Advances in Social Science, Education and Humanities Research, volume 480
Proceedings of the 2020 5th International Conference on Modern Management and Education Technology (MMET 2020)

On Risk Management of Weapon Equipment Research and Manufacturing Investment Based on Incentive Mechanism

Huibin Yu

Department of National Defense Economy, Army Logistics University of PLA, Chongqing 401331, China
Email: 31577889@qq.com

ABSTRACT
The particularity of the military activities determines the high risk of the equipment research and manufacturing investment. The risk comes from two aspects: the research and manufacturing cycle of high-tech weapons and equipment is getting longer and longer and the investment, including the cost risk, the schedule risk, the technical risk and the Project risk, is getting higher and higher. The trend of the investment risk of modern armament research and manufacture indicates that the program demonstration stage which plays a decisive role in the acquisition of armament is the most risky. In the research and manufacture of the weapons and equipment, there is no technological progress without risk. Therefore, it is an effective way to control the risk of the research and manufacture of the weapons and equipment to design incentive mechanism based on the risk management. The ultimate purpose of managing this risk is to deal with it and make it under proper control and the specific ways include the risk aversion, control, taking and transfer. It is of great significance to reduce the risk of the equipment development investment, save the cost and improve the speed of equipment development.

Keywords: *Weapons and equipment，Research and manufacturing, investment, risk analysis*

1. INTRODUCTION

As a kind of venture capital, from the establishment of the project development to the transformation of scientific research results in every stage, the investment of weapon equipment research and manufacture is facing uncertain factors such as technology, demand, etc. The existence of uncertainty determines that the risk of weapon equipment research and manufacture investment exists objectively. From the perspective of the world, the investment risk brought by uncertain factors will bring great harm to the national defense scientific research activities, and all major military powers have experienced the loss caused by risks in the field of national defense scientific research. Therefore, it is the basis of scientific decision-making to treat and analyze the risk of research and manufacturing investment of weapons and equipment correctly, grasp the change trend of the risk of modern weapons and equipment development, and design the incentive mechanism based on risk management to control the risk of modern weapons and equipment research and manufacturing.

1.1. Related Work

The research on the risk management of weapon equipment research and manufacturing investment can be divided into two parts.

1.1.1. Research on venture capital

On the venture capital, Jianwei Lu and Lin Chen gave a comprehensive idea of risk treatment based on risk analysis, and discussed the specific methods of risk avoidance, control, bearing and transfer. [1]From the role of the venture capital, Linyuan Quan analyzed the research and manufacture of equipment and considered that the venture capital not only effectively promoted the scientific research in the field of high technology and the commercialization and industrialization of the research, but also its overall social benefits were far greater than its direct economic benefits, thus bringing high military overflowing benefits.[2]

1.1.2. Research on venture capital of weapons and equipment

Bin Tian and Bing Feng combined the characteristics of the aviation weapons and equipment development, constructed the risk management process of the aviation weapons and equipment development project, analyzed the risk types and characteristics in the equipment development, and studied the risk identification process in the risk management of aviation weapons and equipment development. The above research provided the guidance for the standardized risk management in the research and manufacture of the aviation weapon equipment.[3]

1.2. My Contribution

This paper presents some improvements based on the above research. In my opinion, the risk of investment in research and manufacturing of the weapons and equipment exists objectively, the essence of the investment decision in the research and manufacture of the weapons and equipment is not to eliminate the risks as much as possible, but to try to match the benefits with the risks, and to determine the development risks at a controllable and appropriate level. And it is an effective way of the risk management to formulate different research and manufacturing contracts through the design of the equipment research and manufacturing incentive mechanism.

1.3. Paper Structure

The rest of the paper is organized as follows. Section 2 introduces the formation of the risk of the modern weapons and equipment research and manufacturing. Section 3 summarizes the types of investment risks in research and manufacture of weapons and equipment. Section 4 predicts the trend of the risk change of the modern weapon equipment research and manufacture. Section 5 explores the ways and methods of the risk control of the modern weapon equipment research and manufacturing. Finally, Section 6 concludes the paper and presents direction for future research.

2. FORMATION AND TYPES OF RESEARCH AND MANUFACTURING RISKS OF MODERN WEAPONS AND EQUIPMENT

2.1. Formation of Research and Manufacturing Risks of Modern Weapons and Equipment

The risk of military equipment research and manufacturing investment is determined by the particularity of its activities, and its formation reasons are mainly reflected in two aspects.

