLOS such China.

Second, base on cooperation; Tønnesson(1999; 2003; 2006), Kivimäki(2002), Herberg (2004) , David(2007; 2010) introduced many solutions based on negotiation between the nations. However, the nations have to ignore any issues about sovereignty over sea territory and any historical conflicts between each other. They have to focus on sharing benefit in the dispute areas, making join-development together. However, China always rejects to solve the dispute areas to the mutual benefit of all disputants.

It can be concluded the huge benefit make each claimant nation wants to protect its interest and leads the disputes in difficulty of solving. Moreover, the suspicious between each nation arouse multi arms race in the region. Such conditions are very risky of high resolution conflict or military confrontation in the future.

War

"Every gun that is made, every warship launched, every rocket fired, signifies in the final sense a theft from those who hunger and are not fed, those who are cold and are not clothed."

President Dwight D. Eisenhower, April 16, 1953

War has been developing parallel with the world's history. Even the world now is full of peace and cooperation. But there are still numbers of wars running as well. War can be defined in various mean and it can be discussed in various dimensions.

THE INSTITUTION OF WAR

There are various term of use the word "WAR"⁷. However, the traditional term, originally used for the armed conflict, will be applied in this study.

The very ancient definition about war, Sun Tzu (544-496 B.C)⁸ had expressed the thought in his scripture “*The art of War*” that “*Victory is the main object in war*”. Brian Orend (2008), in *The Stanford Encyclopedia of Philosophy*, mentions the Prussian military thinker, Carl von Clausewitz (1780-1831)⁹ who briefly said that war is “*the continuation of policy by other means.*” and “*an act of violence intended to compel our opponent to fulfill our will.*”

However, a modern military strategist, B.H. Liddell Hart (1857-1932)¹⁰ considered war in the level of national strategy or grand strategy which the factors of economic, man-power and moral resources are integrated to sustain the fighting services. However, the national strategy should consider the peace after war for its security and prosperity as well.

Repeatedly and correspondingly, Yargen(2008), a war is considered as a National Power implementation to pursuit national objective(s) or goal(s); each country uses its power such diplomatic, informational, military, and economic (DIME) instruments of national power to influence other nations to benefit back to itself. *The use of military component is war.*

Bartholomess(2010) had contemplated that *war is about winning does not mean war is about victory. One can win a war, especially a limited war (a war that is consciously limited in either or all of ends, ways, or means), without achieving victory.*

Martel(2007) clarified that the victory of war is depended on the person who decides and the distinction between Victory and War¹¹ he exemplify Saddam Hussein who claimed the victory in Gulf War I by the meaning that his regime had survived even his forces was moribund damage. Martel suggests that security professionals need to think systematically about winning. *The implication is that military victory (tactical or operational victory) without favorable political outcomes is sterile.*

About the reason of war, Aguirre(2010) has discussed the causes of war that direct and indirect factors should be included in the causes of wars such poverty, inequality, greed, grievance, fight for natural resources with strong international demand (as oil or diamonds), restrictions of freedom and human rights violations. He pointed out more that the non state actors at war have been growing in the world.

Meanwhile the modern security school of thought, sustainablesecurity.org(2011)¹², has introduced the moderate security perception about war that “*as the dynamics of world,...there will be greater scarcity of three key resources: food, water and energy...competition for such resources should be expected, both within and between countries, potentially leading in extreme cases to conflict*”¹³.

THE DYNAMICS OF WAR

The impact of war has been discussed widely. As the more complex the world is, the more diverse impacts of war are. There are a number of works about the impact of war. However, as this study intends to consider a war as a National Power¹⁴ implementation. Thus a frame of literatures observation will focus on war's impact related to the National Power element.

The impacts of war in Economics and Social, Stiglitz and Bilmes (2008), the authors of "*The Three Trillion Dollar War*", discussed the wastes and defects of war on terror through the war costs analysis. They draw out the misperception of war cost and its dynamics which have been ignored. Such disregards actually broadly cause an effect obviously the debt of U.S. government.

Likewise, Cost of War Project (2011), Dao(2011), Maguen(2011) and Eisenhower Study Group(2011)¹⁵ examine that costs for the war on terror are far from the past wars' cost of U.S. government, huge costs at war now and more in the future for veterans administration, social security disability and other agencies to assist the casualties. Moreover, as the long life expectancy, the cost for veterans will be longer than the past.

Meanwhile, GlobalSecurity.org(2011) reported that in Africa, War has caused untold economic and social damage. It impedes food production leading to famine. The children have to lives of misery, the traditional cultures are destroyed.

The impacts in other fields, Karbuz(2006) mention the DoD energy consumption at war has increased more than three time at peace¹⁶. Powell(2011) inquires that the U.S. military energy consumption is 80 percent of federal usage. The cost can be more than thirteen time after the logistic costs are included¹⁷. consequently from the increasing of energy consumption by war, Liska and Perrin(2010) pointed out that military operations as major industrial activities contribute significantly to climate change¹⁸. Karbuz (2011) investigated more about CO₂ emission from the U.S. military operation which is 4 percent of total U.S. emission¹⁹.

However , Lawrence Kaplan, a visiting professor at the U.S. Army War College, contradicts that "*The realm of war and peace exists separately apart —and justifiably so — from the economic realm,*" He contends that "*economic answers to a non-economic question.*" (Radio(NPR) 2011)

The literature reviews about war have drawn the constitution and dynamics of war. The most important point that should be emphasized is the misperception of security professions who always ignore many dynamics of war and focus only national goal.

System Dynamics approach to Security, Military and War

There is a similar point System Dynamics and war theory, as Clausewitz *said that* “*In a tactical situation [operation] one is able to see at least half the problem with the naked eye, whereas in strategy everything has to be guessed at and presumed.*” and J.Forrester expressed that “*The image of the world around us, which we carry in our head, is just a model. Nobody in his head imagines all the world, government or country. He has only selected concepts, and relationships between them, and uses those to represent the real system.*”

The two quotes seem to be the same thing, Clausewitz suggested a necessary that military strategist have to guess and presume for the higher level of planning, while J.Forrester recommend the method of imagine and conception for the real system.

What the two philosophers had talked about is mental model in System Dynamics, and it is one of military decision principles called “Intelligence Preparation of the Battlefield (IPB)²⁰,”

In practical term, System Dynamics was applied to war by Coyle(1996; 1999), he used SD to model “The Third World War”, scenarios of war in Europe by applying SD to military operation. Coyle also used SD and Operation Research (OR) for defense analysis. He suggested that as a strategic tool, SD should be developed in the field of military as well.

Choucri (2005) used SD to model state stability, his work covers internal and external factors of a state. Anderson (2007) developed the work of Coyle(1985) about insurgency to make a generic model of insurgency in Ireland. Torres (2009) has modeled the conflict about natural gas between Russia and Ukraine which expanded to be security issue.

Supinajaroen (2010) uses SD to examine about perception of people on complex issue case in National Power management. The result found that in generally, people are lack of systematic thinking about National Power and they made low performance in managing of National Power.

Summary

From the literature reviews, there are many works related to each main issue of this thesis; South China Sea, War and System Dynamics.

However, there is not any work that integrates all topics together. For SCS, even there are some scholars consider solutions in systematical term, however, there is lack of dynamics explanation which might convince concern people realize about solution and its long term effects.

For war and security issue, the lack of systematical thinking, let many wars be driven in the world now. So, it is challenged to study SCS case by SD passed through various dynamics of wars dynamics which have been in the world.

What the survey gives

- There are many scholars considering war as national power but they do not consider the relation between national strategy (method) and national power (instrument). Moreover, relations between national power elements are ignored as well.
- About SCS, even many scholars suggest solutions by peaceful ways, most of them present about the good side of peace but about the bad side if there is no peace. Moreover, there is nobody present it in term of dynamics for long term.
- System Dynamics has been implemented to many issues about war and national security. For SCS as well, it should be challenged for applying SD with SCS.

CHAPTER 3 PROBLEM DEFINITION

Dynamics Problem

The process of problem definition in System Dynamics is to formulate a dynamics problem referring to the indicated behavior in the real world. In this section, the behavior of war must be defined. However, various indicators were used to indicate war's behavior such as casualty, forces operation, military expenditure, education index, humanity resource etc. (Anderton and Carter 2001; Lai and Thyne 2007; Stiglitz and Bilmes 2008; Bartholomees 2010).

According to the framework of this study is to make scenarios of SCS war by examination of potential behavior of SCS war by emphasizing in term of cost and benefit. Thus costs of SCS war and benefits from war will be observed as net benefit to represent the behavior of war.

To define the problem, there are some remarks from the literature reviews about wars that should figure out some problematic behaviors of wars such:

- Escalation and Prolonged war i.e. Vietnam War(Cima 1987.), War in Iraq(Galloway 2007).These war were over expectation in term of the battle field zone and termination of war.(Anderson 2007). In this term, it causes from misperception of opponents' capabilities.
- Underestimation of war cost i.e. the War on Terror (Galloway 2007; Stiglitz and Bilmes 2008; Lutz 2011; Wheeler 2011) the real cost of this war has been higher than the estimation of the U.S. government.
- The expandable of war effect i.e. Vietnam War and War on terror(Stiglitz and Bilmes 2008), the long term consequences of Vietnam War still exists as an obligation of the U.S. government about veterans care. Such effect is going to increase from war on terror. Or Iraq-Kuwait war(Tom Cooper 2003), the war was a trigger to the Gulf War which led Iraq to big troubles till now.

The remarks and examples described above can be concluded into a dynamics problem that war behavior is always different from the initial perception. As war costs are inherent with a

war thus the costs of wars are always over than estimation. In any dimension, war is always worse than estimations.

Reference Mode

A reference mode is a fabric of trends representing a complex pattern. It draws mental models and historical data to gives clues to appropriate model structure. Any time history may incorporate multiple patterns experienced over a single time path, over different geographic locations or over different periods of history. (Saeed 1998) However, when historical information is lack, a modeler must create a hypothesized reference mode. (Albin 1997)

As SCS war has never happened, there were only a few small military conflicts in SCS (Tønnesson 1999; Kivimäki 2002; Kaneda 2006; David Rosenberg 2010) Thus the reference mode must be formulated as a hypothesized reference mode which consists of a simplified curve, typically drawn by hand, capturing the key features of the behavior pattern of the important system components (Albin 1997).

Fundamental ideas about war in this thesis are synthesized from three remarks about war discussed in the previous section. The dynamics related to the war are captured to draw reference modes.

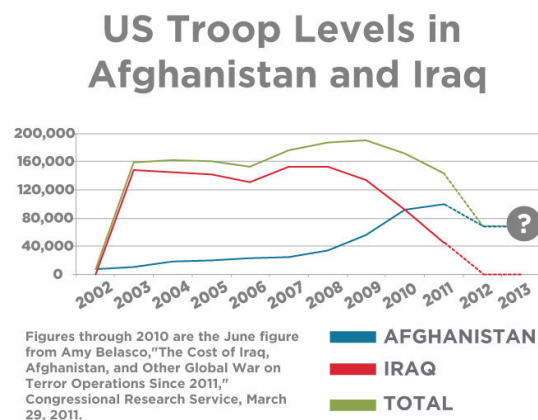


Figure 2: US troop reflects war cost

The cost of war should be steady increasing at the beginning which is the period of superiority acceleration and advantage in military strength the war zone. It might be said that it will be increased to reach the desired cost or equilibrium level. After that when the war ends it should be decrease as Figure 2, the war on terror since 2002 till now.

The benefits from wars are discussed in several points of views by many scholars. Some measured benefit of war indicated by index of gender equality or democracy(J. David Singer and Melvin Small 1974) peace index (Iden 1971; Aguirre 2010) or economic effect(Anderton and Carter

2001; Koubi 2005) etc. However, in this study, the war is defined as a tool to reach of national benefit, so monetary term will be taken in account to indicate the benefit from war.

However, in the real world, all resources are contained by lifetime. Thus the benefit from the resources utilized from area should be goal seeking and then decreasing.

The net benefit of war can be mentioned by the cost and benefit comparison. The gaining of benefit will run after the war has started. Thus at the beginning, net benefit should be minus and then when the benefit start growing, the net benefit would be goal seeking growth and decrease according to the depreciation of area.

How the behavior of war in SCS should be?

The behavior of war in SCS can be mimicked from the past war mentioned before. The cost of war should be a goal seeking. However, as potential SCS war is naval warfare which is not in mainland. Even China wins in the sea, but the mainland of other claimant nations still function. So, after occupied the disputes area, there will be arms races between China and the opponents as well. Thus, the cost of war still keeps increasing.

The benefit should be an overshoot and slowly decreasing. The net benefit should be decreasing rapidly to minus at the beginning because China gets low benefit by high cost at war. Then it will develop as goal seeking and equilibrium for years. Finally it will slowly decrease because the benefit from SCS is decreased.

The hypothesis reference modes are presented Figure 3.

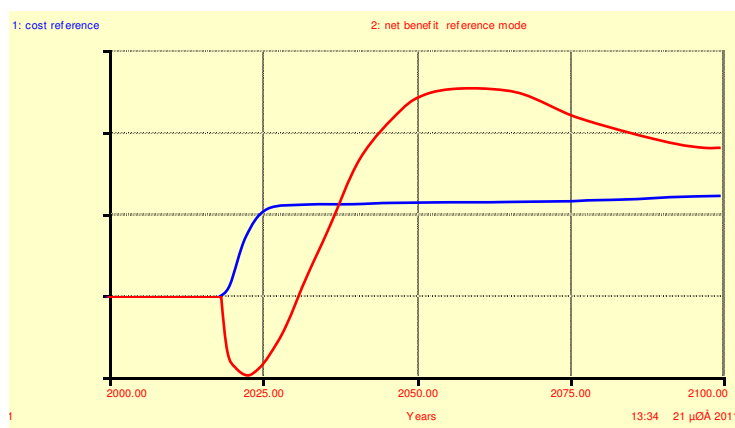


Figure 3: Hypothesized Reference mode Cost of War and Net benefit

CHAPTER 4 HYPOTHESIS AND MODEL

This chapter will explain the dynamic behavior of the system. The realistic cause-effect relations generating the reference mode in previous chapter will be shown by causal loop diagram (CLD) and stock and flow diagram (SFD).

The causal loop diagram is a method to explain the relation between variables of the system. All variables are connected by arrows with the polarity. The plus (+) meanwhile minus (-) sign indicate opposite change between the variables.

Improving from CLD, Stock-and-flow diagrams will present more detailed in term of variable description. Using of SFD, it help the model building process to check the concept drawn in the model as well.

A Mental model of War

“War is the continuation of politics by other means...”

Everything in war is simple, but the simplest thing is difficult.”

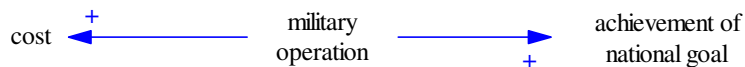
Carl von Clausewitz, “On War”

War is continuum of Military Strategy which is a part of National Strategy to achieve national Goal(s). National Strategy relates to National Power elements. Thus, in brief, war is an implementation of National Power to pursuit National Goal(s). Each nation uses its power such military, politic, social psychological and economic together to influence other nation(s) to fulfill its will. (Bartholomees 2010)

In term of Military Strategy, war is run by Military Operation. Thus to achieve national goal by Military Strategy, it must consider that the higher intensive in military capability will produce higher performance in Military Operation which will increase achievement of National Goal.



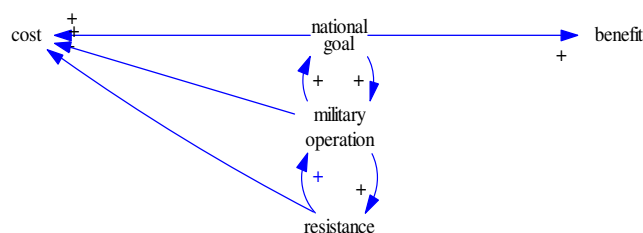
Military Operation is proceeding of war which cost(s) is a part. The more a nation need in Military Operation, the higher cost to be implemented as well.



According to Clausewitz's Trinity of War *"the level of war at which campaigns and major operations are planned, conducted and sustained to accomplish strategic objectives"*

So, a war is not ended up at the winning of military operation in the battlefield but there is one more procedure which is to sustain achieved goal. Thus, when Military Operation has run and the nation achieve the goal, it needs to sustain the goal by more Military Operation. Therefore the relation between Military Operation and National Goal is reinforcing loop.

Moreover, any war is inherent with resistance(S) at least from the opponent; the resistances can be in any dimension e.g. military operation from opponent(s) and 3rd party, economics sanction and the deterioration of domestic economic. In one hand, the resistance increases more military operation and in other hand it will increase cost to the nation as well.



In term of national strategy, the frame of considerations about war needs to be expanded to cover all national power elements. For total national power, it can be derived by Clausewitz's concept of winning a war(Bartholomees 2010) *"The total means at his disposal and the strength of his will."* which can express as an equation¹: $\mathbf{R} = \mathbf{M} \times \mathbf{W}$

\mathbf{R} is power or resistance, \mathbf{M} is the total means available such as military and economic in national power, \mathbf{W} is the strength of will such as harmony an consentaneousness of people to support a national strategy, in other word, it is about politics and social-psychological. Thus to run any national strategy, a nation must maintain M and W to be high enough. National strategy at war as well, a nation must maintain its power in all dimensions.

Besides, according to Art Lykke's theory of strategy, strategy and risk are inherent (Bartholomees 2010). Risk of strategy is defined from various resistances which give negative effect direct and indirect to the strategy.

As the national strategy focusing at war, thus direct resistances are military operations from the opponents or its allies. While indirect resistances, in other word, non-military resistances are any resistances that do not affect on military but on other element such economics effects, boycott of relationship or commercial embargo. Both resistances generated by military operation and they also produce feedbacks to nation.

The military resistances will increase the need of military capability, this loop is a simply cycle of war which can be called as arms race. The non-military resistances are similar. They do not affect directly to military power. But they will affect on other national power elements and its relations. For example if the nation get economic boycott as a resistance, then the economic power will decrease. The decreasing of economic power will directly lower other national power elements. That is, the deterioration of economic will reduce national revenues; the government has to decrease its expenses which might be in social welfare sector or basic structure development sector etc. The people will be anxious about their life and start to object the war. The objection of war represents the decreasing of social-psychological power or national will(Yarger 2008).

This is war's dynamics the level of national strategy. War could not consider only military operation itself but there are some more factors relevant.

