Value Assessment of Biomedical Enterprises Based on Mutation Progression Method

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Abstract: Biology and new medicine is one of the eight key high-tech fields supported by China. However, the distribution of China's pharmaceutical industry structure is not reasonable. Therefore, under the new development opportunities, the speed of mergers and acquisitions and expansion among pharmaceutical enterprises will be further enhanced. In the process of merger and acquisition, how to select and evaluate the value of the acquired enterprise is the key link for the enterprise to improve its operation and management level and for the investors to make accurate investment decisions. In this paper, the catastrophe progression method was introduced to modify the current mainstream method of enterprise value assessment -- BS model, and the effective logical combination of the two was conducted. In addition, an enterprise value assessment index system considering non-financial indicators was constructed, and 24 listed biotechnology companies were selected for effective verification.

1. Introduction

The bio-pharmaceutical industry is one of the most promising science and technology industries in the world. In China, biology and new medicine are also listed as one of the eight high and new technology fields supported by the state. The 13th five-year plan for the development of the biological industry clearly states that by 2020, the sales revenue of the pharmaceutical industry will reach 4.5 trillion yuan. Biology and new medicine, seen as a sunrise industry, is growing fast. However, the structure and distribution of China's pharmaceutical industry are not reasonable. With the continuous breakthroughs in biotechnology and the guidance of policies, the concentration degree of China's traditional Chinese medicine industry will be gradually improved. Therefore, comparing the stock price and enterprise value of listed companies in the biological and new medicine industries will not only help investors make better investment and financing decisions based on the real value of listed companies in the biological and new medicine industries, but also reduce the non-systematic risk in China's capital market.

In recent years, many scholars have studied how to evaluate enterprise value. The commonly used methods include free cash flow method, Eva method, real option method and tobin Q method. Because the biomedical industry has the characteristics of long period, high technology, high investment, high risk and high return, this paper introduces the catastrophe progression into the real option pricing model to study the enterprise value.

At present, researches on enterprise value based on the real option pricing model mainly focus on the following two points:

First, the model is improved to improve the accuracy of the model. Wang proposed a capital budget model in an uncertain environment. (1).S.Q. Huang and Y. Li made an in-depth analysis of the value of biopharmaceutical enterprises from the perspective of fuzzy group decision-making environment, and modified and improved the discounted cash flow model to make it more suitable for the value assessment of biopharmaceutical enterprises (2).Based on previous studies, Y.L. Zhou et al. established the American option pricing model with both jump diffusion process and random

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volatility, and used this model to evaluate the value of patent rights (3).

Second, the research has the option characteristic the asset and the project. Liang-chuan Wu et al. established the system application model of real options in the value assessment of knowledge-based enterprises, and selected the research-intensive knowledge-based representative Lotus for value assessment and verification (4).According to the real option model, J.F. Guo et al. evaluated the value of China's Internet listed companies and found the most promising companies (5).

At present Few scholars apply mutation progression to enterprise value assessment. S.N. Peng introduced the catastrophe progression method on the basis of the discounted free cash flow of equity, and made empirical design and test of enterprise value evaluation model in the listed enterprises of home appliance industry (6). F. Xie and T.T. Liu introduced the catastrophe series into the real option model and conducted an empirical study on listed agricultural companies (7).

From the above we can see, through the real option method to study enterprise value has been a hot topic. However, most domestic experts and scholars only introduce foreign theories and methods of enterprise value assessment, and modify them in accordance with the actual domestic economic development, or directly correct and improve the defects and deficiencies of foreign models and methods of enterprise value assessment. Domestic experts and scholars lack consideration of non-financial factors and non-listed enterprises, and lack of practical empirical analysis and research. On the basis of previous studies and considering the financial and non-financial driving factors of enterprise value, this paper introduces the catastrophe progression method into the real option model and constructs the enterprise value evaluation model based on the catastrophe progression method, which is used to evaluate enterprise value and carry out empirical analysis and research.

