Research on make or buy decision making strategy using system dynamics:
Focused on Korea's military improvement project

Choi, Jeong-Hwan

(Ph.D Student, Seoul National University, Korea, jhchoi@temep.snu.ac.kr)

Lee, Jeong-Dong

(Professor, Seoul National University, Korea, leejd@snu.ac.kr)

Ko, Seong-Pil

(Ph.D Student, Seoul National University, Korea, koerti977@temep.snu.ac.kr)

Abstract

Strategic decision about way of execution of military improvement project is a very important decision for future security. Although strategic decision is so important, way of decision has been done by one-way thinking framework. This research provide a policy decision making leverage in order to confirm dynamic change of military R&D, which is way of execution of military improvement project from make or buy decision making point of view., Results of research are as follows. If the ratio of military R&D investment is under 38%, military capability index from military R&D investment can't overtake increasing effect from foreign purchases in the whole life cycle, so easy to be restricted by another country. From this research, we can confirm appropriate ratio between military R&D and foreign purchases by short term or long term military security strategy and effect of increasing military power, therefore the result is expected to be used when the government want to execute military improvement project properly.

Keywords: make or buy decision making, military R&D, military improvement project

Ⅰ. Introduction

1. Background

There are various circumstances changed rapidly and the firm is exposed to these kind of circumstances to choose the efficient strategy. Among these circumstances, strategic decision which the firm faced make or buy decision making is the most general and important choice that the firm should cope with. The reason why these kind of strategic decision is so difficult is that both of selection plays an important role as a strategic method to minimize the cost from cost perspective because such uncertainties have always existed and have an influence on not only core competency the firm is faced currently but also core competency the firm pursue for future survival viewed in the core competency. So research on the make or buy decision making have been studied for a long time. But make or buy decision making is not the only problem the firm is faced. The nation named as a big firm is composed of people and many things, those are many buildings and organizations so on. Defense area have also difficult in doing these kind of tough question. With respect to the direction for the strategic pathway defense area should consider many aspects than the firm have done. The research on the make or buy decision making have been widely studied from perspective for firm but make or buy decision making for strategic selection of defense area have not been studied compared to research on the firm. And the research areas have been studied were just focused on the qualitative analysis and military R&D is one-sided of possessing strong military power.

Also the defense area has been always exposed to the circumstances changed rapidly and variously same like the firm did.

Because Korea is the only country left as a divided country in the world and geopolitical peculiarities surrounded by many power countries like Russia, Japan and China, the serious circumstances Korea have been exposed was remained as a significant problem. Owing to these kinds of reasons large portion of government budget have been assigned to a defense budget and have coped with against potential threat. 14.7% of government budget was assigned to a defense budget in 2010.

A defense budget is composed of budget for military capability and budget for defense capability improvement, that is the former is the cost to maintain current military capability the latter is the cost to maintain higher iron-tight defense posture than before.

31% of government budget is assigned to budget for defense capability improvement in Korea and the procurement plan for defense capability improvement is divided into direct supply using military R&D and foreign purchases. Military R&D is defined as a way of manufacturing, supplying weapon system and designing system from defense contractor like ADD and so on, foreign purchases is way of buying military capability needed to expand the strengthening of war potential from abroad.

Concerning the continuous flow of time decision of make or buy decision making for general firms coexisted purpose, environment and the situation the firm is faced. But on the other hand with respect to short and discrete point of view choosing one strategy is general principle between both strategies.

Same like general firm, defense area should consider various and sophisticated factors with due regard to various problems occurring from these kind of strategic selection and far-reaching influence from the decision. Way of military improvement through military R&D, which is decision making strategy part of military area needed to sophisticated decision making and foreign purchases can raise various discussion that the effect of military improvement is different between short term and long term.

Although these kind of various effect and discussion, military area, especially make or buy decision making for military improvement, is a long view and has been studied by quantitative and qualitative analysis and the effect could be mainly achieved through military system acquisition have been studied from discrete and quantitative point of view.

But discrete analysis is just focused on the step of training of weapon system which weapon system should accomplish before committing to the battlefield, so it's very difficult to certify dynamics from characteristic of methodology used in analysis in the life cycle.

2. Purpose of research

As mentioned before, research on the make or buy decision making, especially defense area, have been studied focused on supporting the validity of military R&D or executing and evaluating of efficient cost management. As these kind of research are really meaningful, most of the research have their limit to show long-term change and dynamics of military area. So we want to get policy leverage using system dynamics focused on make or buy decision making part of military capability improvement and design the structure of military R&D and foreign purchases. And then we want to present the strategic leverage to maximize the effect of strategy and provide instrumental method for decision making of military improvement from in-depth analysis.

Ⅱ. Theoretical Background and Previous Research

1. Summary of National Defense

1.1 Summary of budget for National Defense

As mentioned before, military budget is composed of budget for military capability and budget for defense capability improvement. Budget for military capability is divided into budget for managing troop, that is cost used as salary of soldier, providing food, and clothes and budget for maintaining the military capability, that is cost for maintaining current military capability used as construction, education and training, maintaining equipment. Defense budget is cost for buying new weapon system or increasing military capability.

