

Research on Goodwill Measurement Models Based on Real Options Theory

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Abstract. High-premium mergers and acquisitions often result in high goodwill and associated impairment risks, which can significantly impact a company's equity and the quality of its accounting information, exacerbate fluctuations in operating performance, and mislead investors' decision-making. Therefore, accurately measuring goodwill and its impairment amounts is of particular importance to both companies and the market. Addressing the shortcomings of the current goodwill initial measurement methods used in practice, this study proposes to incorporate real options theory to improve the cut difference method and establish a modified coefficient assessment system based on corporate capabilities and industry characteristics to accurately evaluate a company's goodwill and impairment amounts. This approach aims to provide dual theoretical support and practical guidance for merger and acquisition decisions and goodwill management in the electronics manufacturing industry.

Keywords: Real options; corporate capabilities; goodwill measurement.

1. Introduction

Paying excessive premiums in merger and acquisition transactions often results in dual pressures on a company's balance sheet: inflated goodwill assets and subsequent impairment risks. The bubble-like nature of goodwill exacerbates fluctuations in corporate profitability. Once the asset bubble created by high-premium mergers and acquisitions bursts, the massive impairment of goodwill will lead to a reversal in company performance. The lag in impairment testing may mask actual operating performance. Some listed companies use goodwill impairment as an excuse to engage in earnings management, misleading investors' decisions and harming the healthy operation of capital markets. In June 2022, the State-owned Assets Supervision and Administration Commission of the State Council issued *the Notice on Strengthening Goodwill Management in Central Enterprises*, emphasizing the need to strictly conduct goodwill impairment testing and strengthen dynamic tracking and monitoring of goodwill impairment indicators.

Currently, many scholars in the academic community have argued through theoretical analysis and empirical testing that the current goodwill measurement system has defects such as measurement bias and strong reliance on subjective judgment. Based on this, scholars at home and abroad have proposed various methods for assessing and analyzing goodwill value, including methods based on corporate capabilities^[1], matrix vector methods^[2], capitalization methods^[3], and hierarchical recognition and measurement methods^[4, 5]. However, the application of these innovative measurement frameworks highly depends on the depth of professional assessors' understanding and data analysis capabilities. For small and medium-sized enterprises, this not only poses dual challenges of method conversion costs and technical implementation difficulties but may also lead to inconsistent management of goodwill due to differences in implementation capabilities, making market supervision difficult. Therefore, it is essential to conduct in-depth research on how to improve traditional initial goodwill measurement methods.

Considering the continuity of goodwill measurement methods and the implementation difficulties of improved methods, this study introduces real options theory to improve the cut difference method and constructs a modified coefficient assessment system based on corporate capabilities and industry characteristics, thereby forming a new goodwill measurement model. This expands research in the

field of goodwill measurement and provides tools for investors and regulators to analyze and supervise corporate goodwill management behavior. Additionally, this paper unifies the accounting treatment of internally generated goodwill and externally purchased goodwill based on the view that they are essentially the same, thereby expanding the scope of goodwill that can be measured.

2. Literature Review

A review of the above literature reveals that although foreign scholars have conducted extensive research on goodwill, Chinese scholars have also made notable progress by building on foreign research literature.

2.1. The Essence of Goodwill

Unlike intangible assets, goodwill cannot be identified separately, leading to ongoing debates within academic circles both domestically and internationally regarding its essence, with no consensus reached to date. Currently, many scholars have proposed various theories such as “goodwill value theory,” “excess income theory,” “total valuation account theory,” and “synergy effect theory” in their research, innovatively analyzing the essence of goodwill from different perspectives. However, “goodwill value theory” is relatively vague and only superficially describes the source of goodwill. Additionally, the measurement of goodwill value is highly uncertain, and it is impossible to calculate the value of each related goodwill factor individually. Therefore, this theory cannot accurately measure the value of goodwill. In the “total valuation account theory”, due to constraints imposed by current financial accounting and reporting frameworks, a significant portion of assets and liabilities may fail to meet strict recognition criteria—specifically, meeting the definitions of accounting elements, measurability, relevance, and reliability—and thus cannot be recognized in financial statements. Consequently, the goodwill defined under this theory includes a mix of diverse factors^[6]. Additionally, this paper argues that the advantages of “synergy effect theory”—formed through integration under this theory—enable companies to outperform competitors in future transactions and achieve excess returns. Thus, “synergy effect theory” is an extension of the “excess income theory”.

Based on the above perspectives, this paper concludes that “excess income theory” better reflects the essence of goodwill, which is an economic resource enabling companies to achieve excess returns in the future.

2.2. Recognition and Measurement of Goodwill

From the perspective of acquisition channels, goodwill can be divided into internally generated goodwill and externally purchased goodwill. However, since the academic community has not yet identified a universally recognized method for reliably measuring the value of internally generated goodwill, China's accounting standards only provide explicit provisions for the accounting treatment of externally purchased goodwill and do not recognize internally generated goodwill. Additionally, most academic research is based on international accounting standards, distinguishing between internally generated goodwill and externally purchased goodwill for separate discussion. Only a small number of scholars have conducted research based on the view that the two are essentially the same.