2.1.1.Research and manufacturing cycle of high-tech weapons and equipment getting longer and longer

After the Second World War, with the continuous improvement of the complexity and technical level of the weapons and equipment, the research and manufacturing cycle of the modern weapons and equipment, especially the large high-tech weapons and equipment, shows a trend of continuous extension. The reasons are mainly as follows. Firstly, the technologies used are becoming more complex and the requirements for advance research are becoming higher and higher. It increases the time for not only the advance research, but also the advance research results to be converted into research and manufacturing results. Secondly, higher and higher requirements are placed on the operational performance, tactics and technical indicators of new weapons and equipment, which greatly increases the difficulty of the research and manufacturing and thus extends the cycle. Thirdly, the large high-tech weapons and equipment are often complex systems with strong supporting properties. While studying and manufacturing its main system, it is necessary not only to study many subsystems, but also to carry out comprehensive research and balance coordination of the whole system, which also increases the time of the research and manufacturing. Lastly, the research and manufacture of the large-scale high-tech weapons and equipment requires a large amount of investment, which is difficult to guarantee. When the research and manufacture fund cannot be fully guaranteed, it is necessary to extend its cycle.

2.1.2. Research and manufacturing costs increasing

With the increase of the technological content of the weapons and equipment, the research and manufacturing funds invested in all countries of the world show an increasing trend. The reason lies in the increasing role of science and technology in the development of productive forces, especially in the research and manufacture of modern weapons and equipment. Since the 1970s, the performance and quality of the weapons and equipment have had an increasing impact on combat capability, prompting all countries to develop and adopt new technologies in the research and manufacturing of the weapons and equipment, which further increases the investment in the research and manufacturing of the weapons and

equipment. According to the statistics, the research and manufacturing cost of the weapons and equipment models in the United States in the 1970s and 1980s increased several times to more than 10 times compared with that of weapons and equipment models in the 1950s and 1960s. [4]

The reasons for the increase of the research and manufacturing funds of the modern weapons and equipment are as follows. Firstly, the modern equipment research and manufacturing requires the use of expensive raw materials and experimental equipment. The reactors needed to build an atomic bomb, for example, each cost hundreds of millions to billions of dollars. Most projects require the use of sophisticated optical equipment, electronic instruments and other testing, experimental equipment and high-precision machine tools, which also increase the cost of the research and manufacturing activities. Secondly, due to the advanced technology, the research and manufacturing of the modern weapons and equipment requires the multidisciplinary technical experts to carry out the comprehensive collaborative research. Moreover, the difficult technology, the long research and manufacturing cycle, and the increasingly difficult to achieve results also increases the investment amount of the equipment research and manufacturing.

2.2. Types of Equipment Research and Manufacturing Investment Risks

The extending cycle of the equipment research and manufacturing activities makes the uncertainty factors increase continuously, and the huge investment amount also makes the space for the various uncertainties to play a bigger role and the possibility is greater. The uncertainty factors are mainly internal and external uncertainty. The internal uncertainty is caused by the technical unknowns and it is strong at the design stage. Now, the new technologies emerge one after another, and the long research and manufacturing cycle makes this kind of technological uncertainty have an increasing trend. The external uncertainty is about the demand for the weapons. This uncertainty is caused by the changes in external threats and the possibility of acquiring alternative weapons.

2.2.1. Cost of risk

The cost risk refers to the possibility that the cost of a research manufacturing project exceeding the budget and the extent of the over expenditure. As a result of competition, the actual expenditure is generally difficult to fall below estimates and too long investment cycle will increase a variety of the uncertainties. In particular, the inappropriate pursuit of the high performance indicators often leads to the high project costs. The cost risk factors are the inaccurate and incomplete budgets caused by the uncertainty ,The impact of the macroeconomic regulation, the high costs caused by the adjustment of the prices of the raw materials and supporting equipment, the influence of technical and planning factors, and the influence of other unforeseeable factors.