2. Construction of Value Assessment System for Biomedical Enterprises

2.1 Factors Influencing the Value of Biomedical Enterprises.

Looking at the development history of the global biological and new medicine industry, we can conclude that it is characterized by long cycle, high technology, high investment, high risk and high return. The characteristics of biomedical enterprises can also be summarized as high technical barriers, high research and development risks, high talent quality. Therefore, non-financial factors are the factors that cannot be ignored in enterprise value assessment. Based on the characteristics of biopharmaceutical enterprises and combining the influence of financial and non-financial factors, this paper fully considers the influence of non-financial factors such as technology, intelligence and culture on enterprise value creation, and conducts an in-depth analysis of the driving factors affecting the value of biopharmaceutical enterprises.

2.2 Establish the Value Evaluation Index System of Biomedical Enterprises.

Based on the characteristics of biopharmaceutical enterprises and combining the influence of financial and non-financial factors, this paper gives full consideration to the influence of non-financial factors such as technology, intelligence and culture on enterprise value creation, and makes an in-depth analysis of the driving factors affecting the value of biopharmaceutical enterprises. In terms of financial factors, according to the interim measures for the comprehensive performance evaluation and management of central enterprises issued by the state-owned assets supervision and administration commission (sasac), a comprehensive investigation is made from three aspects: profitability, production capacity and growth capacity. In terms of non-financial factors, the evaluation was conducted from two dimensions of management ability and innovation ability. The value evaluation system of biomedical enterprises shown in Tab.1 can be constructed.

Table 1 Evaluation System Construction

Level indicators	The secondary indicators	Level 3 indicators	The formula
Financial factors	profitability	Profit margin on sales	Net profit/sales revenue
		Return on equity	Net profit/average net assets
		Net interest rate on total assets	Net profit/average total assets
	Ability to survive	Asset-liability ratio	Total liabilities/total assets
		Quick ratio	Quick assets/current liabilities
		Accounts receivable turnover	Sales revenue/average accounts receivable
	Growth ability	Growth rate of main business income	Current main business income/last period main business income -1
		Growth rate of net assets	Ending /beginning -1
		Net profit growth rate	Net profit of the current period/net profit of the previous period -1
Non-financial factor	Ability to manage	Equity concentration	Number of shares held by the top ten shareholders/ number of shares held
		Rate of return on human capital	Corporate profits/total employee compensation
		Proportion of independent directors	Number of independent directors/total number of directors
		Proportion of remuneration of the top three directors	Executive compensation/total compensation
	The innovation ability	Proportion of employees with bachelor degree or above	
		The proportion of patents and know-how in total assets	
		Ratio of technology and r&d personnel	

3. Model Construction and Calculation

3.1 Entropy Method.

The entropy method is one of the objective valuation methods, that is, to determine the importance of an index by the degree of difference between the observed values of the same index, and to carry out the importance ranking. See C.X. Yang, Y.M. Wang and J.B. Zhang (8) for specific evaluation steps of entropy method.

3.2 Mutation Progression Method

The catastrophe progression method is a kind of comprehensive evaluation method, which decomposes the evaluation target in multiple levels, then combines the catastrophe theory and fuzzy mathematics to produce the catastrophe fuzzy membership function, and then carries on the comprehensive quantization operation, and then carries on the ranking analysis to the evaluation target. See F.S. Meng and M.Y. Li (9) for specific evaluation steps of mutation progression method.

3.3 Real Option Method

The standard form of the b-s option pricing model is.

$$C = S_0 N(d_1) - Ke^{-n} N(d_2); d_1 = \frac{\ln(S_0 + K) + (r + \sigma^2 + 2) * t}{\sigma\sqrt{t}}; d_2 = d_1 - \sigma\sqrt{t}$$

Where, C represents the price of the option; S0 is the current price of the underlying asset; K represents the strike price of the option; N(d1) and N(d2)represent the random probability of standard normal distribution. t is the time before the expiration date of the option; r is the risk-free interest rate; σ2 represents the degree of volatility of the underlying asset price.

3.4 Operation Process

The proportions of financial factors and non-financial factors A and B were determined by the catastrophe progression method. To calculate the relative proportion of financial factors after considering non-financial factors A'=A/(A+ B).Finally, according to the following formula, the enterprise value of listed biomedical companies with non-financial factors considered is calculated: CA=C/ A'. Where C is the enterprise value evaluated according to the b-s model.