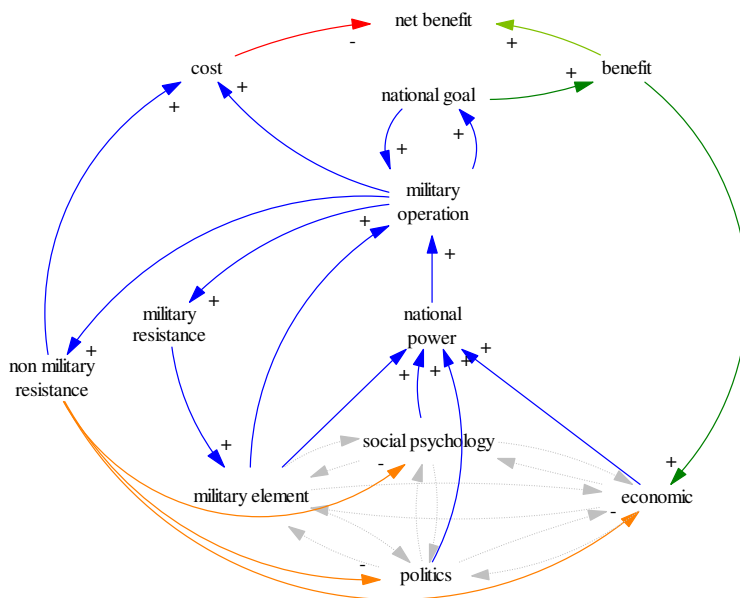


Figure 4: Mental Model of War

A System Dynamics Model of War in South China Sea

MODEL BOUNDARY

Model boundary concerns to the considerations of the model structures and environment. The boundary is the frame of work that guides modeling processes to be on track. Moreover, the model boundary will help people to understand the scope of model as well.

Table 1 shows a model boundary diagram for the model designed in this study. Endogenous column is for dynamic variables involved in the feedback loops of the system exogenous column is for components whose values are not directly affected by the system (Albin 1997) and Excluded is for the variable or relation that this model does not consider or cover to.

Table 1 Boundary of Study

Endogenous	Exogenous	Excluded
<ul style="list-style-type: none"> - Operational Forces - Increasing rate of MO in SCS - Time to conquer SCS - Time of area being used (Utilization) - Utilization Desired of CH military in SCS - ... 	<ul style="list-style-type: none"> - China's GDP growth rate - Adjustment time of CH and Opponents Military improvement - Adjustment time of 3rd party support - Depreciation of area - ... 	<ul style="list-style-type: none"> - War and Resources Price² - The feedback of GDP to CH military Expenditure³

Period of simulation

This model will simulate for 80 years starting from year 2020 to 2100. According to the main resources such oil can support the consumptions for around 60 years.

Causal Loop Diagram (CLD)

The mental model of war has been presented. Henceforward relevant conditions of the potential war in SCS will be applied to the mental model of war to be SCS war model.

In SCS, a national goal of China is the dispute areas in SCS which are anticipated to be miscellaneous benefit for China. Thus national strategy of China is to conquer the dispute areas and use it for benefit.

OVERALL CLD WITH NATIONAL POWER PERSPECTIVE

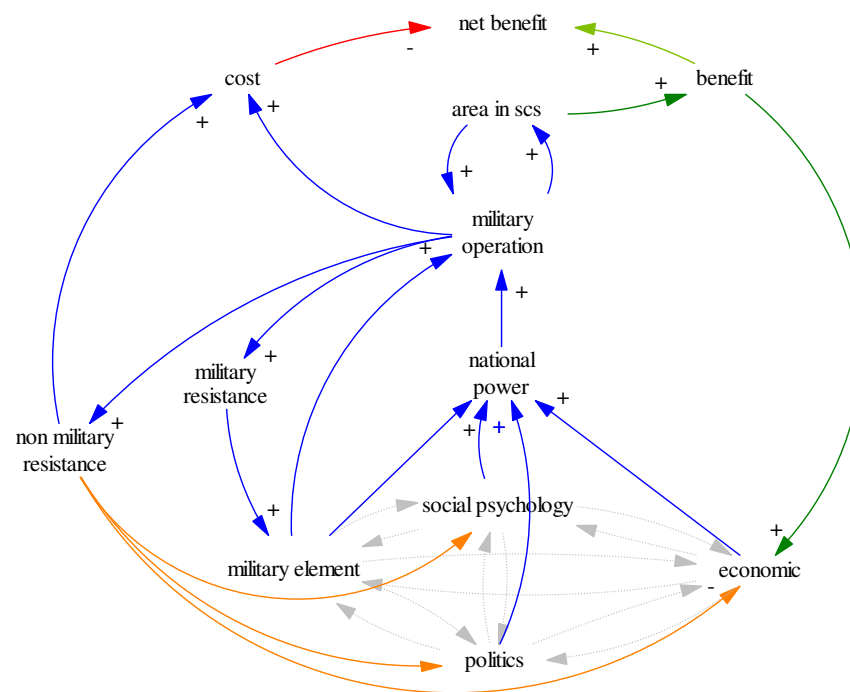


Figure 5: CLD of War in SCS

A System Dynamics Model of war in South China Sea is built to be a tool of simulation in this thesis by applying the relevant factors in to the mental model of war. However, the SCS war model is built on the assumption in the national strategy level which the entire situation must be guessed. The model is divided into four sectors such China sector, Opponent sector and operation and result sector.

SOUTH CHINA SEA WAR SECTOR

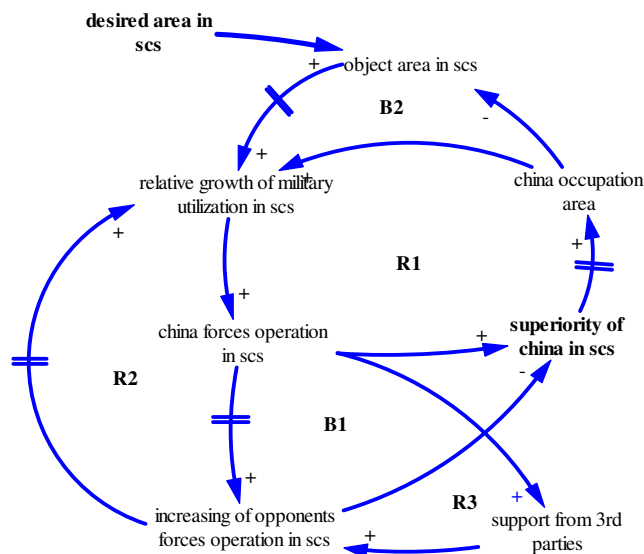


Figure 6 : CLD War in SCS

The casual loop diagram above shows a war in SCS section, the desired area of China⁴ is a goal of this system. The goal determines China effort to increase its military utilization in SCS that will increase the superiority of China in SCS and China occupation area. By the way, the more area that China has occupied, it needs more military operation to protect from its opponents. So, the loop re-enforcing loop R1 also makes the bigger in relative growth of China military in SCS as well. In correspondence to increasing of conquer area, it decreases the gap to reach the goal of the system represented by loop B2. This is a balancing loop which leads the system into a new equilibrium.

Besides, as this relation is the same as arm race model which simulates action reaction of each side (Feichtinger 1997), the China forces operation in SCS causes reaction of the opponents by increasing of opponents forces operation in SCS, likewise the increasing of opponents also feedback to China to increase its forces⁵, the action reaction is represented in re-enforcing loop R2. And the increasing of China force operation in SCS also increase the supporting of 3rd parties supporting to the opponents forces, this will be re-enforcing loop R3.

Additional, another balancing loop B1 is generated from the opponents' forces in SCS will decrease the superiority of China in SCS.

AREA AND BENEFIT SECTOR

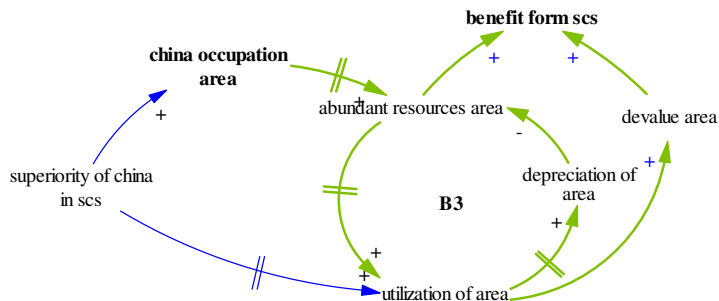


Figure 7: CLD Area and Benefit

Taking effect from SCS war sector, this sector represents the area in SCS that China will occupy by its operation. The occupied area will be the sources of China’s benefit from SCS.

After occupation of the area, China will start getting benefit. However, to reach the goal of the system, there must be time delays, superiority of China in SCS in war sector will determine two adjustment time variables in this sector. First, it influences time to conquer. The higher superiority is, the shorter time to occupy the area. And the occupy area will be utilized under the time variant to superiority of China as well.

However, the level of natural resources is a limit of utilization. Thus when China starts utilization, the depreciation of area will increase and it will decrease the abundant resources area, and then change to be devalue area which earn lower benefit. As the CLD above show Balancing loop B3.

NON-MILITARY EFFECT SECTOR

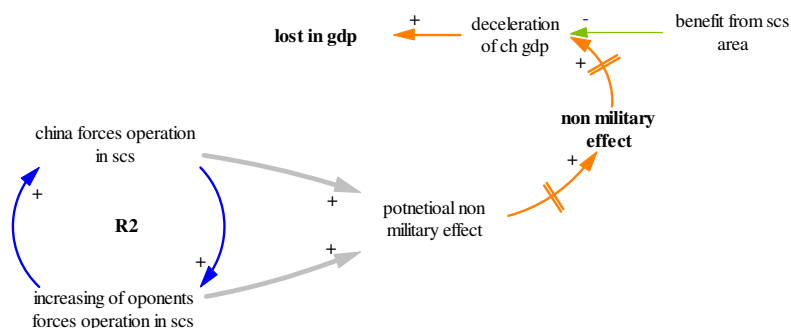


Figure 8: CLD Non-Military Effect

If the war in SCS happens, there is not only effect in the region but the consequences of war must be spread around the world. According to the globalization, the world is almost to become one, so the dynamics of any situation in world community is very importance. In this case, war in SCS will cause effect in many dimensions in the world. At least by geopolitics value of SCS, more than 40 percent of world's oil routes pass through SCS, 50 percent of world tariffs as well (Gallagher 1994; Tønnesson 2003; Rosenberg 2005).

In this sector, the effect the situation in SCS will produce the effect to the world; the effect can be in any dimension. In this study, the economic effect will be taken in account and measured in GDP of China.

The dynamics of war sector by reinforcing loop R2 will make China lost in its GDP growth rate. This dynamics can consider being indirect cost of SCS war⁶. However, benefit gotten from SCS will decrease lost in GDP.

COST AND BENEFIT SECTOR

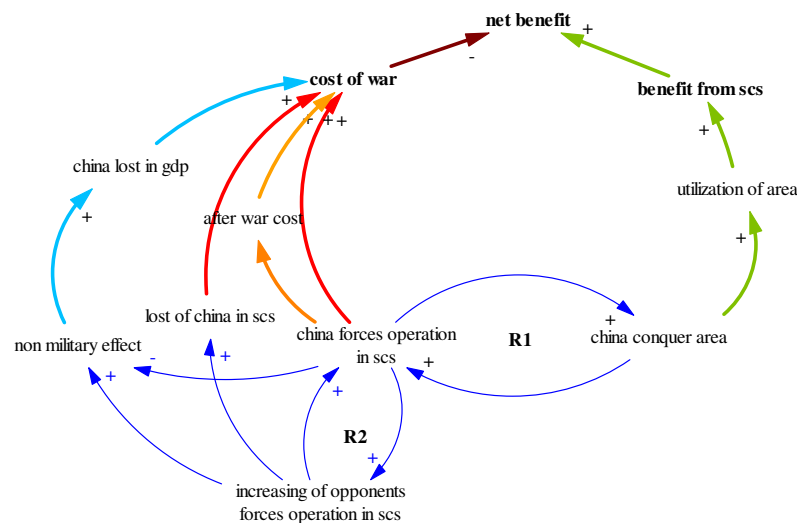


Figure 9: CLD Cost Benefit Sector

The sector does not make any feedback to other sector. But the dynamics from the system will be shown here. Two main variables those are cost of war and benefit from SCS will be calculated together to be net benefit.

Cost of war composes all cost that can be happen from war and its consequences. The cost can be considered into direct cost, hidden cost and indirect cost.

Direct cost is a cost that China that uses to operation in SCS.

Hidden cost is a cost which will happen after war such as social welfare, veteran etc.

Indirect cost is a cost which happens as an effect from war such effect in national or regional economic growth etc.

These three costs are subtracted from the benefit gotten from SCS to be Net benefit.

Stock and Flow Diagram (SFD)

The previous section, the CLD present the points of view in dynamics hypothesis. However, CLD has limitation to distinguish between stocks and flows. Moreover some loops could be specified in more details. Thus, in this section, Stock and Flow Diagram (SFD) will be roughly explained, for the detail will be in appendix.

SFD OVERALL MODEL: NATIONAL POWER PERSPECTIVE

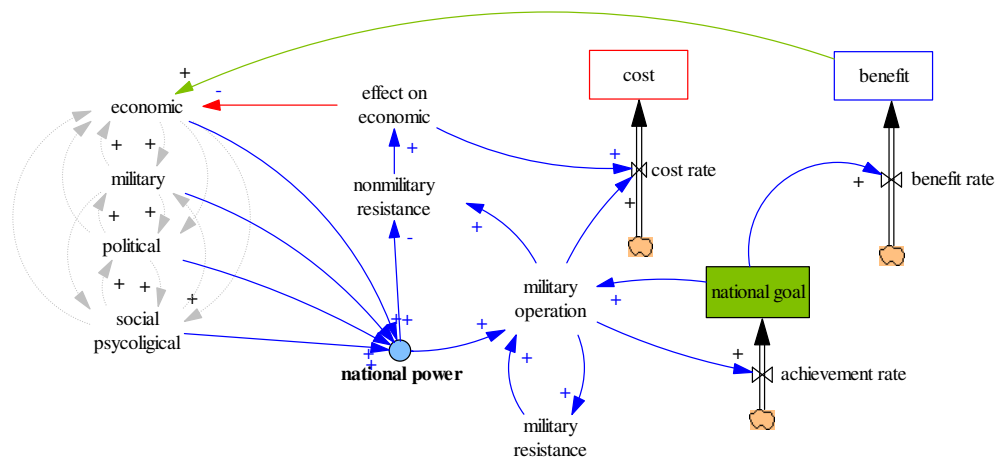


Figure 10 : Top view of SCS war Model

National Power indicates the concentration China to run its strategy to reach its goal. In this case, the Military operation by China will run to achieve a goal which is area in SCS. When China achieves its goal then it gets benefit, the benefit will increase economics power and National power as well.

However, military operation will increase resistances which are military resistance and nonmilitary resistance. Military resistance will press China to increase in operation, thus the operation cost will increase. Non-military resistance will affect in economic, this effect will be

cost of opportunity for China. And non-military resistance will decrease economic power which will affect in National Power of China finally.

National Power sector represent the elements of NP, it actually is a relative value calculated by all element comparing one nation to other nation(s). However, this study needs to consider NP as a single power and four of elements are taken in account. The four elements are calculated to be NP by Clausewitz's concept of winning a war mentioned before as an equation:

$R = M \times W$; R is total power of a nation, M includes military and economic power, W includes politics and social-psychological.

This study applies the equation to be suitable for China. The political and social-psychological power of China can be consider as constant, according to the political system which can control their people in the same way. Thus the model does not endogenous these two variables but set it constant at 1 as exogenous. For military as well, this study set military as 1, because it is the main strategy of China to use military power. But economic power has to be endogenous to the model. This power can be change by other factors.

The national power equation is expressed as:

$$\text{National Power} = (((\text{military} * 3) + (\text{economic} * 2)) / 5) * ((\text{political} + \text{social_psychological}) / 2)$$

The multiplier 3 and 2 represent weigh in national power of military and economic respectively.

WAR SECTOR

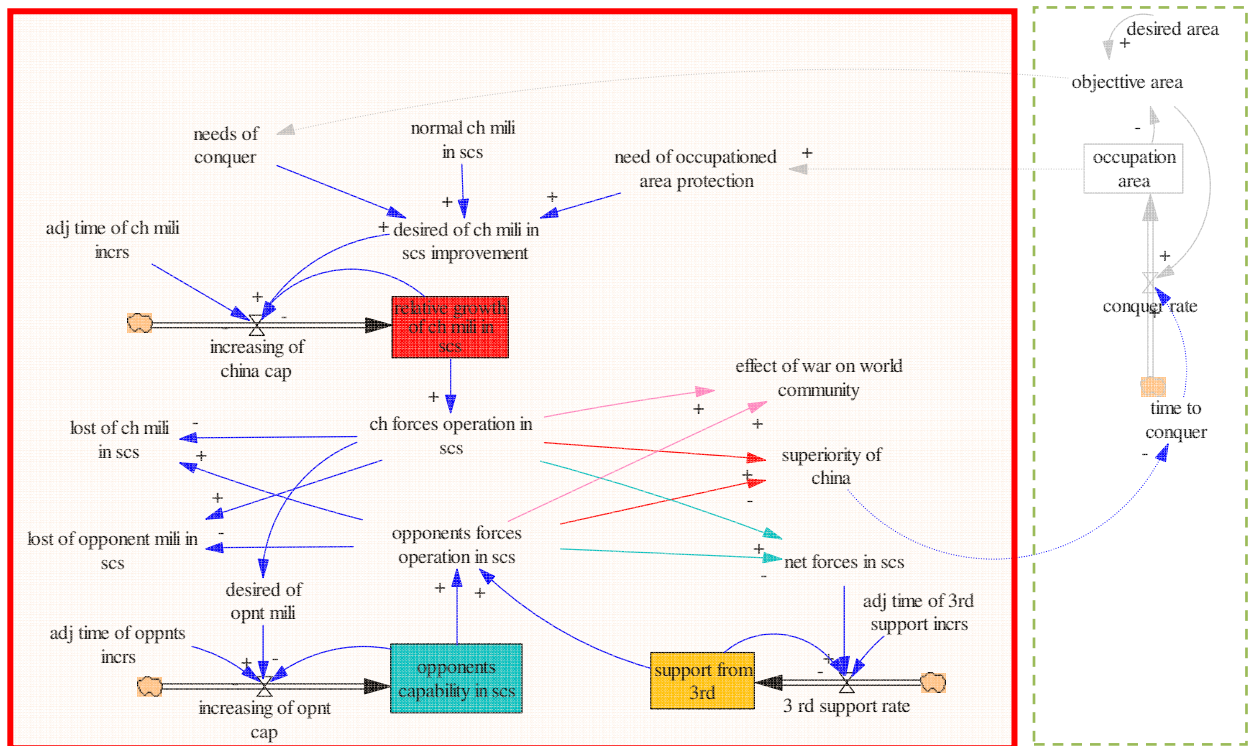


Figure 11: SFD of SCS war sector

War sector includes three main stocks which are Relative growth of CH military in SCS (red), Opponents Capability in SCS (blue) and Support from 3rd (yellow). In one hand, the stocks are changed by the flows and other variables in the system, in other hand, the stocks also influence changing of others stocks and variables as well.

- **Relative growth of CH military in SCS** is assumed as a ratio between the expected forces compare to normal forces which China always uses in SCS and equal to 13,300 Million USD per year⁷. This stock is initiated by `sch_mili_normal__policy_in_scs` set as 1 and changed by a flow named `incrs_rate__of_ch_utl_in_scs`. This rate fills up the stock to reach the Utilization desired of CH in SCS under the adjustment time 1 year.

