THE EVALUATION OF THE EXPORT COMPETITIVENESS OF WEAPON SYSTEMS IN EMERGING MARKET USING FIVE FORCES MODEL

Wonseok Choi, Kwangwoon University
Sukjae Jeong, Kwangwoon University
Jang Yeop Kim, Kwangwoon University

ABSTRACT

The primary purpose for a country developing weapon systems is to strengthen its defense capability. However, recently developed countries are attempting to enhance their arms trade position toward emerging markets in order to maintain its competitiveness in the global defense market. However, there is a significant distinction in weapon systems from general products; thus, there are demands to convert these into products that can be exported. Thus, strategic decisions at the stage of developing weapons systems are required, such as comparing the competing and substitute weapon systems and selecting the emerging markets. This paper proposes a modified five forces model to aid in evaluation of the export competitiveness of a developing weapon system to address the following issues: (1) Entry barrier level of the existing competing weapon system, (2) Threat level of a substitute weapon system, (3) Possibility of acquiring core technology, and (4) Identification of the potential purchasing country and the marketing strategy for a weapon system. The unmanned aerial vehicle (UAV) is considered as a case study for the validity and applicability of the proposed model.

Keyword: Weapon Export, Five Forces Model, Export Competitiveness, Unmanned Aerial Vehicle

INTRODUCTION

Most countries have steadily developed weapon systems for their own national security and strengthening defense capabilities. Developing a weapon system features a large-scale project that requires large investment and a cutting-edge of technology. Due to its characteristics of the industry it is necessary for countries to expand worldwide by exporting to emerging market. In recent years, many countries like United States, Russia, United Kingdom, France and Germany have been attempting to expand their market positon to emerging markets to create new value from the investment and revenue generation. (Johnson, 2017; Kuk, Kim & Ju, 2015)

Therefore, the evaluation of export possibilities from the development stage of the weapon system has become a critical decision-making process in project milestone. Major defense firms from the developed countries that leads exporting weapon systems to worldwide have been attempting to establish a gateway into emerging markets toward Asia, the Middle East and Central and South America regions due to its limitation of market portion in domestic market. Additionally, latecomers such as China and Israel also looking for an opportunity to extend the shares of defense export markets. According to the Stockholm International Peace Research Institute (SIPRI), the global arms trade has grown by 5.5% between 2010-2014 and 2015-2019. It showed continuous increase upward trend that begun in the early 2000s (SIPRI Yearbook 2020). As the importing states increased up to 160 states in 2015- 2019, the export market size has also grown as well. The Korean arms trade market also has expanded substantially since 2016. In 2019, the Korea arms export performance was estimated to be 1700 million dollars.

Expanding the emerging market for weapon systems has been considered as difficulties due to its characteristics since then; many countries have begun to consider tactical export strategies. Especially, countries planning to entering into emerging markets need to know whether their weapon systems have competitiveness in the export market, and they want to focus targeting potential emerging countries that are looking forward to purchase weapon systems.

Many factors can be considered in evaluating weapon system exports. Although it is apparent that price and technology competitiveness are important, the existence of a market for the weapons system under consideration and the competition level of the market must be considered (Castellacci & Fevolden, 2014). The marketing ability and MRO capability of both the government and the weapon systems' manufacturer are also important. Furthermore, when evaluating the possibility of weapons export to a potential emerging country, the support capacity of the exporting country, the diplomatic relationship between the two countries, and the compatibility of the weapons system are also important factors. Therefore, the export possibility of weapon systems should be comprehensively reviewed with many factors, and Multiple Criteria Decision-Making (MCDM) could be a suitable means to effectively assess these problems.

This study proposed an export assessment model by modifying the five forces model to support possibility of exporting weapons systems under development in a country and selecting the potential emerging countries based on the five forces model. Our proposed model concept includes four factors as follows:

1) Entry barrier level of the existing competing weapon system.
2) Threat level of substitute weapon system.
3) Possibility of acquiring core technology.
4) Identification of potential country of purchasing weapon system and marketing strategy.

The results from this model provide a useful reference for the development of strategies for the weapon system export and will act as valuable guides for other countries when developing their own weapon system. The Unmanned Aerial Vehicle (UAV) was considered a case study for the validity and applicability of the proposed methodology.

The remainder of this paper is as follows. Section 2 provides an overview of previous research on MCDM and five forces model utilized in this study. Section 3 explain why we utilize the modified five forces model based on differentiations of exportability between general products and weapon systems. In section 4, the detailed procedures of model are demonstrated. In section 5, we test the applicability through the case study of a UAV weapon system. In the conclusion in section 6, we discuss the contribution of our research and provide the future research work.

LITERATURE REVIEW

Studies have been conducted using MCDM method to select suppliers or analyze competitiveness of product in various industries. Nallusamy, et al., (2016) used fuzzy logic, AHP and Artificial Neural Network (ANN) methods together to select suppliers that can deliver adequate production amount with high quality in the manufacturing industry. Yazdani (2014) derived the final ranking by calculating the fuzzy preference through the similarity between weights derived from AHP and ideal solution from the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method in the selection of suppliers. In Wang et al. (2018), the MCDM method are utilized to apply a supply chain operations reference (SCOR) metrics, AHP, and TOPSIS when evaluating and selecting suppliers in the gas and oil industries for considering the quantitative and qualitative factors such as reliability, responsiveness, agility, costs and assets simultaneously. Wang, et al., (2018) used a MCDM method for selecting suppliers in a rice supply chain and Wang & Tsai (2018) proposed fuzzy based MCDM model that uses AHP and Data Envelopment Analysis (DEA) methods together, for evaluating and selecting the suppliers in Taiwan's solar panel industry. Metin, et al., (2009) used MCDM model for deriving weights of elements for the selection of rifles through AHP and calculating the final ranking of inorganic systems through fuzzy TOPSIS. In Cheng, et al., (1999), combined fuzzy-AHP was used to evaluate the weapon systems based on linguistic terms. Sánchez-Lozano & Rodríguez (2020) found the best case of a combination of Fuzzy MCDM based on a set of criteria of differing natures to select the best military advanced training aircraft in the Spanish Air Force.

There have been a few studies using the Five forces model for a strategic decision-making. Ortega, et al., (2013) carried out a strategic analysis of the urban public transport system target of this work centres on the explanations search on the future of the sector of the collective urban transport in Spain using the five forces model. Lee, et al., (2012) proposed a new method of deriving the weights and rating on the sub-forces produces required to the operationalization of five forces model though combination of network model of Analytical Network Process (ANP) and five forces model. Zhao (2015) established five forces model with five major stakeholders (competitors, suppliers, buyers, potential competitors and substitutes), as the analytical framework to review the competitiveness of the biomass power industry of China. Kumar, et al., (2015) provided a new set of five forces that affect not only a node's financial profitability but also its vulnerability within its ecosystem and the survival of the ecosystem itself. Wellner & Lakotta (2020) investigated the profitability potential of the German railway industry using adapted five forces framework that includes governmental interventions and the support by complementary goods as two additional forces. Yunna & Yisheng (2014) used five forces model for analyzing competition situation of in the shale gas industry of chia from five aspects: supplier and buyer powers, barriers to entry, threat of substitution and degree of rivalry.