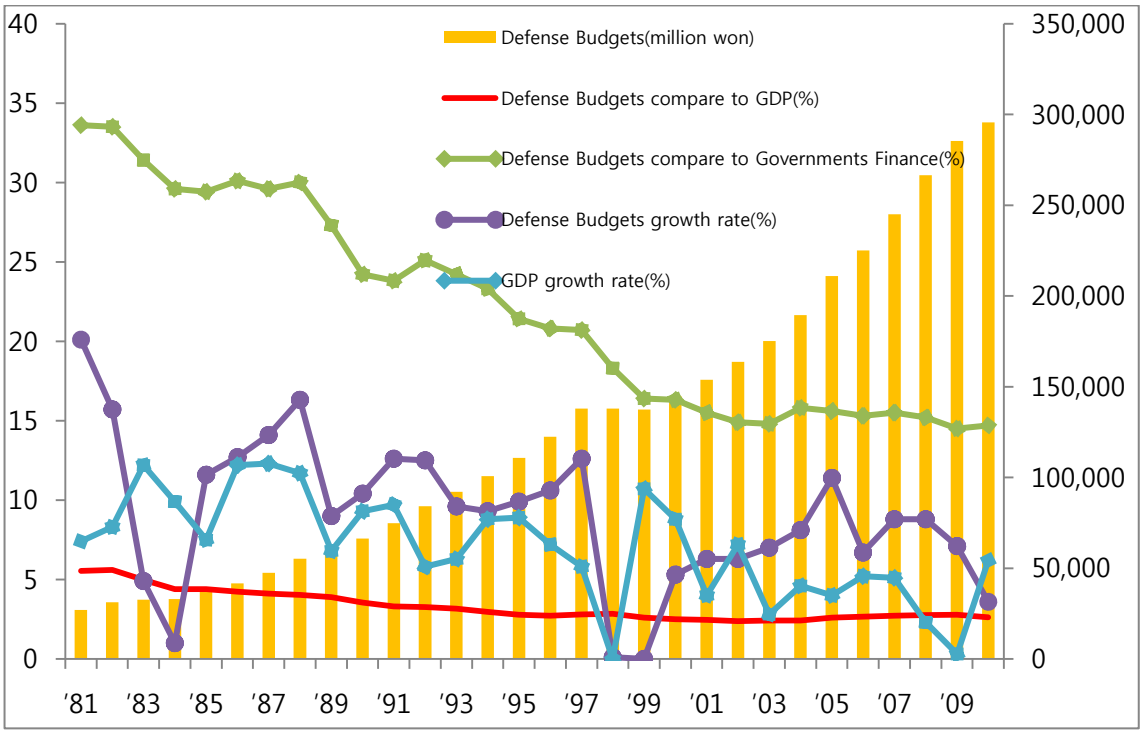
Korea’s military budget have increased for a long time. The reason of increasing military budget is that Korea is the only country left as a divided country in the world and as a result of continuous threat of North Korea. As time goes by, trend of decreasing defense budget or the ratio of defense budget to GDP, government budget is changed continuously and it has a significant meaning. Especially the ratio defense budget to GDP is a significant index used as a evaluating national security, so this index

reflects the willpower and recognition for national threat from enemy.

In 2010, Korea's defense budget decreased 14.7%($ 2.4 billion) compare to defense budget in 1981. The defense budget in 2011 was $ 26.2 billion, 5.54% of GDP, 33.6% of government budget in detail. The size of defense budget increased 11 times in 30years and the ratio to average increase of defense budget is about 8.74%.

The change of increasing rate of defense budget have been changed by economic condition and external threat. First of all changes from external threat were greatly increased by a case of terrorism occurred in Aung mountain in 1983, KAL explosion occurred in 1985. As economic condition changed defense budget decreased from 0.1%(1998) to negative growth(1999) by financial Crisis.

On the other hand, as the military revolution progressed the request Self-reliant defense increased, defense budget jumped up in 2003, 2005.



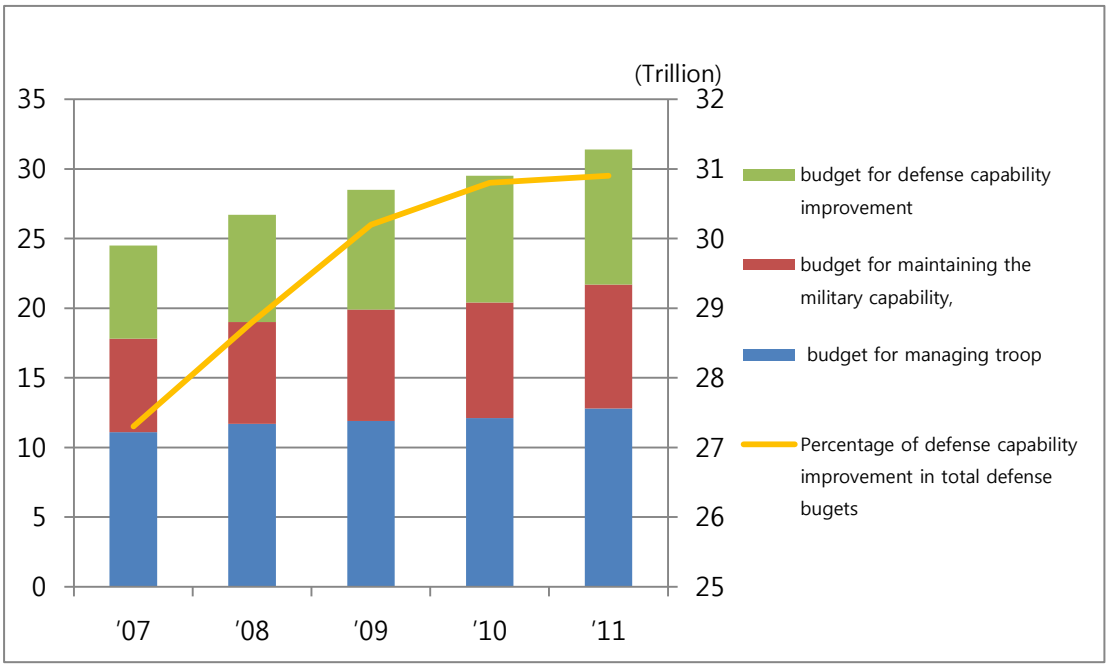
<Figure 1> National Defense Budgets trend

1.2 Military Improvement Project

As noted above, military improvement project is weapon system purchase for improving military power and R&D included newly development, improvement of power, project constructed to support all of these.