$utilization_of_ch_mili_in_scs(t) =$

$$utilization_of_ch_mili_in_scs(t - dt) + (incrs_rate_of_ch_utl_in_scs) * dt$$

Desired_of_CH_mili_in_SCS_improvement represents the expected forces need for CH to achieve its goal compare to normal situation. It combines `cost_of_area_protection`,

cost_to_conquer and ch_mili_normal_policy_in_scs which are the direct potential costs from war.

Needs of conquer is considered in two dimensions, first it is calculated from the area that CH gets from war compares to its normal area and second it is calculated base on amphibious warfare⁵ principle that CH needs five time superiority to conquer the sea.

Need of occupation area protection is from the conquer area which is a stock in area sector compares to normal area of CH in SCS which initiated by 350,000 sq km².

Normal CH military in SCS is the normal expenditure of CH in SCS, initially as 1

- **Opponents Capability in SCS** represents opponents' capability. This stock is changed by opnt_increase_rate. The desired of this stock is the CH forces operation in SCS. However as the data of military expenditure from SIPRI in year 2010, the opponents have lower military capacity and there is a limit of increasing opponent forces in SCS by percentage of their GDP. Thus the MIN function is used for the rate as

opnts_forces_desired_in_SCS =

$$\text{Min}((\text{normal_opnt_mili_in_scs} * \text{opnt_mili_strength}), (\text{ch_force_operation_in_scs_opnt_force_in_scs}))$$

And adjustment time for opponents' improvement is 2 year

- **Support from 3rd** is a level of the military support from 3rd parties to opponents. The rate filled in this stock is from the net forces in SCS which shows the difference between CH forces and opponents' forces by the equation.

$$\text{Net_forces_in_SCS} = \text{ch_force_operation_in_scs} - \text{opnt_forces_operation_in_scs}$$

The difference is divided by the adjustment time 2 year to be a 3rd parties support rate.

These stocks are used to present the capability of each party in the war sector. Utilization of CH is multiplied by its normal policy to be CH Forces operation in SCS. The other two stocks those are opponent force in SCS and Military support from 3rd are added together to be opponents' military operation in SCS.

The two keys variables represent the strength of each side at war. The comparison of all parties is considered in three variables those are

Superiority of CH in SCS, this variable show the ratio between each side by the equation

$$\text{Superiority of CH in SCS} = \text{ch_force_operation_in_scs} / \text{opnt_forces_operation_in_scs}$$

And it affects on two adjustment time variables in Area Sector those are time to conquer and time to use area

Effect of war on world community, this variable is assumed as the effect of the crisis in SCS which will be sensitive to the world in various dimensions especially in economic term. According to the importance of SCS to world economic as the main route of energy and commerce between Indian Ocean and Pacific Ocean, so there must be some effect on many countries in the world if there is a crisis in the area.

However, the situation is defined in two ways for this study, of which first if China can conquer by the superiority higher than 5 then it can control and establish the area return to normal, all the ship can pass through as usual. So, it does not make high sensitivity to the world.

In contrast, if China cannot maintain it forces to be higher than 5 times of opponents, it means the area is still in unsecured and the ship cannot pass through. It will be high sensitive to the world.

The effect from the situation will be used as a graphical function as shown in Figure 12

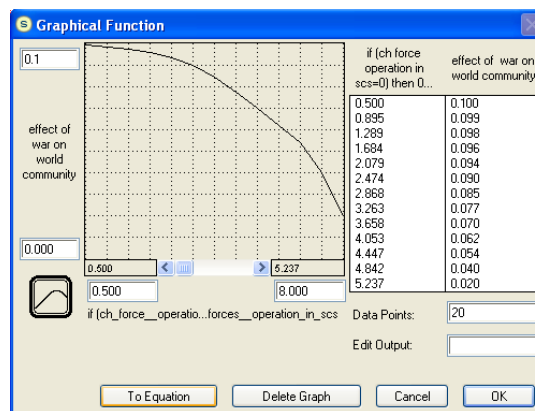


Figure 12: Graphical Function of Effect of Situation on World community

Forces ratio China and Opponents represent the ratio between both sides, the ratio is used to approximate the lost for CH and Opponents in the war by the sub variable Possibility of Lost which are graphical function. For more details can see in Appendix

AREA AND BENEFIT SECTOR

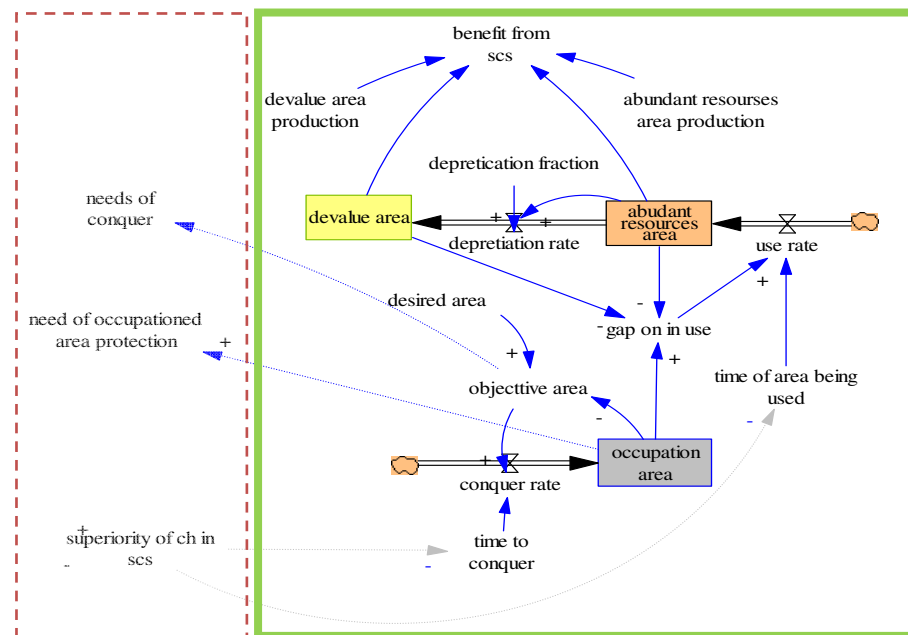


Figure 13: Area and Benefit Sector

Area and Benefit sector states the war results which are the occupation area in SCS and the benefit from various resources in SCS. Three main stocks are represented the development of the area conquered and used.

- **Occupation area in SCS** shows the level of dispute area that CH has conquered, initiated by 0. The rate of conquer to fill this stock is from the objective area which means the area that CH has not conquered yet. This variable is a gap filled under the adjustment time to conquer.
- **Abundant resources area** is the area that CH can get high benefit after it conquers SCS, However to start getting the resources, it must take a period of time after conquer and establish secured area. The time variable used to the rate to this stock is time of area being used.
- **Devalue area** is a stock which flow rate in from the abundant resources area with the adjustment time 20 years. This area has been used for a period of time so the resources are depreciative. The benefit gotten from this area is less than abundant resources area. There must be noted that in the realistic, Devalue area should have flow out as well. However, according to the life time for this flow is very big compare to the frame of study. So, this study does not consider about this flow.

Benefit from conquer is a variable showing the benefit per year that CH will get from the area. As many researches mention in literature review, it is believe that there is tremendous natural gas in SCS sufficient for 150 year CH consumption. So, the model separates the benefit in two categories of area; Abundant and devalue production which are presented in two stock above. The benefit rate per area per year is calculated from CH energy consumption rate.

Time to conquer and *Time of area being used* are determined by superiority of CH in SCS from War sector. These two adjustment times are functioned with superiority of CH in SCS. If CH has high superiority in SCS, then it takes shorter time to conquer and use the area to gain benefit.

NON-MILITARY EFFECT SECTOR

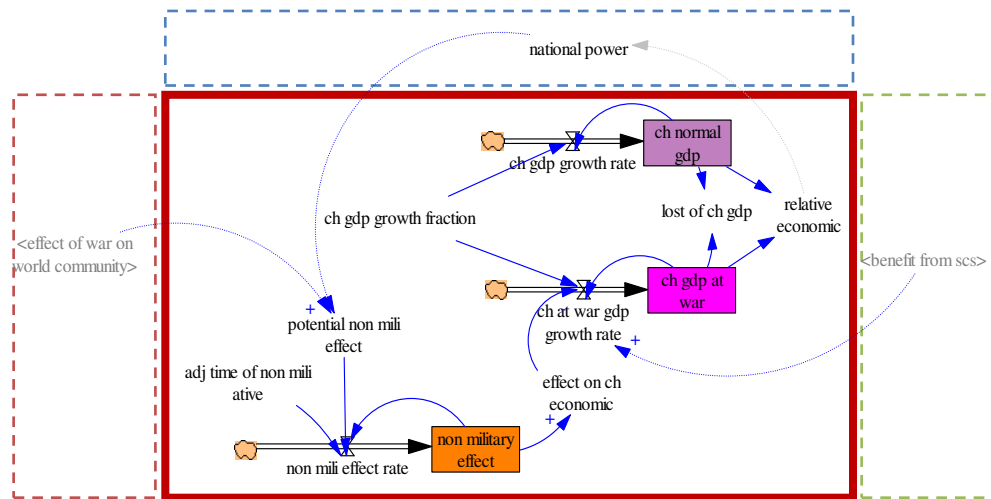


Figure 14: Non-Military Effect Sector

This sector show the effect of war which does not come directly from war but it is unavoidable if a war happens. There are one key stock and two minor stocks to draw non-military effect.

- **Non-military resistance** as a key indicator represents sensitivity of world to the war, initiated at 0. The in-flow is from potential non-military resistance compares to the stage of this stock with the adjustment time of resistance active defined as 2 year. The variable Potential Non Military Resistance is determined by the effect of war on world community in War sector. The graphical function has been shown in the war sector already. The stock of non-military resistance is used as the economics effect which will effect on GDP growth rate of CH in the next minor stock.

- **CH at War GDP and CH Normal GDP** shows the development of CH economics indicator in two situations. The stock CH Normal GDP is given the growth rate 0.07 per year meanwhile the growth rate of GDP at war is disturbed by the effect of war so it is slower than in normal situation. The rates of these two stocks are compared to see the lost in economics per year.

COST BENEFIT SECTOR

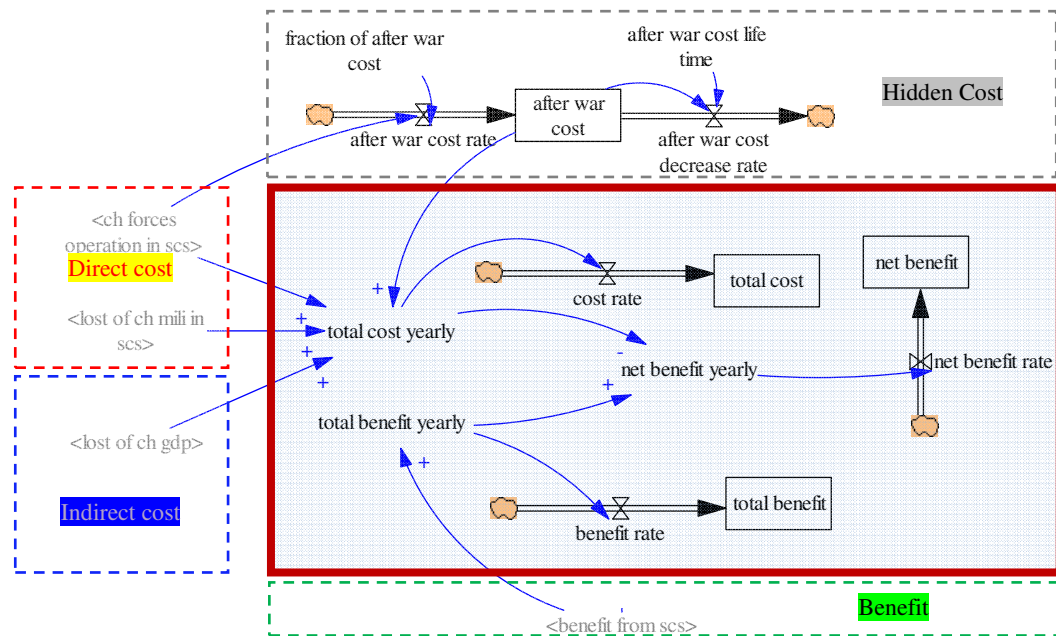


Figure 15: Cost Benefit Sector

As the dynamics of war was explained in the previous sectors, this sector will present all cost and benefit of SCS war. Only some main stocks in Figure 15 will be explained.

This study categorizes the cost relevant into three categories.

- **Direct Cost** is defined as the cost that directly used at war which are military operation cost and cost of lost in the war field. In this model, the direct costs are shown in variables CH forces Operation in SCS and Actual Lost of CH in SCS
- **Hidden Direct Cost** is a cost that used in war operation but it is necessary after war has run or finished. In the realistic this cost relates veteran, medicare or social welfare etc. The stock presenting this value is After-war cost. The rate for this stock is calculated from the lost of CH from war. Life time of this cost is around 40 years according to the age of soldiers and the high life expectancy.

- ***Indirect cost*** is the cost that is not directly related to war operation. This cost is an affect of war consequences on economics. According to a number of literatures mentioned that war affects negatively on economic growth. This model assumes that the lost in economics is a part of war cost by measuring of GDP in Non-Military Effect sector, the lost of government revenue is implemented in this cost

CHAPTER 5 MODEL VALIDATION

Validation Description

The reliability of any model should be represented by the method of validation which is the base to people to justify each model. However, it is impossible that a model will pass through all the tests. In this study, the model is tested by a number of validation methods including two main validation processes which are Structure Validation and Behavior Validation. The two main validation can be categorized in two three types of test those are Direct Structure test, Structure-Oriented Behavior Test and Behavior Pattern Test (Barlas 1994).

The test of model structure will test the whole model together. However, the test of model behavior starts by each sectors separately, the base condition at War Sector which is the main sector of this system will be tested. Meanwhile the other two sectors; Area and Benefit sector and Non-military effect sector will be tested well.

This process is to test on each sector before combination together as a treatment of the model. After that the test implemented to the whole model will be done again.

Direct Structure Tests

The aim of this test is to verify the model by comparing model structure to the real system under the purpose of modeling. However, as this model is purposed to represent scenarios in the level of national strategy and the study purpose which points on making of scenario than making of policy.

Thus, the scenarios are the situations which are assumed base on the literatures about the principles of war, national strategy and international relationship. And they are mimicked from some contemporary war. A number of variables in the model are processed from the existing information, some are direct information and some are secondary in formation.

As Forrester (1979) said that “In System Dynamics Models, model structures can be compared directly to descriptive knowledge of real-structure and model behavior may be compared to real-system behavior.

STRUCTURE AND PARAMETER VERIFICATION

All of the structures are based on the situation mentioned in the real world even it happened in other parts but it happened repeatedly as a theory. However it might or might not happen in SCS. By the methods of modeling in the previous chapters, it is reasonable for this study and the rest should be evaluated by the reader.

In the parameter, this is a weak point of this model in term of parameter verification. Because a number of parameters in this model such as time of CH Military improvement, time of 3rd support, normal CH military in SCS etc. are inaccessible. Moreover some are different depend on the source mentioned. The parameters, however, are initiated conceptually to the realistic. More over they are tested by sensitivity test and the results show that those parameters do not change much behavior of the model. So, the use of these parameters still keeps the model on track of study purposes which is building a generic model independent to the parameter.

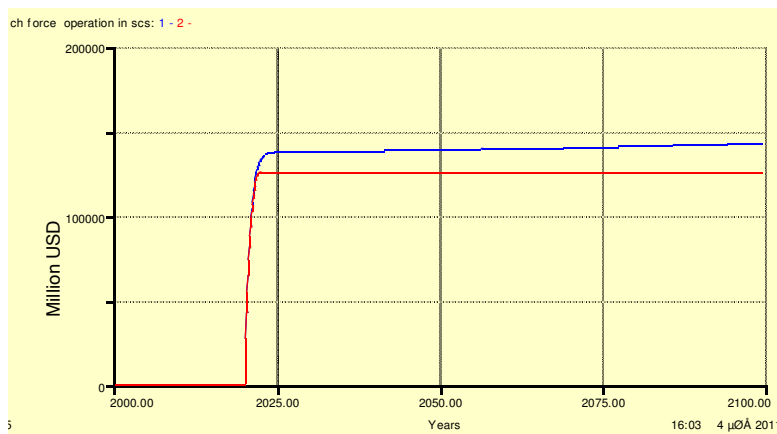


Figure 16: CH forces operation in SCS if the Area Protection feedback is cut.

Blue line is base run, Red line the loop is cut.

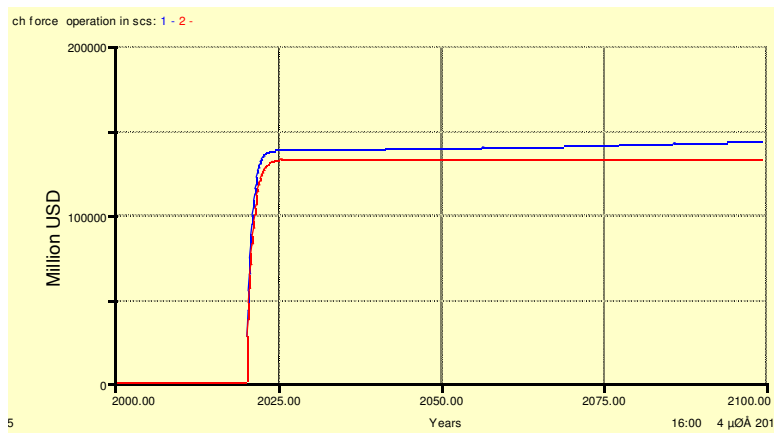


Figure 17 : CH forces operation in SCS if the feedback from superiority is cut.

Blue line is base run, Red line is loop excluded.

BOUNDARY ADEQUACY

This test is a frame of modeling during the whole study. Hence this section will only discuss in some points.

Firstly, this model excludes feedback of economic indicated by CH GDP on military expenditure, according to the reason that the comparison between CH military and Opponents is very large by the ratio one-five times in year 2010 and consider to CH economic growth rate compare to the opponent's, it is a big different as well. So, this study frame an assumption that CH has ample military capability to control SCS compare to opponents.

However, the test of this feedback also done, indicted by the variable CH military operation in SCS compare between determination by GDP and non-determination by GDP. The result shown in Figure 18

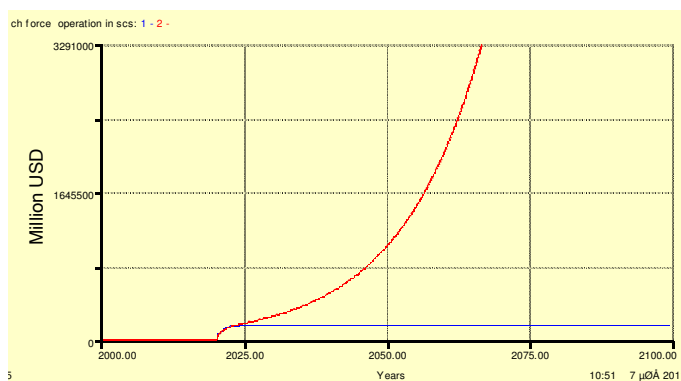


Figure 18: Comparison of CH forces operation in SCS

Blue line is GDP excluded; Red line is determinate by GDP

The result shows that if CH force operation is determinate by GPD as percentage of GDP, it will be over requirement after 5 year, which is not reasonable in the logic of government budget decision. It is more logically modeling to the realistic by setting the Ch forces independent from GDP. So, this model the feedback from economic to CH forces operation in SCS is excluded.