4. Empirical Analysis of the Enterprise Value Assessment of Listed Biomedical Companies

In this paper, the biological medicine class under the reference index of listed company co., LTD., on December 31, 2016, in the biological medicine biotechnology tertiary industry listed companies of the secondary industry, consider the integrity of financial indicators, reliable, and comparable, excluding the ST listed company at the same time, finally chose 24 biotech companies as samples. At the same time, because the growth of listed companies is dynamic, in order to avoid the impact of abnormal data in a few years on the overall growth of enterprises, this paper adopts the average index of the six years from 2012 to 2017 to better evaluate the growth of listed new energy companies. All the data in this article comes from the reset database.

4.1 The Entropy Method Determines the Order of Index Importance.

In this paper, the financial factors and non-financial factors of the enterprise are considered separately. Through the entropy method, the standardized indexes are processed to determine the relative importance of each three-level index. Specific indicators and types are shown in the Tab.2

Table 2 Specific indicators and system types

Level 1	Level 2	Level 3	Weight	Type	Type
Financial factors A	Profitability A_1	Profit margin on sales A_{11}	0.0398	comple mentary	Dovetail mutant line
		Return on equity A_{12}	0.0301		
		Net interest rate on total assets A_{13}	0.0236		
	Ability to survive A_2	Asset-liability ratio A_{21}	0.2669	No comple mentary	Dovetail mutant line
		Quick ratio A_{22}	0.0839		
		Account sb receivable turnover A_{23}	0.0453		
	Growth ability A_3	Growth rate of main business income A_{31}	0.2334	comple mentary	Dovetail mutant line
		Growth rate of net assets A_{32}	0.2051		
		Net profit growth rate A_{33}	0.0720		
Non-financial factor B	Ability- to manage B_1	Equity concentration B_{11}	0.1798	No comple mentary	The butterfly mutation
		Rate of return on human capital B_{12}	0.0479		
		Proportion of independent directors B_{13}	0.0317		
		Proportion of remuneration of the top three directors B_{14}	0.0104		
	The innovation ability B_2	Proportion of employees with bachelor degree or above B_{21}	0.5026	No comple mentary	Dovetail mutant line
		The proportion of patents and know-how in total assets B_{22}	0.1174		
		Ratio of technology、 r&d personnel B_{23}	0.1102		

4.2 Catastrophe Progression Determines the Financial and Non-Financial Capabilities of an Enterprise.

Due to the large number of samples selected and the completion of data standardization in the entropy method. Therefore, this section takes "zhifei biology (300122)" as an example to focus on how to determine the financial ability and non-financial ability of an enterprise with the catastrophe progression method.

Financial factors: The membership function of the three level index is calculated as shown in Tab.3:

Table 3 The three level index membership function is calculated

Profitability	**Ability to survive**	**Growth ability**
Complementary dovetail mutation	***Non-complementary swallowtail mutation system***	***Complementary swallowtail mutation system***
$X_{A11}=A_{11}^{1/2}=0.2220^{1/2}=0.4712$	$X_{A21}=A_{21}^{1/2}=0.0119^{1/2}=0.1090$	$X_{A31}=A_{31}^{1/2}=0.2999^{1/2}=0.5476$
$X_{A12}=A_{12}^{1/3}=0.2482^{1/3}=0.6285$	$X_{A22}=A_{22}^{1/3}=0.6070^{1/3}=0.8467$	$X_{A32}=A_{32}^{1/3}=0.0588^{1/3}=0.3888$
$X_{A13}=A_{13}^{1/4}=0.5288^{1/4}=0.8528$	$X_{A23}=A_{23}^{1/4}=0.1625^{1/4}=0.6349$	$X_{A33}=A_{33}^{1/4}=0.0386^{1/4}=0.4432$