Differences in academic understanding of the nature of goodwill have further extended to the measurement level, leading to ongoing debates over whether to adopt the amortization method or the impairment method for subsequent goodwill measurement. The currently prevalent view is to follow the content of international accounting standards and continue using the goodwill impairment test method. However, due to ambiguity in the description of identifiable net assets in accounting standards^[7], management has significant discretion in earnings management. The key to resolving the controversy over subsequent goodwill measurement methods lies in clarifying the essence of goodwill during initial recognition and measurement. In practice, the asset valuation system comprises three methods: the cost approach, the market approach, and the income approach. However,

the multidimensional integration of goodwill's constituent elements makes its value difficult to measure using conventional methods. Therefore, the academic community has proposed using the excess earnings method and the cut difference method for the initial measurement of goodwill. Among these, the excess earnings method reflects the future expected earnings nature of goodwill, but the determination of the earnings period, discount rate, and prediction of excess earnings largely depends on the appraiser's experience and judgment, thereby carrying a certain degree of subjectivity^[8]. Additionally, intangible assets such as trademarks, patents, and land use rights can also generate excess returns, so using the excess earnings approach to calculate goodwill may overestimate its value. The cut difference method, as the method currently used in China's accounting standards, undoubtedly has its rationality and scientific basis. Many scholars in the academic community have pointed out that the cut difference method is easy to operate and its assessment results are more reliable than those of the excess earnings approach. However, some scholars have also questioned its accuracy. First, the merger price in the difference-of-value method is influenced by factors such as the stock market conditions at the time of the merger, the status of the merging parties, and negotiation skills, causing the merger price to deviate from the company's intrinsic value^[9, 10]. Second, some assets and liabilities within a company may not have a public market, making it difficult to determine their value, which in turn makes it challenging to determine the fair value of identifiable net assets^[11].

Based on this, many scholars both domestically and internationally have begun to propose the use of different methods to assess and analyze goodwill value, including methods based on corporate capabilities, matrix vector methods, capitalization methods, and hierarchical recognition and measurement methods. Although these methods have their theoretical basis and merits, they represent entirely new measurement frameworks and involve specialized, in-depth knowledge. Compared to the measurement methods under current standards, they span a significant gap, making implementation challenging for small and medium-sized enterprises. This could lead to inconsistent management of goodwill and make market supervision difficult. Therefore, exploring optimization pathways for traditional goodwill measurement methods holds important theoretical value and practical significance.

3. Construction of the New Goodwill Measurement Model

Depending on the source, goodwill can be classified into two types: internally generated goodwill and externally purchased goodwill. However, the value formation of internally generated goodwill exhibits dynamic evolutionary characteristics, making it difficult to reliably trace its historical cost, and its valuation carries a high risk of manipulation. Therefore, current Chinese accounting standards stipulate that only externally purchased goodwill should be recognized. However, this paper argues that purchased goodwill essentially serves as a transitional vehicle for goodwill value at the point of property rights transactions, while the dominant role in a company's ongoing operations is still played by internally generated goodwill^[12]. In other words, a significant portion of the externally purchased goodwill recognized in merger and acquisition transactions actually originates from the self-generated goodwill of the acquired company. After the merger and acquisition integration is completed, the externally purchased goodwill elements obtained through the merger and acquisition will dynamically integrate with the acquiring party's existing internally generated goodwill system. Under the mechanisms of organizational synergy and resource integration, it will ultimately be internalized as the group's comprehensive goodwill assets, thereby creating excess returns for the enterprise.

Although internally generated goodwill is accumulated by the company over the long term through its production and operations^[13], externally purchased goodwill is obtained through M&A activities, this paper argues that internally generated goodwill and externally purchased goodwill are fundamentally consistent in nature. Both are key resources that can create excess returns for the company in the future, and there is no substantial difference in their value attributes. Therefore, this paper proposes that the same model can be used to measure the value of both.

As analyzed earlier, the traditional valuation methods for goodwill—the excess earnings approach and the cut difference method—share a common flaw: neither can adequately reflect the uncertainty inherent in goodwill value. However, from a computational perspective, the cut difference method reduces the need for predicting numerous parameters and subjective selection processes, thereby minimizing the influence of subjective factors on assessment results. Additionally, given that accounting standards require a certain degree of continuity in goodwill measurement methods, this paper selects the cut difference method as the foundation for model construction. Subsequently, to ensure that the new measurement model reflects the essence of goodwill and its uncertain value characteristics, this paper proposes to incorporate real options theory to modify the original formula of the cut difference method, thereby leveraging the advantages of option pricing models in calculating the value of uncertain assets. Finally, the traditional cut difference method does not consider qualitative factors such as social recognition, industry development status, and external policy environment that influence goodwill value. To address this shortcoming, this paper plans to construct a scientifically reasonable adjustment coefficient evaluation system based on corporate capabilities and industry characteristics, integrating the company's goodwill value with various financial and non-financial influencing factors. Ultimately, the goodwill value assessment results obtained after applying the improved formula will achieve relatively reasonable and accurate evaluation values based on a more comprehensive consideration of all relevant factors. The schematic diagram of the new goodwill measurement model constructed in this paper is shown in Figure 1.

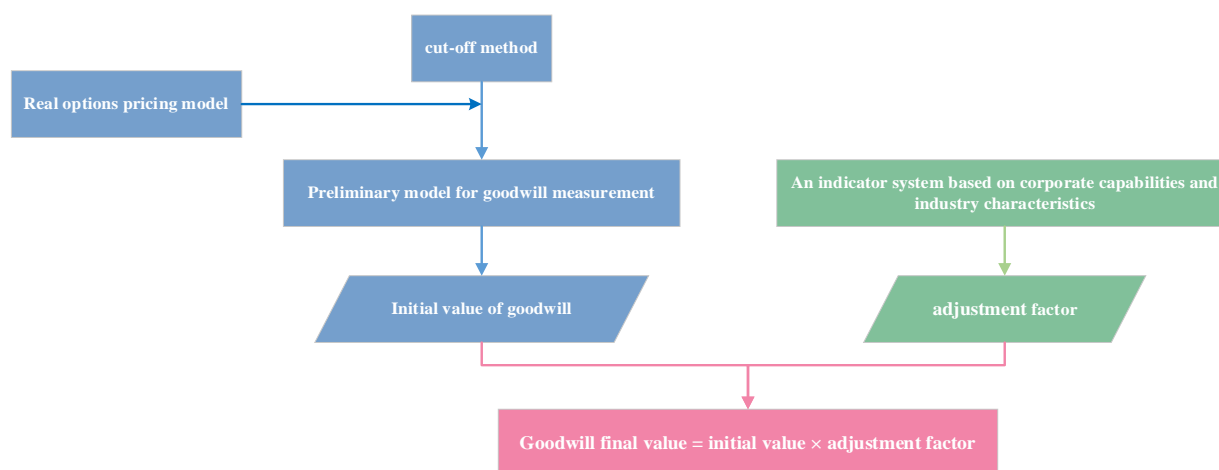


Fig.1 Principle diagram of the new goodwill measurement model

3.1. Improving the Cut Difference Method by Introducing Real Options Theory

Real options are a theoretical innovation based on the option theory framework, extending the principles of financial derivative pricing to the realm of physical assets. Essentially, they provide corporate management with the discretion to dynamically adjust action plans based on future uncertainties during strategic investment decision-making processes. Real options evolved from financial options, thus real option models can also be used to calculate the value of assets with option characteristics.