In order to improve the export possibility of weapon systems, not only do these factors need to be identified, but the overall decision process, which includes the identification of competitiveness of their own weapons and the selection of promising target market, needs to be established.

In relation to the export possibilities of general products, many studies have actively used Porter's five forces model to analyze the level of competition within and industry and business strategy development (Hu & Yang, 2016; O'Hara, Nophale, Marra & Spiegel, 2017; Sutherland, 2014). To the best of our knowledge, however, only few studies have analyzed the possibility of exporting weapons systems by applying the five forces or similar models of course, it is difficult to apply this model and questions to the export of weapon systems because it has different characteristics from the export of general products. However, we attempt to establish the revised model of five forces in evaluating the export possibility of a weapon system in the future export market.

Using the Five Forces Model for Analyzing Exportability of Weapons Systems.

In the general product market, the market shares of a leading country that possess product and technology innovation is higher than following countries because a leader country dominates with the competitive advantages of performance and product price. Regarding the export of general products, a leader country maintains its dominant position until follower countries produce imitative products and enter the export market. However, when the life cycle of the product reaches the maturity stage, the competitiveness of follower countries with low labor costs may be higher than a leader country because the price competitiveness is more important than the technology competitiveness at that stage. Thus, countries that have a high possibility of purchase also gradually increase as the product life cycle phase progresses. However, the export of a defense weapon system is different in many ways from the export of general products. While it is possible to produce a large quantity of general products for export, a defense weapon system has a limited e production quantity and number of potential purchasing countries. Although the export market is attractive, the follower countries find it difficult to enter the market because they are not able to easily narrow the technological gap between them and a leader country, and the development of a weapon system needs a huge investment.

The growth stage in the life cycle of a defense weapon system that requires high technology lasts longer than that for the general product, and it has a brief maturity duration. Dunne & Surry (2006) defined this occurrence as structural disarmament. Therefore, the export competitiveness of a defense weapon system could depend not only the economy of scale of the production infrastructure but also the long-term economics of repetition and recombination. Although follower countries invest in production infrastructures and use cheap labor, it is difficult to imitate the technology of a leader country and secure market share in the global export market. Another difference from the general product is that arms trade is conducted in Government-to-Government (G to G) or Government-to-Corporation (G to C) structure. The government support and strategy could be important success factors for exporting weapon systems to other countries.

The five forces model has been used extensively in analyzing the competitiveness of general products. This model is a framework for understanding the competitive forces at work in an industry and which drive how economic value is divided among industry actors.

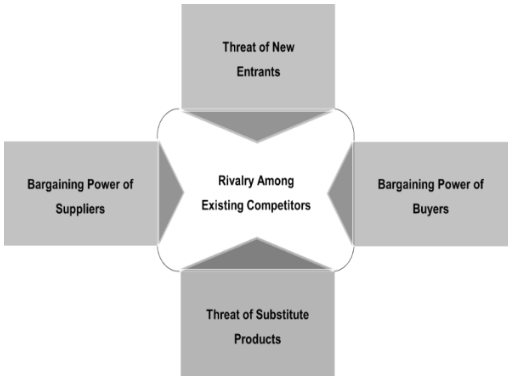


FIGURE 1
PORTER'S FIVE FORCES MODEL

As shown in Figure 1, the five forces model, which consists of the supplier power, the buyer power, the barriers to entry, the threat of substitution and the degree of rivalry, provides certain solutions to questions as follow: What are factors affecting industry? How do they affect the industry? What is the development trend? Moreover, the model provides Strength-Weakness-Opportunity-Threat (SWOT) analysis (Helms & Nixon, 2010) for evaluating the competitiveness of corporation.

A country commonly develops its own weapon system for its security and political interest with allied or partner states. However, if a country sets a goal of developing a defense weapon system for export, evaluating the export possibility of a defense weapon system in the development stage may be more effective than evaluating it after completing the weapon system. Thus, we focused on evaluating the validation of weapon development for export at the research and development stage. Therefore, the five forces presented in this study need to differ from the general five forces model when we evaluate the export possibility of a weapon system in the future export market.

We propose a five forces model-based weapon export assessment model for evaluating the competitiveness of a weapon system at the research and development stage in figure 2.

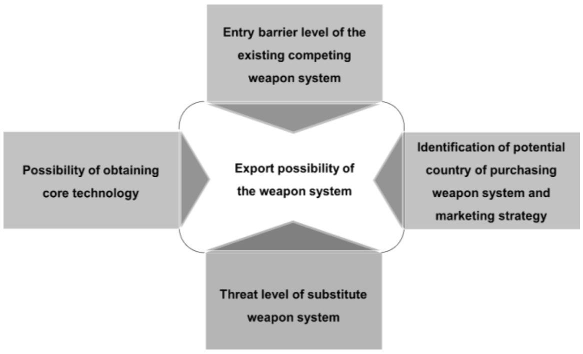


FIGURE 2
THE PROPOSED MODEL

We explain that we selected competitive factors by comparing our proposed model with the general five forces model. Identifying the existing competitors and evaluating the rivalry among the existing competitors are critical for analysis in the general model because the process of identifying competitive products is the most pre-employment factor in analyzing the competitiveness of products that have previously been released to the market.

The weapon system is a product that requires high technology and investment in contrast to general products. When renovated for export after development, this product requires as much time and expenses as does the development of new weapon system. Therefore, our concern is to evaluate the validation of weapons development for export at the research and development stage.

The traditional five forces model evaluates the threat of new entrants. This analysis is important that competitors can access the market frequently because the technology gap between a leader company and follower companies is narrowed in the growth and maturity stage of the product life cycle. However, in case of following countries doesn't hold high technology and capital, it is not easy for them to enter the export defense weapon system market, because potential purchase countries prefer purchasing the highly trusted weapon system of a leader country to purchasing the weapon system of a new entry. In addition, a leader country is reluctant to share the core technology or performance of a weapon system due to its own security. Therefore, analyzing the threat of new entrants is not necessary for evaluating the export possibility at the research and development stage. We evaluated the threat level of entry barriers of the existing competing weapon system instead of the threat of new entry.

