

# Research on Pricing of High-value Patent Mining in Equipment R&D

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## **Abstract:**

This paper focuses on the structural system of mining factors for high-value patents in equipment R&D. According to the characteristics of high-value patents in equipment R&D, this paper starts from five primary influencing factors including military, economy, technology, law and efficiency to establish 14 secondary influencing factors including national defense classification, use yield, innovation, examination and approval system and efficiency. In addition, these 14 secondary influencing factors are explained in detail, and an improved real option model is constructed to evaluate high-value patents.

**Keywords:** *Equipment R&D, High-value patents, Screening.*

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## I. INTRODUCTION

Technological innovation is an important means to improve the competitiveness of the equipment manufacturing industry and even the country. Continuous technological innovation is the trend of equipment development and an important guarantee to win the war in the new era [1]. As the patent technology plays an increasingly obvious role in the construction of national defense equipment, we should not only improve the starting point of R&D, but also accelerate the pace and efficiency of equipment R&D, thus promoting the improvement of combat effectiveness. Therefore, the use and protection of patent technology in equipment R&D has attracted more and more attention. Patents in equipment R&D mainly refer to patents that military scientific research units need to use in equipment R&D, including patents that have been successfully developed by military units or private enterprises and have been applied or will be applied soon, which are characterized by confidentiality, timeliness, dynamics and weak correspondence. From the current actual situation, there is a great breakthrough in the number of patent applications every year. However, due to the current system and national defense characteristics, many advanced patent technologies cannot be fully applied in the

improvement of equipment performance and combat effectiveness, which greatly hinders the development of equipment construction.

This paper holds that in order to select high-value patents from the vast number of patents, it is necessary to vigorously improve the quality of patents and cultivate high-value patents, which will become a major task for China to build a strong intellectual property country and support innovation-driven development, and which is also a top priority.

## **II. THE CONNOTATION OF HIGH-VALUE PATENTS IN EQUIPMENT R&D**

What is a high-value patent? In the current research results, the concept definition and practice of high-value patents have just started. Generally speaking, high-value patents are divided into narrow and broad categories. In a narrow sense, high-value patents refer to patents with high economic value, that is, patents that can bring greater economic benefits to the obligee. In addition to economic value, the concept of high-value patent in a broad sense also includes technical, legal, market and strategic values [2]. In fact, any evaluation criteria are relative and need to be constantly improved in development. The prerequisite for the existence of high-value patent is that it is a valid patent.

High-value patents in equipment R&D are an important part of equipment R&D, which plays an important role in stimulating innovation, promoting the transformation of patents into combat effectiveness and promoting national defense construction. First of all, high-value patents will inevitably bring about technological innovation, which is a powerful way to promote the development of weapons and equipment, an effective way to improve the overall level of weapons and equipment, and will inevitably become an important guarantee for safeguarding national defense security. Secondly, high-value patents in equipment R&D pay more attention to the benefit of funds, which not only saves funds for military scientific research units, but also effectively promotes the development of the national economy after the achievements are transformed into combat power. Therefore, this paper holds that the standards for measuring high-value patents in equipment R&D are technological innovation and cost-effectiveness ratio, which are two core basic attributes.

## **III. ANALYSIS OF SCREENING FACTORS OF HIGH-VALUE PATENTS**

Based on the above analysis, this paper constructs a screening factor system consisting of 5 primary influencing factors and 14 secondary influencing factors, and analyzes these factors.

### **3.1 Structural System of Screening Factor**

In this paper, after consulting relevant documents and materials, the screening factors of high-value patents in equipment R&D are taken as the core, with five first-level influencing factors, namely military factor, economic factor, technical factor, legal factor and cost-effectiveness factor, and 14 second-level influencing factors, including national defense security level, use yield, innovation, examination and approval system and efficiency. And then the structural system of influencing factors is established. The structural system of screening factors for high-value patents in equipment R&D is shown in Fig 1:

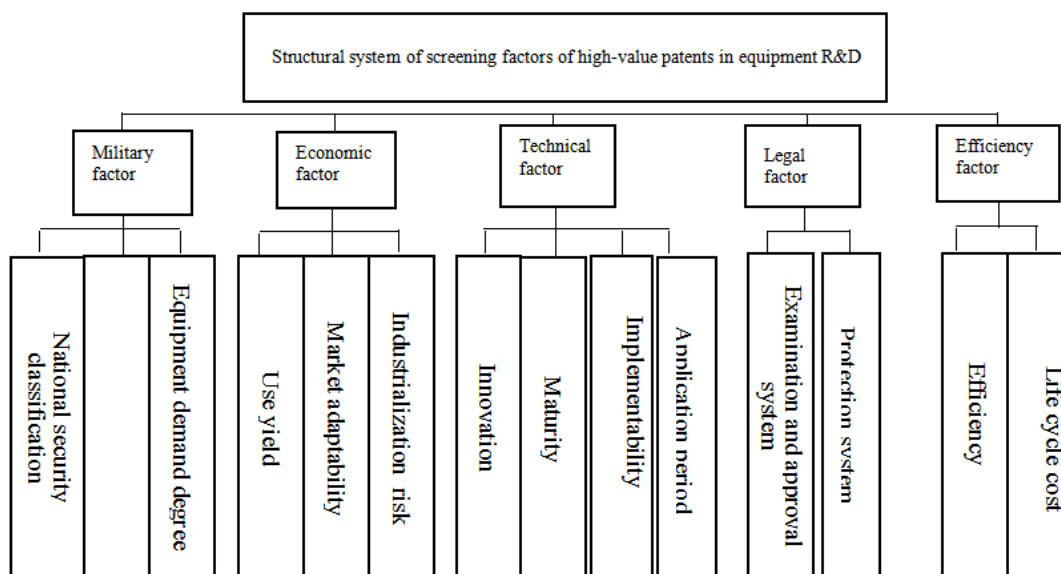


Fig 1: structural system of high-value patent screening factors in equipment R&D

### 3.2 Interpretation of Screening Factors

#### 3.2.1 Military Factors

It mainly includes three specific influencing factors: national defense security level, national defense strategic influence level and equipment demand degree.

#### 3.2.2 National defense security level

High-value patents in R&D of equipment are confidential, which will limit their marketization and commercialization. In the process of using high-value patents in equipment R&D, they can be classified into three levels in turn: secret, confidential and top secret according to the degree to which the patents play a role in equipment R&D.

### 3.2.3 National defense strategic influence level

As the international situation is changeable, our national defense construction strategy is constantly adjusted. We should accurately estimate the principles and policies of national defense construction and equipment development, and make a reasonable plan to ensure the scope and depth of patent influence on equipment R&D. According to the different levels of influence, the national defense strategic influence can be specifically divided into influence at national level, influence at military level, influence at services and arms level and influence at certain equipment level.

### 3.2.4 Equipment demand

The purpose of strengthening China's national defense construction is to improve its comprehensive national strength, form a deterrent force in the world, and provide a powerful guarantee for the vigorous development of politics, economy and culture. The use of a patent in the R&D of an equipment should cater to the mainstream of China's national defense development and meet the needs of China's national defense construction. For example, in the development and construction of aircraft carriers in China, electromagnetic ejection technology has become an urgently needed patent in the R&D of this equipment. When a patent is urgently needed in the R&D of military equipment. The shorter the time it is put into use and the more carrier equipment it is used, the proportion of screening factors of the patent will increase accordingly. Equipment demand can be measured by the time of putting into use and the quantity of required equipment.

## 3.3 Economic Factors

It mainly includes three secondary influencing factors: use yield, market applicability and industrialization risk.

### 3.3.1 Use yield

Use yield is the yield brought by the use of the patent, which reflects the efficiency of resource allocation brought by the use of the patent to the whole weapon equipment.

### 3.3.2 Market applicability

It refers to whether the patent is suitable for market demand. Market adaptability can be

decomposed into application scope and application degree. The wider the application range, such as extending from military to civilian, the greater the application degree, and the better the market applicability, such as deep application in military and civilian equipment. Although patents in equipment R&D have incomplete marketability, with the in-depth reform of China's socialist market economy and military enterprise system, high-value patents are more in line with the market, and the market will become an influencing factor to determine high-value patents in equipment R&D.

### 3.3.3 Industrialization risk

In the industrialization process of using patents to produce corresponding weapons and equipment, there must be uncertain factors, which leads to the existence of risks. The size of risks shows the resistance of high-value patents in equipment R&D. The risk of industrialization is a conclusion drawn from relevant mathematical statistics, which is mainly related to the patent itself and the industrialization level of the whole industry.

