

Research on Pricing of Enterprise's Intellectual Property Securitization

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Abstract: The pricing of patents is a complex mathematical problem, which involves many aspects of scientific research, economy, society, etc. There are many traditional pricing models. Some models are based on artificial scoring, and some models are difficult to obtain parameter data. This paper proposes the Monte Carlo cut difference method to solve the problem of patent pricing based on the shortcomings of these models. Aiming at the issue of patent pricing, this article uses variables to represent the economic factors related to patents, such as technical dimensions and legal dimensions, and then gives the impact of each parameter on the company's expenditure and income, and abstracts the process into a mathematical model. This model shows the amount of change in the market value of the company before and after the patent is purchased. This amount of change is used to express the value of the patent. This model is called the gap model. Because the calculation of the gap model is very complicated, this article introduces the Monte Carlo method to calculate the model, uses a computer to simulate the actual operating process of the company (mainly including income and expenditure), and uses the simulation results to replace the real values. We collected relevant data on the Internet and used the Monte Carlo cut model to estimate the value of a certain electronic equipment patent and a daily chemical patent. The results were 1,671,400 yuan and 153,507 million yuan respectively. Finally, based on the model and calculation results, a proposal was written to relevant departments.

1. Problem restatement

In the era of knowledge economy, the proportion of knowledge assets in the value of corporate assets has risen sharply, gradually replacing traditional physical assets as the core competitiveness of enterprises, and at the same time driving enterprises to shift the focus of financing from physical assets to intangible knowledge assets. The securitization of intellectual property will provide owners of intellectual property rights with a brand-new financing channel based on intellectual property rights, effectively integrating knowledge assets and financial capital, so as to realize a virtuous cycle of capital demand and supply in the process of independent innovation.

However, as an intangible asset, due to the uncertainty of the value of intellectual property, intellectual property securitization is faced with the problems of difficulty in evaluation and disposal. At present, my country's intellectual property service desk has not yet formed a mature and unified intellectual property transaction service mechanism. Therefore, it is urgent to establish a scientific, authoritative and intellectual property value evaluation system that meets market needs. Patent is an important form of intellectual property rights, and the value evaluation system of patents presents a status quo of inconsistent standards and mainly qualitative. Currently, most patent trading platforms are pricing mechanisms based on bargaining and auction bidding, and patent pricing lacks scientific reference basis. This makes the patent transaction rate low, which is not conducive to the transformation of my country's scientific and technological achievements, and it is difficult to ultimately realize the value of patents.

From the perspective of the value of patents, it mainly has five dimensions: market value, technical value, legal value, strategic value, and economic value. Traditional economic methods of asset evaluation mainly include cost method, market method, income method, real option method, etc.; however, these methods often only consider a single value indicator and cannot fully analyze the intrinsic value of patents. Comprehensive multi-index value evaluation methods include analytic hierarchy process, fuzzy analysis, etc.; however, these methods are highly subjective and cannot

achieve accurate quantitative evaluation.

This paper studies high-value invention patents, collects relevant data as much as possible (such as market value, technical value, legal value, strategic value, economic value, etc.), establishes a mathematical model for the pricing of high-value invention patents, and proposes specific details based on the results of modeling analysis Suggest.

2. Problem analysis

We need to establish a mathematical model for the pricing of high-value invention patents from the dimensions of market value, technological value, legal value, strategic value, and economic value. Some of the existing models do not fully consider the value of patents, some add subjective evaluations by a large number of people, and some are out of reality and difficult to perform model calculations. In order to solve the above defects, this paper proposes the Monte Carlo cut method. The basic idea of the Monte Carlo method is to collect patent-related data indicators, such as: technical dimensions, legal dimensions, which in turn include: patent citations, technical relevance, scientific relevance, technical application scope, power requirements, Legal status, length of substantive examination, technology life cycle, patent independence, market competition intensity and other indicators; then establish a market value model based on the indicators, and then use a computer to simulate market operation to calculate the increase in market value after the company buys patents, and use this value as Calculation results.

3. Problem solving

3.1 Relevant data analysis

From the relevant data of intellectual property rights published by the State Intellectual Property Office from January to September 2020, we can know that from January to September, there were 1.103 million invention patent applications and 361000 invention patents authorized; 2.213 million utility model patents were authorized, 1.725 million were authorized; 561000 design patents were applied, and 555000 were authorized.