The general model evaluates the threat of substitute products. In the general market, the higher the product price is, the lower the threat of substitute products is. The threat of substitutes is high with low product prices. Most countries develop weapon systems for their national security. Therefore, potential purchase countries that purchase weapon systems developed for export are targeted to least developing countries such as those in South-East Asia, Latin America and the Caribbean. These countries find it highly possible to purchase substitute weapon systems at a relatively low price because they cannot afford to develop a weapon system due to their low military expenditures. Therefore, these countries prefer to purchase substitute weapons that achieve the same goal. We evaluated the threat level of the substitute weapon system in our model.

The bargaining power of suppliers is an important evaluation factor in the general five forces model. Many follower companies enter the product market at the growth and maturity stage in the product life cycle. Therefore, the relation with suppliers, the volume of raw material, the prime cost, and the differentiated raw material could impact on dominating the competitive advantage in a competitive market.

However, the possibility of success in developing the weapons system of a country depends on whether the core technology can be secured. Therefore, if the country is not equipped with the core technology to develop the weapon system, it is very important that the country receive a technology transfer from the country that owns the core technology. Most of the core technologies of weapons systems are held in advanced countries such as the United States, Europe, and Israel, which have the ability to develop their own weapon system and advance into export markets. Thus, these countries do not prefer to supply core technologies or components to other countries. Eventually, the acquisition of a core technology or of the capability of developing a core technology has a strong influence on export success. Thus, we considered the possibility of acquiring a core technology instead of considering the bargaining power of suppliers in our model.

Lastly, the traditional five forces model considers the bargaining power of buyers. The general product customers are unspecified individuals, and the price and the performance of a product attracts the customer's willingness to purchase. The defense weapon system is similar to the general product feature; however, weapon system customers are limited to a few countries, and the quantity of export is small. Therefore, selecting countries that have a high possibility of purchasing a weapon system and establishing a customized strategy for those countries could be important competitive factors. This paper considered the identification of potential countries to purchase a weapon system and to differentiate a marketing strategy instead of the bargaining power of buyers in the traditional five forces model.

Analytical Procedures of Proposed Model

Our proposed model passes through the following steps:

1) The entry barrier level of the existing competing weapon system.
2) The threat level of substitute weapon system.
3) The possibility of obtaining core technology.
4) The identification of both a potential country to purchase the weapon system and the marketing strategy.

The experts' response and evaluation results are collected from focus group interviews (FGI) (Krueger & Casey, 2014) at each step of the proposed model, and the selection and use of experts are described in detail in the case study in section 4. The following sub-sections provide the details of the procedural analysis at each step.

Entry Barrier Level of the Existing Competing Weapon System

When reviewing the export possibility of target weapon systems, it is essential to compare competing weapon systems. If there is a high entry barrier in the market, it will be difficult for the target weapon systems to enter the market.

First, we identify competing weapon systems. In this paper, we define the competing weapon systems as the weapon system that has the same operational concept and the same performance requirements as the target weapon system with high market share. After investigating all current operating weapon systems, we determine the ranking based on the market share, and we consider high ranked weapon systems as competing weapon systems. We consider the market share because the market shares of competing weapon systems and the entry barrier level are relevant. If one of the competing weapon systems has a high market share, the target weapon systems will encounter a high entry barrier when entering the export market. Conversely, if the competing weapon systems have similar market share, they could have a similar level of competitiveness. For validation of the selected competing weapon systems, expert verification is required in the FGI.

For evaluating the entry barrier level, we evaluate technology and price competitiveness of a target weapon system through comparison with competing weapon systems. Then, we evaluate the technology performance and the export price of target weapon and competing weapon as inferiority, superiority and similarity based on the basic technology specification and the price of weapon systems.

Lastly, the level of influence of the entry barrier is measured by FGI. The experts evaluated this level based on the above information; we used the mean values as the entry barrier score.

Threat Level of Substitute Weapon Systems

We define a substitute weapon system as weapon systems that can conduct the same mission of the target weapon system and that have a competitive price. Substitute weapon systems will raise the possibility of threatening the target weapon system's export competitiveness due to the market share. For example, if countries that want to purchase the weapon system are underdeveloped, there will be a high possibility of purchasing substitute/similar weapon systems at a low price. Therefore, this possibility can threaten the export competitiveness of the target weapon systems.

After expert validation of the selection criteria of the substitute weapon system, we determine candidate substitute weapon systems based on those criteria. Then, we conduct a validation process of experts, selecting candidates for substitute weapon systems.

For evaluating the level of threat of a substitute weapon system, we apply the same method that is used to analyze the entry barrier level of competing weapons systems.

If the technological performance of substitute weapon systems is higher than that for the target weapon system, the export competitiveness of the target weapon system may decrease. We investigate a substitute weapon system's threat against the target weapon system through comparison of technology competitiveness. We provide price information of target and substitute weapon system with expert and request evaluation for the effect of the price gap between target and substitute weapon systems on export of target weapon system. Finally, experts evaluate a level of threat of substitute weapon systems based on data from the preceding procedures. We use average value of expert's scores as comprehensive estimation of a threat of substitute weapon systems.

Possibility of Obtaining Core Technology

When exporting target weapon system, a method of obtaining core technology is a key to improving export competitiveness because the method influences the price of weapon system. We first investigate configuration technologies of weapon system for identifying core technologies.

After arranging the configuration technologies, this paper identifies the core technologies using three methods, as follow:

First, if defense weapon system pre-search is completed, the core technologies of weapon system are determined based on the level of Technology Readiness Levels (TRL). We define core technologies as the technology of the lowest TRL among the configuration technologies. Second, we identify core technologies of the weapon system based on the level of technology of the advanced country in the Investigation Report of Defense Science and Technology. Third, if weapon systems do not apply to both cases, we utilize the expert's opinion to identify core technologies.

We classify the method of obtaining core technologies into five types in Table 1. To determine a suitable method for the target weapon, we consider the technology level of the target weapon system, the developed country technology level, the technological ripple effect, the economic ripple effect, the possibility of introduction of technical knowhow from an advanced country (Possibility of E/L), the civil technical level, and the development status of difficulty of selected core technologies. Table 2 shows conditional logics for determining the method of obtaining core technology based on these components.

Finally, experts evaluate the level of possibility of obtaining core technology based on data from the preceding procedures. We use the average value of expert's scores as the comprehensive estimation of the possibility of obtaining core technology.