$$\begin{aligned}
 \text{Goodwill value} &= \text{Merger and acquisition price} - \text{the sum of the fair value of the identifiable net assets of the acquired company} \\
 &= \text{Discounted cash flows of the enterprise in the current and future periods} - \text{total liabilities} - \text{assessed value of shareholders' equity} \\
 &= (\text{EV} + \text{cash}) - \text{total liabilities} - \text{assessed value of shareholders' equity} \quad (1) \\
 &= (\text{Company market value} + \text{total liabilities} - \text{cash}) + \text{cash} - \text{total liabilities} - \text{assessed value of shareholders' equity} \\
 &= \text{market capitalization} - \text{assessed value of shareholders' equity}
 \end{aligned}$$

Under the cut difference method, the formula for measuring goodwill value is the difference between the merger consideration and the sum of the fair value of the identifiable net assets of the acquired entity. This paper converts the value of goodwill into the difference between the market value of the enterprise and the equity valuation through a series of transformations, as shown in Formula (1).

In the course of business operations, companies face complex and ever-changing market environments. In favorable market conditions, shareholders or managers holding company equity possess the flexibility to decide whether to continue or adjust business strategies. When faced with adverse circumstances, they may also proactively initiate liquidation procedures to mitigate the risk of significant losses. This management option embedded in strategic flexibility is valuable and essentially constitutes a real option. Therefore, a company's equity is essentially a residual claim right and can also be viewed as a call option^[14]. Consequently, real option models can be used to value it, thereby calculating the company's goodwill value.

3.1.1 Selection of Real Option Pricing Models

According to Formula (1), the value of goodwill is equal to the difference between the market value of the company and the assessed value of its equity. Since the value of equity is continuously changing, the Black-Scholes (B-S) option pricing model can be used to determine it. The B-S option pricing model is based on the following basic assumptions:

- a. The market is frictionless, i.e., there are no taxes or transaction costs;
- b. The underlying asset does not distribute profits during the valuation period;
- c. Options can be freely traded, with no restrictions on short selling;
- d. Stock trading in the market is continuous at all times;
- e. There are no risk-free arbitrage opportunities in the market;
- f. The risk-free interest rate is a constant;
- g. Stock price changes follow the law of random Brownian motion.

The formula for the Black-Scholes option model is as follows:

$$C = S * N(d_1) - X * e^{-rT}N(d_2) \quad (2)$$

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r + \frac{\sigma^2}{2}\right) * T}{\sigma\sqrt{T}} \quad (3)$$

$$d_2 = d_1 - \sigma\sqrt{T} \quad (4)$$

3.1.2 Selection of parameters for the B-S option model

(1)Current price of underlying asset (S)

When valuing company equity as a call option, the underlying asset is the company as a whole. Currently, the academic community primarily uses the discounted cash flow (DCF) model and the market comparison method to calculate enterprise value. However, in the absence of an effective trading market, the application of the market comparison method is significantly limited; simultaneously, the DCF model faces challenges due to its high reliance on subjective parameter selection during the valuation process, resulting in insufficient objectivity in the results. Given the regulatory requirements of China's capital market, the annual financial reports of listed companies must be audited by third-party accounting firms, ensuring that the disclosed data has a high degree of credibility and fairness. Additionally, the balance sheet structures of companies within the same industry exhibit strong comparability. Therefore, using the book value of total assets as the current value S of the underlying asset aligns with accounting information quality requirements and facilitates horizontal comparative analysis.

(2)Option exercise price (X)

Within the option pricing theory framework, the exercise price specifically refers to the amount that the option holder must pay or receive when exercising their right to acquire or transfer the underlying asset. Based on the priority rules in corporate bankruptcy liquidation, creditors have priority rights to the company's remaining assets, while shareholders retain only subordinate residual claims. Therefore, this study selects the total liabilities disclosed in the audited financial reports as the option's exercise price X.

(3)Option validity period (T)

Within the financial theory framework, a company is assumed to be a perpetual entity. However, in reality, when a company incurs significant losses, stakeholders such as shareholders may trigger the bankruptcy liquidation mechanism, resulting in the company's existence having a finite duration. Therefore, this paper uses the company's expected lifespan as the option exercise period T.

(4)Risk-free interest rate (r)

The risk-free interest rate serves as the benchmark for idealized investment returns in financial theory, representing the interest rate that investors can expect to earn while completely avoiding risk. This paper argues that in China's bond market, government bonds possess low risk and high market credibility, making their annualized yield an appropriate proxy for measuring the risk-free interest rate.

(5)Volatility of the underlying asset's price (σ)

Volatility of the underlying asset's value is essentially an uncertainty indicator measuring the extent to which changes in the asset's value affect the holder's interests. Since the real option valuation model uses the company's overall asset portfolio as the underlying asset, this can be quantified by the dispersion of the total asset return rate.

3.1.3 Optimization of the B-S option model

(1)Introduce dividend yield 'q'

The B-S option pricing model assumes that the underlying asset does not pay dividends during the valuation period. Since the case companies selected in this paper paid dividends continuously during the calculation period, this paper proposes that the dividend yield 'q' can be introduced into the model to optimize it. The specific optimized model is shown below:

$$C = S * e^{-qT}N(d_1) - X * e^{-rT}N(d_2) \tag{5}$$

$$d_1 = \frac{\ln\left(\frac{S * e^{-qT}}{X}\right) + \left(r + \frac{\sigma^2}{2}\right) * T}{\sigma\sqrt{T}} \tag{6}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{4}$$

$$q = \frac{\text{Total annual dividend per share}}{\left(\frac{\text{Highest share price of the year} + \text{lowest share price of the year}}{2}\right)} \tag{7}$$

(2)Replace σ

The case companies in this paper experienced negative returns on total assets during the calculation period, causing their yield distribution to deviate significantly from the log-normal distribution. To address this issue, this paper draws on the parameter adjustment method proposed by Amram and Kulatilada (1999) and uses stock price volatility to replace the volatility σ of total asset returns in the original model to ensure that the prerequisites for model application are met.

