Research on Valuation Revision of Chinese Steel Enterprises under the Dual Carbon Background — Core Indicator Analysis from a Quantitative Finance Perspective

Huan Qu

Jianlong Iron and Steel Holdings Co., Ltd. Beijing , China, 100070
quhuan1986@hotmail.com

Abstract:

Against the backdrop of China's dual carbon goals of "peaking carbon before 2030 and achieving carbon neutrality before 2060," the traditional price-to-book ratio (PB) valuation method for steel companies is insufficient to quantify the long-term value generated by green transformation, leading to serious distortions in corporate valuation. This paper takes 32 listed steel companies on the Shanghai and Shenzhen A-share markets from 2019 to 2024 as a sample. It employs a three-stage quantitative framework of "core indicator screening - weight calculation - valuation correction," combined with random forest models and multiple regression analysis, to identify key valuation drivers and construct a corrected valuation model. The results show that the core valuation indicators are: green investment ratio (27.3%), capital turnover rate (24.6%), carbon emissions per unit of output (19.8%), and credit loan ratio (16.2%). These indicators account for a cumulative 87.9% of the valuation fluctuations. After using the corrected model , the valuation error of the traditional PB model (14.3%) is reduced to within 1%, and for every 1 percentage point increase in the green investment ratio, the corporate valuation premium increases by 1.7% (p<0.01).

Keywords: dual-carbon policy; steel company valuation; quantitative finance; valuation correction; core indicators

1. Introduction

As a global leader in production, scale, and low-carbon technologies, China's steel industry provides a unique context for valuation research. Its crucial role in the dual-carbon transition, its vast data base, and its representative green practices offer an ideal environment for quantitative analysis. However, existing

research lacks integrated analysis of green and financial dimensions, fails to capture the synergistic effect of green transformation and financial efficiency, and the application of quantitative tools in the valuation of domestic steel companies is insufficient [1,2,3] . Traditional price-to-book (PB) ratio models focus only on historical asset size, ignoring the value of green transformation, differences in capital efficiency, and the incremental value of green businesses, resulting in an average valuation deviation of 14.3% [4]. To address these shortcomings, this study constructs a three-order framework ("core indicator screening—weight calculation—valuation correction") using random forests and multiple regression. This research theoretically enriches the quantitative financial applications of the steel industry and provides practical tools for accurate valuation, guiding companies to achieve synergistic effects of green finance and reasonable capital market pricing during the dual-carbon transition.

2. Research Methods

2.1 Sample Selection and Data Sources

2.1.1 Sample Selection

The research sample comprises A-share listed steel companies on the Shanghai and Shenzhen stock exchanges from 2019 to 2024. After excluding 11 ST companies (with abnormal financial data) and companies with missing data, 32 companies were ultimately retained, yielding 192 observations. The sample period covers the entire implementation cycle of China's dual-carbon policy (2020-2024), including industry cycle fluctuations and the large-scale application of green technologies, thus ensuring dual representativeness in terms of both time and cross-sectional data.

2.1.2 Data Sources

(1) Financial indicators: Capital turnover ratio (annual turnover of current assets), credit loan ratio (credit loan amount / total loan amount), sourced from Wind database,

with data reliability verified by industry report [5].

(2) Green indicators: green investment ratio (green investment amount / operating revenue), carbon emissions per unit of output (carbon emissions / output value), derived from companies' annual ESG reports and publicly available data from the China carbon trading market;

(3) Valuation metrics: Year-end market capitalization (RMB 100 million), sourced from the official websites of the Shanghai and Shenzhen Stock Exchanges, ensuring data timeliness and accuracy.

2.1.3 Data Processing

? is used to handle outliers: the mean (μ) and standard deviation (σ) of each indicator are calculated, and extreme values outside the range [$\mu-3\sigma$, $\mu+3\sigma$] are excluded to avoid interference from outlier data on model results; Meanwhile, all indicators are standardized using Z - score to unify the standard, eliminate differences in units, and ensure comparability between indicators .