Table 1
ACQUIRING METHOD OF CORE TECHNOLOGIES

Acquiring Method	Specification
Research and Development (R&D)	As a core source technology, despite its low level of domestic technology, it is classified as a technology that should be developed as a core technology because it is difficult to transfer technology from advanced countries
Civilian-Military co-operation	It is classified as a technology that is highly likely to utilize commercial technology, or expected to be highly applicable to private sector after development
International co-operation	International technology cooperation and international joint technology development project, it is classified as a technology that is expected to have a high efficiency of development and a great economic effect
Development project	When the level of domestic technology reaches a certain level, and considering the utilization of technology, it is classified as an effective technology to be included in the development project of the weapon system
Purchasing overseas technology	Technology that is low in domestic technology level but easy to introduce technology from advanced countries

Table 2
CONDITION LOGICS FOR ACQUIRING CORE TECHNOLOGY

Acquiring method	Factors	Condition logic
Research and development	- Domestic technology level	• Domestic technology level is under 70%
	- Possibility of E/L	• Possibility of E/L is low
	- The development degree of difficulty	• Development degree of difficulty is low
Civilian-Military co-operation	- Civilian technology level	• Civilian technology is superior to military
	- Technological ripple effect	technology level
		• Technological ripple effect is high
International co-operation	- Domestic technology level	• Domestic technology level is under 70%
	- Developed country technology level	• Developed country technology level is under 70%
	- Economic ripple effect	• Economic ripple effect is high
Development project	- Domestic technology level	• Domestic technology level is under 70%
	- Technological ripple effect	• Technological ripple effect is high
Purchasing overseas technology	- Domestic technology level	• Domestic technology level is under 70%
	- Possibility of E/L	• Possibility of E/L is low
	- Developed country technology level	• Technological gap that is over 20%

Identification of Potential Country of Purchasing Weapon System and Marketing Strategy

Regarding establishing an export strategy, identifying potential countries that have a high possibility of purchasing the weapon system will be vital in deciding the export possibility of target weapon systems. There are difficulties in analyzing the 200 states in the world. Therefore, we first selected candidate countries based on the GDP, the defense expenditure, and the scale of defense trade. It is very important that the countries selected have the conditions to purchase target weapon systems. In Table 3, the purchasing power of prospective countries includes the country GDP, Relations with Republic of Korea, the Military expenditure and the possibility of war; these were considered for evaluation. In addition, we classified the purchase power factors of potential purchase countries into four grades, as shown in Table 4.

Table 3
PURCHASE POWER FACTORS OF POTENTIAL PURCHASE COUNTRY

Common identification factors	Contents
GDP	Extract GDP for the subject countries from the IMF World Economic DB and classify them into four grades
Relations with Republic of Korea	Based on data on the MOU and the export of defense products, the countries under consideration are classified into four categories
Military expenditure	Based on the SIPRI data to extract the defense spending of the countries under review and classify the countries under review into four groupings
Possibility of war	Score dispute potential, and classify the candidate states into four classes by using Global Peace Index (2018)

Although potential countries have sufficient purchasing power for target weapon system, they do not purchase the weapon system if it is not necessary. For example, regardless how of competitive a target weapon system may be, if the weapon system is operating in the purchasing country or if the country can manufacture it, the attractiveness of the purchasing country will be low. In addition, if the geographical/environmental conditions do not match to the target weapon system, it could be difficult for purchasing countries to purchase it. This causes the declining of the attractiveness in purchase.

Table 4
QUARTILE FOR PURCHASE POWER FACTORS OF A POTENTIAL PURCHASING COUNTRY

Quartile	Rating	Rating Symbols	GDP (Unit: Billion $)	Defense budget (Unit: Million $)	MOU points	Global Peace index
1 quartile	Very High (4 score)	★	0 ~ 146	0~2,405	0	0.0 ~ 1.806
2 quartile	High (3 score)	○	~248	~ 4,921	0.5	~ 2.130
3 quartile	Normal (2 score)	△	~506	~ 10,289	1.5	~ 2.408
4 quartile	Low (1 score)	X	~17,416	~ 577,511	2	~ 3.377

This paper analyzes the purchasing attractiveness of potential country through four factors in Table 4 and we classify the purchase attractive factors of potential purchase countries into four grades as shown in Table 5.

Table 5
PURCHASE ATTRACTION FACTORS OF POTENTIAL PURCHASE COUNTRY

Identification factor	Evaluating Criteria
Capacity of the weapon system	• Organize the candidate countries status of capacity /operation

The possibility of developing weapon	• Evaluate the requirement possibility of the candidate
Geographical/Environmental conditions	• Evaluate the geographical/ environmental conditions of the candidate countries
The capability of producing weapon	• Evaluate the production ability of weapon systems in the candidate countries

Table 6
QUARTILE FOR PURCHASE ATTRACTION FACTORS OF POTENTIAL PURCHASE COUNTRY

Purchase attraction factors	Analysis standards and contents
Capacity of the weapon system	★ (Very high): When candidate states possess a relevant weapon system
	(Rotary type UAV)
	○ (High): In case of possessing similar/substitute weapon system
	(ex. Tiltrotor type UAV)
	▵ (Normal): Possessing other similar weapon systems (e.g., fixed wing UAV)
	X (Low): Does not possess any weapon system that is equivalent or similar
he possibility of developing weapon	★ (Very high): High dispute condition (confrontation) with neighboring states
	○ (High): Intermediate dispute (confrontation) relationship with the neighboring states
	▵ (Normal): Possibility of potential dispute (confrontation) relationship with a neighboring states
	X (Low): Does not possess any weapon system that is equivalent or similar)
Geographical/Environmental conditions	★ (Very high): Does not have any problem operating the weapon system subject to geographical/environmental condition
	○ (High): Have few problem operating the weapon system subject to geographical/environmental condition
	▵ (Normal): Have significant problem operating the weapon system subject to geographical/environmental condition
	X (Low): Cannot be operated in terms of geographical/environmental aspect
The capability of producing weapon	★ (Very high): Have sufficient capability in R&D and producing the weapon system
	○ (High): Have partial capability in R&D and producing the weapon system
	▵ (Normal): Have production capability, but doesn't have R&D capability
	X (Low): Does not have entire capability of R&D and producing the weapon systems

For calculating the weighted total score of purchase power factors and purchase attraction for candidate countries, we conduct an AHP analysis. The total weighted score of the purchase power factors and the purchase attractions is calculated by multiplying the score of each factor and the weighted value of each factor form AHP. Moreover, we convert the total weighted score of purchasing power and purchasing attractiveness to a Z-value for identifying the final potential countries. Finally, we draw the graph where the x-axis displays the z-value of purchasing power and the y-axis displays the z-value of purchasing attractiveness.

Case Study

For the validation of the proposed methodology, this paper considered Unmanned Aerial Vehicle (UAV), which remains under the development phase in Korea. Military UAV can be operated for various purposes such as surveillance and reconnaissance, wide area image and signal intelligence, anti-gamming, deception control, communication relay, electronic warfare, and assault, which depends on the mission purpose. The UAV is classified into a rotary wing and fixed wing type; the rotary wing type UAV is being developed in Korea. According to Jane's (www.janes.com) and the Forecasting international. Military UAV market is expected to grow to 125billon dollars (USD), with annual average growth of 9.6% through 2030, which will create a great ripple effect throughout the economy and technology. This information proves that UAV is suitable for our case study model. To prove the feasibility of development of the rotary wing type UAV for export, we proceeded to analyze the following four factors: 'Entry barrier level of the existing competitor's UAVs', 'Threat level of the substitute weapon system', 'The possibility of acquiring a core technology' and 'The selection of promising country for export and differentiated strategies for them'.