(3)Stage division parameter T

The expected lifespan of a company varies depending on its size. Therefore, this paper intends to refer to the classification method for large, medium, small, and micro enterprises proposed by the National Bureau of Statistics and divide the exercise period into categories according to the size of the company. The specific classification method is shown in Table 1.

Table 1. Parameter T Stage Division Table

Company Size	T
Large enterprises	10
Medium-sized enterprises	5
Small enterprises	3
micro enterprises	1

3.2. Determining the Goodwill Value Adjustment Coefficient Based on Corporate Capabilities

The unique and scarce resources accumulated by a company through its production and operations form its capabilities. These capabilities are intangible, knowledge-based phenomena and the primary reason companies earn profits and gain competitive advantages. Therefore, cultivating, accumulating, and utilizing these capabilities is a fundamental strategy for companies to remain successful in the long term. The essence of goodwill is the economic resource that enables a company to achieve excess returns in the future. Therefore, goodwill is a comprehensive reflection and value manifestation of a company's ability to adapt to the market and develop various capabilities, as well as a concentrated expression of its core competitiveness.

Table 2. Indicator system for goodwill value adjustment coefficients based on enterprise capabilities

Principle Level	Indicator Level	Specific Indicators
Overall Operational Efficiency	Return on Equity	Return on Equity
	Cost-to-Profit Ratio	Cost-to-Profit Ratio
	Labor Productivity	Revenue per Employee
	Capital Utilization Efficiency	Current Asset Turnover Ratio
	Company Size	Natural Logarithm of Operating Revenue
Industry Potential	Market Share	Market Share of Leading Products
	Commercial Credit Rating	(Accounts Payable + Notes Payable) / Total Assets
	Corporate Integrity	10-Administrative Agencies in the Current Period
	R&D Investment	Ratio of new R&D expenses to operating revenue
Development Potential	R&D Team Status	Ratio of direct R&D personnel to total employees
	R&D Capability	Natural logarithm of new patents in the current year
	Management Education Level	Ratio of management personnel with a master's degree or higher
	Profit Growth Rate	Net profit growth rate

Based on this, this paper draws on Li Yuju's view that “goodwill is the value manifestation of capabilities”^[8], dividing corporate capabilities into three dimensions: comprehensive operational efficiency, industry potential, and development potential. These three capabilities serve as the criteria layer for the goodwill value adjustment coefficient indicator system. Additionally, considering the characteristics of the industry in which the case company operates—such as large industrial scale,

rapid technological updates and iterations, strong industrial interconnectivity. A goodwill value adjustment coefficient indicator system centered on corporate capabilities is designed. The specific details are presented in Table 2.

Next, this paper intends to use the entropy method to process the company data across the entire industry of the case company, and then determine the weights of each indicator in the goodwill value adjustment coefficient index system. Then, the fuzzy comprehensive evaluation method will be employed, with multiple renowned industry experts invited to score. The industry average level will be set at 50 points, with scores categorized into five levels: excellent, good, average, poor, and very poor. The goodwill value adjustment coefficient will be derived based on these scores. Finally, the adjusted coefficient is multiplied by the goodwill result calculated earlier using the real options model to obtain the adjusted goodwill value, thereby ensuring the accuracy of the assessment results.

4. Application of the New Goodwill Measurement Model

4.1. Case Company Overview

4.1.1 L Company profile

L Company is a wholly foreign-owned high-tech enterprise that listed on the Growth Enterprise Market of the Shenzhen Stock Exchange in 2015. The company adopts a development strategy driven by technological innovation, leveraging its intelligent manufacturing system to establish a network of nine multi-functional R&D and manufacturing bases spanning regions such as Hunan, Jiangsu, and Vietnam. It innovatively applies new materials such as glass, sapphire, and ceramics to the industrialization of consumer electronics terminals and in smart automotive touchscreen applications.

L Company's core business focuses on comprehensive solutions for the entire smart terminal value chain, encompassing mobile smart devices (e.g., smartphones and tablets) and precision structural components for intelligent cockpit systems in new energy vehicles, as well as for smart headsets and wearable devices. By establishing vertically integrated capabilities spanning industrial design, mold development, and mass production delivery, the company has formed a complete closed-loop ecosystem encompassing "equipment R&D, process innovation, and manufacturing." Currently, the company has established deep strategic partnerships with leading brands in the global consumer electronics and new energy vehicle sectors, driving industrial innovation and upgrading through technological collaboration and production capacity synergy.

4.1.2 Purpose of L Corporation's acquisition

In 2020, the electronics manufacturing industry entered a critical development phase driven by 5G technology, with major countries around the world completing large-scale deployment of 5G communication technology infrastructure. Driven by both technological evolution and consumer demand, the markets for consumer electronics products centered on mobile terminals and smart wearable devices, as well as high-end smart cars, have demonstrated significant demand for technological upgrades and product iterations. Therefore, based on its in-depth analysis of industry trends, L Company anticipates that the demand scale for its core products among its key customer base will expand significantly.

Prior to this merger and acquisition, L Company's vertically integrated strategy, cultivated over many years, had already begun to show results: the company continued to strengthen its competitive advantages in the fields of mobile terminals, new energy vehicles, and smart home appliances, achieving reduced device size while enhancing functional density through deeper hardware integration across multiple categories of smart terminals. At the same time, the company had established a digital supply chain collaboration platform, utilizing blockchain technology to achieve material traceability and demand forecasting, thereby helping customers reduce overall supply chain costs. As of the first half of 2020, all of L Company's production bases were operating at full capacity, with core product revenue achieving significant year-on-year growth. The company's market share in the global premium customer segment and mid-to-high-end niche product segments had increased

significantly. Given that the second half of the year is the traditional peak sales season for consumer electronics and components, the company expects order demand to continue to rise.