2.2 Third-order Quantization Analysis Framework

2.2.1 Selection of Core Indicators

Eight candidate indicators were initially selected from financial and green dimensions (capital turnover rate, credit loans ratio, ROE, asset-liability ratio, green investment ratio, carbon emissions per unit of output, environmental protection investment growth rate, and number of green certifications). Core indicators were then determined through a two-step screening process.

2.2.1 .1 Correlation Test - Identifying Indicators Closely Related to Valuation

The Pearson correlation coefficient between each indicator and valuation (year-end market capitalization) is calculated, and indicators with a correlation coefficient < 0.3 are excluded (e.g., environmental protection investment growth rate, which exhibits low correlation with valuation).

2.2.1 .2 Multicollinearity Test - Remove duplicate indi-

cators that are „too similar" to each other

The variance inflation factor (VIF) test is employed to exclude indicators with high redundancy (such as the debt-to-asset ratio, which is collinear with the credit loans ratio), ultimately retaining four core indicators.

2.2.2 Calculation of Indicator Weights

A random forest model is used to calculate the feature importance of the core indicators and determine the contribution of each indicator to the valuation. Model parameters are set as follows:: 100 decision trees (to balance model accuracy and computational efficiency), maximum depth 9 (to avoid overfitting), and minimum leaf nodes sample size of 5 (to ensure node representativeness). The model is optimized through 5-fold cross-validation, ultimately outputting the feature importance score (weight) of each indicator.

2.2.3 Construction of Valuation Adjustment Model

Based on the marginal effect of core indicators verified via multiple linear regression, and incorporating previously unquantified valuation factors such as the proportion of green investment and the proportion of credit loans, a valuation correction model is constructed. The regression model is defined as follows:

$$
\begin{aligned}
Valuation = \beta_0 + \beta_1 \times \\
Green\ Investment\ Ratio + \beta_2 \times \\
Capital\ Turnover\ Ratio + \beta_3 \times \\
Carbon\ Emissions\ per\ Unit\ Output + \\
\beta_4 \times Credit\ Loan\ Ratio + \epsilon
\end{aligned} \tag{1}
$$

Wherein, valuation refers to standardized valuation (year-end market capitalization / net assets), β_0 is a constant term, β_1 - β_4 are regression coefficients (marginal effects), and ϵ is the random error term.

By integrating indicator weights and marginal effects, a valuation correction model is ultimately constructed: Corrected valuation = PB valuation × [1 + 0.273 × (Green investment ratio - Average green investment ratio) + 0.246 × (Capital turnover rate - Average capital turnover rate) - 0.198 × (Carbon emissions per unit of output - Average carbon emissions per unit of output) + 0.162 × (Credit loan ratio - Average credit loan ratio)]

Among them, "average green investment ratio", "average capital turnover rate", "average carbon emissions per unit of output value" and "average credit loan ratio" refer to the industry averages of the core indicators among sample enterprises during 2019–2024.

2.3 Model Performance Evaluation Indicators

The estimation accuracy of the corrected model and the traditional PB model is compared using three metrics: root mean square error (RMSE), mean absolute error (MAE), and goodness of fit (R^2).

RMSE: It reflects the mean squared deviation between the model's predicted values and the actual values; the smaller the value, the higher the accuracy.

MAE: It reflects the average absolute deviation between the model's predicted values and the actual values; the smaller the value, the stronger the stability.

R^2 : It reflects the model's ability to explain valuation fluctuations; the closer the value is to 1, the better the fit.

3. Research Results and Analysis

3.1 Results of Core Indicator Identification

After screening, four core valuation indicators were ultimately retained, and their feature importance scores and definitions are presented in Table 1. The four indicators have a cumulative weight of 87.9%, indicating that they jointly dominate the valuation logic of Chinese steel companies. Among them, the green dimension indicators (green investment ratio + carbon emissions per unit output) have a weight of 47.1%, significantly higher than the global steel industry average of 30% [1]. This highlights the dominant role of green attributes in the value of Chinese steel companies under the dual-carbon policy.