Military improvement project was begun by project named by Yul-Gok from 1970s to 1995 and then passing by manipulating military power, have progressed by military improvement project. The goal of this project was acquisition of the state-of-the-art military power against current and coming threat to strengthen the security power.

In 2011, the rate of budget for military improvement project to whole defense budget showed an increase of 3.6% and $ 1.5 billion over 2007.



<Figure 2> Defense budget allocation and trend of change of military improvement budget

The ratio of military R&D in the make strategy part of military improvement project has been steadily increased from 4.5% in 2001 to 6.1% in 2010.

Except for transient rise in 2008 to improve naval military power but on the other hand, foreign purchase has decreased steadily.

<Table 1> State of military R&D and foreign purchase investment

Previous research		'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
Military R&D	Scale (Hundred million)	6,915	7,682	7,861	8,495	9,087	10,595	12,584	14,522	16,090	17,945
	Ratio of defense (%)	4.5	4.7	4.5	4.5	4.5	4.7	5.1	5.4	5.6	6.1
Foreign Purchase	Scale (Hundred million)	-	-	16,098	19,006	20,100	12,468	12,345	18,602	22,848	19,316
	Ratio of defense (%)	-	-	9.2	10	5.9	5.5	5	7.1	8.0	6.5

source : Finance by probability 2009, Congress

2. Make or Buy decision making theory

2.1 Make or buy decision making

It is very difficult and classical discussion about make or buy decision making strategy to most of the firms. (Anthony J.G, 1980). Make or buy decision making could significant influence not only short term but also long term in case of management of firm.

Besanko D(2003) define make or buy decision making as the firm consider cost of exchange whether to make internally or outsource externally. Discussion related to production area is divided into make or buy decision in corporate perspective (Anne. P; 2007). Make or buy decision making issue treats vertical integration of firm or outsourcing and handles efficiency, core competency concerning transaction cost. The reason why many firms should think about the problem of make or buy decision making is that result of decision reduces cost, enhances core competency and improves efficiency of firm.

In this research, make or buy decision making could be defined as acquisition from military R&D used for military improvement and acquisition from foreign purchase, this kind of result should be confirmed whether to change dynamic or not for the perspective of transaction cost and core competency.

2.2 Transaction Cost Theory

TCE has been widely used in non-business area as well as in the area of strategy, organization theory, management etc and applied as a very important method to consider when a firm needs to solve the problem of strategic decision making.

In the theory, the firm considers the ex-ante and ex-post costs of exchanges as the primary determinant of whether to conduct an activity internally or externally(Coase, 1937). Due to opportunism and bounded rationality, asset specialty and uncertainty are key transaction cost drivers, as they increase the costs of market exchange, motivating the firm to produce internally (Williamson 1975,1985). Also the higher the cost of exchange, the higher motivation of producing internally.

From TCE perspective, the firm produces custom goods internally whereby outsources generic ones. As described by Williamson, ‘where firms are observed to both make or buy an identical good or service, the internal technology will be characterized by higher asset specificity than will be external technology(Williamson, 1985;96).

Technology level can also influence on make or buy decision, greater uncertainty can lead to adaptation problems and to difficulties in evaluating performances, both of which may motivate the firm to internalize the activity (Mahoney, 1992). On the other hand, uncertainty includes both the potential for environmental change and the unpredictability of a partner’s behaviors (williamson, 1985). In this research, I designed military improvement effect acquired by spending military budget which is component of transaction cost.

<Table 2> Previous research about transaction cost

Previous research	Main Contents
Coase(1937)	Option between market and internal organization is determined by comparative cost
Elam(1988)	Option between make product or service internally and outsource is determined by transaction cost
Williamson(1985)	Transaction cost include searching cost, negotiating cost, manipulating cost, bargaining cost
Jones, Hill&Kim(1988)	The causes of transaction cost are bounded rationality, opportunism, environment uncertainty, number of trading alternatives, asset specificity, frequency of transaction
Malone, Yates& Benjamin(1987)	Assessment on the effect of outsourcing as a hierarchical market and vertical structures concerning transaction cost and production cost

2.3 Core competency theory

A firm produces products that are suitable to its area of expertise, core competency, relative to items it already produces. Every firm is different, so some goods will be a better fit with its resource or knowledge base than others. If the good is a poor fit, it will be more efficient to outsource(Rubin, 1973; Kogut and Zander, 1992; Corner and Prahalad, 1996; Grant, 1996). Supplier's costs will depend on their relative expertise, resources, and capabilities and thus each individual supplier will offer a somewhat different blend of price, delivery, quality, and other attributes for the sourcing firm to consider(Penrose, 1959; Barney, 1991).

But if both of firms and suppliers possess significant expertise, they should decide make themselves or buy from suppliers. When a firm concurrently source, learning will be enhanced, since it gains both the deep tacit knowledge of internal production and the broader, more diverse understanding from external supply relationship. If a firm can't accurately predict the type of change forthcoming, having both types of sourcing available will improve the firm's likelihood to succeed by being 'ambidextrous' and able to deal with both suppliers and internal development groups in the face of technological change(Afuah, 2001). By having both internal and external suppliers, the firm gains thd option to switch between them, resulting in greater process flexibility(Kulatilaka and Marks, 1988). In times of greater technological change and uncertainty, these options became more valuable and therefore concurrent sourcing should be likely.(Sa Vinhas, 2002)