Table 1 patent application of scientific and technological achievements of universities and scientific research institutions

	School	Institute	All
0-10%	56.6	35.5	45.8
10-20%	16.9	11.2	14.0
20-30%	7.9	15.8	11.9
30-40%	2.4	5.6	4.1
40-50%	4.0	1.0	2.5
50-60%	2.4	5.6	4.1
60-70%	1.5	7.6	4.6
70-80%	6.4	5.9	6.1
80-90%	0.9	2.9	2.0
90-100%	0.9	8.9	5.0
All	100	100	100

In addition, the State Intellectual Property Office conducted a questionnaire survey on patent related knowledge in universities, scientific research institutions and enterprises across the country in 2019. It can be seen that with the development of science and technology in China, the number of high-value patents in China is gradually increasing. There are many shortcomings in the traditional patent value evaluation system, such as the subjectivity of evaluation methods (AHP, AHP, etc.) Fuzzy comprehensive evaluation method, etc.) is difficult to quantify evaluation or complex calculation. The index scores in the evaluation method will be greatly different due to the different professionalism, experience and understanding of the raters. In practical application and data

processing, the results will have strong subjectivity and uncertainty. Therefore, in this paper, we establish a patent value evaluation model based on different index dimensions of patents.

3.2 Index selection

In this problem, we need to build patent value evaluation model from the market value, technical value, legal value, strategic value, economic value and other dimensions. The economic value is mainly embodied in factors such as cost, market and risk. The technology market is mainly embodied in advanced technology, technology and technology life cycle of patent technology. Legal value is mainly reflected by factors such as legal status, maintenance time and maintenance time. Market value is mainly embodied in market share and market prospect. The index system is set as follows:

Table 2 Index System

dimension	index
Technology dimension	Number of patent citations
	Technical relevance
	Scientific relevance
	Technical application category
	Power requirements
Legal dimension	Legal status
	Duration of substantive review
	Remaining protection period
	Patent payment times
	Attribute of patentee
Market dimension	Technology life cycle
	Patent family size
	Patent independence
	Market competition intensity

3.3 Model establishment

The traditional pricing model has many defects. First of all, it lacks of scientific basis. According to the direct judgment of the enterprise, the value of high-value patent is often not given by a few people based on their experience. What's more, enterprise personnel may not be professional researchers in the industry, and experience pricing may be auctioned and the value will be unreasonably high. Secondly, many seemingly perfect pricing models In fact, it is difficult to calculate, and the values of some indexes can only be given artificially, which leads to the error of calculation results; finally, some models will inadvertently take into account the influence of other irrelevant indicators, resulting in the actual calculation results with noise deviation. The basic idea of Monte Carlo cut method is to establish a virtual company model on the computer The company includes all the expenses and income related to the patent, and calculates the growth of the market value of the company after the company purchases the patent.

First of all, we should choose the most representative market interest rate, and then we can get the parameters of the model by selecting the appropriate theoretical model and using the appropriate parameter estimation method. On the choice of market interest rate benchmark. It should reflect the real feelings of market traders on the supply and demand of market funds and the real price of funds. This kind of capital price can be reflected from the prices of bonds traded in the market, especially the Treasury bonds without default risk, and can also be approximated by the interest rate in the money market.

This paper uses quarter time segmentation, so the historical data used for regression should be quarterly data. In order to avoid excessive singular values caused by directly referring to the quarterly closing price, and to obtain better timeliness, the monthly closing data is obtained and converted into the quarterly mean value as the regression object. By solving the minimization

problem, the estimated parameters are as follows:

$$\alpha = 0.0039, \beta = -0.14, \sigma^2 = 4.76, \gamma = 1.63$$

Table 3

	Error standard check	T statistic	P_Value
α	0.0014	2.86	0.0068
β	0.51	-2.63	0.0125
σ	0.97	2.31	0.0268
γ	0.18	2.22	0.0079
R^2	0.22	-	1.69
adjust R^2	0.27	-	7.85(0.0014)

From the effect of fitting test, the significance of each parameter is guaranteed, but the overall fitting degree of the model is not very high.

The construction of Monte Carlo cut method is as follows

$$PV = a * TP + b * LP + c * SP - (\alpha * \bar{TP} + \beta * \bar{LP} + \gamma * \bar{SP})$$

Among them, PV represents patent value, TP represents technology dimension related indicators, LP represents legal dimension related indicators, SP represents market dimension related indicators; $\bar{TP}, \bar{LP}, \bar{SP}$ denotes the index parameters after the introduction of patents.