Selection and use of Specialized Experts

We conducted a Focus Group Interview (FGI) to evaluate the validation of result from each procedure. The questionnaire used in FGI is in the appendix A. The interview was conducted for 2 weeks by means of telephone and e-mail. The authors consisted of 13 experts, but only 10 experts accepted the interview requests. The FGI was conducted with 10 experts engaging in relevant company and Air force and, University, National institution (See Table 7). The questionnaire used in FGI is in the appendix A. The authors consisted of 13 experts; however, only 10 experts accepted the interview requests. The FGI was conducted with 10 experts engaging in relevant company and Air force and, University, National institution.

Table 7
THE LIST OF EXPERTS PARTICIPATING IN FGI

No	Name	Interview	Company	Title	E-mail
1	***, KIM	YES	Defense Acquisition Program Administration	Deputy director	Kws*** @korea.kr
2	***, KIM	YES	Defense Acquisition Program Administration	Deputy director	9710***@korea.kr
3	***, HAN	-	Defense Acquisition Program Administration	Commander	hkh****@korea.kr
4	***, HAM	YES	Air force	Major	Hse***@airforce.mil.kr
5	***, SIM	YES	Defense Agency for Technology and Quality	Senior researcher	sgl***@dtaq.re.kr
6	***, CHOI	YES	Air force	Major	choi***@airforce.mil.kr
7	***, JEON	YES	Defense Acquisition Program Administration	Senior researcher	jij****@korea.kr
8	***, KIM	-	Hanwha Systems	Board director	Kim***@gmail.com
9	***, PARK	YES	LIG Nex1	Board director	Park***@gmail.com
10	***, CHOI	YES	Korea National Defense University	Professor	Cji***@kndu.ac.kr
11	***, LEE	YES	Korea National Defense University	Professor	lIE***@kndu.ac.kr
12	***, JANG	-	Hanwha Techwin	Advisor	Gian***@naver.com
13	***, LEE	YES	Hanwha Techwin	Advisor	Ljf***@gmail.com

Analysis Results

Entry Barrier Level of Existing Competitor's UAVs

The first step is to select competitive UAVs in the current export UAV market to calibrate the entry barrier level of exiting competitors' UAVs. Table 8 shows selected competitive UAVs, as follows: MQ-8 Fire Scout, Skeldar V-200, Camcopter S-100, Hoax X -

240, Neo S-300 and R-350. The selected UAVs are rotary wing type UAVs that have been exported overseas. Specifications such as payload, duration of flight, speed and flight altitude of Camcopter S-100 model were superior to the remainder of competitive UAVs. In addition, the market share of Camcopter S-100 model is higher than for other models.

We evaluated the entry barrier level through the comparison of competitors' technologies and export prices. Table 8 shows the technology level and the export price of existing competitors' UAVs and the target UAV. We first compared the domestically developed UAV with the existing competitive UAVs based on the UAV specifications such as the flight altitude, the flight speed, the duration of flight and the payload. While Camcopter S-100, which is the best from the selected UAVs, and the target UAV have similar performance in the flight altitude and the payload, the duration of flight and the flight speed of Camcopter S-100 were superior to the target UAV. The flight altitude of target UAV represented superior or was similar to other competitive UAVs except for the Camcopter S-100 but is less than MQ-8B Fire-Scout model. The duration of flight of the target UAV was higher than most of the competitive UAVs, and the flight speed was superior or similar to other competitive UAVs. While the payload of target UAV was less than the MQ-8B Fire-Scout model, it was similar or superior to other models. In summary, the technology of the target UAV was worse than the Camcopter S-100 and the MQ-8B Fire Scout but was superior or similar to other competitive UAVs.

Table 8 shows the result of price comparison between the target UAV and competitive UAVs. We used the estimated export price[1] of the target UAV because it is under progress. While the estimated price of the target UAV was similar to the price of the MQ-8 Fire Scout, the Skeldar V-200, the Camcopter S-100 and the R-300 but was higher than the KOAX X-240 and the NEO S-300.

TABLE 8
THE PERFORMANCE COMPARISON OF COMPETITIVE UAVS AND TARGET UAV

Target UAV	**Operating Altitude***		**Duration of Flight****		**Maximum Speed*****		**Payload******		**Price (M$)**
Spec.	**3.4 km**		**5 hour**		**165 km/h**		**50 kg**		19.5
Competitive Model	**performance**	**Comparison (over target)**	**performance**	**Comparison (over target)**	**performance**	**Comparison (over target)**	**performance**	**Comparison (over target)**	-
Camcopter S-100	3.6 km	Similar	5 hour	Similar	222 km/h	Superior	50 kg	Similar	20
Skeldar V-200	3.5 km	Similar	6 hour	Similar	140 km/h	Inferior	40 kg	Similar	20
R-350	4.5 km	Similar	4 hour	Similar	145 km/h	Inferior	40 kg	Similar	18
KOAX X-240	1.5 km	Inferior	1.5 hour	Inferior	75 km/h	Inferior	8 kg	Inferior	12.5
NEO S-300	2.5 km	Inferior	2 hour	Inferior	120 km/h	Inferior	20 kg	Inferior	15
MQ-8B Fire Scout	6 km	Superior	3 hour	Inferior	203.7 km/h	Superior	90 kg	Superior	18.6

* Operating Altitude: Guarantee survivability from ground attack and fly at altitudes where noise limited on the ground
** Duration of Flight: Ability to operate 24 hours in the area (Min. 0 hrs over)
*** Maximum Speed: Max. speed level for equivalent type UAV (over OOO km/h)
**** Payload: Able weight load of equipment during the operation (Below OO kg over)

Lastly, we conducted an FGI and five Likert scale questionnaires for quantifying the entry barrier of the existing competitive UAVs based on the above results. Consequently, the average score of the entry barrier was 4.2, which means that the entry barrier of the existing competitive UAVs is high if the target will enter the UAV export market. When we synthesized the experts' opinions, the largest problem was the low technology level of the target UAV. Low technology causes an increase in the price of the weapon due to high dependency on foreign technology. The high dependency on foreign technology makes it difficult for an export country to continually provide maintenance. Therefore, the technology development that can reduce the export price is necessary for acquiring the competitiveness in the UAV export market.