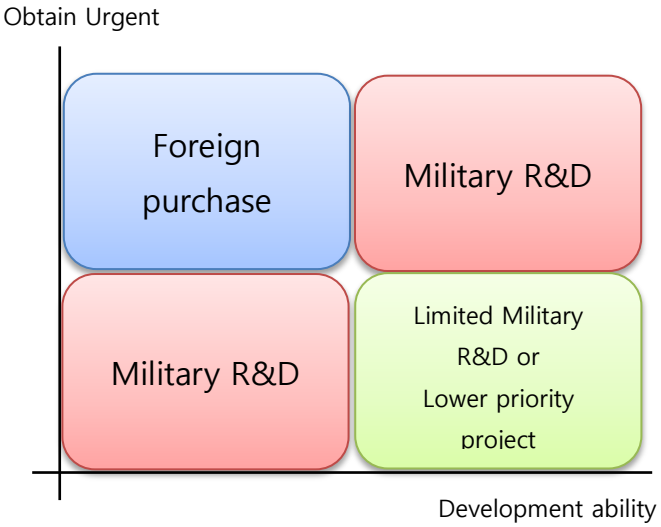
Ⅲ. System dynamics model of military improvement project

1. Causal loop and Analysis

1.1 The direction of military improvement project

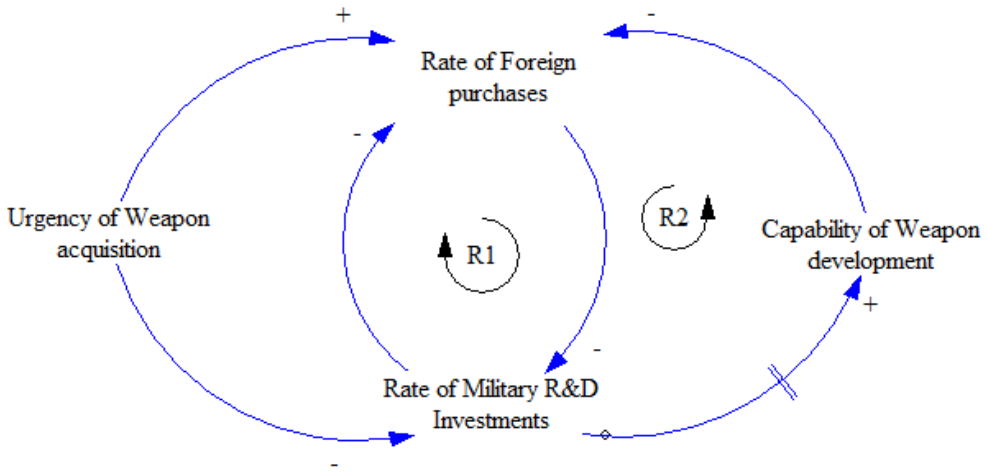
From make or buy decision making point of view, make decision is explained as acquisition of weapon system through military R&D and buy decision is explained as foreign purchases. In order to set the direction of military improvement project, urgency of military improvement and development capability are the biggest impact on setting the strategy of military improvement project. As an example of improvement of military power, Joint chief of staff announced the plan of how to arrange the troop and military equipment after North Korea's shelling of Yeon-pyeong Island

In the block planning, short range precision guided weapon, Spike missile equipped with artificial satellite navigation system is included, In case of North Korea's shelling of Yeon-pyeong Island, if South Korea does not have enough technology to make suitable weapon system like Spike missile and the weapon system South Korea has is short of performance compare to they need, so they bought the weapon system ready to use as a weapon system. Military R&D and foreign purchase that decide the direction of strategy military improvement project is provided in figure 3.



<Figure 3> Rates of military improvement project according to urgency and development capability

From literature review, causal loop using two important variable, urgency and development capability, is designed in figure 4. The relation between military improvement and foreign purchase is R1 loop, which is reinforcing loop just developed one way by choice. R2 loop that added effect of acquisition of technology through military R&D investment, although it has time delay military R&D investment decrease foreign purchase by improving weapon system development capability eventually.

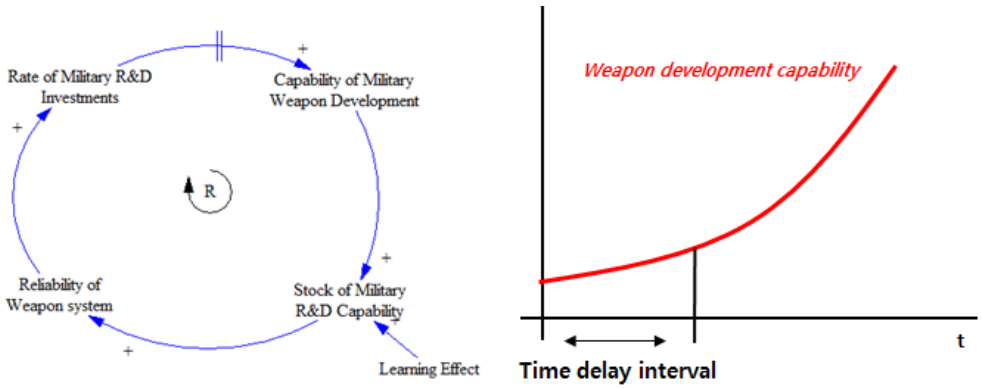


<Figure 4> Causal loop of military improvement project concerning urgency and development capability

1.2. Performance by military R&D investment

Figure 8 stands for reinforcing loop on performance of military R&D. Military R&D has time delay but it can improve reliability of weapon system by accumulation of R&D capability.

Acquisition of ability to weapons progressed so slowly because of initial time delay but learning effect and continuous R&D investment have development capability accumulated, time delay shortened and development capability risen in a short time.