DIMENSION CONSISTENCY

The dimension consistency in this model is tested directly by the software using to build and simulated for this study. The model is tested of the unit consistent.

Structure Oriented Behaviors Test

This validation aim to test the model indirectly by apply some certain value to the model. In this study several of tests are applied such.

DIRECT EXTREME CONDITION

This test aims at how well the equations in the model deal with some extreme condition.

Time of China military improvement = 0.01 and 1000 year

This adjustment time relates to time to conquer the area. So, the expected result should be in the logic that if time of CH military improvement is very small, it means that CH military use very short time in filling the gap of desired area. In other hand if the time is large, CH military takes long time to occupy the area.

The simulations in Figure 19: Occupation Area comparison by different time of CH military improvement show that the model still keeps on track in the extreme condition

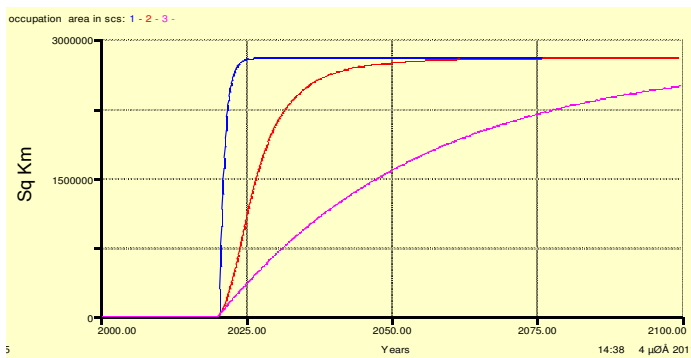


Figure 19: Occupation Area comparison by different time of CH military improvement

Blue line is 0.01 year, Red line is Base run and Pink line is 1,000 year

Desired Area = 0 and 5,000,000 sq km.

The desired area is the goal of the model. The test expected that the model will produce the behaviors to reach its goal. If there is no desired area, the occupation should not be changed, and if the goal is higher than base run, the occupation area should be higher as well.

The results are show in Figure 20

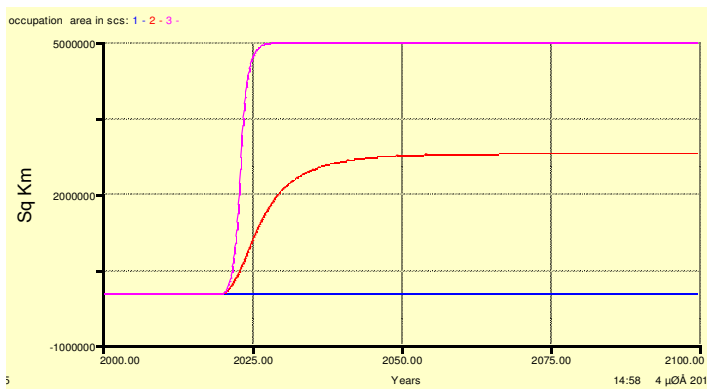


Figure 20: Occupation Areas comparison between each desired areas extremely test

Blue line is 0 sq km, Red line is base run and Pink line is 5,000,000 sq km

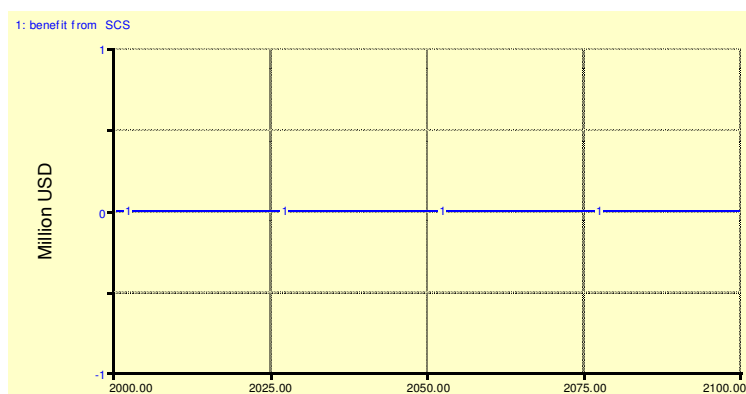
Desired area = 0 sq km

The desired area is 0; it means that CH does nothing in the area. So there is not any effect to equilibrium stage of the system, the opponent forces, 3rd support and CH forces do not operation in SCS. All forces are 0



Figure 21: Desired area is 0, there is equilibrium at 0 in system

This means that there is no conquer in SCS thus there is not benefit area as well.



BEHAVIOR SENSITIVITY TEST

This test aims to see that the function variables used in the model are sensitive for the model behaviors or not.

Effect of War on World Community

The graphical function is test by changing the behavior. The normal use for base run is exponential decay. For the test, it is changed to be exponential collapse and s-shape as shown in Figure 22

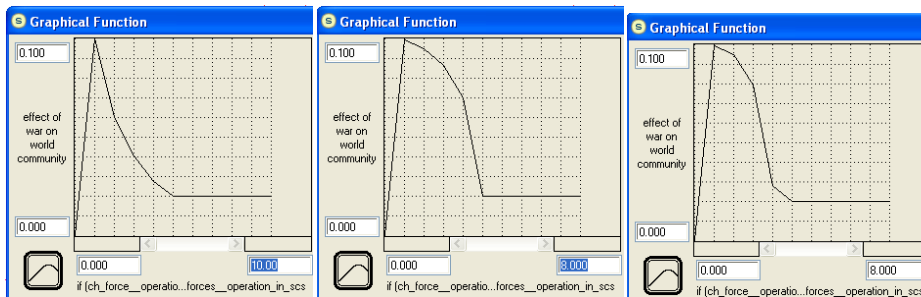


Figure 22: exponential decay (in use), increasingly decreasing, S-Shape

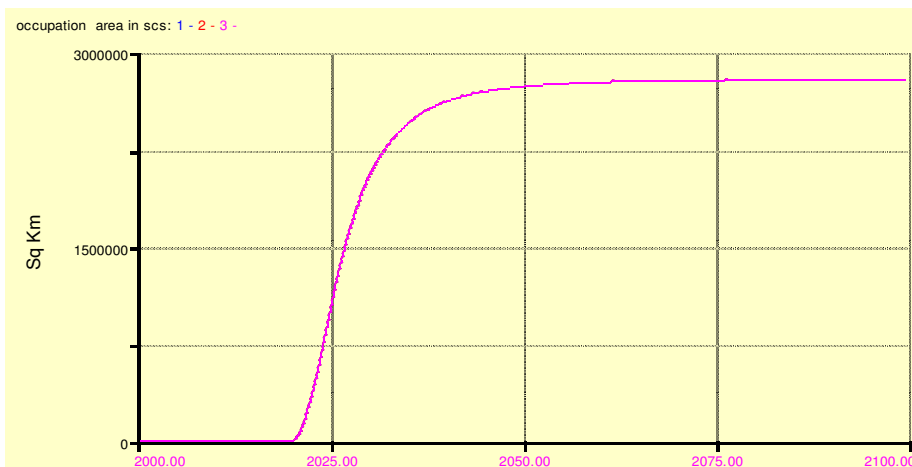


Figure 23: Occupation area comparison in Function test

The result of simulation in Figure 23 shows that there is no difference between each simulation. So, the model is not sensitive to the graphical function.

China military Improvement time

By this test, the adjustment time is set by the range $\pm 100\%$ and $\pm 50\%$. The result shows that the change of this variable does not change the model's behavior sensitively.

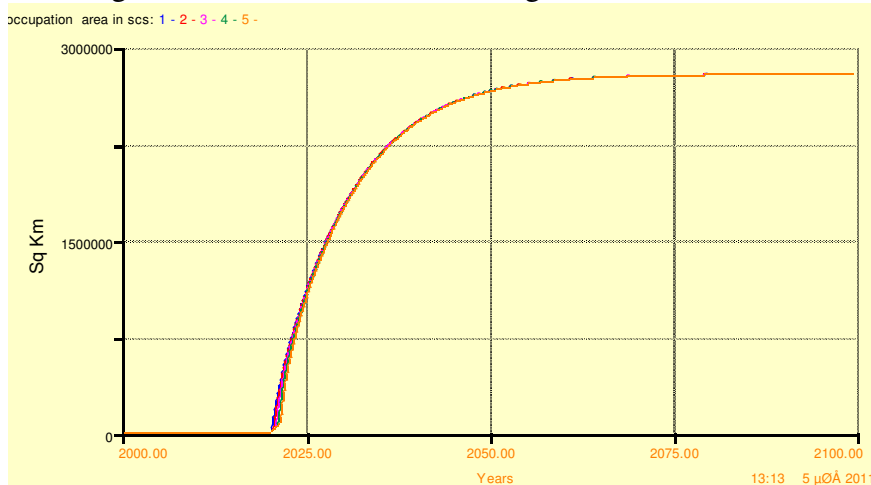
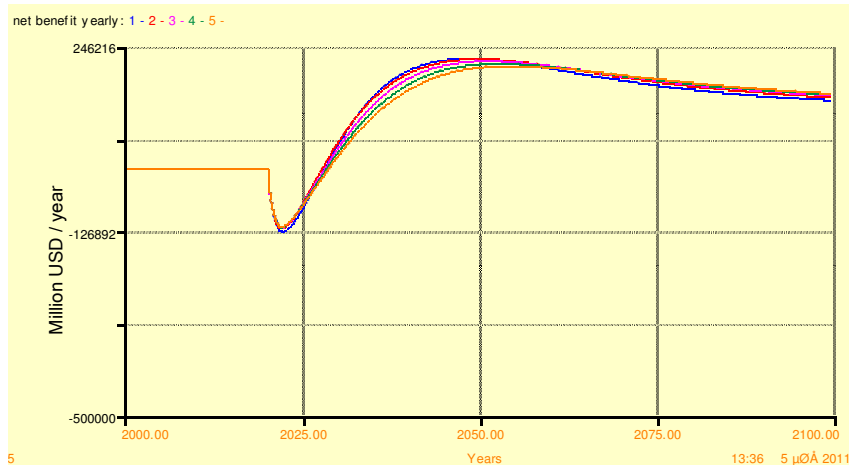


Figure 24: Occupation are with CH military Improvement time Sensitivity test

Opponent military improvement time

The adjustment time is set by the range $\pm 100\%$ and $\pm 50\%$. The result shows that the change of this variable does not change the model's behavior sensitively.



BEHAVIOR REPRODUCTION

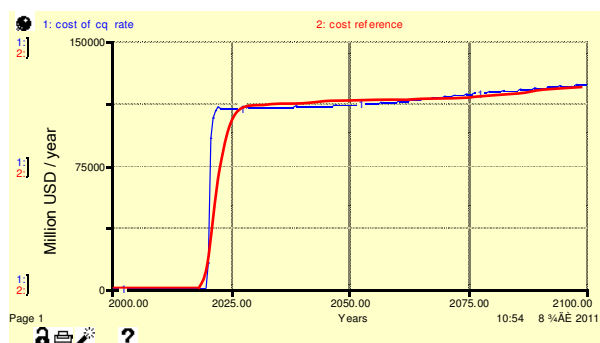
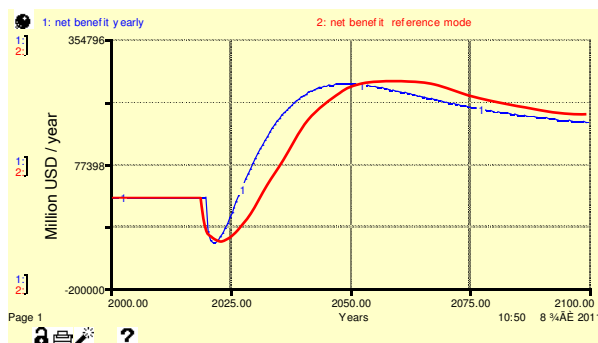
This method is to see that how fit the model can simulate with the historical data or the reference mode. Because of lack of information, the real reference mode for this model could not be built. However according to Saeed(1998)

“Last, but not least, any time history may incorporate multiple patterns experienced over a single time path, over different geographic locations or over different periods of history”.

And Albin(1997) *“When no historical information is available, a modeler must create a hypothesized reference mode. The hypothesized reference mode consists of a simplified curve, typically drawn by hand; capturing the key features of the behavior pattern of the important system components”*

Thus this study hypothesized the reference mode for some uncertain but presumable situation by mimic from similar situation in different geographic location and periods of history.

The excellent expected result is that the model can simulate fit to the reference both in term of quantity and quality. Nevertheless, because the purpose of the model is to build a generic model which can describe the behavior of war, so only fitting in term of quality is acceptable.



INTEGRATION ERROR

The time step using in the model should be suitable for the model. In this test, the time step is tested by cutting down for half of the initial then simulate the model to see whether the behavior of the model change or not. If the time step used is suitable for the model, then the behavior should not be distinct from the base run.

By this testing method, the used time step is 0.1 year, and then we change the time step to 0.05. The model still keeps the same behavior as initiated. So, the time step using is suitable and the model is not sensitive to time step.

Summary

The structure and behavior of model is tested by a number of methods and the results are presented in this chapter partly in this chapter. For the scenario test will be done in the next chapter.

Nevertheless, in this chapter, it is not all kind of tests can be done but the study chose the tests which make satisfaction of the model structure and behavior within the frame of study and model purpose. The model passed all the tests applied. So, by these results, it can be concluded that the model is validated.

CHAPTER 6 SCENARIOS AND DISCUSSION

In the previous chapters, the study conventions are settled, the model and relevant structures as tools of simulation are built. In this chapter, they will be used to simulate the base case and introduced new structures as treatments to simulate the possibility scenarios.

Base run scenario serves as the normal war considered from fundamental war strategy. The considerations are based on military operation and resistance from the opponents in the battle field. In this scenario, traditional military thought is applied under the consideration of military power leading to national strategy.

Scenario one, the hidden cost of war will be considered to shift the paradigm about costs of war that used to calculate only military operation relevant or not. The hidden cost added to this scenario will show how the difference of war's cost is.

Scenario two, if the war is expanded to be a great war by the strong resistance then what are going to happen. This scenario, the 3rd party intervention will be introduced as a part of opponents. Thus the opponents' capability will be very high.

Scenario three, with the Great War in scenario two, according to the question to war about its side effect, if the non-military effect is considered, how the results of war are.

Scenario four, if the goal of CH to SCS is resources. Then there is another way for it to gain the resources by avoiding of war. In this scenario, the regional integration is implemented by assuming that the areas are shared by China and each opponent. The benefit is shared and there is not cost of war.

Table 2 all scenarios comparison

Scenario	Direct Cost		Hidden Cost	Indirect Cost	Effect on National Power
	Military Operation	Lost from Operation	After-war cost	Non-Military Effect	
Base Scenario	Low	Low	Not include	Not include	+
Scenario 1	Low	Low	Low	Not include	+
Scenario 2	High	High	High	Not include	+
Scenario 3	High	High	High	Include	-
Scenario 4	No	No	No	No	+

Base Scenario: SCS War

The base scenario presents the regional war which run under the hypothesis of China as a strong side against and the opponents as a weak side. The goal of the war is area size 2,800,000 sq km approximately¹ or 80 percent of SCS.

In this scenario, CH capability SCS will be increased by the desired area in SCS, however its movements will drive the opponents' capability increased, this is a loop R1.

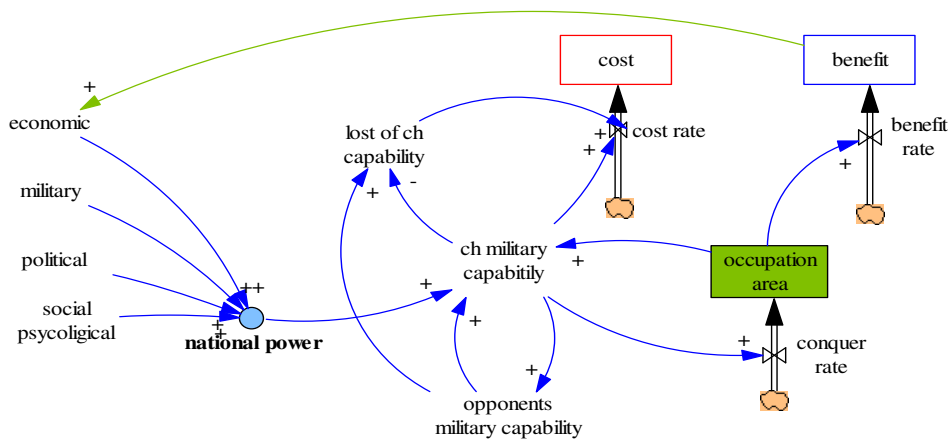


Figure 25: Base Scenario

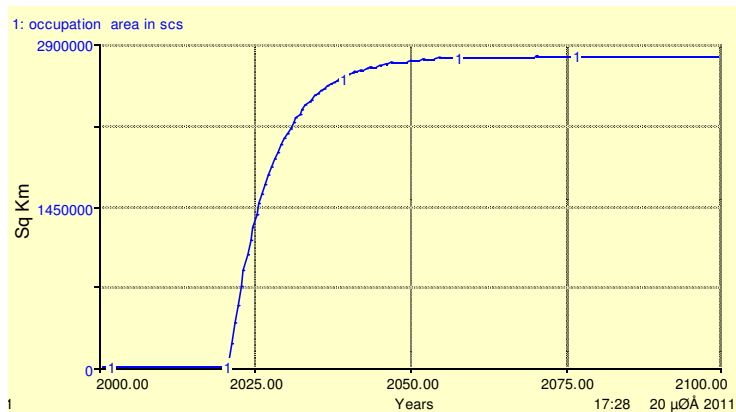


Figure 26: Base run of Occupation area

By the normal perception, China can conquer its desired area in SCS as a goal seeking behavior

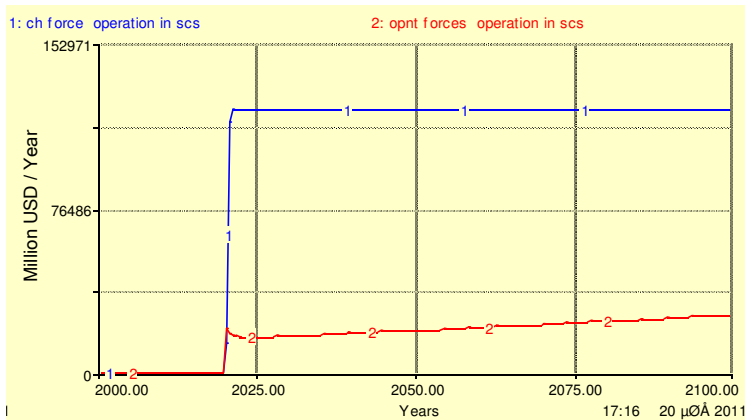


Figure 27: Base run of China forces and Opponents force

CH forces will reach the level that enough to cover SCS (5 times to normal), however, the opponents will gradually grow to follow CH

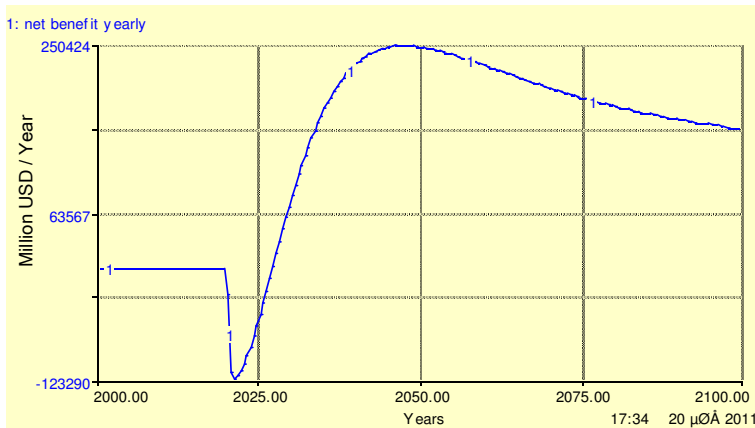


Figure 28: Base run of Net Benefit yearly

Net benefit is in negative at first 6 years of war. It turns to be positive by the benefit of conquer area starting higher than operation cost. However, the area will be depreciated, so the benefit will increase from year 50.