## 3.4 Technical Factors

It mainly includes three secondary influencing factors: innovation, maturity, implementability and application period [3].

### 3.4.1 Innovation

Innovation means that the patented technology has made significant progress compared with the existing technology. Using this patent in equipment R&D can make the equipment have better performance, and the corresponding pricing of the right to use will be higher. The innovation of the patent in equipment R&D can be reflected by the advanced degree of the patent. The advanced degree of patent technology can be divided into several levels from high to low, namely, international leading, international advanced, domestic leading, domestic advanced, military leading and military advanced. The higher the level, the stronger the innovation of the patented technology, and the higher the pricing of its right to use.

### 3.4.2 Maturity

Every patent may go through four stages: trigger stage, development stage, mature stage and decline stage [4]. Patents in trigger stage are not mature in technology, and it is risky to use them in equipment R&D; patents in development stage are constantly improved, and may have been tried in some projects; patents in mature stage are widely used, and corresponding

industries or markets may have been formed. At this time, the patents are in their heyday and have great advantages in equipment R&D. Patents in decline stage mean that they can not meet the needs of equipment construction and may be replaced by new technologies. Therefore, the pricing of the patent use rights in the trigger stage and declining stage will be relatively low, while the pricing of the patent use rights in the development stage will be higher and the pricing of the patent use rights in the mature stage will be the highest.

### 3.4.3 Implementability

Implementability is the level of application of a patented technology in equipment R&D. Patent implementability in R&D of equipment can be reflected by technological level of R&D unit, technical level of workers and production standardization level.

### 3.4.4 Application period

Patents are applied to equipment for different periods of time, and some patents are updated quickly and may be eliminated in the next batch of equipment R&D, so the pricing of their right to use is lower and their screening proportion is lower. Some patents are updated slowly and applied to equipment for a long time, so the pricing of their right to use is higher and their screening proportion is higher.

## 3.5 Legal Factor

It mainly includes two secondary influencing factors: examination and approval system and protection system.

### 3.5.1 Examination and approval system

Examination and approval system refers to the examination and approval process of using the patent in equipment R&D. If the examination and approval of patent use is strictly controlled, the examination and approval time will be longer. Although it will affect the pricing of patent use right, it will also control the quality of patents to a certain extent. The specific impact depends on the specific examination and approval system.

### 3.5.2 Protection system

The protection system refers to the regulations on the protection and management of patents. The more perfect the patent protection system is, the more laws can be followed in the

process of using patents and the less the loss and confusion caused by inadequate patent protection, which is more beneficial to screen out high-value patents.

### 3.6 Cost-Effectiveness Factor

It mainly includes two secondary factors: efficiency and life cycle cost [5].

#### 3.6.1 Efficiency

Efficiency is used to describe the ability of patented technology to meet the requirements of tasks of equipment R&D, that is, the ability of patented technology to reach objectives of equipment R&D under specified conditions. Generally, the system analysis method is used. On the basis of collecting information and data, an ability measurement algorithm comprehensively reflecting the achieve of equipment R&D goal by patent use is established to obtain the efficiency evaluation value. The higher the efficiency evaluation value, the higher the degree to which the patent can meet the equipment target, and the higher the possibility of meeting the high-value patent.

#### 3.6.2 Life cycle cost

Life-cycle cost refers to the sum of the related costs of patent use in the whole life cycle [6]. The life cycle of a high-value patent in equipment R&D is the number of years in which the unit can use the patent as stipulated in the contract. In this life cycle, the sum of other expenses brought by patent use is analyzed from a systematic point of view, which generally includes the initial investment of patent use and the expenses of proper upgrading of patented technology according to the equipment R&D objectives.

## **IV. REVISED BLACK-SCHOLES PRICING MODEL**

### 4.1 Variable Analysis

B-S option pricing model is only applicable to financial assets such as stocks and bonds at first. However, some scholars have found that although the real environment is not completely consistent with the assumptions of the model, it can still be used for pricing research of high-value patents by adjusting some assumptions in the model, revising parameters or introducing some new parameters. Therefore, after detailed explanation above, B-S pricing model can be used to study the pricing of high-value patents in equipment R&D, and of course, some parameters need to be revised again. Parameter meanings of high-value patents in

equipment R&D are shown in Table I:

**Table I. Parameter meanings of high-value patents in equipment R&D**

OPTION	VARIABLE	RIGHT OF USE OF PATENTS IN EQUIPMENT R&D
OPTION VALUE	C	Option value of patent use right
CURRENT PRICE OF THE UNDERLYING ASSET	S	Sum of the present value of all future cash flows of the project of patent use right
EXECUTION PRICE	X	Initial input cost of the project of patent use right
TIME FROM DUE DATE	T-t	Economic validity period of patent use right
FIXED RISK-FREE INTEREST RATE	r	Risk-free interest rate
VOLATILITY OF STOCK PRICE	$\sigma$	Future volatility of patent use right

Each parameter is analyzed in detail below:

(1) S: indicating the sum of the present value of all the benefits that the high-value patent can bring to the unit within the effective period. The determination of this parameter requires forecasting according to the historical operating conditions of the unit and the changes of the future operating environment of the unit, and then discounting the cash flow predicted every year according to a certain discount rate to obtain the present value of the high-value patent project at the investment time;

(2) X: indicating the initial input cost of the high-value patent project, and the value of this parameter is the cost that needs to be reinvested after the high-value patent is purchased and used in the equipment R&D project;

(3) T-t: indicating the economic validity period of the high-value patent, that is, the period that the high-value patent can bring benefits to the unit. This validity period is not necessarily equal to the legal validity period, but mainly depends on the advanced nature of the patented technology and the length of the benefit period. Usually, the economic validity period is determined by the service period in the contract terms signed by both parties;



(4)  $r$ : indicating the risk-free interest rate. The yield to maturity of the national debt with the same term is generally used as the risk-free interest rate;

(5)  $\sigma$ : indicating the volatility of future earnings of high-value patents. The volatility of the same or similar high-value patents can be used to approximate the standard deviation of the high-value patents.

#### 4.2 Parameter Correction of B-S Option Pricing Model

The standard B-S option pricing model is derived under idealized assumptions. However, for high-value patents in equipment R&D, because of its own particularity, there are certain differences between the actual situation and the assumed conditions of the model. Therefore, it is necessary to properly revise and introduce the parameters in the model, redefine the parameters and select the corresponding methods for determining important parameters in combination with the characteristics of high-value patents in equipment R&D and the environment used.

##### 4.2.1 Correction of discount rate

Risk-free interest rate refers to the yield that investors can obtain by investing funds in investment projects without any risks. The standard B-S option pricing model is mainly for short-term financial bond valuation. In the short term, if inflation and other uncertain factors are not taken into account, the parameter  $R$  in the model can adopt risk-free interest rate. However, for high-value patents in equipment R&D, the benefit period is generally longer. Because once the high-value patent is obtained through the license contract, the unit will use the patent for the development of the equipment and assemble it for use by the army, and even if the weapon and equipment are updated and upgraded, the patent may still be used in it for a long time, like several years or even ten years. High-value patents in equipment R&D refer to patents that have been successfully developed and applied or will be applied to equipment projects. Therefore, when pricing high-value patents, there is no need to consider the technical risks of patents in the development process. However, within the economic validity period of patent right, high-value patents will be affected not only by relevant national policies, but also by the social and economic development level at that time, so inflation and market uncertainty, that is, risk premium, need to be considered. Therefore, on the basis of risk-free interest rate, the discount rate needs to be determined in a dynamic way by including market risk and enterprise risk. The capital asset pricing model is used to determine discount rate  $k$ :

$$k = r + \beta \times MRP + r_f \quad (1)$$

Wherein:

r: risk-free interest rate. Selection of the value: the yield to maturity of the national debt with the same period of patent use and the same expiration time as stipulated in the license contract should prevail;

$\beta$ : equity system risk coefficient;

MRP: market risk premium;

$r_f$ : undetermined risk adjustment factor.

#### 4.2.2 Determination of future volatility of high-value patents

Volatility is used to measure the uncertainty of benefits provided by patent use right. For high-value patents in equipment R&D, they have extremely low exchangeability, weak correspondence between cost and value and certain confidentiality. Generally, the relevant data of the same or similar projects in the industry are used to approximate the future volatility of the value of high-value patents, and the formula is as follows:

$$\gamma = \sqrt{\frac{\sum(u_i - \bar{u})^2}{n-1}} \quad (2)$$

Where in:

$$u_i = \ln\left(\frac{S_i}{S_{i-1}}\right) \quad (3)$$

Where in:

$\gamma$ : revised volatility;

$S_i$ : the stock price of listed companies with the same or similar time  $i$ ;

$\bar{u}$ : the average value of  $u_i$ .