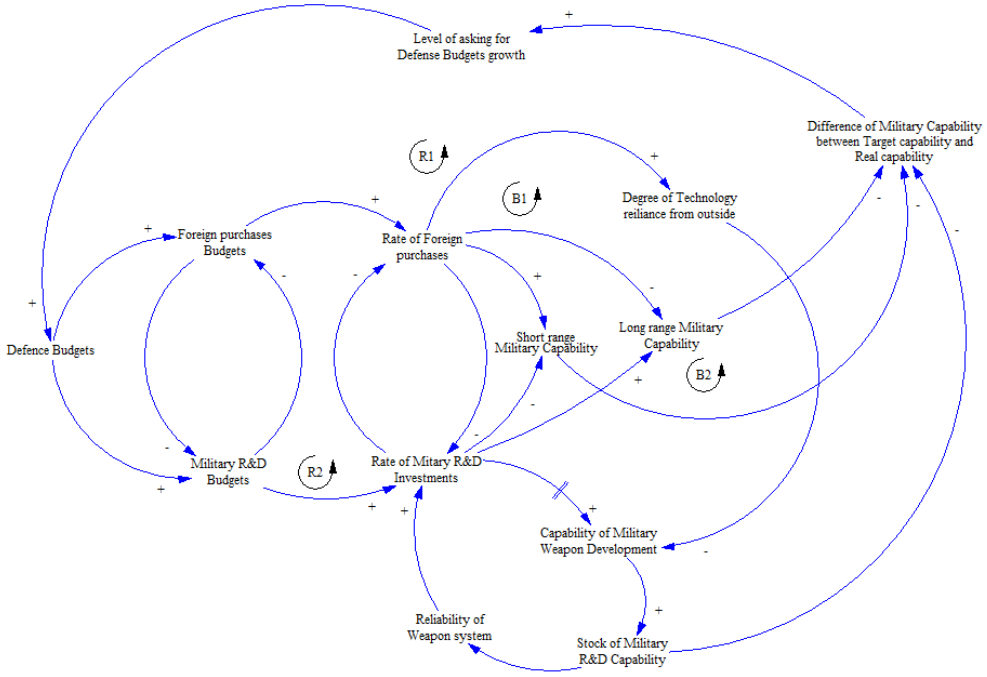
<Figure 5> Causal loop of military R&D performance and change of military R&D development capability

1.3. Integrated causal loop

Based on the causal loop described in previous step, analysis of dynamic structure of make of buy decision making of military area is presented in figure 6. R1 loop, foreign purchase influence on acquisition of military power, shows that foreign purchase has an negative effects on development capability of weapon system by own technology for

the long run, so military budget is expected to increase.

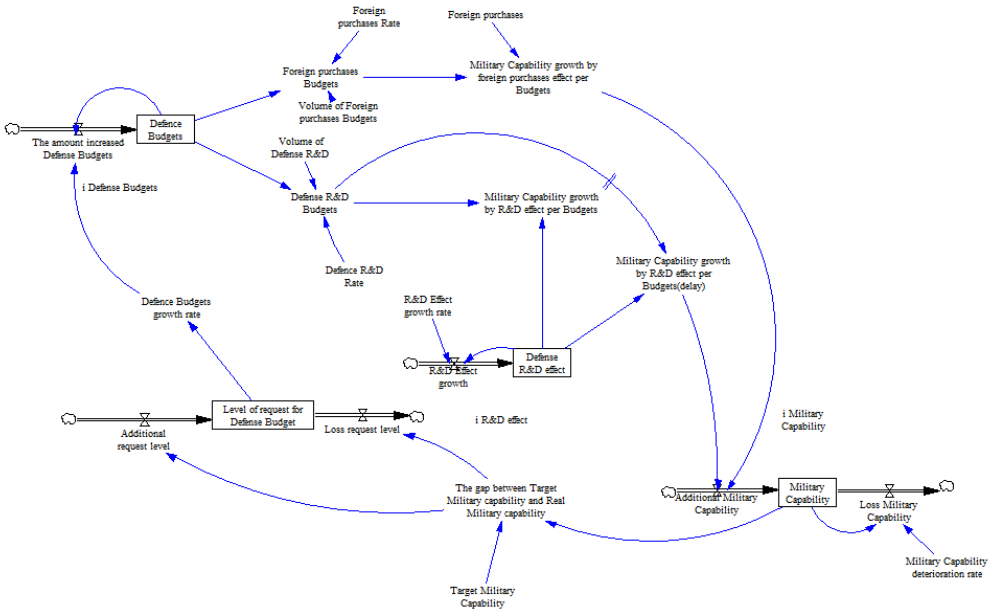
On the other hand, B1 loop have a positive effect on short term acquisition of weapon system decreasing the needs to additional input, so it has an effect on military budget a certain level of maintaining. Contrary to the effects of foreign purchases, effects of military R&D is the key to the high level of acquisition of military power in the long term, so it has military budget maintained by acquisition of military power. Foreign purchase is the cause of acquisition from the area of insufficiency so it has military budget increased in the short term,



<Figure 6> Causal loop of military improvement project by make or buy decision making

2. Simulation model of military improvement project

We have made stock and flow chart for simulation with the variables that came out from military capability improvement process and cause and effect diagram. In this model, there are 4 stock variables, 6 flow variables, auxiliary variables and the constants. Each variable is made up of the budget of defense, R&D and foreign purchase and military capability index by this budget and control variable to be needed for the difference between target military capability index and military capability index. And also we added variables to see the dynamics of the increase of military capability by the ratio of military R&D and foreign purchase. In stock and flow chart, the initial military budget, military R&D and foreign purchase ratio are based on the national defense white paper by the ministry of national defense of Korea.