In this paper, the above three indicators are subdivided into:

The technical dimension includes: patent citation times, technology relevance, scientific relevance, technology application scope, and power requirements. The mathematical model is as follows:

$$TP = \sum_{i=1}^5 a_i TP_i, \quad 1 = \sum_{i=1}^5 a_i$$

The legal dimensions include: legal status, duration of substantive examination, remaining protection period, times of patent payment and patentee attribute. The mathematical model is as follows:

$$LP = \sum_{i=1}^5 b_i LP_i, \quad 1 = \sum_{i=1}^5 b_i$$

The market dimension includes: technology life cycle, patent family size, patent independence and market competition intensity

$$SP = \sum_{i=1}^4 c_i SP_i, \quad 1 = \sum_{i=1}^5 c_i$$

3.4 Solution of the model

Using Monte Carlo method to calculate the model is the characteristics of this model, the specific calculation of the model will be calculated according to the data of different companies.

According to the definition of probability, the probability of an event can be estimated by the frequency of the event in a large number of tests. When the sample size is large enough, the occurrence frequency of the event can be regarded as its probability. Therefore, a large number of random variables affecting the reliability of the structure can be sampled at first, and then these sampling values can be substituted into the function formula to determine whether the structure fails or not, and finally the failure probability of the structure can be obtained. This method is based on Monte Carlo analysis.

It can be seen from the idea of Monte Carlo method that this method avoids the mathematical difficulties in structural reliability analysis. No matter whether the state function is nonlinear or the random variable is not normal, as long as the simulation times are enough, a more accurate failure probability and reliability index can be obtained.

We collected the transaction price data of some patents from the state-owned achievement trading publicity system, and the patent citation times, technology relevance, patent family size and other data from the patent retrieval and analysis website of the State Intellectual Property Office. Some of the data are shown in Table 3. The numerical results of the model are calculated in question two, and only the idea of calculation is given in question one.

Compared with other numerical methods, Monte Carlo simulation method has the advantages of dimension independence and fast convergence, but from an objective point of view, as a non analytical algorithm, its operation efficiency is still relatively low, so it is particularly necessary to select appropriate variance reduction technology. In this paper, we decide to optimize the patent return cash flow only by variance reduction, and choose the simplest dual variable technology in theory. Dual variable technique aims to eliminate part of variance by introducing negative correlation between each pair of simulated paths. In short, dual variable technology is to carry out two simulation processes at the same time in each simulation calculation: one is to extract a group of random samples to get the results according to the ordinary Monte Carlo simulation method; the other is to take the corresponding dual random samples to get the simulation results; finally, the average value of the results of the two simulation processes is the final result. As far as the research object of this paper is concerned, using normal distribution as the distribution generated by random number conforms to the condition of using dual variable technique

$$VOP_1 = \frac{1}{m} \sum_k VOP_k$$

On the basis of this $Z_i (i = 1, 2, \dots, n)$, we construct dual random numbers $Z_j = -Z_i$. From the properties of normal distribution, we can see that they also obey normal distribution. We also simulate this process. The estimated values generated by dual random numbers are as follows:

$$VOP_2 = \frac{1}{m} \sum_k VOP_k$$

The new estimates are:

$$VOP = \frac{VOP_1 + VOP_2}{2}$$

If the estimated value of the sample simulated by random sampling is small, the estimated value of the corresponding dual random variable simulation may be too large, and the average value of the two may be close to the real value.

4. Model evaluation

4.1 Model advantages

Aiming at the problem of patent pricing prediction in the process of patent right transfer, this paper establishes the index system of patent evaluation. The indicators in the index system are all based on the actual data integration, which despises the shortcomings of the traditional patent value evaluation methods such as strong subjectivity of indicators. Monte Carlo method is used to simulate the value of patents in enterprises, so as to objectively measure the value of patents, reduce human factors, and increase the impact of the objective market on the value of patents. The model is flexible and changeable. New parameters can be added to adjust the results of the model, and the model results can be calculated only with the data.

4.2 Model shortcomings

The model mainly considers the value of patents in the market (enterprise), and does not consider the R & D expenditure of R & D personnel. This is mainly because the expenditure is not necessarily proportional to the income, and when the patent is sold to the enterprise, it mainly needs to consider the interests of the seller (enterprise). If it is not in line with the interests of the enterprise, the enterprise will not buy it. In addition, the model has different calculation parameters for different patents of different enterprises, which is not a simple consistency model.

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