#### 4.2.3 Introduction of the expected yield of patent right

The standard B-S pricing model is based on the risk-neutral pricing assumption. Under the completely planned economy system, the attitude of military scientific research units towards high-value patents in equipment R&D is neutral. That is to say, the precondition of risk-neutral pricing is met. However, with the adjustment of the establishment system of military scientific research units and the deepening of marketization, each unit is a relatively independent "economic man", and it still hopes to obtain certain benefits from the use of patents, which does

not satisfy the premise of risk-neutral pricing in this case. Therefore, the value of a high-value patent is determined to some extent by the expected yield of the patent user for the high-value patent. At this time, it is necessary to introduce the expected yield  $ex$  of the patent user for the high-value patent to correct the B-S pricing model, which will directly affect the pricing of the high-value patent to a certain extent. It should be emphasized that the expected yield of high-value patents in equipment R&D takes into account of not only economic factors, but also comprehensive factors such as military, technology, law and efficiency. In this paper, the comprehensive evaluation method is used to determine the expected yield  $ex$  of high-value patents in equipment R&D. The process is as follows:

a. Theoretical basis. This paper analyzes and determines the expected yield of high-value patents in equipment R&D by comprehensively drawing on the ideas of determining the patent license rate in Huawei Case (Huawei v. IDC Company, USA) and Microsoft Case (Microsoft v. Motorola's dispute over violation of patent licensing commitment). In the "Huawei Case", the comparison method was adopted (under the condition that the transaction conditions are basically the same, the standard essential patentee should charge the standard essential patent implementer basically the same license fee or adopt basically the same patent use right rate) [7]; in the "Microsoft Case", the court used the hypothetical bilateral negotiation method (by simulating the seven categories of factors that directly affect the patent value, the hypothetical bilateral negotiation is conducted to determine the reasonable patent use right rate) [8].

b. Ways of practice. In this paper, based on the factors that affect the pricing of patent use right, the experts score the patent as a process of simulating bilateral hypothetical negotiation, and the adjustment coefficient of the patent use right was obtained by corresponding standard treatment, which was then adjusted by the average expected yield  $\bar{ex}$  of high-value patents in equipment R&D, so as to obtain the effective expected yield of high-value patents. It needs to be emphasized that the determination of the average expected yield  $\bar{ex}$  of high-value patents needs to be summed up and calculated through actual investigation and a large amount of historical data. Analytic hierarchy process (AHP) and comparative analogy method are also used to determine the expected yield  $ex$  of high-value patents in equipment R&D.

#### 4.2.4 Corrected B-S option pricing model

By correcting the parameters in the standard B-S option pricing model, this paper obtains a B-S option pricing model which is more in line with the pricing of patent use right in equipment R&D:

$$C = Se^{(ex-r)(T-t)}N(d_1) - Xe^{-r(T-t)}N(d_2) \quad (4)$$

Wherein:

$$d_1 = \frac{\ln(S/X) + (r + \gamma^2/2)(T-t)}{\gamma\sqrt{T-t}} \quad (5)$$

$$d_2 = d_1 - \gamma\sqrt{T-t} \quad (6)$$

## V. SUPPORTING IMPROVEMENT MEASURES FOR MINING AND CULTIVATING HIGH-VALUE PATENTS IN EQUIPMENT R&D

Combined with the above summary, this paper puts forward the following suggestions on the research of high-value patents in equipment R&D:

### 5.1 Establishing and Improving the Legal System for Screening and Cultivating High-Value Patents

The enactment of a series of laws and regulations on national defense is an important part of patent management, and a legal basis for organizing the implementation of equipment price management and equipment procurement evaluation, which reflects the Chinese army's emphasis on national defense intellectual property represented by patents and is an important guarantee for the equipment modernization and innovative development of Chinese army. Of course, it is an urgent and arduous task to build a legal system for screening high-value national defense patents, which can be improved by establishing top-level laws and supporting laws. For example, the Equipment Regulations of the People's Liberation Army is taken as the top-level regulation, and relevant provisions on national defense intellectual property rights, such as high-value patents in equipment R&D are added to clarify the principles, requirements, responsibilities at all levels, rewards and punishments of patent screening and cultivation; according to the top-level laws and regulations, special supporting laws and regulations are revised and formulated, and specific procedures are formulated for screening and cultivating high-value patents, so that the implementation of the high-value patent system can be based on laws and evidence.