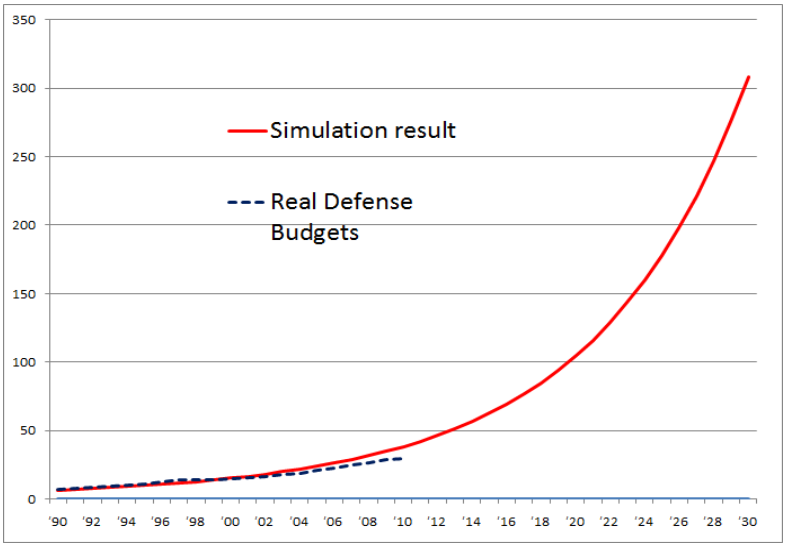
<Figure 7> Stock & Flow chart of military improvement project

2.1. Validation & basic simulation

In Figure 8 is the result of comparison of changes in the national defense and the results by the simulation for 40 years with initial value of 1991's national defense budget. We set the simulation term for 40 years because 10 to 15 years are needed to be real war power and average life cycle of it is 20 years.

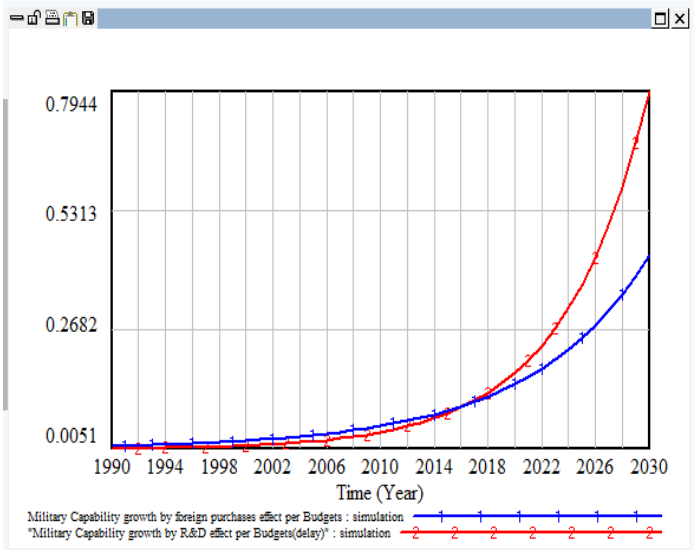
We assume that time delay of accumulation of technology is 5 years and the effect of the national R&D investment includes the improvement of both the performance and maintenance.

In Figure 8, we found out that the real cost of national defense from 1990 to 2010 almost coincides with the result of simulation and dynamic changes. This means our model can be valid.



<Figure 8> Comparison between simulation and real budget for defense

Next, we performed a simulation to see the dynamic changes in ratio of the national defense R&D and military capability index. In this basic simulation, we did a simulation with the same value of the national defense R&D and foreign purchase.



<Figure 9> Effect of increase of military of each section

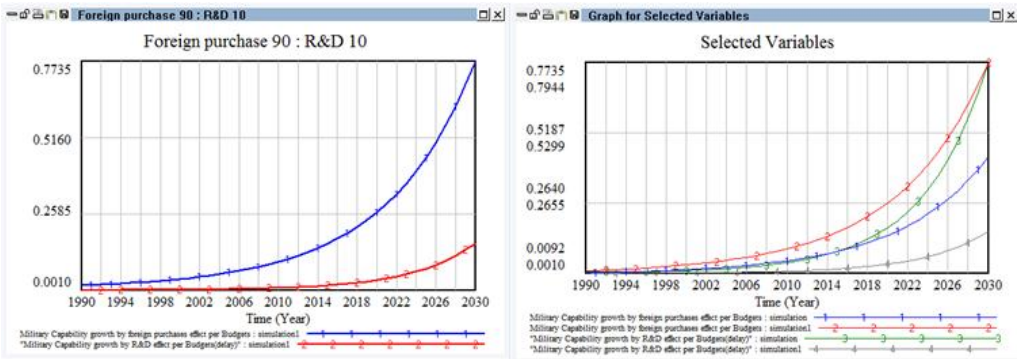
We found out there is no significant effect due to foreign purchase to the increase of the military capability in the early R&D investment term but since 2017 the effect of R&D investment has incrementally increased and the gap between the effect of R&D investment and foreign purchase got bigger. The increase of the national defense capability came a little later than normal term of 10~15years because we used 0 value of technology accumulation. But if we used standard technology accumulation, the result of this simulation would be the same.

2.2. Analysis of simulation on policy scenarios

We have analyzed that the effect of military capability increase. the total military capability index in each department and the gap to the target capability index. In this scenario, we assume that the minimum value of R&D investment and foreign purchase is 10% and performed simulations. And the result is as follows.

1) Policy Scenario 1 : Foreign purchase 90%, R&D investment 10%

At first, we have simulated with assuming the portion of foreign purchase 90% and R&D 10% and the results are in Figure 10.(a) and (b) is the result of same rate like basic simulation.



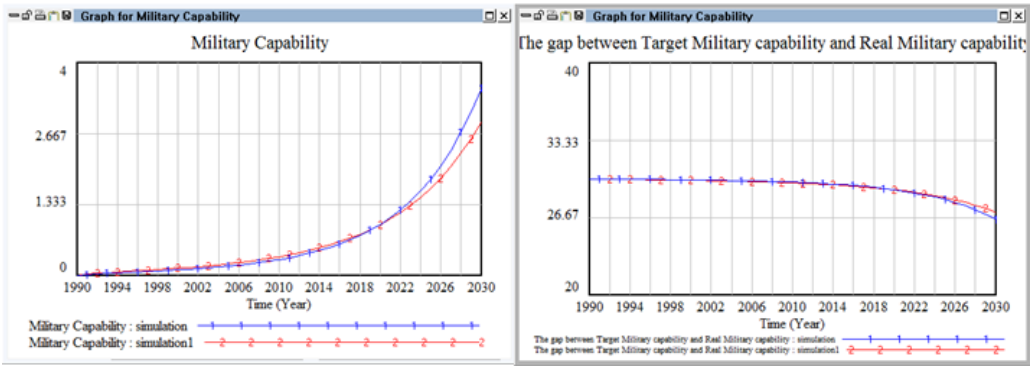
(a) (b)

<Figure 10> Effect of increase military capability of each section

(Foreign purchase 90%, R&D investment 10%)

When we set foreign purchase portion 90% and R&D investment 10%, the effect of R&D investment is always lower than the effect of foreign purchase and we also found out the decrease of military capability by the decrease of R&D investment portion is bigger than the increase of military capability by the increase of foreign purchase portion. This means the technology accumulation by R&D investment is very important.