Threat of Substitute Weapon Systems

We defined a concept of the substitute weapon system as weapon that can achieve the same purpose of target UAV. However, the export price of the substitute weapon system is usually lower than the target weapon system. We selected tilt-rotor UAV (Fixed wing type) as the substitute weapon system for the target UAV. Table Ⅸ represents the export performance, the export price and the market share of the tilt-rotor UAV. We analyzed the threat level of a substitute weapon system with the Eagle eye and the Panther, which have higher market shares than that of other tilt-rotor UAVs.

As shown in Table 9, the threat level of the substitute weapon system was evaluated through the comparison of the level of technology and price between tilt-rotor UAVs and the target UAV. A common feature of the tilt-rotor UAV and the target UAV is that Vertical Takeoff and Landing (VTOL) are possible. However, the target UAV (rotary wing type UAV) is suitable for low speed/low altitude/short distance operate ion, and the tilt-rotor UAV (fixed wing type UAV) is developed for a fast speed/high altitude/long distance operation requirement. Table 10 shows that the altitude, the duration of flight and the flight speed of the tilt rotor UAV is higher than the target UAV. The tilt-rotor UAV and the target UAV may have different markets based on their usage purposes. However, the tilt-rotor UAV could be a threat to the target UAV because the tilt-rotor UAV can quickly and widely achieve its mission. However, the tilt-rotor UAV is limited to the payload due to its operational purpose of high and fast flight. If the engine breaks in the air, it is difficult to land the tilt-rotor safely.

The export price of tilt-rotor UAVs is lower than the target UAV. A low price could attract underdeveloped country with a low defense budget to purchase a substitute weapon system of the target UAV. However, due to the high cost of operation and maintenance for the tilt-rotor UAV, there may be difficulties operating it long-term.

TABLE 9
COMPARISON OF RESULTS BETWEEN THE TARGET UAV AND SUBSTITUTE UAVS

UAV	**Operating Altitude**		**Duration of Flight**		**Maximum Speed**		**Payload**		**Price (M $)**
Spec.	3.4 km		5 hour		>= 165 km/h		>= 50 kg		19.5
Substitute UAV	performance	Comparison (over target)	performance	Comparison (over target)	performance	Comparison (over target)	performance	Comparison (over target)	-
Eagle eye	6.5 km	Superior	8 hour	Similar	200 km/h	Superior	20 kg	Inferior	5.7
Panther	4 km	Superior	6 hour	Similar	165 km/h	Similar	30 kg	Inferior	4.8

We conducted focus group interviews to evaluate and quantify the threat level of a substitute weapon system based on the above results such as evaluating the entry barrier level of the existing competitive weapon system. Consequently, the average score of the threat level of substitute weapon system was 4.3, which means that the tilt-rotor UAV is a threat to the target UAV. Based on the expert's opinion, most of the countries will prefer the tilt-rotor UAV rather than the rotary wing type UAV, because the military trend will rapidly accelerate to much wider and higher operational requirements in the future.

Possibility of Acquiring Core Technologies

We introduced the acquiring methodology of each core technology in chapter 3.3. We first selected core technologies of UAV before we determined the acquisition method of each core technology. After selecting core technologies, we investigated seven factors such as the technology level of the target weapon system, the developed country technology level, the technological ripple effect, the economic ripple effect, the possibility of the introduction of technical know-how, the civil technical level, and the degree of development difficulty of selected core technologies. We then applied six factors into the proposed conditional function to determine the acquisition method of each core technology.

For selecting core technologies, we first investigated the basic technologies of the rotary wing type UAV. The rotary wing type UAV consists of six basic technologies such as the system integration technology, the airframe technology, the engine technology, the flight control technology, the avionics technology and the mission operation technology. If the level of technology is under 70%, we defined that technology as core technology. We used the Survey of the National Defense Science and Technology (2019) to investigate the level of six basic technologies and selected the flight control technology and the mission operation technology as core technologies. For the validation of selected core technologies, we conducted the feasibility survey to experts in the focus group interview. Consequently, most of experts provided opinions that two technologies are suitable for core technologies. We finally determined core technologies and investigated the six factors of core technologies, which are applied to the conditional function.

Table 10 shows the acquiring method of each detailed technology by applying the seven factors into the proposed conditional function. As shown in figure 3, the effective acquiring method of high-efficiency anti-jamming technology and data based navigation technology in the flight control technology was recommended as technology development through civil-military cooperation because the level of civilian technology is superior to that of the military. A suitable acquiring methodology of co-operative operability technology and UAV distributed control technology in the mission operation technology was selected for research and development (R&D) and technology development through international cooperation, respectively.

Table 10
SEVEN FACTORS OF DETAILED TECHNOLOGIES OF CORE TECHNOLOGY

Core technology	Detailed technology	Developed country technology level	Target technology level	Technological ripple effect	Economic ripple effect	Possibility of introduction of technical know-how	Civil technical level	Development degree of difficulty
The flight control technology	High-efficiency Anti-jamming	88%	64%	Big	Big	Normal	Military<Civil	Normal
	Data based Navigation	92%	72%	Big	Normal	Normal	Military<Civil	Normal
The mission operation technology	Co-operative operability	73%	60%	Big	Norma	Very Low	Military≫Civil	Very High
	UAV Distributed control	77%	59%	Big	Big	Very Low	Military>Civil	Very High