Scenario 1: SCS War and Hidden Cost

For the base run, war cost and the benefit from war are compared. The result shows that China needs almost 6 year to get net benefit in positive. However, when the net benefit has reached the peak point around year 2050, it turns decreasing according to the depreciative of resources area.

The scenario 1 aims to present the idea that what actually should be added to the cost of war. The cause of this question is from many logical remarks that running any war, there must be a number of veterans which need some more continued cost to take care of them.

Mimic to US war observations, some scholars mentioned that the health care and disability compensation costs for veterans from past wars came 30 to 40 years after those wars ended(DAO 2011). Also, Linda Bilmes, a Harvard academic who has done extensive research on

the impact of the wars, said that with the life expectancy getting longer, the actual cost over 30, 40 or 50 years will be even higher than the projection and will peak later than past war.”

So after-war cost should be unavoidable for the total costs of war and it must be calculated. Before the step of other considerations, the after-war cost must be implemented. This scenario adds structure of after-war cost and calculates it as a part of the costs relevant.

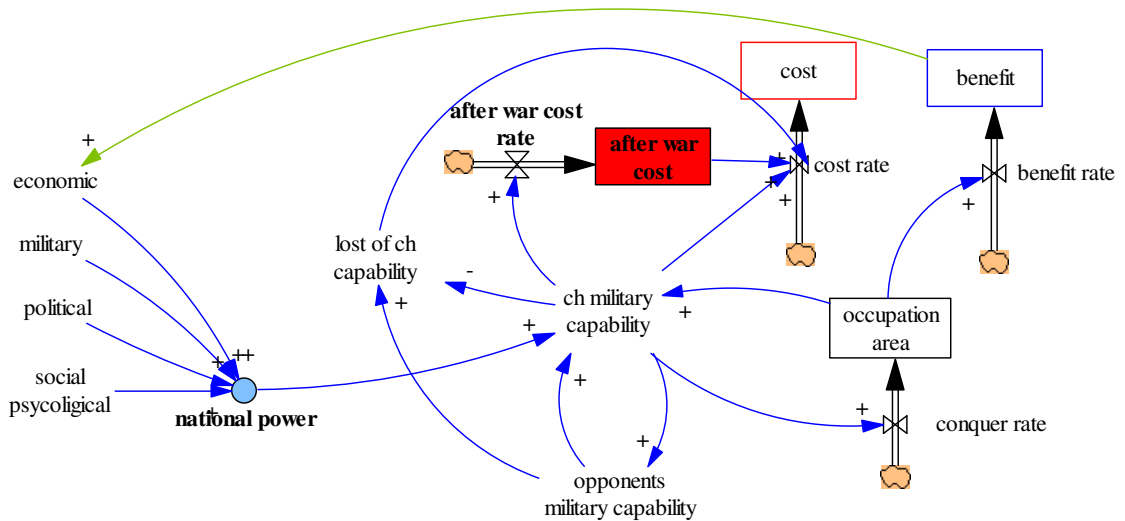


Figure 29 : Scenario1

Test of the structure

The after-war cost structure is test by on its fraction and life time.

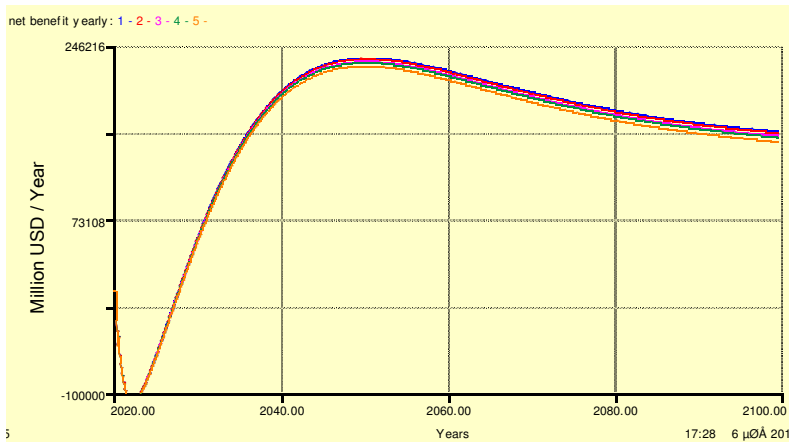


Figure 30: sensitivity test at the fraction of after-war cost

Firstly, the fraction of lost at war which determine the rate in of after-war cost is tested by the values 0.02, 0.04, 0.08(existing value), 0.1 and 0.16 the results are shown in Figure 30. There is not much different.

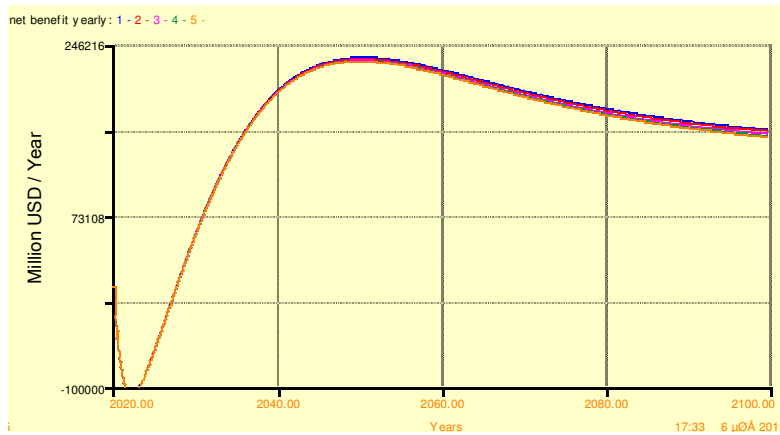


Figure 31: sensitivity test at the life time of after-war cost

Secondly, the life time of cost is tested by the values 10, 20, 40(existing value), 60 and 80 years. The results are shown.

From the sensitivity test to the constant variables of after-war cost structure, it shows that the model is not sensitive. The main cause of veterans is from operation war cost; the new structure takes a part from this variable by approximately fraction of 0.08².

The result show that earliest stage of war, the net benefit is not clearly, but around 10 years after, the difference is starting clearly.

Thus, the scenario shows that it is necessary to include the after-war cost to the war cost according to its size in quantity term, besides this cost happens in any war. So, after this scenario, this hidden cost of war will be added as one of the model structure and considered as a part of war costs.

Simulation of Scenario 1

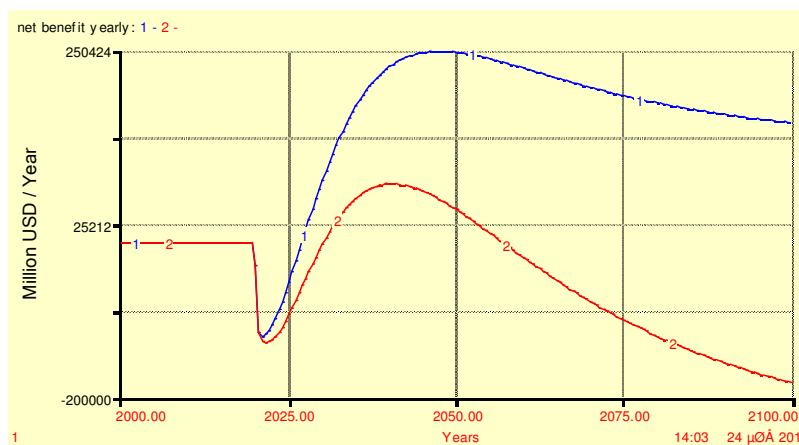


Figure 32: Net Benefit yearly

Blue is base line, red is Scenario2 (after-war cost is applied)

Net benefit yearly added with after war cost is lower.



Total net benefits are different significantly, after year 70, it starts lower than 0.

Figure 33: Total net benefit

Blue is base line, red is Scenario2 (after-war cost is applied)

Scenario 2: SCS War with Strong Military Resistance

In scenario 1, the normal cost of war is added with the hidden cost. However, the previous case is assumed on the perception of total war with a weak resistance. In this scenario, the environment of SCS war will be changed by the intervention of 3rd party.

The intervention of 3rd party is in term of military capability promotion to the opponents operation in SCS. This treatment will make the opponents high capability compare to CH.

In the model, the structure of 3rd military support is added. The support is a stock which flow in by the rate to fill the goal which is the net force between CH and opponents in SCS.

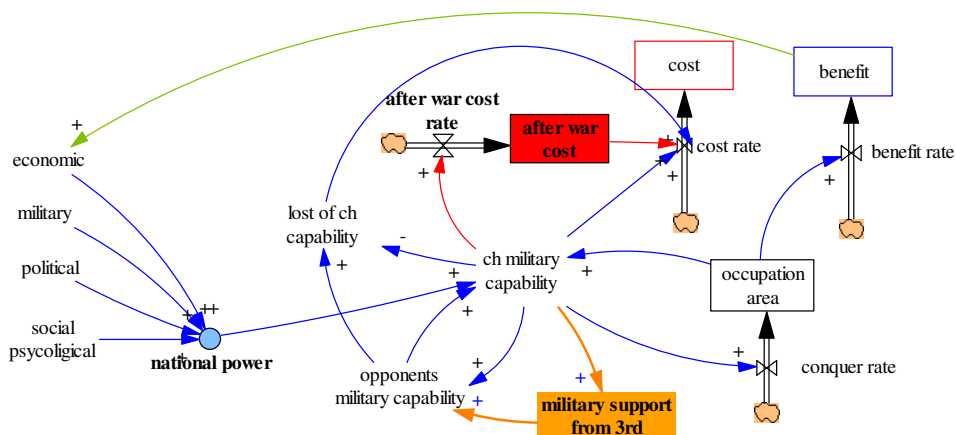


Figure 34 : Scenario2

Test of the structure

The test to this structure will be on the variable time of 3rd support which is initiated 1.5 years, the time that 3rd will take to support the opponents. The test introduces value of 0.5, 1, 1.5(initial value), 2 and 2.5 years to the variable to see the change in Opponents force.

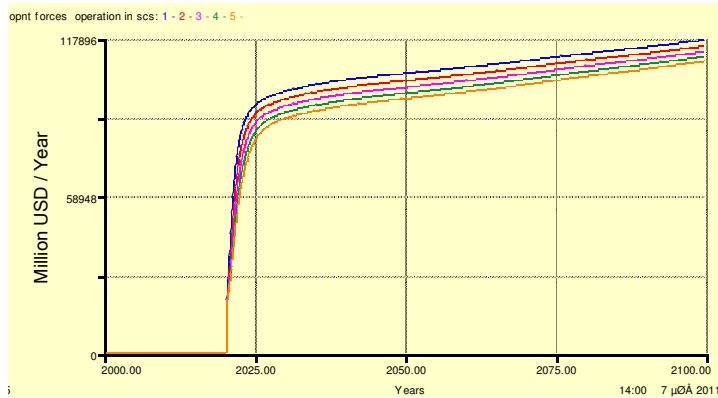


Figure 35: comparison of Opponent Capability in SCS for the test of 3rd support structure

The result is shown in that the time effects on opponents' capability in term on quantity but it still keep the trend when the variable is changed.

Simulation of Scenario 2

As the new structure added will fill the gap between opponents and CH which in the model is “net forces in SCS” with the adjustment time 1.5 years, so this will affect on decreasing of the superiority of CH in SCS as

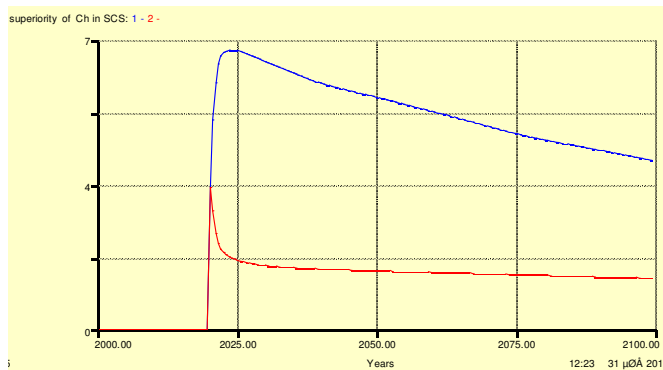


Figure 36: superiority of CH in SCS comparison

The superiority of CH is lower, according to the support of 3rd

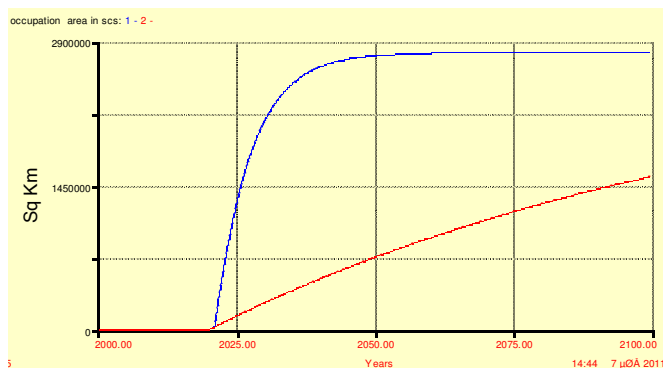


Figure 37: Occupation area in SCS

Affected from superiority, CH can conquer SCS slower.

Blue line is base line; red line is with 3rd intervention, superiority is no-unit.

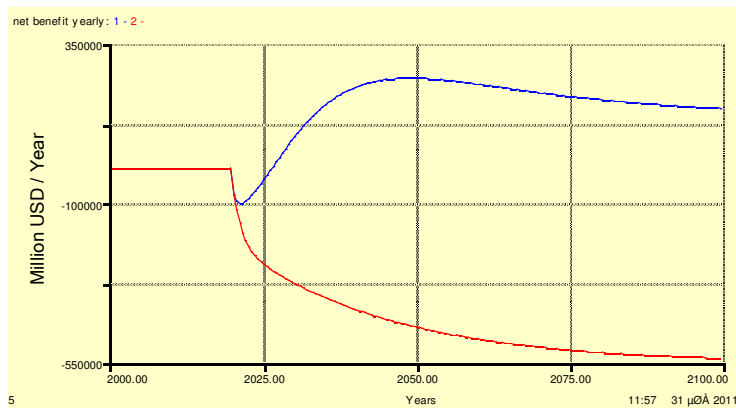


Figure 38: Net benefit yearly

The net benefit yearly is keep going down. There is not benefit in positive.

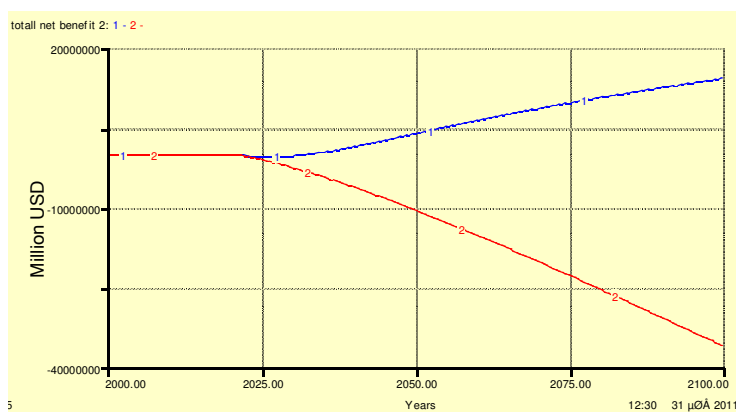


Figure 39: Total net benefit

The total net benefit is in minus till -33 trillion USD

Blue line is base line; red line is with 3rd intervention

The results of scenario 3 are shown in Figure 35 to Figure 38. The superiority of CH in SCS is intervened by the high capability of the opponents which gets supporting from 3rd party, result that the superiority is decrease, the time to conquer increase thus the conquer area of CH does not grow much. See in Figure 37, the occupation area does not reach the goal, so the benefit from SCS for CH is very low as well.

The net benefit yearly of CH keeps going down from the high cost paid and the low benefit gain.

Scenario 3: War with Strong Military Resistance and Non-military Resistance

The previous scenarios, war and its direct cost have been presented. It is obviously that during a war, the priority is to win. No one wants to second-guess the generals on how money should be spent. However, today, no serious economist holds the view that war is good for the economy, so the question is not whether the economy has been weakened by war. The question is only how much (Stiglitz and Bilmes 2008).

This scenario will add the structure of war's economic effect. The structure added presents the negative effect of war on CH GDP. The measurement is indicated by government revenue.

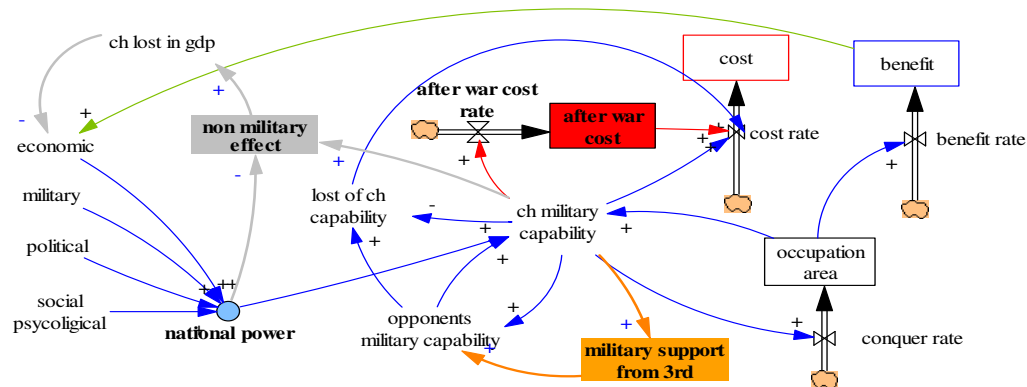


Figure 40: Scenario3

Test of the structure

The test is done on by the adjustment time of 3rd military support. The test introduce the values 0.5, 0.8, 1(initial value), 1.5, 2 years. The result shows in Figure 41

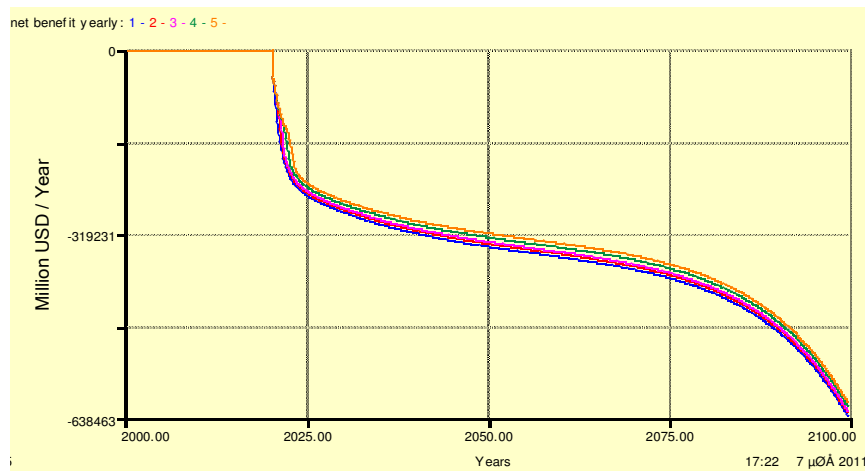


Figure 41: Net benefit yearly

The net benefit yearly behaviors are still in the same trend. So, the structure does not change much to the model.