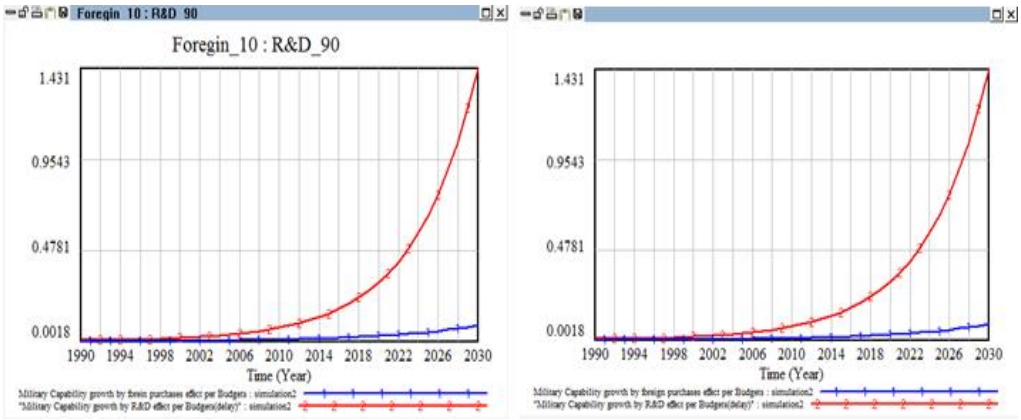
And then, we have compared the difference between the change of military capability and target military capability and the result is in Figure 11. From simulation, we can see the military capability index got lower since 2020 with the same portion of investment both in R&D and foreign purchase. This shows how the acquisition of core competence in technology is important.



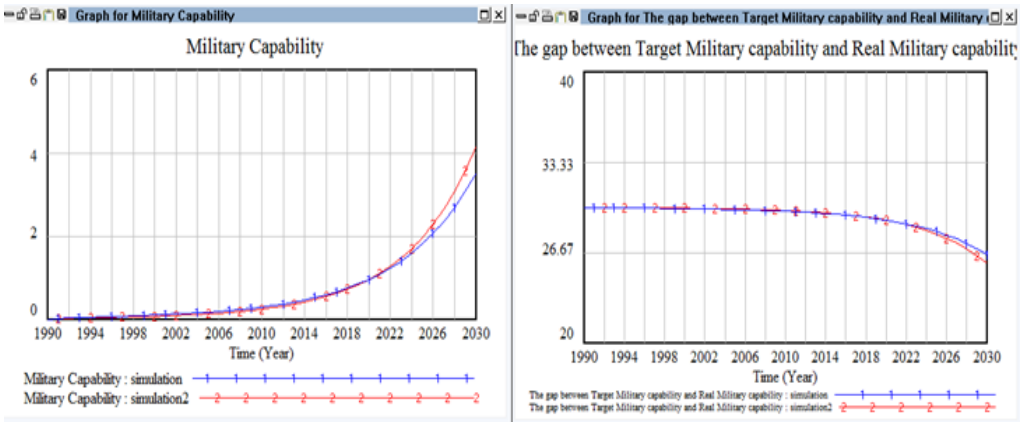
<Figure 11> Level of military improvement & comparison between target military capability (Foreign purchase 10%, R&D investment 90%)

2) Policy Scenario 2 : Foreign purchase 10%, R&D investment 90%

Next, in contrary to Scenario 1, we performed a simulation assuming that foreign purchase 10%, defense R&D investment 90% and Fig.12 shows the result. Finally, we found out the effect of defense R&D investment on military capability increase is 1.6 times larger than the effect of foreign purchase on military capability increase and comparing to the simulation with the same condition, the increase military capability due to the defense R&D investment is 1.85 times larger than the military capability decrease due to the foreign purchase.



<Figure 12> Effect of increase of military capability from each section
(Foreign purchase 10% / R&D investment 90%)



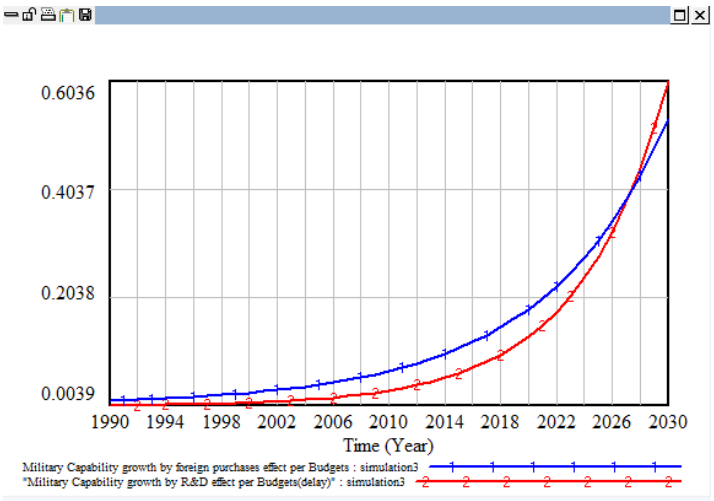
<Figure 13> Level of military improvement & comparison between target military capability (Foreign purchase 10%, R&D investment 90%)

In Figure 13, the military capability index is higher than the same investment in foreign purchase and defense R&D investment since 2020 and it is the result of comparison when the same portion of foreign purchase and the defense R&D investment is applied.