Many equipment projects fail not because of their technically impossible, but of their economically unaffordable. For example, since the end of 1970s, the United States has been studying and manufacturing "Sergeant York" division anti-aircraft gun. One target was the Soviet attack helicopter, which could fire anti-tank missiles from up to 4 kilometers away. But before the long investment cycle was over, the Soviet Mi-28 attack helicopter was capable of launching anti-tank missiles from 6 kilometers away. This ability has necessated adjustments to the "Sergeant York" plan, which have been limited by the availability of the funds. The project was terminated in 1985 after 8 years and a $1.8 billion investment. [5]

2.2.2. Schedule risk

The schedule risk refers to the possibility and extent of delay of the weapon equipment research and manufacturing projects that cannot be completed on schedule. The main factors causing schedule risk are the influence of the insufficient and complete schedule demonstration, the investment intensity, the technical and planning factors, and other unforeseen factors.

Losing control of progress is also a common problem faced by all countries in the field of the defense research. For example, the project delay and over-budget are the biggest problems in the acquisition and management of British weaponry and equipment. As of June 1998, only two of the 25 major weapons and equipment acquisition projects in progress were on schedule, while the other 23 projects were on an average delay of 43 months. Of all the major weapons and equipment acquisition projects, some 16 are over budget.[6] Thus it can be seen that low schedule risk will reduce the acquisition efficiency, while high schedule risk will lead to project suspension.

2.2.3. Technical risk

The technical risk refers to the possibility and margin of the weapon equipment research and manufacturing projects that fail to meet the required tactical and the technical targets under the predetermined resource constraints or the probability that some part of the research manufacturing plan produces unexpected results in advance that have a relevant impact on the overall system performance. The main factors of technical risk are: unable to complete the project as

required without corresponding technical development capability, the pre-research being not sufficient and the theoretical argumentation being not mature, lack of technical support capacity, the technology and production areas being not coordinate, the scientific and technological achievements being difficult to transform.

2.2.4. Project risk

The project risk is the possibility and consequences of the adverse effects of external resources and activities not under the control of the project on the weapons and equipment engineering project. The project risk is related to management, and the effectiveness of management can effectively prevent it.

The main factors of the project risk are the interruption and delay of the material supply, the unavailability of the personnel, the environmental impact, the decision-making changes and mistakes of the authority, the constraint of funds, the stability of the manufacturing side, etc.

3. CHANGING TREND OF INVESTMENT RISK OF MODERN ARMAMENT RESEARCH AND MANUFACTURE

Generally speaking, the equipment research and manufacturing can be divided into two stages: the advance research and the model research and manufacturing, which are further subdivided into the comprehensive demonstration, scheme demonstration, preliminary design, technical design, achievement transformation and other processes. In the process of the equipment research and manufacturing, the degree of risk and uncertainty decreases gradually with the change of demonstration, design and achievement transformation. The questions raised in the first few stages of the demonstration are more qualitative. With the progress of the research and manufacturing work, after in-depth design calculation and test verification, the information is increasing and the quantitative indicators are more and more certain. By the end of the trial production, the most abundant and accurate data had been obtained, with the least risk and uncertainty.

In the process of the equipment purchase, the early scientific decision determines the main part of the whole life cost of the equipment. Although the investment in the programme demonstration phase is less than 5% of the planned cost of the equipment research and manufacturing project, its influence on its lifetime reaches 70%. At the end of the preliminary design stage, the influence degree of the investment on the whole life cost of the equipment reaches 85%; at the end of the comprehensive research and manufacturing stage, it has reached 95%.[7] In other words, the lifetime cost of weapons and equipment is a foregone conclusion. Therefore, although the cost is lower during the research manufacturing phase especially the programme demonstration phase, it plays a decisive role in the acquisition of the weapons and equipment and has the greatest risk.

4. RISK CONTROL OF INVESTMENT IN RESEARCH AND MANUFACTURE OF MODERN WEAPONS AND EQUIPMENT

The equipment research and manufacturing investment is a rational investment, the subject is also the interest of the preference and risk aversion. On the one hand, the investment subjects hope to obtain the maximum investment return; on the other hand, they hope not to take risks, or avoid risks, or think the less risks the better, or even pass risks on. But the relationship between return and risk is closely linked. In the research and manufacture of the weapons and equipment, there is no technological progress without risk. Therefore, the designing incentive mechanism based on risk management is an effective way to control the risk of the research and manufacture of the weapons and equipment.