Simulation of Scenario 3

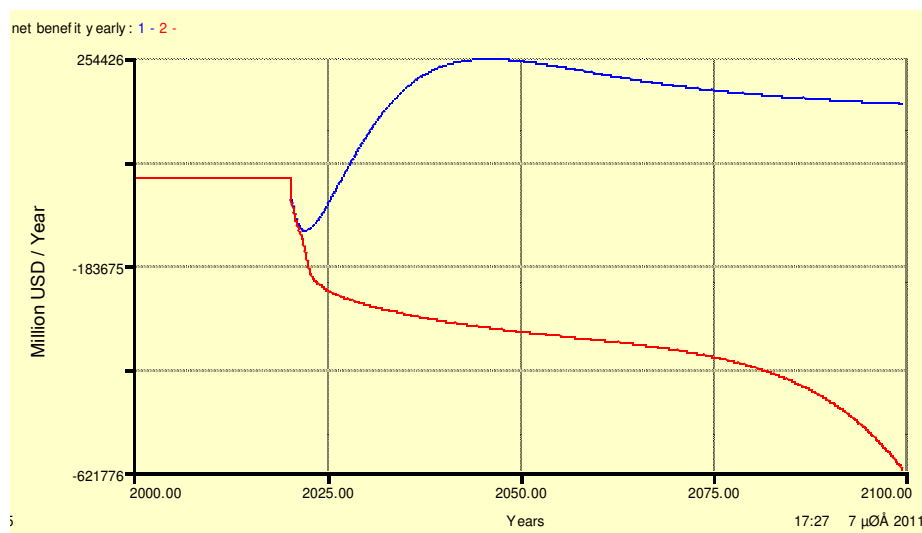


Figure 42: net benefit yearly

The added new structure does not change the model sensitively.

China starts losing with decreasing increasingly rate at the beginning, then when the benefit from conquer starts, it makes the lost slower. However, in long term, the effect of lost in GDP will make the net benefit of CH worse.

Scenario 4: Alternative solution by sharing and avoiding war

As the basic assumption, that the goal of China is its benefit in SCS. Consideration on China's elements of national power which is a tool of a nation to reach its goal, there are many elements on its hands to control this issue. As the three previous scenarios, it can be concluded that war is not a good answer in any dimension to achieve the goal in SCS. Thus Scenario 4 will

guide an alternative way to “what else if not war”. This scenario is far away from war in contrast it points to the cooperation between the parties by sharing the right and benefit on the dispute.

Only a part of all war costs shown in the last three scenarios is in account which is cost to protection. This cost is not meaning in military term. But it is normal cost implement for management of any area.

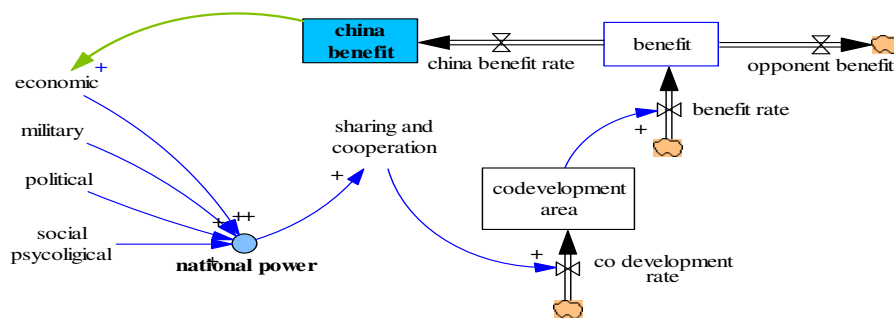


Figure 43: Scenario4

Simulation of Scenario 4

The result of this scenario will be shown below

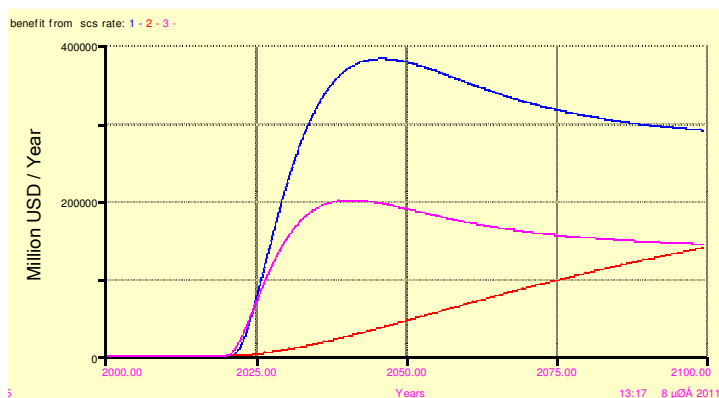


Figure 44: benefit from SCS

Benefit from SCS for Scenario4 is lower than base scenario, the behaviors are same. Compared with Scenario 3, the benefit is better.

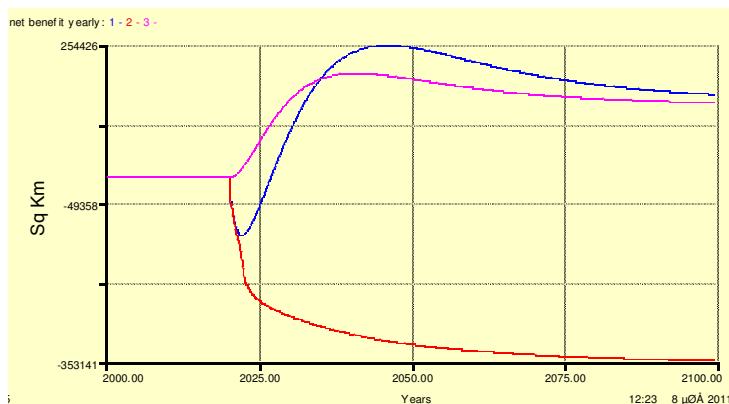
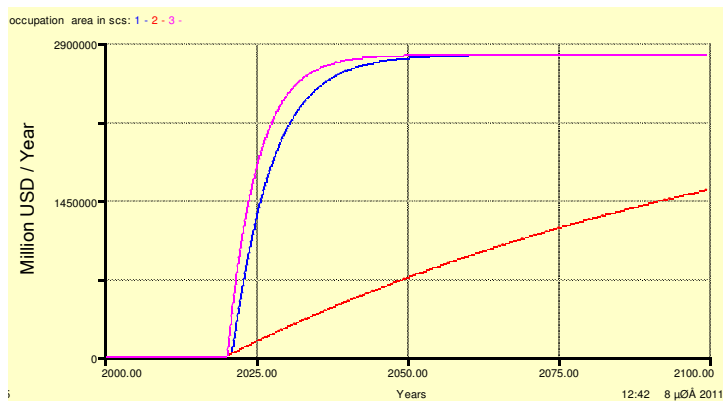


Figure 45: Net benefit yearly

Net benefit of scenario4 is better than base line for first 10 years, according to it does not have cost of war. However, in the long run, the net benefit decreases because of area depreciation.

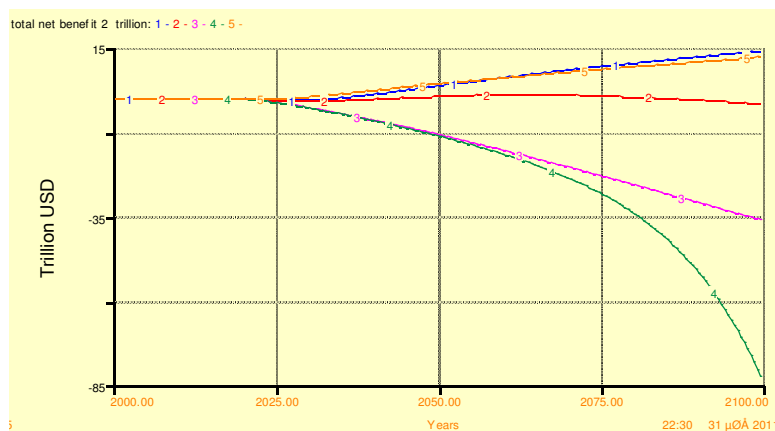


Co-development area will reach the desired area before the base run.

Figure 46: Area in Control

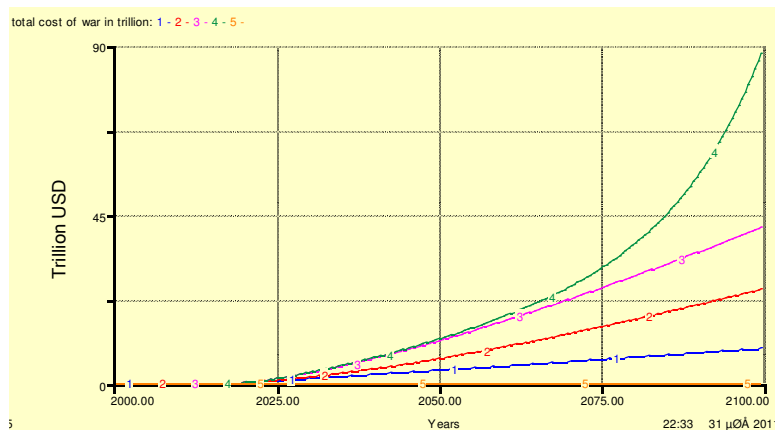
Base run (blue), Scenario3 (red) and Scenorio4 (pink)

Scenarios Comparison



The total net benefit of all scenarios shows that the base scenario (blue) gives the best benefit about 18 trillion USD. The worst benefit is scenario 4 (green); it is minus for 47 trillion USD.

Figure 47: Total Net Benefit for all Scenario, prioritized by number



The cost of war from scenario 3 (green), reach to 87 trillion USD. In contrast, it is 0 for sharing scenario (orange).

Figure 48: Total Cost of War

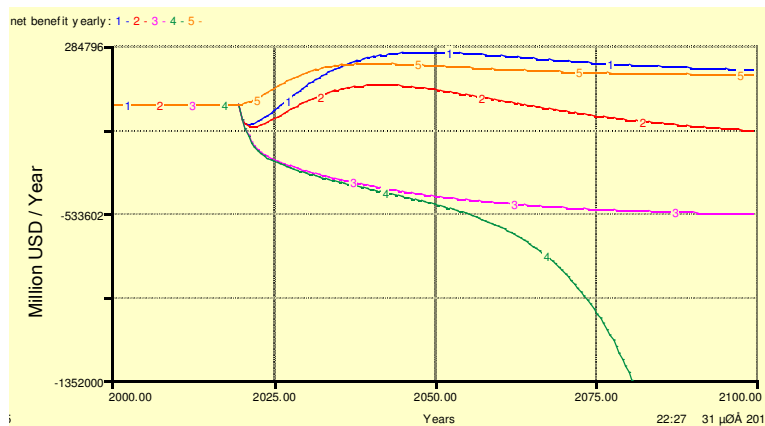


Figure 49: Comparison for All Scenarios, prioritized by number

Net benefit yearly shows the decreasing decreasingly in scenario 3 (green), the others will reach to equilibriums.

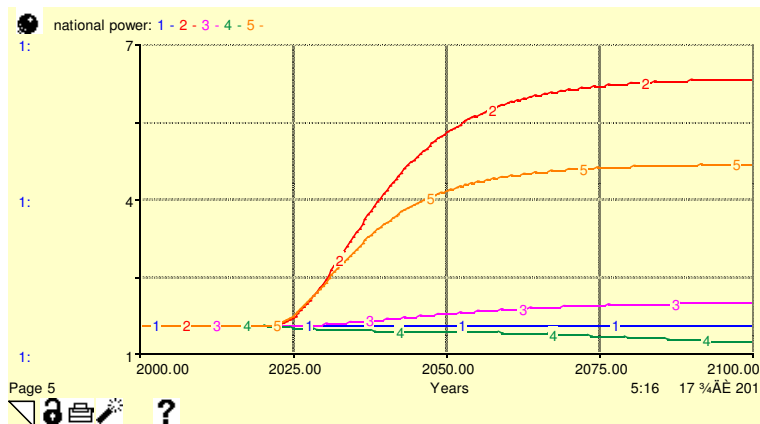


Figure 50: Comparison for National Power

The best National Power is Scenario1 (red). Scenario3 (green) National power get effect in economic, so it decrease under 1. Base scenario (blue) is not included National Power in the model, so it is stable at 1.

Discussion

According to a main purpose of the thesis is to examine the potential war in SCS by simulation SCS war scenarios. The simulation might help to answer the questions such is war an answer for China in SCS? How the situation could be? Are there any alternative solutions beyond the war?

The study results, there are two points of view to be discussed.

1. The generic model and its usability

The model covers mechanism of war as a national strategy. But, in term of the national power element, the model does not cover all relation of each national power element. Only economic and military elements are taken in account. But it is enough for China that can control political and Social-psychological element, so they do not effect to national strategy.

However, the simulation for all scenarios reflect hypothesis of war dynamics and costs, where the boundary are point of adding after-war cost, the point of long term cost-benefit.

2. SCS war implementation

The base scenario reflects environments of conventional security thought which ignores the horizontal relation between each National Power elements, in other words, isolates the issue in front line(battle field) and back line(peace area) absolutely. The scenario bases on the assumption that CH can control other intervention. And the war in SCS is a close system. The result shows the worthwhile of CH to conquer the SCS in long term till year 2100. Even though at the beginning, it might be risky at the lost in net benefit for 6 years approximately. The net benefit is in deficit because the loop of war is stronger than the benefit production. But in the long term, the base case represents the positive benefit. However, as the base scenario is like an experiment in the closed room without any noise to system.

1st scenario (*SCS War and Hidden Cost*) has expanded the frame of conservation security by considering the hidden cost of war which should be accounted. By adding this cost, the result shows that, in short term but longer than the base case, China still has risk of lost benefit. It will get the positive benefit in the middle term. And finally in long term, it lost.

The hidden cost of war is the cost that directs variation to the intensive of war. And it always comes with life time approximated from the life of soldiers who come back from the war and still alive or got injure or became handicap. This cost will start and remain around 40 years. The distinction of this cost can be seen around 10 years after war has started in the simulation. And it makes very big difference comparing to the base scenario. Thus the hidden cost is implied in either term of quantitative and qualitative. Thus the hidden cost is considered as a part of the model.

In the 2nd scenario (*SCS War with Strong Military Resistance*), the result shows that China never gets positive net benefit from the war.

In this scenario, if there is an intervention from 3rd party to support the opponents, the war will be hard to finish. China has to fight with the strong opponents. The lost from war is high meanwhile the benefit is low. There is no point of getting advantage in this situation.

3rd Scenario (*War with Strong Military Resistance and Non-military Resistance*) If the strong opponents happen, the war will be as a major war. There will be effects on world sensitivity. According to the major war will effect on the stability of the area which will decrease the international trade and oil route. The effect of non-military will be considered and

taken in account. The scenario shows that, not only China will lose tremendously at the battlefield, but it also loses in economics.

All the war scenarios seem to be deadlocks, what is the alternative scenario possible? There actually have been many alternative solutions for SCS. However, one of the notable ways is about regional cooperation. For this solution, China and each opponent have to make a negotiation to share the area and the benefit.

The 4th scenario (*Alternative solution by sharing and avoiding war*) shows that China does not get total net benefit as good as the base case because it has to share the benefit with each opponent. However, there is no war happen, so China does not have to waste the budget on war.

From all scenario simulated, the base scenario seem to be the best way for China if it control all factors as in the model. But in the realistic, a lot of the factors are uncontrollable. Thus in term of strategy, the goal of China might have to change; otherwise it has to do every way to manage the risk.

CHAPTER 7 CONCLUSION & FUTURE RESEARCH

*“Victorious Warriors win first and then go to war,
While defeated warriors go to war first and then seek to win”*

Sun Tzu

Systematically consideration, war might not be a good answer for China in SCS. The scenarios from this study have drawn this conclusion by the cost and dynamics of potential war in SCS.

For any war in the world, there have been many misperceptions of wars in the world history. Such misperceptions are war itself and war consequences. The obvious and up to date case is the war on terrorism. First, a very big blunder in estimation of military strategy and operation, by many reasons, the US and allies' forces underestimated of its opponents' capability who led to the war exist longer than their estimation. And second, they (policy makers) also ignored and used misperception of war cost and war dynamics as well.

These two types of misperceptions are very interesting. They actually could be classic cases for reference and studied by System Dynamics. However, *this thesis has been focused on the second misperception which is about cost and dynamics of war.*

The essences gotten from this study can be concluded that

“For China, the most powerful who design the future of SCS, introspection at Costs and dynamics of war is important. Because such issues are widely affect to others issues of the nation. However, lack of systematic consideration about war, led many nations fall in misperceptions of war and still try to start it. This study has exemplified parts of misperception which show directly affects on economic sector; this link has crossed the boundary of war in the battle field to the territory of peace. The consequence of this link will be extended to various elements as un-estimation dynamics.

“Thus war could not be thought in the term of military itself, but it should be scrutinized in the top view of national strategy and the implementation of national power. Otherwise, the win in the battle field by military capability might lead to the lost of the nation”

As Clausewitz concluded that military victories were meaningless unless they were the means to obtain a political end, “those objects which lead directly to peace.” Thus, strategy was

“the linking together of separate battle engagements into a single whole, for the final object of the war.” And only the political or policy level could determine that objective. (Jablonsky 2010)

Finally, this study, there are some points those are excluded and should be challenge to research more.