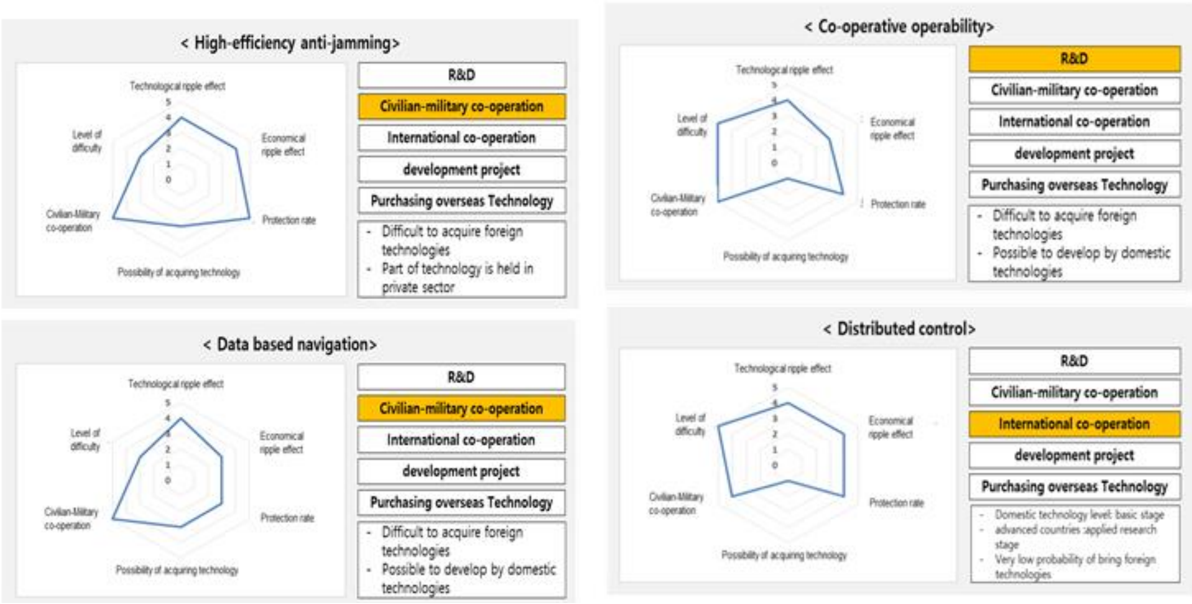


FIGURE 3
POSSIBILITY OF ACQUIRING OF EACH SUB-CORE TECHNOLOGIES

For the validation of recommended acquiring methods of detailed technologies of core technology based on our proposed conditional function, we conducted an FGI. Consequently, most of experts gave opinions that our proposed acquiring methods of core technologies is reasonable. However, certain experts said more effective acquiring method of high-efficiency anti-jamming technology is research and development (R&D) because the civilian technology level is not sufficiently mature as well. The acquiring method of UAV Distributed control technology is much more suitable for research and development (R&D) because it is nearly impossible to do *via* international cooperation. Table 11 shows the final acquiring method of core technology based on opinions of experts.

We finally quantify the possibility of the acquiring method of core technologies from experts. Consequently, the average score was 2.9, which means the possibility of recommended acquiring method of core technologies is low. The reason is that the technology gap between domestic and advanced country is large, and civil-military cooperation is limited to develop technology unless government funding is supported.

Table 11
ACQUIRING METHOD OF EACH CORE TECHNOLOGIES

Core technology	Detailed technology	Acquiring method
The flight control technology	High-efficiency Anti-jamming	Civilian-military co-operation
		(However, if it is difficult to be Civilian-military co-operation, develop through R&D if it is necessary)
	Data based navigation	Civilian-military co-operation
The mission operation technology	Co-operative operability	Developing through R&D
	UAV distributed control	International co-operation
		(However, develop through R&D if it is difficult)

Identification of Potential Country of Purchasing Weapon System

We first selected certain candidate countries based on the GDP, the defense expenditure, and the scale of defense trade in the world. Table 12 shows the thirty-eight selected countries, which consist of twelves countries in Asia and CIS, six countries in the Middle East, nine countries in the Americas, eight countries in Africa and three countries in Europe.

Table 12
PROMISING CANDIDATE COUNTRIES THAT IS HIGHLY POSSIBLE TO PURCHASE THE DOMESTIC WEAPON

Region	List of candidate countries
ASIA/CIS (12)	India, Indonesia, Thailand, Malaysia, Philippines, Singapore, Vietnam, Bangladesh, Australia,
	New Zealand, Kazakhstan, Ukraine
Middle State (6)	Turkey, Saudi Arabia, UAE, Iraq, Kuwait, Azerbaijan
America (9)	Brazil, Columbia, Argentina, Venezuela, Chile, Peru, Ecuador, Paraguay
Africa (8)	South Africa, Nigeria, Egypt, Algeria, Libya, Kenya, Botswana, Rwanda
Europe (3)	Poland, Serbia, Albania
Total	**37 states**

Table 13
THE RESULT OF GRADING PURCHASE POWER AND ATTRACTION FACTORS (ASIA/CIS)

Potential purchase Countries		purchase power factors				purchase attraction factors			
		Size of gdp	Relation with rep. Korea	Conflict possibility	Military expenditure	Operatin g status	Demanding possibility	Geography & Environmental Condition	Domestic Manufacturing Capability
ASIA/CIS	India	★	△	★	★	△	○	★	○
	Indonesia	★	★	△	○	△	○	★	△
	Thailand	○	○	○	○	△	○	★	X
	Malaysia	○	X	X	○	△	○	★	X
	Philippines	○	★	★	△	△	X	★	X
	Singapore	○	X	X	○	△	○	★	○
	Vietnam	△	X	X	△	△	○	★	X
	Bangladesh	△	X	△	X	X	△	★	X
	Australia	★	★	X	★	★	△	★	○
	New Zealand	△	○	X	X	△	X	★	X
	Kazakhstan	△	X	○	X	△	△	○	X
	Ukraine	X	X	★	○	△	△	★	X

★: very high (4 score), ○: high (3 score), △: middle (2 score), X: low (1 score)

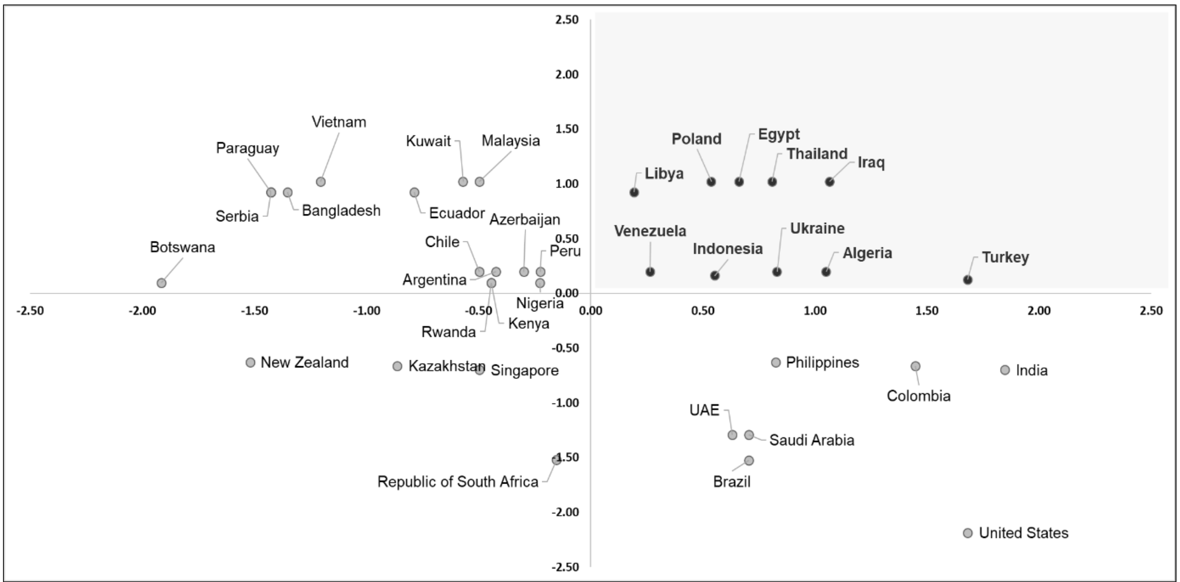
Then, we investigated general factors and purchase attractions of the target UAV for selected candidate countries. The general factors include GDP, relations of candidate states (37 countries) with Korea and sales country (the Korea), the possibility of dispute and national defense expenditure. The purchase attractions of candidate countries include the UAV capacity, the possibility of developing UAV, the geographical and environmental condition, and the capability of producing UAV. Table 13 represents the result of four grade for general factors and purchase attractions in the countries of Asia and the CIS.