4.1. Risk appetite

The method to determine the return and risk matching of the weapon equipment research and manufacturing scheme can only rely on the subjective preference of individual investors. The subjective preferences of the investors can be described by the utility function. The investor's utility function falls into three categories: the concave utility function, the convexity utility function, and the linear utility function. The three utility functions respectively represent the investors' different attitudes towards risks.

4.1.1. Concave utility function

This function indicates that the investor's utility increases with the increase of return, but the utility of return decreases. It indicates that the investors hold a risk-averse attitude, and only a large increase in returns can bring utility satisfaction to such investors and make them willing to take larger risks.

4.1.2. Convex utility function

This function represents the increasing marginal utility of the investor's return. When there is a small increase in income, there is a larger percentage

increase in utility. Willing to bear the big risk to pursue the high yield, this kind of investors are the risk preference.

4.1.3. Linear utility function

This function indicates that the marginal utility of the investor's return is constant. It suggests that the investors are risk-neutral.

4.2. Risk management

In general, the risk treatment is to take corresponding measures to identify and evaluate the risk problems after analysis. The ultimate purpose of the risk management of the weapon equipment research and manufacturing project is to deal with the risk and make it properly controlled. And different types of risk preference will lead to different risk treatment.

4.2.1. Risk aversion

The risk aversion is actually a risk-averse attitude, which can be expressed as: do not accept this choice because of its potential adverse consequences. In many cases, a low-risk option can be chosen from a number of alternatives and making a low-risk option is a risk-averse decision.

4.2.2. Risk control

The research and manufacturing programme for the risk control for the weapons and equipment has been finalized and the research and manufacturing phase has begun. This is the most common of all risk management techniques and it can be expressed as in order to mitigate their impact, the risks are acknowledged but efforts will be made to reduce their occurrence. The risk control is the process of the continuous monitoring and correction for the weapons research and manufacturing projects.

4.2.3. Risk taking

The risk taking refers to the consequences of the adverse events that result from a conscious decision to accept the research and manufacture of the weapons and equipment projects. In the process of the equipment research and manufacturing, no matter how to avoid and control the risks, there are always a certain number of risks that need to be undertaken. Therefore, the project manager must set an appropriate, safe and acceptable level or minimum acceptable position for the specific situation which includes the performance degradation, the cost overruns and the schedule delays, etc.

4.2.4. Risk transfer

The risk transfer is a kind of practice developed on the basis of the risk avoidance, the risk control and risk taking whose guiding ideology is risk sharing. In other words, the client and the research and manufacturing unit share the risk. It may also be deemed that the client and the research and manufacturing unit transfer the risks to the client. Generally speaking, this transfer contract is the result of the risk game between the research and manufacturing client and the unit, which is beneficial to both sides.

5. CONCLUSION

In view of the objectivity of equipment research and manufacturing risk, the essence of investment decision-making and management is not to eliminate risks as much as possible, but to prevent and control risks as much as possible. Therefore, it is necessary to strengthen the contract management of the weapons and equipment research and manufacturing to coordinate the relationship between the army and the units. The formulation of the contract needs to balance the risks and benefits, which reflects the distribution of the benefits between the army and the units. From the perspective of the risk management, establishing the effective research and manufacturing incentive contracts is an effective way of the risk management.

REFERENCES

[1] M. Xiang, Private Enterprises Encouraged to Invest in Military Scientific Research, Economic Management Press, 2018.

[2] W. Xie, K. Ai, Competitive Procurement of Equipment, National Defense Industry Press, 2015.

[3] Y. Zhang, Competitive Equipment Procurement Theory, National Defense Industry Press, 2015.

[4] H. Ma, On Incentive Mechanism of Military-civilian Collaborative Innovation in National Civil-Military Integration Innovation Demonstration Area, Journal of Chinese Military Science 43(3) (2018)56-59.

[5] Z. Xiao, D. Yang, Z. Xu, Research on Whole-process Competition and Countermeasures of Scientific Research and Production of Weapons and Equipment, Journal of Equipment University 32(4) (2014)37-41.

[6] Z. Wang, Suggestions on Reform of Military Equipment Procurement System, Journal of Chinese Government Procurement 27(5) (2019)12-18.

[7] B. Shu, Coordinate and Promote Participation of Competitive Private Enterprises in Equipment Research and Production, Journal of Equipment University 33(5) (2015)84-90.