The second-level indicators meet the principle of "complementation takes the average", and the non-complementation principle of "large and small takes the small", thus:

$$A_1=(0.4712+0.6285+0.8528)/\ 3=0.6508;$$

$$A_2= \min(A_{21},A_{22},A_{23})=0.1090;A_{3=}(0.5476+0.3888+0.4432)/\ 3=0.4599 \quad (1)$$

The three indicators under the financial factor are complementary swallowtail mutation system, so its membership function is: A=(A1+ A2+ A3)/ 3=0.4066

Non-financial factors: The membership function of the three-level index is calculated as shown in Tab.4:

Table 4 The Three Level Index Membership Function Is Calculated

Non complementary butterfly mutant system	$X_{B11}=B_{11}^{1/2}=0.8138^{1/2}=0.9021$	$X_{B13}=B_{13}^{1/4}=1.4536^{1/4}=1.0980$
	$X_{B12}=B_{12}^{1/3}=0.6925^{1/3}=0.8847$	$X_{B14}=A_{14}^{1/5}=1.3932^{1/5}=1.0686$
Non-complementary swallowtail mutation system	$X_{B21}=B_{21}^{1/2}=0.0952^{1/2}=0.3085$	$X_{B23}=B_{23}^{1/4}=0.9443^{1/4}=0.9858$
	$X_{B22}=B_{22}^{1/3}=0.2768^{1/3}=0.6517$	

Secondary indicators meet the principle of non-complementary "large and small", so:

B1= min(B11,B12,B13, ,B14)= 0.8847;B2= min(B21,B22,B23)= 0.3085

The three indicators under non-financial factors are complementary swallows tail mutation system, so its membership function is: B=(B1+ B2)/ 2=0.5966

Calculate and consider the weight of financial factors under non-financial factors A'=A/(A+B)=0.4053

4.3 The Enterprise Value is Determined by the Real Option Method.

This paper evaluates the value of 24 biotechnology companies based on the b-s option pricing model. Where, the value of the underlying asset S0 is the total asset; Option strike price K is the total liabilities; The annual volatility of the underlying asset price can be regarded as the volatility of the overall value of the enterprise. The average life of biotechnology is 10 years from the expiration date of the option. The risk-free interest rate r in the effective period of the option is 4.36% in 2018.The enterprise value evaluated is C, and the evaluation results are modified according to formula (1) to obtain the evaluation value CA that takes into account financial factors and non-financial factors. The specific evaluation results are shown in Tab.5.

Table 5 Revised intrinsic value of biotech companies

Company code	C (billion)	financial rights	CA (billion)	company agent	C (billion)	financial rights	CA(billion)
000403	9.35	0.7409	12.6188	300239	9.03	0.5058	17.8602
000661	71.62	0.5096	140.5361	300289	15.82	0.4903	32.2576
002007	54.88	0.4479	122.5357	300294	42.74	0.5066	84.3705
002022	28.49	0.3937	72.3664	300318	17.98	0.4920	36.5515
002030	35.30	0.4282	82.4269	300381	30.95	0.5237	59.0914
002166	16.98	0.5641	30.1055	300406	16.66	0.4436	37.5592
002252	112.96	0.4634	243.7751	300439	32.26	0.5079	63.5136
002550	28.22	0.4127	68.3806	300463	34.16	0.3947	86.5595
002581	34.87	0.4527	77.0213	300583	20.06	0.5370	37.3560
300009	21.53	0.4298	50.0963	600161	45.19	0.6161	73.3349
300122	48.52	0.4053	119.7259	600530	17.43	0.5586	31.2061
300204	25.59	0.3881	65.9393	603658	20.64	0.6328	32.6085

4.4 Comparative Analysis of the Revised Appraisal and the Market Value of the Enterprise.

In the table, this paper also reflects the average equity price of each sample company in December 2018, compares the revised valuation with the market value of the enterprise, and calculates its deviation degree, are shown in Tab.6