The acquisition of Companies B and C at a cost of 9.9 billion yuan marks a landmark event in the company's vertical integration strategy entering a new phase. Companies L, B, and C are in an upstream-downstream business relationship. Company L believes that the target companies possess cutting-edge technological R&D capabilities, highly automated production systems, experienced technical management teams, and stable production capacity guarantees. Following the strategic merger and acquisition to integrate resources, the company will not only achieve further expansion of production capacity but also strengthen its vertical integration service capabilities, providing customers with end-to-end solutions. Additionally, this will accelerate the implementation of the company's medium- to long-term strategic plan, which focuses on leveraging its core competitiveness in smart manufacturing to deepen supply chain synergy and establish a robust market competitive barrier. This merger and acquisition will create favorable conditions for the company to expand its business into downstream supply chains, continuously enhance its comprehensive competitive strength and profit margins, and reinforce its leading position in the industry.

4.2. Initial Measurement Analysis of L Company's Goodwill

4.2.1 Initial measurement of goodwill under the cut difference model

On August 18, 2020, Company L and Company A signed a "Share Purchase Agreement," agreeing to acquire 100% of the shares of Companies B and C held by Company A for RMB 9.9 billion in cash, which would be converted into US dollars at a fixed exchange rate of 6.9362 (the midpoint rate on the day prior to signing) and remitted to Company A. By the end of 2020, both parties had completed all the closing procedures for this transaction. On February 25, 2022, based on strategic development and operational management needs, Company B was merged into Company C.

The fair value of the acquisition cost was determined through negotiations between the parties to the acquisition based on the target company's financial statements for the most recent fiscal year, combined with market valuations of comparable companies. However, due to the significant appreciation of the RMB against the USD between the signing date and the completion of the transaction, the final acquisition consideration, paid in USD, was converted to RMB 9.398 billion. The fair value of the identifiable assets and liabilities of the acquired party as of the merger date was determined based on the asset valuation report issued by Beijing Zhonglin Asset Valuation Co., Ltd. Therefore, the initial recognition amount of goodwill under the acquisition method is shown in Table 3.

Table 3. Initial measurement results of L Company's goodwill under the cut difference method
Unit: yuan

Project	Amount
Acquisition price	9,398,037,080.67
Fair value share of identifiable net assets of the target company	6,427,892,851.32
Goodwill	2,970,144,229.35

4.2.2 Initial measurement of goodwill under the new goodwill measurement model

All data used in the model are sourced from the Guotai An database (CSMAR). The specific values selected for the parameters of the goodwill measurement model based on real options theory are presented in Table 4. Based on formulas (4), (5), (6), and (7), the equity valuation (C) of the corporate group prior to the merger and acquisition transaction was RMB 51,030,135,506.75. After the completion of the acquisition of 100% equity in Companies B and C, the equity valuation (C) of Company L increased to RMB 69,354,904,350.67.

Table 4. L Company's New Goodwill Measurement Model parameter data

Parameters	Before the Merger(June 2020)	After the Merger(December 31, 2020)
S	51,030,509,077.34	79,575,591,399.32
X	26,602,231,946.70	37,256,999,722.49
T	10	10
q	0	0.0137
r	2.895%	3.203%
σ	2.7712	7.3715

According to the Guotai An database, the market value (P) of Company L prior to the merger and acquisition was RMB 149,195,329,319.61. L Company's overall goodwill value (G) was RMB 149,195,329,319.61 minus RMB 51,030,135,506.75, totaling RMB 98,165,193,812.86.

By the end of 2020, L Company had finally completed the acquisition of the target company. As of that date, Company L's market capitalization (P) was RMB 171,138,820,706.87. At this point, L Company's overall goodwill value (G) was RMB 171,138,820,706.87 minus RMB 69,354,904,350.67, totaling RMB 101,783,916,356.20.

Then, using all available data from the case company's industry, after excluding data with missing values, the weights for each indicator in the goodwill adjustment coefficient system for June 2020 were obtained using the entropy weighting method. The specific weight values are shown in Table 5.

Table 5. L Company's goodwill adjustment coefficient indicator weighting for June 2020

Principle Level	Weighting(%)	Indicator Level	Weighting(%)
Overall Operational Efficiency	5.181	Return on Equity	15.694
		Cost-to-Profit Ratio	9.406
		Labor Productivity	17.074
		Capital Utilization Efficiency	57.825
Industry Potential	36.256	Company Size	4.146
		Market Share	83.551
		Commercial Credit Rating	11.626
		Corporate Integrity	0.677
Development Potential	58.563	R&D Investment	8.263
		R&D Team Status	7.296
		R&D Capability	79.86
		Management Education Level	4.176
		Profit Growth Rate	0.405

Table 6. L Company's June 2020 relevant indicator evaluation table

Principle Level	Indicator Level	Excellent	Good	Average	Poor	Very Poor
Overall Operational Efficiency	Return on Equity	6	4	0	0	0
	Cost-to-Profit Ratio	4	5	1	0	0
	Labor Productivity	0	3	3	4	0
	Capital Utilization Efficiency	7	3	0	0	0
	Company Size	9	1	0	0	0
Industry Potential	Market Share	7	3	0	0	0
	Commercial Credit Rating	0	3	5	2	0
	Corporate Integrity	10	0	0	0	0
	R&D Investment	0	0	0	3	7
Development Potential	R&D Team Status	0	0	0	2	8
	R&D Capability	7	3	0	0	0
	Management Education Level	0	3	4	3	0
	Profit Growth Rate	6	4	0	0	0

Next, the fuzzy comprehensive evaluation method was used to calculate the adjustment coefficients. Ten industry experts were invited to score the performance of L Company's relevant indicators against the industry average. The scoring range was set at 0–100 points, with the industry average set at 50 points. Based on the experts' scores, the results were categorized into five grades: 80–100 points for excellent, 60–80 points for good, 40–60 points for average, 20–40 points for poor, and 0–20 points for very poor. The statistical evaluation of L Company's relevant data indicators is shown in Table 6.