1. The effect of war on oil price. This relation is still in argument among economists (Stiglitz and Bilmes 2008). However, each war has different conditions, thus for the SCS case, there need to model more about the oil sector to examine that SCS war will increase or decrease the demand of oil and how the oil from SCS support China or the world supply.
2. The effect of war on economic, like the effect on oil price, it might be various to each country. There are some literatures agree that war might soar the GDP. The reason that war increases GDP growth rates in country such the countries that have military industry as the main production. However, this study assumes that SCS war gives negative effect to China GDP as a part of trade sanction from world community. In other words, it can be mentioned from World Bank report 2009 that war will reduce GDP growth rate in average (0.6%). Thus, there need more research that whether China gets positive effect on GDP or not.
3. War and Climate Change, according to war consumes enormously of energy (Karbusz 2006 ; Perrin 2010; Karbusz 2011) Thus it is a source of CO₂ emission as well. A good example that DOD is trying to decrease its energy consumption by promote of alternative energy, efficiency of energy use. The climate change can be measured as cost as well. Moreover, it is a very interesting dynamics effect from war.
4. The complete consideration of National Power elements, the relation between all elements should be included in the model. The advance model including all national power elements will show more justifiable dynamics of war which can be refer to the national strategy.
5. Even this thesis examine for the long run (2000-2100), however it still lacks of consideration about monetary value. Thus, the consideration about real value of present value should be done. This might improve the work complete.

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APPENDIX I

Variables and Information

The data used in model is an important element of model building. The rectified and acceptable data will support the model to be justified and reasonable. In this study there are two main methods concern to data used. Firstly, the information used in the model such as military capability, China trade trend etc. are related to many sources of references. All the rare data is collected as primary information process then it was interpreted in to monetary term. Secondly, to make sure that the model is not much sensitive on the unsure variables, the model is validated in the method of validation.

Military information refer from the world military expenditure database of SIPRI¹; this database does not only present the military expenditure of countries in the world but it also show several papers concern to world and regional military trend. However, the data from SIPRI is decoded to the expenditure in SCS by an assumption from area (sea) size.

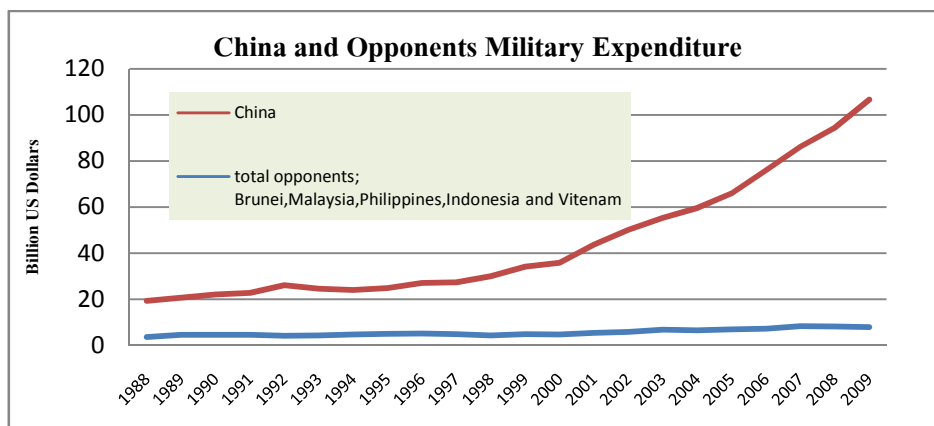


Table 3: China and Total Opponents Military Expenditure

By the data in Table 3, CH initial expenditure in SCS is approximately for 10 percent of its total expenditure. Thus in year 2010 CH military in SCS should be around \$11,000 billion/year.

South China Sea resources approximation this information are mentioned from many sources. However, it must be noted that this data is an important issue, because it effects on the result of net benefit which show the wealthiest of China in the SCS war as well.

AREA	km ^{^2}
SCS total area ²	3,500,000
CH desired area for 80 % of total area	2,800,000
Currently CH control area	350,000

Table 4: Area

Resources in SCS		Value	Unit	comment
OIL	crude oil ³	213	billion barrel	
	CH consumption per year at year	3	bbl per year	Year 2010
	oil price 2010 by IEA	98	\$/bbl	
	Benefit from Oil per area per year	294	\$ billion/area/ year	IEA
Natural Gas	Gas(tcf) ³	2000	Tcf	Trillion Cubic Feet
	Gas (cu m)	5.664E+13	cu m	
	Gas price	150	\$/ kilo cum	Year 2010
	CH consumption of gas ⁴	8.7	Billion CUM	Cubic Meter
	CH income from gas	13.5	\$ billion/year	
	time to finish gas in SCS	651.03	years	
Fishery	Real china fishery value in 2008 ⁵	8.2	\$ billion	
	Estimation income in SCS	32.8	\$ billion / year	
	Benefit from abundant resource area	339.85	\$ billion/year	
	Benefit from devalued area	58.9	\$ billion/year	

Table 5: Resources and Benefit

Benefit per Area per Year	Benefit per Area (\$/Km ^{^2})	Note
Oil Value	105,000	294 \$ billion / 2,800,000 Km ^{^2}
Gas Value	46,428.57	13.5 \$ billion / 2,800,000 Km ^{^2}
Fishery	11,714.29	32.8 \$ billion / 2,800,000 Km ^{^2}
Benefit Abundant area	163,142.9	0.16 \$mil/ Km ^{^2} / Year
Benefit Devalued area	58,142.86	0.06 \$mil/Km ^{^2} / Year

Table 6: Estimated Benefit

Adjustment time	Years	Note
time of CH military in SCS improvement	1	Approximation from annual budget
time of opponents military improvement	2	
time of 3 rd supporting	1.5	
time of non-military effect	1	
Time of after-war cost effecting	40	Age of veterans
Time of area depreciation	20	At current consumption, oil in SCS can support for 20 years

Timeline: Disputes in the South China Sea (SCS)

Source : *The Singapore Institute of International Affairs (SIIA 2011)*

19 July 2011 The South China Sea dispute is a key topic of discussion at the ASEAN Regional Forum in Bali. Indonesian President expresses frustration over the drawn-out nature of the talks and urges foreign ministers to accelerate negotiations and finalize guidelines. The Philippines announces that it will send five congressmen to the disputed Spratly Islands to support its territorial claims; China says the trip "serves no purpose but to undermine peace and stability in the region and sabotage the China-Philippines relationship."

17 July 2011 A small group of Vietnamese march to denounce China's actions despite a police crackdown.

15 July 2011 Vietnam and US launch a series of naval exchanges. The exercises are confined to noncombat training and are stressed by the US to be part of routine exchanges that were planned months in advance. China deems the timing of the exercises "inappropriate," saying they should have been rescheduled.

14 July 2011 Armed Chinese soldiers allegedly beat a Vietnamese fisherman and threaten other crew members before driving them out of waters near the contested Paracel Islands.

13 July 2011 The Philippines states that China's refusal to allow a UN-backed tribunal to rule on the territorial dispute indicates that Beijing's claim stands on shaky legal ground.

11 July 2011 American and Chinese military chiefs argue about US exercises in the SCS; Chinese army chief says the US military exercises with the Philippines and Vietnam were "extremely inappropriate". The US remains committed to maintaining its presence in the Sea.

9 July 2011 The US, Japanese and Australian navies hold a joint drill in the SCS, Japan's first joint military exercise in the territory.

6 July 2011 The Philippines' Foreign Secretary Alberto Rosario visits China to seek a diplomatic solution. He calls for the dispute to go before a UN tribunal, but China rejects the proposal. The two countries agree "not to let the maritime disputes affect the broader picture of friendship and cooperation of the two countries."

3 July 2011 About 100 anti-China protesters march peacefully in Vietnam, denouncing China's actions in the Sea, despite a heavy security clampdown.

28 June 2011 The US and the Philippines begin routine naval drills near the SCS.

27 June 2011 The US Senate unanimously passes a resolution condemning China's use of force in the SCS, urging a peaceful, multilateral solution. China rejects the resolution, saying that the disputes should only be resolved through negotiations between claimants and maintaining that it has "indisputable sovereignty" over the entire Sea.

26 June 2011 China and Vietnam agree to hold talks and resolve the territorial dispute. China reports a pact with Vietnam to resolve the conflict through "negotiations and friendly consultations," though no detail is provided on how these negotiations will take place.

25 June 2011 The US calls for China to cool tensions over the disputed territory and reiterates its commitment to defending its longtime ally, the Philippines. China rejects this call, telling the US to stay out of its regional disputes.

23 June 2011 The Philippines says it hopes to lease naval equipment from the US in the face of rising friction with China.

18 June 2011 The US and Vietnam jointly call for freedom of navigation and rejects the use of force in the SCS.

13 June 2011 Vietnam holds live-fire drills in the SCS. Anti-China protests break out in Hanoi, as more than 100 people demonstrate against what they see as bullying behaviour by Beijing. Taiwan, which claims the Spratlys, Paracel and Pratas islands in its constitution, mulls strengthening its presence in the area by sending missile boats.

12 June 2011 Anti-China rallies continue in Ho Chi Minh City and Hanoi for a second straight weekend. Vietnam seeks US support in the dispute.

9 June 2011 Vietnam reports that a Chinese fishing boat, supported by Chinese naval patrols, cut a cable being used by a craft operated by state-run energy company PetroVietnam. Vietnam says the ship was operating over its continental shelf and within its exclusive economic zone.

8 June 2011 China steps up its criticism of the Philippines, calling on Manila to stop infringing its sovereignty with claims over the SCS.

5 June 2011 The SCS dispute dominates discussion at the Shangri-La Dialogue in Singapore. Vietnam confirms that it holds China responsible for the 27 May incident, while China commits itself to maintaining peace and stability in the Sea. US Defense Secretary Robert Gates warns that “there will be clashes” in the Sea unless multilateral mechanisms are strengthened.

1 June 2011 Manila reports that Chinese navy boats erected pillars and set unloaded materials near Amy Douglas Bank inside the Philippines’ exclusive economic zone.

28 May 2011 China criticizes Vietnam for its offshore exploration of oil and gas in the Sea.

27 May 2011 Chinese patrol boats cut the cables of a Vietnamese ship while performing an underwater survey of the SCS. Vietnam accuses China of violating its sovereignty and a 1982 UN convention on the law of the sea, while China argues that Vietnam’s oil and gas operations have undermined China’s interests and rights in the area.

13 April 2011 The Philippines states that Beijing’s stance on the disputed areas in the Sea have no basis under international law.

28 March 2011 The Philippines announces its increase in air and naval patrols and its plans to upgrade an airstrip on an island it occupies in the SCS.

4 March 2011 The Philippines reports that two Chinese patrol boats threatened to ram a survey ship near the Reed Bank

23 July 2010 China is angered after the United States takes up the issue of disputes in the SCS at a regional forum.

March 2005 Oil companies from China, Vietnam and the Philippines sign a deal to jointly protect oil and gas resources in the Sea.

May 2003 Vietnam issues a “sovereignty” declaration on the Chinese ban on fishing in the SCS, claiming that Vietnam has rights to the Paracel and Spratly Islands.

November 2002 China and ASEAN adopt the Declaration on the Conduct of Parties on the SCS, setting the stage for possible commercial cooperation and long-term stability.

2000 In May, Chinese and Philippine foreign ministers agree to “contribute positively toward the formulation and adoption of the regional Code of Conduct in the SCS.” In December, Vietnam and China sign two agreements to resolve long-standing territorial disputes over the Gulf of Tonkin.

1995 China and the Philippines have a conflict in Mischief Reef, signaling China’s aggression toward nations besides Vietnam in the SCS. In August, the Philippines and China reject the use of force to settle their disputes; the Philippines and Vietnam negotiate a similar creed in November.

1994 China distributes a map claiming the entire SCS, including all the Spratly Islands.

1992 China lands forces on Da Ba Dau reef near Vietnam’s claims in Sin Cowe East, triggering a small military skirmish between the two powers. Amid mounting criticism, China offers to negotiate Spratly disputes and reiterates its pledge not to use force.

1991 China passes the Law on Territorial Waters and Their Contiguous Areas, formalizing its claim to the Paracel and Spratly Islands. Indonesia organises a meeting for the six claimants to the Spratly Islands to find a peaceful solution. At the meeting, China and other countries along the SCS agree to resolve differences peacefully and to avoid unilateral actions that would increase tension.

1988 China and Vietnam fight a naval battle just off the Spratly Islands in March.

1978 Philippine President Ferdinand Marcos claims the entire territory as part of the Philippines, redrawing the country's map.

1975 South Vietnam occupies part of the Spratly Islands.

1974 In January, Chinese military units seize islands in the Paracels, occupied by South Vietnamese armed forces, and China claims sovereignty over the Spratlys.

1951 Japan renounces all rights to the Spratly Islands. No resolution is made on who owns them.

1947 The Philippines claims some of the eastern Spratly Islands and the Scarborough Reef.

1946 China declares the Spratlys as part of Guangdong province.

1939 The Spratly Islands are invaded and occupied by Japan during the Second World War.

1885 China officially claims all the Spratly Islands.

200-300BC China first discovers the Spratly Islands and other islands in the SCS, and begins to occupy and govern them.

Equations

Sector 1 : SCS war

$mili_spp_from_3rd_parties(t) = mili_spp_from_3rd_parties(t - dt) + (mili_spp_rate - mili_spp_depreciative_rate) * dt$
 INIT mili_spp_from_3rd_parties = 0
 INFLOWS: mili_spp_rate = if scenarios=3 or scenarios=4 then (net_forces_in_SCS - mili_spp_from_3rd_parties)*policy_of_3rd_spp/time_of_3rd_spp else 0
 OUTFLOWS: mili_spp_depreciative_rate = mili_spp_from_3rd_parties*actual_lost_of_opponents_in_scs
 $opnt_capability_in_scs(t) = opnt_capability_in_scs(t - dt) + (opnt_increase_rate - opnt_depreciative_rate) * dt$
 INIT opnt_capability_in_scs = 20000
 INFLOWS: opnt_increase_rate = if time >= war_start_time then opnts_forces_desired_in_SCS/adj_time_of_opn_mili_improvement else 0
 OUTFLOWS: opnt_depreciative_rate = opnt_capability_in_scs*actual_lost_of_opponents_in_scs
 $relative_growth_of_ch_mili_in_scs(t) = relative_growth_of_ch_mili_in_scs(t - dt) + (incrs_rate_of_ch_utl_in_scs - dcrs_rat_of_ch_utl_in_scs) * dt$
 INIT relative_growth_of_ch_mili_in_scs = sch_mili_normal_policy_in_scs
 INFLOWS: incrs_rate_of_ch_utl_in_scs = if improvement_desired_of_CH_mili_in_SCS=relative_growth_of_ch_mili_in_scs then 0 else (improvement_desired_of_CH_mili_in_SCS - relative_growth_of_ch_mili_in_scs)/time_of_ch_military_improvement
 OUTFLOWS: dcrs_rat_of_ch_utl_in_scs = if scenarios=5 or incrs_rate_of_ch_utl_in_scs > 0 then 0 else if national_power < 1 then 0*(1-national_power)*relative_growth_of_ch_mili_in_scs else 0
 $actual_lost_of_ch_in_scs = lost_from_war * opnt_forces_operation_in_scs * possibility_of_ch_lost$
 $actual_lost_of_opponents_in_scs = if\ time \geq\ war_start_time\ then\ lost_from_war * possibility_of_opnt_lost\ else\ 0$
 adj_time_of_opn_mili_improvement = 2
 $ch_capabity_i_n_scs = if(\text{sharing_policy}=1) \text{ and } time \geq war_start_time \text{ then } ((relative_growth_of_ch_mili_in_scs * Ch_mili_base_capabity)) \text{ else } (relative_growth_of_ch_mili_in_scs * Ch_mili_base_capabity/3)$
 $ch_force_operation_in_scs = if((scenarios=5) \text{ or } time < war_start_time) \text{ then } 0 \text{ else if } objective_area = 0 \text{ then } 0 \text{ else if } SWITH_GDP_or_not = 1 \text{ then } ch_capabity_i_n_scs \text{ else } determined_by_GDP$
 $Ch_mili_base_capabity = FV_Fnct * Ch_mili_base_in_scs$

```

Ch_mili_base__in_scs = if time >=2900 then 0 else 13300
ch_normal_area = 350000
cost_of_area_protection = if sharing_policy<2 then
((occupation__area_in_scs/350000)*sch_mili_normal__policy_in_scs)*cut__area_protection__loop_test else
((occupation__area_in_scs/350000)*sch_mili_normal__policy_in_scs/3)*cut__area_protection__loop_test
cost_to_conquer = if objective__area=0 then 0 else if (time>=war_start_time and ch_force__operation_in_scs>0) then
((objective__area/ch_normal_area)*sch_mili_normal__policy_in_scs)+(superiority_need*opnt_forces__operation_in_scs/ch_for
ce__operation_in_scs) else 0
cut__area_protection__loop_test = 0
determined_by_GDP = CH_AT_WAR_GDP*percentage_at_war*relative_growth_of_ch_mili_in_scs
forces_ratio__ch_and_opn = if(opnt_forces__operation_in_scs=0) then 0.0000001 else
ch_force__operation_in_scs/opnt_forces__operation_in_scs
FV_Funct = ((1+0.00)^(time-war_start_time))
improvement_desired_of_CH_mili_in_SCS = if cost_to_conquer = 0 then
0+(cost_of_area_protection*sch_mili_normal__policy_in_scs)
else(((cost_of_area_protection*sch_mili_normal__policy_in_scs)+(cost_to_conquer*sch_mili_normal__policy_in_scs*1)+sch_
mili_normal__policy_in_scs))
net_forces__in_SCS = if (ch_force__operation_in_scs-opnt_forces__operation_in_scs<0) then 0 else
ch_force__operation_in_scs-opnt_forces__operation_in_scs
opnts_forces_desired_in_SCS = Min((percentage__normal_opnt_mili_in_scs*opnt_mili_streng),
(ch_force__operation_in_scs-opnt_capability__in_scs))
opnt_forces__operation_in_scs = if ch_force__operation_in_scs=0 then 0 else
(opnt_capability__in_scs+mili_spp__from_3rd_parties)*1
percentage_at_war = 0.05
percentage__normal_opnt_mili_in_scs = 0.05
policy_of_3rd_spp = if superiority_of_Ch_in_SCS>5 then 1 else 1
sch_mili_normal__policy_in_scs = 1
superiority_need = 5
superiority_of_Ch_in_SCS = if time<war_start_time then 0 else if ((opnt_forces__operation_in_scs = 0 )) then 999 else
ch_force__operation_in_scs/opnt_forces__operation_in_scs
SWITH_GDP_or_not = 1
time_of_ch__military__improvement = 1/national_power
time_of_3rd_spp = 1.5
war_start_time = 2020
effect_of_war_on_world_community = GRAPH(if (ch_force__operation_in_scs=0) then 0 else
ch_force__operation_in_scs/opnt_forces__operation_in_scs)
opnt_mili_streng = GRAPH(TIME)
posibility_of_ch_lost = GRAPH(forces_ratio__ch_and_opn)
posibility_of_opnt_lost = GRAPH(forces_ratio__ch_and_opn)

```

Sector 2: Area and Benefit

```

abundant__resources_area(t) = abundant__resources_area(t - dt) + (use_rate - depretiation__rate) * dtINIT
abundant__resources_area = 0