### 5.2 Establishing Professional Evaluation Agencies, Pay Attention to the Potential Value of Patents

As patent R&D is ultimately paid with defense expenditure, only relying on negotiations between patent users and users can not give objective results, and corruption is easily caused. Therefore, it should be realized with the help of professionals from professional institutions. It is suggested that the relevant departments of the headquarters should take the lead in setting up

a special national defense patent evaluation institution and establishing a complete evaluation standard system and expert database involving various fields. At the same time, property owners should pay full attention to the potential value of patents and strengthen their awareness of patent protection.

### 5.3 Formulating Classification and Grading Methods

The cultivation of high-value patents also needs high-level screening and evaluation. Patent value evaluation is an important means to judge and measure patent value. Establishing evaluation standards and methods of high-value patents can provide objective and fair value judgments for the operation and management of high-value patents, which can make the cultivation of high-value patents more accurate and fruitful.

This paper focuses on the screening factors of high-value patents in equipment R&D. Due to the complicated attributes of patents and the influence of confidentiality and other factors, the traditional evaluation and classification methods are difficult to reflect the value of high-value patents. Therefore, it is necessary to establish a more comprehensive, scientific and detailed classification method model, and carry out comprehensive evaluation of the value of high-value patents through preliminary screening, classification evaluation and grading evaluation.

### 5.4 Defining the Scope and Ownership of Intellectual Property Rights

This paper discusses the use right of patents developed by units or enterprises with self-financing, and their rights and interests belong to R&D units. However, for patents formed by state investment, it is a prerequisite for formulating the right to use measures to clarify its rights and interests distribution. Based on the basic principles of reducing repetitive R&D and promoting innovation and development, we should emancipate our minds and seek truth from facts to formulate practical and feasible plans. At present, there is no perfect reporting system for intellectual property rights. If it is not allowed to collect royalties, there will be no incentive to implement, which is not conducive to technology sharing, and will lead to repeated R&D and waste of resources. It is suggested to allow charging certain legal royalties for the right to use as a reward. For those formed by joint investment, the royalties may be adjusted and collected according to the proportion of financial fund and self-financing.

### 5.5 Improving the Information Platform and Reporting System

The premise of patent transaction is the acquisition of relevant information. To strengthen

the effective management of applied national defense patents by means of information technology, a corresponding patent database can be established, and the transaction data of various national defense patents can be continuously collected and enriched by using the big data platform. At the same time, through various platforms, such as the internet, newspapers and periodicals and compiling entries, the existing patents can be made public under the condition of confidentiality, so that all units will have efficient exchanges and cooperation. It is also necessary to regularly clean up and report patents to ensure the timeliness and accuracy of information.

## **REFERENCES**

- [1] Hou Y, Zhao DB, Guo QS (2009) Analysis of the difficulties and objects in the process of technological innovation management of weapons and equipment. *Technology Foundation of National Defence* (1):3-5.
- [2] Ma TQ (2018) Screening of high-value patents. Beijing: Intellectual Property Press:001-003.
- [3] Zhang YL (2012) Research on Legal Issues of Investment in Patent License Right. Chongqing University.
- [4] Li CL, Liu Y (2013) Research on intellectual property cost accounting in equipment procurement. *Journal of Naval University of Engineering (Comprehensive Edition)* 10(3):46-50.
- [5] Zhang HQ, Wei RX, Liang X (2007) Equipment Economic Analysis. Beijing: National Defense Industry Press:119-130.
- [6] Zhang HQ, Wei RX, Huang D, et al (2008) Equipment whole system life cycle management. Beijing: National Defense Industry Press:107-110.
- [7] Ye RS, Zhu JJ, Chen WQ (2013) Judicial Applicability of FRAND Rule in Standard Essential Patent Fee Dispute-Comment on Huawei Company v. IDC Company of the United States. *Electronics Intellectual Property* (4).
- [8] Li Y, Liu Y (2014) Calculation of necessary patent royalties of FRAND standard-from the perspective of comparison of related cases between China and the United States. *Science Technology and Law* (5):866-883.