Then, multiply the set of indicator weights obtained from the aforementioned entropy method was multiplied by the corresponding single-factor evaluation matrix to obtain the first-level fuzzy evaluation matrix. The comprehensive evaluation of overall operational efficiency are presented below:

$$\begin{aligned}
 A_1 &= [0.1569 \quad 0.0941 \quad 0.1707 \quad 0.5783] \times \begin{bmatrix} 0.6 & 0.4 & 0 & 0 & 0 \\ 0.4 & 0.5 & 0.1 & 0 & 0 \\ 0 & 0.3 & 0.3 & 0.4 & 0 \\ 0.7 & 0.3 & 0 & 0 & 0 \end{bmatrix} \\
 &= [0.5366 \quad 0.3345 \quad 0.0606 \quad 0.0683 \quad 0]
 \end{aligned}$$

Similarly, a first-level fuzzy evaluation matrix of industry momentum and development potential can be obtained.

$$\begin{aligned}
 A_2 &= [0.0415 \quad 0.8355 \quad 0.1163 \quad 0.0068] \times \begin{bmatrix} 0.9 & 0.1 & 0 & 0 & 0 \\ 0.7 & 0.3 & 0 & 0 & 0 \\ 0 & 0.3 & 0.5 & 0.2 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix} \\
 &= [0.6289 \quad 0.2897 \quad 0.0581 \quad 0.0233 \quad 0]
 \end{aligned}$$

$$A_3 = [0.0826 \quad 0.0730 \quad 0.7986 \quad 0.0418 \quad 0.0041] \times \begin{bmatrix} 0 & 0 & 0 & 0.3 & 0.7 \\ 0 & 0 & 0 & 0.2 & 0.8 \\ 0.7 & 0.3 & 0 & 0 & 0 \\ 0 & 0.3 & 0.4 & 0.3 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \end{bmatrix}$$

$$= [0.5615 \quad 0.2537 \quad 0.0167 \quad 0.0519 \quad 0.1162]$$

Then, the weight set of the criterion layer is multiplied by the secondary fuzzy evaluation matrix composed of A1, A2, and A3 to obtain the overall evaluation of the ten experts on the relevant data of Company L.

$$A = [0.0518 \quad 0.3626 \quad 0.5856] \times \begin{bmatrix} 0.5366 & 0.3345 & 0.0606 & 0.0683 & 0 \\ 0.6289 & 0.2897 & 0.0581 & 0.0233 & 0 \\ 0.5615 & 0.2537 & 0.0167 & 0.0519 & 0.1162 \end{bmatrix}$$

$$= [0.5846 \quad 0.2709 \quad 0.0340 \quad 0.0424 \quad 0.0681]$$

Finally, according to the maximum membership principle, the correction coefficient K can be obtained by multiplying the evaluation results by the matrix of maximum values for each score segment. The result is expressed as a percentage. Therefore, the goodwill value adjustment coefficient K for Company L in June 2020 is 85.23%.

$$K = [0.5846 \quad 0.2709 \quad 0.0340 \quad 0.0424 \quad 0.0681] \times \begin{bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{bmatrix} = 85.23$$

Table 7. L Company Goodwill Initial Measurement Results Table

Parameters	Before the Merger(June 2020)	After the Merger(December 31, 2020)
G	98,165,193,812.86	101,783,916,356.20
K	85.23%	86.05%
G'	83,670,637,034.36	87,587,829,096.26

Similarly, the goodwill value adjustment coefficient K for Company L at the end of 2020 is calculated to be 86.05%. Therefore, the goodwill value of Company L before and after the completion of the merger and acquisition is shown in Table 7.

As shown in the table, firstly, this merger and acquisition transaction has indeed increased the goodwill value of L Company's entire corporate group, indicating that this acquisition has indeed had a positive impact on L Company's future development, with its future excess profitability and competitiveness significantly increasing. Secondly, the goodwill adjustment coefficient can help us assess L Company's market position and competitive advantages. Prior to the merger and acquisition transaction, L Company's goodwill adjustment coefficient was 85.23%. According to the expert panel's scoring criteria, this coefficient falls into the 'excellent' category, indirectly reflecting that L Company ranks among the top in the entire electronics manufacturing industry and possesses strong competitive advantages. Factors such as brand influence, technological strength, and market channels have collectively contributed to this outstanding performance. After the completion of the merger and acquisition transaction, L Company's goodwill adjustment coefficient further increased to 86.05%. This change indicates that the merger and acquisition activity successfully promoted the optimization and integration of internal resources and fully unleashed synergies, thereby laying a more solid foundation for the company's sustainable development.

4.3. Subsequent Measurement Analysis of L Company's Goodwill

4.3.1 Subsequent measurement of goodwill under the impairment test method

A review of L Company's annual report data over the years shows that the results of goodwill impairment tests for each year following the completion of L Company's merger and acquisition transactions are presented in Table 8. As observed from the table data, at the end of each year following the completion of this merger and acquisition transaction, the carrying value of the asset group or asset group combination containing goodwill was lower than its recoverable amount. Therefore, L Company determined that the goodwill formed through this merger and acquisition had not incurred any impairment losses.

Table 8. Subsequent measurement results of L Company's goodwill under the impairment testing method

Unit: 10,000 yuan

Project	End of 2021	End of 2022	End of 2023	End of 2024
Acquisition price	1,091,000.00	1,065,800.00	1,020,758.71	998,721.43
Fair value share of identifiable net assets of the target company	1,072,934.88	1,039,810.75	984,475.78	943,310.28
Goodwill	0	0	0	0

4.3.2 Subsequent measurement of goodwill under the new model

According to the provisions of the Enterprise Accounting Standards, goodwill arising from business combinations should be tested for impairment annually, regardless of whether there are any signs of impairment. Based on this, this paper uses a newly constructed goodwill measurement model to measure the goodwill of Company L, with the relevant measurement results presented in Table 9.