3) Policy Scenario 3 : Foreign purchase 62%, R&D investment 38%

(When the defense R&D investment comes higher than foreign purchase for the first time)

Scenario3 is set to find the minimum rate that military capability increase by the defense R&D investment overcomes the one by overseas buying in the existing weapon system is replaced in life-cycle. As a result of simulation, more than 38% of defense R&D investment is needed that the effect of defense R&D investment overcomes the effect of foreign purchase and we see that result in 2028 that is almost the last part of the simulation. Therefore, we think that this 38% will be the minimum portion to accelerate the effect of improvement of weapon system.



<Figure 14> Minimum ratio need that R&D investment can overrun overseas

Ⅳ. Conclusion and Policy suggestions

In this research, we found out the framework of defense R&D investment and foreign purchase as the project to improve the military capability through causal loops in system dynamics and thinking and checked the variables that influence on the defense capability improvement project in the view of make or buy. And also, we have confirmed that the minimum portion of defense R&D investment and foreign purchase in the view of dynamic changes, transaction cost and core competency in the defense capability improvement project. As a result, we suggest policies as follows.

At least 38% of defense R&D investment should be needed to achieve Self-reliant defense system and the acquisition of self development capability of weapons. It is necessary to distribute resources effectively to achieve the best output to the budget in short/mid/long-term through the defense capability improvement project. It is essential to take defense R&D investment and foreign purchase into consideration in defense capability improvement project as make or buy decision. With no considering of risk, cost and existing technology, it is impossible to invest all to achieve the military capability index. If you concentrate only on foreign purchase to raise up the defense capability in the short term, you might get into technology restriction. If you concentrate only on defense R&D, it might cause increase in Self-reliant defense and too much cost. So, the effective distribution is very important. In this research, we have considered Korea's defense budget, budget distribution rate and life cycles from weapon development to retirement and found the minimum rate for military capability index by defense R&D investment to overcome military capability index by foreign purchase. According to the result in this research, when the portion of defense R&D investment is lower than 38%, the defense capability index increase by foreign purchase cannot overcome the defense capability increase by R&D investment so the technology restriction might happen. Therefore, we can find out that the portion of the defense R&D should be at least 38%.

This result provides the policy makers with their reasonable portion of the minimum defense R&D investment for self defense system in cost and core-competency model

and helps them to know the right time to invest and establish flexible strategies to the external condition.

System dynamics is the thinking strategy to change the system effectively with considering the system operation mechanism and methodology to make it easy to predict dynamic changes to the variables influenced by various internal and external factors like defense improvement cost. Therefore, it is possible to find the indices by R&D investment and foreign purchase and the optimal rate between defense R&D investment and foreign purchase when we want to measure the military capability index. In this research, we considers yearly changes in increase and decrease of defense improvement cost dynamic changeable things. To maximize the military capability index, it is the best solution to focus on foreign purchase in short term, mix it in the mid-term and focus on defense R&D investment in the long-term. But considering limited budget and technology restriction, it is possible to make strategies for short, mid, long-term of defense R&D investment and foreign purchase. Also, it is possible to make the optimal national defense policies and distribute the defense budget effectively finding the military capability index and changes in cost through this simulation.

This research has a limitation that there is no consideration for exogenous factors influence the national defense budget. As we said in the preface, defense department is influenced by various variables. So, we will focus on these exogenous factors and domestic and foreign economic conditions and find out better solution for policy and implications.

References

Alexandre Rodrigues and John Bowers, "System Dynamics in project management" a comparative analysis with traditional methods," System Dynamics Review 12(1996):121-139

Gordon E. McCray and Thomas D. Clark Jr., "Using System dynamics to anticipate the organizational impacts of outsourcing," System Dynamics Review 15(1999):345-373

David N. Ford and John D. Sterman, "Dynamic modeling of product development processes," System Dynamics Review 14(1998):31-68

Chu, Angus C. and Lai, Ching-Chong, "Defense R&D: Effects on Economic Growth and Social Welfare," MPRA 16325(2009)

Dan Peled, "Defense R&D Economic Growth in Israel: A Research Agenda," Samuel Neaman Institute(2001)

T-S Jan and C-G Jan, "Development of Weapon system in developing countries: a case study of long range strategies in Taiwan," Journal of the Operational Research Society 51(2000):1041-1050

John Mccain and P. Mckeon,"Defense Acquisitions: Additional Guidance needed to improve visibility into the structure and management of major weapon system subcontracts," GAO(2010)

Raymond Franck et al., "A transactions Cost Economics Approach to Defense Acquisition management," Acqusition research sponsored report series(2006)

Seo, Hyeko and See, Sang-Eun, "A Leverage Strategy of the Defense Program Analysis Based on Systems Thinking," Korean System Dynamics Review 12(2009):77-95

Seo, Hyeko and Myung, Geon-Seek, "The Korean Defense Industry System And Its Policy Leverages," Korean System Dynamics Review 12(2007):83-114

Park, Hun-Joon, Oh, We-Hong and Kim Sang-Jun "Leverage Strategy to National R&D Investment in Korea : A SYstem Dynamics Approach", Korean System Dynamics Review 5(2004):33-66

Kim, Dong-Hwan, An, Seung-GU "System Dynamics Modeling for The Allocation of National R&D Investment", Korean System Dynamics Review 12(2011):153-176

Lee, Young-Suk et al., "A Study on Policies for the Activation of WiBro Market", Korean System Dynamics Review 12(2011):37-67

ROK Ministry of National Defense, "White paper"(2010)