Table 6 The comparison between the revised valuation and the market value

Company code	Market value	Intrinsic value	Deviation degree %	Cast	Company code	Market value	Intrinsic value	Deviation degree %	Cast
000403	68.6350	12.6188	-18.61	no	300239	17.1678	17.8602	4.03	yes
000661	297.6965	140.5361	-52.79	no	300289	27.9288	32.2576	15.50	yes
002007	305.0688	122.5357	-59.83	no	300294	116.9544	84.3705	-27.86	no
002022	48.3280	72.3664	49.74	yes	300318	32.6133	36.5515	12.08	yes
002030	81.0171	82.4269	1.74	yes	300381	33.5166	59.0914	76.30	yes
002166	26.8491	30.1055	12.13	yes	300406	49.3258	37.5592	-23.85	no
002252	398.4672	243.7751	-38.82	no	300439	46.2787	63.5136	37.24	yes
002550	48.6400	68.3806	40.59	yes	300463	81.4680	86.5595	6.25	yes
002581	42.6189	77.0213	80.72	yes	300583	35.7982	37.3560	4.35	yes
300009	133.2482	50.0963	-62.40	no	600161	185.1170	73.3349	-60.38	no
300122	620.1600	119.7259	-80.69	no	600530	34.4760	31.2061	-9.48	no
300204	52.8189	65.9393	24.84	yes	603658	205.3380	32.6085	-84.12	no
000403	68.6350	12.6188	-18.61	no	300239	17.1678	17.8602	4.03	yes
000661	297.6965	140.5361	-52.79	no	300289	27.9288	32.2576	15.50	yes
002007	305.0688	122.5357	-59.83	no	300294	116.9544	84.3705	-27.86	no
002022	48.3280	72.3664	49.74	yes	300318	32.6133	36.5515	12.08	yes
002030	81.0171	82.4269	1.74	yes	300381	33.5166	59.0914	76.30	yes
002166	26.8491	30.1055	12.13	yes	300406	49.3258	37.5592	-23.85	no

Through comparison, the following analysis conclusions can be made :(1) the deviation between the evaluation value and the total market value of the company is positive, indicating that the listed company is undervalued and has certain investment value and development potential, indicating that the listed company is undervalued and has certain investment value and development potential. Among the 24 biotechnology listed companies evaluated, 13 have a positive deviation degree, accounting for 54.1% of the total number, indicating that there are few biotechnology companies with investment value, and most of the listed agricultural companies are overvalued.(2) there are 15 listed companies whose deviation degree is between 0 and 50%, accounting for 62.5% of the total number. Among them, the deviation degree of about 53.3% is less than 20%. Considering the

complex macroeconomic situation and changeable industry conditions faced by enterprises, the deviation between their evaluation value and the total market value is not too large.(3) the listed companies whose deviation degree is between 50% and 100% account for 37.5% of the total number, and the listed companies whose deviation degree is >80% account for 16.7% of the total number, which reflects that there are a lot of bubbles in the stock prices of some listed biotechnology companies. Therefore, in this case, the fact that the appraisal value is not consistent with the stock price does not mean that the appraisal value deviates from the actual value. On the contrary, investors should make accurate judgment on listed companies according to the evaluation value and prevent blind investment due to overvaluation of stock prices.

5. Research Conclusions and Suggestions

In this paper, by introducing mutation series correction, the real option model to our country's 24 biotech companies evaluate the enterprise value of the city, and the shares of listed companies and the enterprise internal value comparison analysis shows that 24 in the listed company has 11's intrinsic value is greater than the stock price, and part of the enterprise internal value and stock price deviation degree is bigger, illustrates some agricultural enterprises in the securities market share price bubbles exist. Based on the above research conclusions, this paper puts forward the following two Suggestions:

(1) Investors should accurately judge the actual value of the enterprise. There are a lot of bubbles in the capital market, resulting in the overvaluation of enterprise value. For investors, when making investment, financing, merger and acquisition and reorganization, they should make accurate judgment on the listed companies based on the assessed value and prevent them from making decisions blindly due to overvaluation of stock prices.

(2) Evaluation agencies should enhance the diversity of evaluation methods. For evaluation institutions, the evaluation of the enterprise value of listed biological science and technology companies should not be limited to the traditional three evaluation methods. For enterprises with the characteristics of options, they should not only consider the use of real options, but also consider the value of non-financial factors, which is conducive to the accurate evaluation of enterprise value.

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