An analysis of the data in Tables 7 and 9 reveals that the market value of Company L decreased at the end of 2021, while the value of equity continued to grow, resulting in the corporate group's overall goodwill value at the end of 2021 being lower than that at the end of 2020. Therefore, an impairment provision of RMB 23,425,110,164.84 (calculated as RMB 87,587,829,096.26 minus RMB 64,162,718,931.42) should be recognized. The growth in shareholders' equity value reflects the market's recognition of L Company's development potential and further indicates that this acquisition has indeed had a positive impact on L Company. As for the decline in goodwill value, the fundamental reasons are as follows: on the one hand, another subsidiary under L Company was dissolved on October 26, 2021, resulting in L Company disposing of its equity control over the company, thereby reducing the company's overall competitiveness; on the other hand, rising raw material prices and imbalances in chip supply and demand have prevented fully realized production capacity from being fully utilized, making it impossible to achieve expected benefits in the short term.

Table 9. Subsequent measurement results for L Company's goodwill under the new goodwill measurement model

Parameters	End of 2021	End of 2022	End of 2023	End of 2024
C	74,092,961,568.85	69,285,678,340.91	53,585,854,494.17	64,283,286,025.77
P	147,914,023,422.40	86,313,889,369.98	96,639,632,495.43	141,080,327,849.31
Goodwill (G)	73,821,061,853.55	17,028,211,029.06	43,053,778,001.25	76,797,041,823.54
Adjustment Factors	86.91654837	86.27523804	86.79248329	90.63681313
Goodwill (G')	64,162,718,931.42	14,691,129,598.56	37,367,443,076.16	69,606,391,284.66

By the end of 2022, the decline in L Company's market value was significantly greater than the decline in shareholders' equity value, resulting in the overall goodwill value of the corporate group decreasing to RMB 14,691,129,598.56. Therefore, at the end of 2022, L Company should have recognized a goodwill impairment of $64,162,718,931.42 - 14,691,129,598.56 =$ RMB 49,471,589,332.86. The decrease in shareholders' equity value was due to L Company's significant cash dividends for the year, while the substantial decline in the company's market value was primarily attributed to two factors: firstly, the recurring COVID-19 pandemic impacted production and delivery of orders, operational scheduling, logistics, procurement, and related costs; secondly, as a supplier to Apple Inc., the volume of products sold to Apple accounted for a significant portion of the company's total sales. However, in recent years, Apple has continuously reduced its procurement of mobile phone components from China, coupled with rising production costs such as raw materials, while the growth in demand from other customers was insufficient to compensate for the shortfall in Apple orders, resulting in poor operating performance and a continuous decline in stock prices.

In 2023, L Company continued to distribute large cash dividends, resulting in a further decline in shareholders' equity value. However, the market value of L Company began to rise that year, leading to an increase in the goodwill value of the corporate group to RMB 37,367,443,076.16. Therefore, L Company did not need to record goodwill impairment for that year. The consumer electronics industry, to which L Company belongs, is a typical cyclical industry, and the industry cycle began to recover in 2023. Additionally, after two years of construction, L Company's whole-machine assembly production line in the Xiangtan Industrial Park has entered a phase of rapid development. Combined with the vertical supply chain strategy formed through the 2020 acquisitions of B and C Companies, which has been further developed, this has driven the continuous enhancement of the company's competitiveness, resulting in significant growth in both market value and goodwill value.

In 2024, L Company's core business segments——smartphones and computer products, as well as new energy vehicles and intelligent cockpit products——all saw significant growth in revenue. Additionally, driven by innovations in cutting-edge technologies such as artificial intelligence and 5G networks, demand in these markets experienced explosive growth. Against this backdrop, investors remain optimistic about L Company's profitability in 2024, driving the continuous rise in its stock value and thereby leading to a significant increase in the company's market capitalization. Since the growth rate of the company's market capitalization far exceeded the growth rate of shareholders' equity value, the goodwill value of L Group continued to grow to RMB 74,990,867,379.90 in that year, so L Company still did not need to make a provision for goodwill impairment that year. Meanwhile, L Company further adjusted its sales strategy, attempting to pursue 'de-Apple-ize' operations. The proportion of sales to its largest customer——Apple Inc.——decreased from 57.83% to 49.45% of the annual total sales. This not only helps L Company establish a more independent brand image to attract a wider range of customers but also diversifies its customer base and optimizes its market layout, thereby reducing operational risks associated with fluctuations in a single customer and enhancing the company's operational stability and risk-resilience.

4.4. Reasonableness Test of the New Model Measurement Results

First of all, given the nature of goodwill, it is an intangible asset closely associated with a company's future excess earnings. Therefore, changes in a company's goodwill value should, to some extent, reflect changes in its excess earnings capacity.