For calculating the weighted total score of general factors and the purchase attractions for candidate countries, we conducted an AHP analysis. Table 14 shows the relative weighted total score of the general factors and the purchase attractions using Z-transformation in the countries of Asia and CIS.

Table 14
OVERALL SCORE AND Z-SCORE OF CANDIDATE COUNTRIES (ASIA/CIS)

	State	Overall score of common identification factor	Overall score Identification factors by weapon system	Common Identification factor Z-transform score	Identification factor for WS Z-transform score
ASIA / CIS	India	3.76	3.00	1.85	-0.70
	Indonesia	2.81	3.26	0.55	0.16
	Thailand	3.00	3.53	0.81	1.02
	Malaysia	2.04	3.53	-0.50	1.02
	Philippines	3.01	3.02	0.82	-0.63
	Singapore	2.04	3.00	-0.50	-0.70
	Vietnam	1.52	3.53	-1.21	1.02
	Bangladesh	1.41	3.50	-1.35	0.92
	Australia	2.92	2.30	0.70	-2.97
	New Zealand	1.29	3.02	-1.52	-0.63
	Kazakhstan	1.77	3.01	-0.86	-0.66
	Ukraine	3.02	3.27	0.83	0.20

The same approach was applied to countries in the Middle East, Africa, and Europe; Figure 4 represents the Z-score of all countries. In this graph, the X-axis represents the general factors, and Y-axis represents the purchase attractions. Therefore, we selected countries in the second quadrant as countries that are highly likely to purchase the target UAV because the general factors and purchase attractions of these countries are higher than that of other countries.



Region	Identified expert promising states
ASIA/ CIS	Indonesia, Thailand, Ukraine
Middle East	Turkey, Iraq
Africa	Libya, Egypt, Algeria
South America	Venezuela
Europe	Poland

FIGURE 4
GRAPHICAL REPRESENTATION OF Z-SCORE OF CANDIDATE COUNTRIES

Comprehensive Results (The Export Possibility of Target UAV)

We show up overall results for the export possibility of the target UAV from the perspective of four factors consisting of a threat of competing weapon, a threat of substitute weapon, a possibility of acquiring core technology and a selection of promising countries of purchasing target UAV. An average score of experts about “threat level of competing weapon” was an approximately 4 of 5 score, which can be evaluated in high threat level. Advanced country’s level of UAV technology is currently higher than target UAV technology. It is difficult to execute the technology transfer from advanced country due to many regulations. These circumstances drive target UAV technology to be developed in autonomously, resulting in decreasing the price competitiveness and technology, which eventually lead to failure of export because purchasing countries will prefer advanced countries UAV. The “threat level of substitute weapons” was also high, and its score was 4.2. This finding means that the tilt-rotor UAV will be a strong competitor when the target rotary UAV enters the market because future warfare will accelerate to go farther and faster in tactical air reconnaissance and surveillance mission. The score for “the possibility of acquiring core technologies” was on average 2.9, which means that it will be difficult to achieve them. The reason that the gap of technology level between advanced countries and target is due to many regulations that makes difficult for technology transfer. However, if it appears to make a suitable combination between government investment in research and development (R&D) and civilian co-operation, it may be possible to acquire the core technology of UAV early. Lastly, “the export possibility of selected potential emerging countries” was low, and the score was on average 2.9. The selected purchasing countries were mainly underdeveloped or developing countries which would mostly prefer to acquire low price weapon systems, while target UAV prices will be likely to stay at high level.

Based on the results of analysis, we discuss the export competitiveness of target UAV based on SWOT factors. Because Korea Aerospace Research Institute (KARI) and several domestic companies have an experience that has developed UAVs, Korea has previously owned certain core technologies. This factor is a major strength. Nevertheless, UAV that is developing in Korea has weakness. First, among the competing model, the Camcopter S-100 is overwhelmingly leading to market in vertical take-off and landing UAV sector. It must be a major entry barrier of market to the domestic UAV of Korea. Korea also plans the engines that are one of the core technologies to purchase from Austria. Thus, exporting countries may be restricted due to difficulties of DOD Export License (E/L) approval. Furthermore, opportunities are significant. As the UAV market is growing at an average annual growth rate of 9.6% in the private sector, there could be a possibility of exporting the products to commercial sector. In addition, due to the high level of domestic IT technology of Korea, it is possible to develop the core technologies through civilian-military cooperation. In particular, countries such as Egypt, Algeria, and Venezuela are expected to expand potential export opportunities in terms of technology exports simultaneously. The tiltrotor type UAVs, which are selected as an alternative weapon system, are superior to target VAV belonging to vertical takeoff and landing type UAVs in terms of both technology and price competitiveness; thus, tiltrotor type UAVs have advantage to encroach the vertical takeoff and landing UAV market. When Korea exports target UAV, this will be a major threat.

CONCLUSION

In this study, we propose a modification of five forces model for analyzing export competitiveness from the emerging markets at R&D stage of weapon system. The government needs to establish a precise strategy at the developing stage of certain weapon systems that are vital when measuring factors that can lead to successful or unsuccessful in target emerging market. These findings are related due to its characteristics of exporting weapon systems, which include government purchase, high market entry barrier, and restrictions on accessing information regarding purchase of arms. Particularly, in the international weapons market, for the sake of securing export competitiveness, strategical and market-oriented research is necessary at the development stage.

Thus, this research suggests a new evaluation model for export competitiveness of weapon system based on five forces model; to validate the applicability of proposed model, the case study based on UAV that is developing in Korea is implemented.

It is expected that this research will be widely used to compare competing and substitute weapon systems and to select strategical target markets for the export of weapon systems that are to be researched and developed in the future. This research is expected to serve as a decision-making method when establishing a customized export strategy.

FOOT NOTE

The criteria of production unit price estimation (unit: 100 million won) Vehicle 166.7, control equipment 11,5, ground relay equipment 9.4, group support equipment 18.6, group equipment integration 0.7, repair parts 8.3; applied exchange rate: 1100 won/$)

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3. The corresponding author For "The evaluation of the export competitiveness of weapon systems in emerging market using five forces model" : Sukjae Jeong, Jang Yeop Kim, Kwangwoon University, South Korea, Email: sjjeong@kw.ac.kr, jykim1670@kw.ac.kr

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