```

INFLOWS: use_rate = gap_on_in_use/time_of_area_being_used
 OUTFLOWS: depretiation__rate = abundant__resources_area/depretiation_of_area
 devalue_area(t) = devalue_area(t - dt) + (depretiation__rate) * dtINIT devalue_area = 0
 INFLOWS: depretiation__rate = abundant__resources_area/depretiation_of_area
 occupation__area_in_scs(t) = occupation__area_in_scs(t - dt) + (ch_cq_rate) * dtINIT occupation__area_in_scs = 0
 INFLOWS: ch_cq_rate = if time__to_conquer>100 then 0 else objective__area/time__to_conquer
 abundant_resources_area_production = .2*FV_of_oil
 adj_time_for_sharing = 5
 adj_time_to_use_in_sharing = 5
 benefit_from__SCS = if sharing_policy=2 then
 ((abundant__resources_area*abundant_resources_area_production)+(devalue_area*devalue_area_production))/2 else
 ((abundant__resources_area*abundant_resources_area_production)+(devalue_area*devalue_area_production))
 ch__scs_desired_area = desired_area*policy_function
 depretiation_of_area = 20
 desired_area = 2800000
 devalue_area_production = .1*FV_of_oil
 FV_of_oil = if FV_Funct > 1 then ((1+0.00)^(time-war_start_time)) else 1
 gap_on_in_use = (occupation__area_in_scs*1)-abundant__resources_area-devalue_area
 objective__area = ch__scs_desired_area-occupation__area_in_scs
 policy_function = if (policy_to_war=1 or sharing_policy=2) and (time>=war_start_time) then 1 else if policy_to_war=0
 then 0 else 0
 time_of_area_being_used = if (sharing_policy=2)then 5 else if superiority_of_Ch_in_SCS=999 then 10000000000 else if
 (superiority_of_Ch_in_SCS) >=5 and sharing_policy=1 then effect_of_superiority_on_time_to_use_area else if
 (sharing_policy=2) then adj_time_to_use_in_sharing else effect_of_superiority_on_time_to_use_area
 time__to_conquer = if(sharing_policy=2)then adj_time_for_sharing else if superiority_of_Ch_in_SCS=999 then
 1000000000000 else effect_of_superiority__on_time_to_conquer
 effect_of_superiority_on_time_to_use_area = GRAPH(superiority_of_Ch_in_SCS)
 effect_of_superiority__on_time_to_conquer = GRAPH(superiority_of_Ch_in_SCS)

Sector 3: Non-military effect

CH_AT_WAR_GDP(t) = CH_AT_WAR_GDP(t - dt) + (CH_GDP_AT_War__Growth_rate) * dtINIT
 CH_AT_WAR_GDP = 55000
 INFLOWS: CH_GDP_AT_War__Growth_rate = (CH_AT_WAR_GDP*((CH_GDP__Growth_Fraction*(1-
 effect_of_non_military_effect_on_ch_economic))+effect_of_scs_benefit_on_gdp_growth))
 CH_normal_GDP(t) = CH_normal_GDP(t - dt) + (CH_GDP__normal__Growth_rate) * dtINIT CH_normal_GDP = 55000
 INFLOWS: CH_GDP__normal__Growth_rate = CH_normal_GDP*CH_GDP__Growth_Fraction
 Non_military_effect(t) = Non_military_effect(t - dt) + (non_mili_effct_rate) * dtINIT Non_military_effect = 0
 INFLOWS: non_mili_effct_rate = if (gap_of__non_military_effect>0) then
 (gap_of__non_military_effect/adj_time_of__non_mili_effct_active) else 0
 adj_time_of__non_mili_effct_active = 2, CH_GDP__Growth_Fraction = 0.07
 effect_of_non_military_effect_on_ch_economic = Non_military_effect
 effect_of_scs_benefit_on_gdp_growth = benefit_from__SCS/CH_AT_WAR_GDP
 gap_of__non_military_effect = potential__non_mili_effct-Non_military_effect

lost_of_CH_GDP = if CH_GDP_AT_War_Growth_rate > CH_GDP_normal_Growth_rate then 0 else
 CH_GDP_normal_Growth_rate - CH_GDP_AT_War_Growth_rate
 potential_non_mili_effect = if (time-war_start_time >= 0) then
 effect_of_war_on_world_community * non_mili_effect_function * (1/national_power) else 0
 relative_economic = CH_AT_WAR_GDP / CH_normal_GDP

Sector 4 : Cost Benefit Sector

after_war_cost(t) = after_war_cost(t - dt) + (after_war_cost_rate - after_war_dcrs_rate) * dt
 after_war_cost = 0
 INFLOWS: after_war_cost_rate = ch_force_operation_in_scs * fraction_of_after_war_cost
 OUTFLOWS: after_war_dcrs_rate = after_war_cost / life_time_of_after_war_in_effect
 total_net_benefit_2(t) = total_net_benefit_2(t - dt) + (all_net_benefit_rate) * dt
 total_net_benefit_2 = 0
 INFLOWS: all_net_benefit_rate = net_benefit
 fraction_of_after_war_cost = if scenarios=1 then 0 else .08
 life_time_of_after_war_in_effect = 40
 net_benefit = sc_benefit_yearly - sc_cost_yearly
 sc_benefit_yearly = benefit_from_SCS
 sc_cost_yearly = if scenarios=1 then ch_force_operation_in_scs + actual_lost_of_ch_in_scs else if scenarios=2 or
 scenarios=3 then ch_force_operation_in_scs + actual_lost_of_ch_in_scs + after_war_cost else if scenarios=4 or scenarios=5
 then ch_force_operation_in_scs + actual_lost_of_ch_in_scs + lost_of_CH_GDP + after_war_cost else 0
 total_net_benefit_2_trillion = total_net_benefit_2 / 1000000

Sector 5: National Power Sector

economic = relative_economic
 military = 1
 national_power = ((military*3) + (economic*2)) / 5 * ((political + social_psychological) / 2) else 1
 political = 1, social_psychological = 1

APPENDIX II

Chapter 1

¹ The territory disputes are in many parts of SCS among the regional nations such China and Philippines, Malaysia, Brunei, Indonesia, Vietnam, Thailand, Singapore and Cambodia. However, Singapore, and the two states of the Gulf of Thailand, Thailand and Cambodia, are not involved in the South China Sea conflict proper since they do not have claims to the disputed islands in the central part of the South China Sea. Cambodia claims, however, an exclusive economic zone (EEZ) in the Gulf of Thailand which overlaps with the Thai and Vietnamese EEZs. See. Kivimäki, T. (2002). War or peace in the South China Sea? Copenhagen, NIAS.

² The Association of Southeast Asian Nations, or ASEAN, was established on 8 August 1967 in Bangkok, Thailand by the Founding Fathers of ASEAN, namely Indonesia, Malaysia, Philippines, Singapore and Thailand. Brunei Darussalam then joined in 1984, Viet Nam in 1995, Lao PDR and Myanmar in 1997, and Cambodia in 1999, making up today the ten Member States.

³ Oxford Dictionary defines "Arms Race" as a *competition between nations for superiority in the development and accumulation of weapons*. See. <http://oxforddictionaries.com/definition/arms+race>

It was originally used to describe a competition between two or more parties for the best armed forces. Each party competes to produce larger numbers of weapons, greater armies, or superior military technology in a technological escalation. Nowadays the term is commonly used to describe any competition where there is no absolute goal, only the relative goal of staying ahead of the other competitors, essentially the goal of proving to be "better". See. http://en.wikipedia.org/wiki/Arms_race

⁴ *National Power*; each country uses its power such diplomatic, informational, military, and economic (DIME) instruments of national power to influence other nations to benefit back to itself. It can define national power in term of physical term and psychological term as well. By this war, diplomatic and information are psychological, military and economic are physical. National power represents the will of nation from psychological term and it represents the means available from physical term. The use of military component is war.

Elements of National Power

“Power is the ability to influence the behavior of others to get a desired outcome. Historically, power has been measured by such criteria as population size and territory, natural resources, economic strength, military force, and social stability. Hard power enables countries to wield carrots and sticks to get what they want. [...] Soft power is the ability to attract people to our side without coercion.” See. Armitage, R. L. and S. N. Joseph (2007). "CSIS Commission on Smart Power: A Smarter, More Secure America." Center for Strategic & International Studies.

⁵ In 1982, the U.N. adopted the United Nations Convention on the Law of the Sea (UNCLOS) in an effort to peacefully settle disputes over maritime matters. Despite several oversights, UNCLOS remains the most recognizable document regarding maritime disputes. Within UNCLOS, three sections are generally recognized as being most relevant to the South China Sea dispute. Article 3 states: Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles, measured from the baselines determined in accordance with this convention.

See. Nations, U. (1982). "United Nations Convention on the Law of the Sea ". 2010, from http://treaties.un.org/Pages/ViewDetailsIII.aspx?&src=TREATY&mtdsg_no=XXI-6&chapter=21&Temp=mtdsg3&lang=en.

⁶ Exclusive Economic Zone (EEZ) is a seazone over which a state has special rights over the exploration and use of marine resources, including production of energy from water and wind. It stretches from the seaward edge of the state's territorial sea out to 200 nautical miles from its coast. In casual usage, the term may include the territorial sea and even the continental shelf beyond the 200-mile limit.

See. Nations, U. (1982). The United Nations Convention on the Law of the Sea. U. Nations, Division for Ocean Affairs and the Law of the Sea, Office of Legal Affairs, United Nations.

⁷ Oxford Dictionaries Online defines many terms of war

I. a state of armed conflict between different countries or different groups within a country

II. a state of competition or hostility between different people or groups

III. a sustained campaign against an undesirable situation or activity

See. Oxford.Dictionaries.Online.project (2011). Oxford Dictionaries Online. O. D. O. p. team, Oxford University Press.

⁸ An ancient Chinese military general authored *The Art of War*, an influential ancient Chinese book on military strategy. He has had a significant impact on Chinese and Asian history and culture, his work has continued to influence both Asian and Western culture and politics.

⁹ Carl von Clausewitz is widely acknowledged as the most important of the major strategic theorists.

¹⁰ An English soldier, military historian and leading inter-war theorist, said that “*Grand strategy should both calculate and develop the economic resources and man-power of nations in order to sustain the fighting services. Also the moral resources—for to foster the people’s willing spirit is often as important as to possess the more concrete forms of power. Grand strategy, too, should regulate the distribution of power between the services, and between the services and industry. Moreover, fighting power is but one of the instruments of grand strategy—which should take account of and apply the power of financial pressure, of diplomatic pressure, of commercial pressure, and, not the least of ethical pressure, to weaken the opponent’s will....Furthermore, while the horizon of strategy is bounded by the war, grand strategy looks beyond the war to the subsequent peace. It should not only combine the various instruments, but so regulate their use as to avoid damage to the future state of peace—for its security and prosperity. The sorry state of peace, for both sides, that has followed most wars can be traced to the fact that, unlike strategy, the realm of grand strategy is for the most part terra incognita—still awaiting exploration, and understanding” See. Bartholomees, D. J. B. (2010). ""Theory of War and Strategy."." *Issues I*.*

¹¹ The theory of victory is and must be distinct from the theory of war. Security professionals need to think systematically about winning. The implication is that military victory (tactical or operational victory) without favorable political outcomes is sterile... It certainly is from the point of view of the tactical commander—the view from the perspective of the operational or strategic commander might be quite different. It is this characteristic that allowed Saddam Hussein to claim victory after the First Gulf War. He suffered a huge tactical and operational loss, but his regime had survived (his strategic objective after the coalition intervened). The war was thus a strategic win for him—at least in his eyes and from his perspective. This again suggests the issue of who decides who wins and loses, which we will address later.

¹² This website is an initiative of [Oxford Research Group](#) (ORG) and represents one part of a larger programme, "Moving towards sustainable security" begun in 2006, intends to be an important platform for promoting a better understanding of the real

threats to global security in the 21st century and the policies that should be implemented to address those threats at their root cause.

¹³ “*as the dynamics of world, the environmentally constrained but more populous world...there will be greater scarcity of three key resources: food, water and energy. Demand for all three resources is already beyond that which can be sustained at current levels...competition for such resources should be expected, both within and between countries, potentially leading in extreme cases to conflict*”.

¹⁴ National Power; each country uses its power such diplomatic, informational, military, and economic (DIME) instruments of national power to influence other nations to benefit back to itself. It can define national power in term of physical term and psychological term as well. By this war, diplomatic and information are psychological, military and economic are physical. National power represents the will of nation from psychological term and it represents the means available from physical term.

The use of military component is war.

¹⁵ The human and economic costs of these wars will continue for decades, some costs not peaking until mid-century. Many of the wars’ costs are invisible to Americans, buried in a variety of budgets, and so have not been counted or assessed. For example, while most people think the Pentagon war appropriations are equivalent to the wars’ budgetary costs, the true numbers are twice that, and the full economic cost of the wars much larger yet. Conservatively estimated, the war bills already paid and obligated to be paid are \$3.2 trillion in constant dollars. A more reasonable estimate puts the number at nearly \$4 trillion.

¹⁶ refer to US Defense Energy Support Center Fact Book 2004, the US military fuel consumption increased to 144 million barrels, it is 40 million barrels more than the average peacetime usage and the 395 000 barrels per day almost as much as daily energy consumption of Greece. See. Karbuz, S. (2006 Feb 25). "The US military oil consumption." from <http://www.energybulletin.net/node/13199>.

¹⁷ The U.S. military energy consumption accounts for 80 percent of U.S. government use (government energy use is 2% of the total use of nation). By setting official price at \$3.03, but including the logistic, the cost can be as \$50 a gallon.

¹⁸ “Military operations are major industrial activities that use massive amounts of fuel and materials that significantly contribute to climate change... Military security for protection of global maritime petroleum distribution is part of the acquisition process, but in addition, recent Middle Eastern wars may also be related to securing petroleum reserves”.

¹⁹ Energy consumed per active duty military and civilian personal is 35 percent higher than the U.S. energy consumption per capita, which is amongst the highest in the world. While consuming that amount of energy, DoD emitted 73 million metric tons of CO₂, corresponding to over 4 percent of the total emissions in USA... The U.S. is the strongest military power in the world and just like any other military in the world, energy, in particular energy derived from oil, is at the heart of that power. Oil accounts for nearly 80 percent of total DoD energy consumption, followed by electricity (11 percent), natural gas and coal.

²⁰ IPB because is the primary mechanism a commander uses to develop his mental vision of how an operation will unfold. The four steps of the IPB are defined the battlefield environment, describe the battlefield effects, evaluate the threat, and determine enemy courses of action. The standard products of the IPB process include modified combined obstacle overlay, situation template, and event template. See. Thomas M. Smith, L. C. and M. David G. Puppolo (2011). "IPB with a Purpose." Military Intelligence Professional Bulletin from http://findarticles.com/p/articles/mi_m0IBS/is_2_27/ai_80772560/.

Chapter 3

¹ Clausewitz pointed out that war is both a physical and moral struggle. His recipe for victory was simple: “If you want to overcome your enemy you must match your efforts against his power of resistance, which can be expressed as the product of two inseparable factors, viz. *the total means at his disposal* and *the strength of his will*.” (italics in original) One can express that as a mathematical formula:

$$\mathbf{R} = \mathbf{M} \times \mathbf{W}$$

In the formula, **R** represents the power of resistance, **M** is the total means available, and **W** is the strength of will. Victory then is achieved as **R** approaches zero; that is, as the power of resistance drops to an ineffective level. One can push **R** toward zero by reducing either **M** or **W** (or both). In some respects one might think of a strategy designed to attack the **M** aspect of the equation as a physical approach and a strategy designed to address the **W** aspect as psychological, although making such a distinction too starkly can be dangerous since both elements will appear in any strategy. The traditional concept of winning a war is based on reducing the enemy’s means of resistance.

See, J. Boone Bartholomees, j. (2010). "A THEORY OF VICTORY." U.S. Army War College Guide to National Security Issues I: 89.

Chapter 4

² War and resources price

Despite many scholars justify that war and resources price is related to each other. However, in this study, such relation is excluded by the reason that the disputes in SCS are potential sources which have not produced any supply to the world market yet, even the war might increase the demand of oil but for a short time it will make more supply, thus it will not disturb world supply in the long term.

³ China's GDP and its military expenditure?

In this study, there might be some questions about the relationship between GDP and military expenditure. There are two reasons that the relation is excluded.

First, the capability of CH and Opponents is very different; it can be considered that CH's GDP is abundant compare to its opponent. So, a very small part of its GDP is used in SCS occupation, which roughly calculated around 0.005 percent of GDP. SO, the change of CH GDP does not affect much in CH military expenditure in SCS. For the technical explanation of this reason can see in Model Validation, section Model adequacy.

Second, imitation from the super power war like the US's war, the budget invested at war can be from other source, so it means that even the GDP distinctly affects on military expenditure, but if the nation will is at war, the budget can be gain in term of borrow or mobilized from other parts. Thus it does not affect in military budget whether there is strongly decreasing in GDP or not. Moreover, at war, the nation must set the priority to military section for example about oil consumption as a report from Office of Under Secretary of Defense says "Because DOD's consumption of oil represents the highest priority of all uses, there will be no fundamental limits to DOD's fuel supply for many, many decades." This present the government can mobilize all budgets to support military at war time. See. Karbuz, S. (2006 Feb 25). "The US military oil consumption." from <http://www.energybulletin.net/node/13199>.

⁴ Beijing reiterated its assertion of control over some 80 percent of the South China Sea and all the islands and reefs in a U-shaped claim extending deep into the maritime heart of Southeast Asia.

See. Richardson, M. (2011, April,3 2011). "Beijing's troubling South China Sea policy." Retrieved May,27, 2011, from <http://search.japantimes.co.jp/cgi-bin/ea20110428mr.html>.

⁵ The increasing of opponents' forces operation in SCS will change according to the principal of 5:1 in naval warfare. "Current military doctrine calls for a 5-to-1 attacker to defender ratio for amphibious assaults". see Moore, F. W. (2000). "China's Military Capabilities".

⁶ The calculation in this part is done by the difference between China normal GDP growth rate approximated 8 percent per year subtract with at war GDP growth rate.

⁷ Estimated from the 10% of China military annual budget in year 2010(SIPRI)

¹ According to Virtual Library South China Sea, the area of SCS is around 3,500,000 sq km²
See, Rosenberg, D. (2010, June 15, 2010). "the Asian Studies WWW Virtual Library South China Sea." from <http://www.southchinasea.org/why.html>.

² This is approximation by the U.S. war on terror which is around 1%. However, SCS war will be a naval warfare, so the veteran should be lower than land warfare.

¹ Stockholm International Peace Research Institute. See. Stockholm International Peace Research Institute. (2010). SIPRI yearbook 2010 : armaments, disarmaments and international security. Oxford, Oxford University Press.

² According to Virtual Library South China Sea. See. Rosenberg, D. (2010, June 15, 2010). "the Asian Studies WWW Virtual Library South China Sea." from <http://www.southchinasea.org/why.html>.

³ The total for the South China Sea could be as high as 213 billion barrels... estimates that the entire South China Sea contains more than 2,000 Tcf of natural gas resources.

See. Globalsecurity.org (2010, 11-07-2011 07:29:48). "South China Sea Oil and Natural Gas." Military. from <http://www.globalsecurity.org/military/world/war/spratly-oil.htm>.

⁴ Natural Gas Units & Online Calculator. See. <http://www.natgas.info/html/natgasunitscalculator.html>

⁵ UN global environment facility(GEF) See. <http://www.fao.org/docrep/013/i1820e/i1820e.pdf>