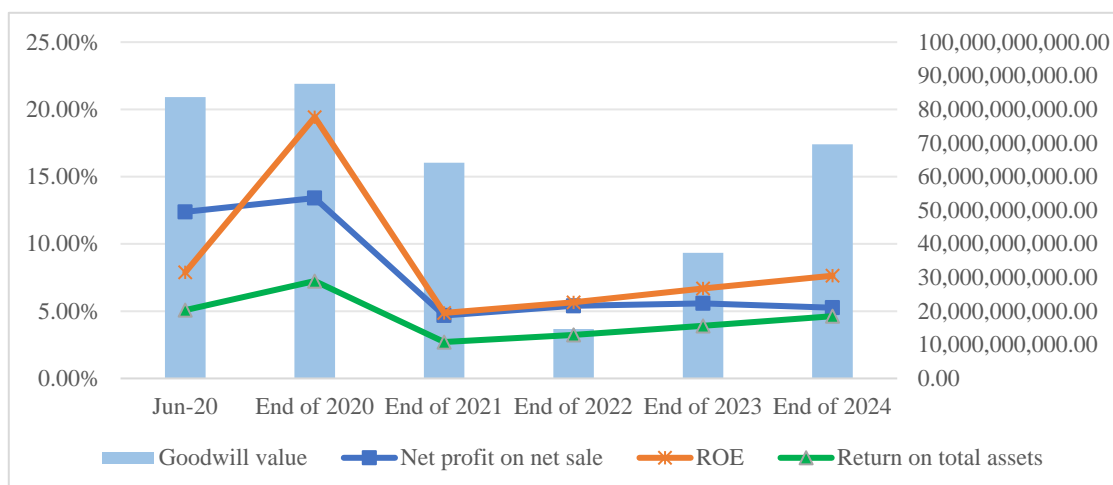


Fig.2 Principle diagram of the new goodwill measurement model

As shown in Figure 2, L Company's excess returns underwent a process of declining from a high level before gradually increasing again. However, under the traditional impairment testing method, L Company's goodwill book value remained at the initial recognition amount after the merger and acquisition transaction, with no impairment provisions recognized. This approach fails to account for the substantive changes in the company's profitability, leading to a divergence between the goodwill measurement results and the company's economic substance. Under the new goodwill measurement model proposed in this paper, L Company's goodwill value rose before the end of 2020, followed by a sustained decline, then bottomed out and rebounded after the end of 2022, with continued growth thereafter. In contrast, the new goodwill measurement model constructed in this paper dynamically adjusts goodwill measurement results by incorporating real options theory, with outcomes that are highly aligned with L Company's actual profitability trends. Therefore, compared to traditional goodwill measurement methods, the new goodwill measurement model proposed in this paper more accurately reflects changes in the company's excess earning capacity.

Secondly, goodwill is a concentrated manifestation of a company's core competitiveness in the market. In other words, the stronger a company's core competitiveness, the easier it will be to defeat its competitors in the future and obtain returns that exceed normal levels. Therefore, the higher its goodwill value will be.

Table 10. Comparison table of goodwill value calculation results and competitiveness rankings

Stock Code	Market Capitalization(P)	Shareholders' Equity Value(C)	Adjustment Factors (K)	Adjusted Goodwill (G')	Competitiveness Ranking
000100	345,025,449,795.39	210,071,819,632.48	94.08%	126,964,000,182.80	134
000725	349,393,052,919.81	214,028,342,990.22	93.12%	126,049,171,789.00	176
002415	231,568,614,016.08	104,837,373,232.44	96.41%	122,183,400,806.83	230
000977	127,169,464,157.33	69,279,206,222.60	95.49%	55,276,946,612.67	246
688981	388,844,613,977.62	353,415,296,000.00	93.68%	33,189,490,858.26	294
002236	73,556,910,017.27	40,109,471,370.15	96.87%	32,399,035,814.65	298
300296	30,132,138,328.90	10,073,025,322.56	93.20%	18,695,282,470.60	359
603019	56,278,343,366.81	34,972,455,542.02	86.67%	18,465,642,992.43	395

To verify the accuracy of the results obtained from the new goodwill measurement model developed in this study, we selected several listed companies in the same industry as Company L, calculated their goodwill values using the new model, and ranked them accordingly. Next, the rankings were compared with those published in the World Brand Lab's "2024 (21st Edition) China's 500 Most Valuable Brands" ranking^[15]. If the two rankings were generally consistent, this would validate the accuracy of the measurement results. The specific test results are shown in Table 10. Data in the table show that the ranking of goodwill value for the selected sample companies in the

reasonableness test of the measurement results is consistent with their competitiveness rankings. Therefore, it can be concluded that using the new goodwill measurement model constructed in this paper to calculate the goodwill value of companies in the consumer electronics industry yields accurate results.

5. Conclusions and implications

5.1. Research Conclusions

Based on the analysis above, the following research conclusions are drawn: (1) The excess return theory better reflects the essence of goodwill. Based on this essence, this paper defines goodwill as an economic resource that enables a company to generate excess returns in the future. (2) A considerable part of the purchased goodwill comes from the self-generated goodwill of the acquired enterprise, and the two are essentially the same, so a unified measurement model can be used for the two. (3) Using real option theory to improve the cut-off method can not only solve the problems of measurement deviation and subjectivity in the current goodwill measurement system, but also give full play to the advantages of option pricing model in calculating the value of uncertain assets, and better reflect the essential characteristics of goodwill with high uncertainty.

5.2. Research Implications

Goodwill embodies a company's future excess earning capacity and has significant strategic significance for maintaining competitive advantages and optimizing capital allocation decisions. Therefore, it is necessary to deepen our understanding of the essential characteristics of goodwill and construct a more scientific and forward-looking valuation method. Based on the aforementioned research findings, this study proposes the following recommendations: First, the modified cut difference method, improved using real options theory, should be adopted as the initial and subsequent measurement model for goodwill. Financial regulatory authorities can establish a parameter and weighting system for the assessment framework based on industry-specific characteristics, thereby enhancing the accuracy, objectivity, and comparability of goodwill valuation. Second, market regulatory authorities should strengthen management of corporate merger and acquisition transactions, establishing standardized, systematic, and mandatory standards for goodwill disclosure. Especially when significant impairment losses occur, companies should be required to disclose the measurement methods for goodwill value, the basis for parameter selection, and the conclusions of third-party audit reviews to enhance transparency. Third, companies should proactively increase the frequency of goodwill value assessments, focusing on evaluating the strategic execution capabilities of internal management teams, the sustainability of innovation and R&D capabilities, and the stability of customer relationship networks within corporate groups. This will help identify the drivers of changes in goodwill value and facilitate corporate value growth.

Additionally, this study has its limitations. First, while the optimized model provides a quantitative analysis framework for goodwill valuation, the underlying assumptions of the B-S option pricing model still differ from the actual capital market environment, resulting in certain discrepancies in the final measurement outcomes. Second, all indicators in the goodwill adjustment coefficient system are quantitative data, with a lack of qualitative indicators, which may lead to an incomplete assessment of goodwill, and further research is needed to improve this aspect.

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