Table 1: Core Valuation Metrics and Weights

Key Indicators	Weight (%)	Direction of influence	Indicator Definition	Data source
Green investment ratio	27.3	positive	Green investment amount / Operating revenue	Corporate ESG Report
Capital turnover rate	24.6	positive	Annual turnover of current assets	Wind Database
Carbon emissions per unit of output	19.8	negative	Carbon emissions (tons) / Output value (100 million yuan)	China's carbon trading market
Credit loan ratio	16.2	positive	Credit loan amount / Total loan amount	Corporate Annual Report

3.2 Marginal Effect Results of Core Indicators

Results of multiple linear regression (Table 2) indicate that the impact of the four core indicators on valuation passes the significance test at 1% or 5%, with marginal effects consistent with expectations.

Green investment ratio : The regression coefficient $\beta=1.7$ (p<0.01) indicates that, controlling for other variables, for every 1 percentage point increase in the green investment ratio , the corporate valuation premium increases by 1.7%. This is 1.5 times the average level of global steel companies[1], far exceeding the global average and reflecting the high recognition of green investment in the domestic market;

Capital turnover rate: The regression coefficient $\beta=2.6$ (p<0.01) indicates that for every 1 time/year increase in capital turnover rate, the company's valuation rises by an average of 2.6 times , which is higher than the global industry average of 1.8 times (Li, 2021). This is attributed to higher capital occupation costs for domestic companies, making the value release from efficiency improvements more pronounced.

Carbon emissions per unit of output : The regression coefficient $\beta = -1.3$ (p < 0.01) indicates that for every 100 tons/100 million yuan reduction in carbon emissions per unit of output, the company's price-to-book ratio (PB) increases by 0.3 times. This verifies the existence of the "low-carbon premium" under the dual-carbon policy ;

Credit loan ratio : The regression coefficient $\beta=0.9$ (p<0.05) indicates that companies with a credit loan exceeding 50% have a valuation that is 12.4% higher than those with a ratio of less than 30%, reflecting the sensitivity of the domestic capital market to corporate credit risk.

Table 2: Regression Results of Marginal Effects of Core Indicators

variable	Regression coefficient	Standard error	t-statistic	p value	VIF
Green investment ratio	1.7	0.23	7.39	<0.01	1.85
Capital turnover rate	2.6	0.31	8.39	<0.01	1.62
Carbon emissions per unit of output	-1.3	0.18	-7.22	<0.01	1.78
Credit loan ratio	0.9	0.38	2.37	<0.05	1.91
constant term	0.8	0.15	5.33	<0.01	-
R^2 coefficient of determination	0.82	-	-	-	-
F statistic	67.21	-	-	<0.01	-

Note: VIF < 2 indicates that there is no multicollinearity among the indicators and the regression results are reli-

able.

3.3 Performance Results of the Valuation Correction Model

3.3.1 Overall Performance Comparison

Table 3 presents the performance comparison results between the corrected model and the traditional PB model.

The corrected model's RMSE (root mean square error) is 0.11, a 31.25% drop from the traditional PB model (0.16); the MAE (mean absolute error) declines from 0.14 to 0.09 (a 35.7% reduction); and R² increased from 0.61 to 0.82. This indicates that the corrected model has a significantly enhanced ability to explain valuation fluctuations and can more accurately capture the actual value characteristics of Chinese steel companies.

Table 3: Model Performance Comparison

Model	RMSE	MAE	R²	Average valuation deviation (%)
Traditional PB model	0.16	0.14	0.61	14.3
Corrected model	0.11	0.09	0.82	0.8

3.3.2 Case Verification: Bayi Steel (2025)

Taking the 2025 valuation of Bayi Steel as an example, the practical effect of the corrected model is verified as follows:

(1) Basic data : Bayi Steel's 2025 PB valuation is 5.98 billion yuan, with an actual market capitalization (September 1, 2025) of 6.847 billion yuan. According to regression analysis, the core indicators are: green investment ratio of 7.2%, capital turnover rate of 2.6 times/year, carbon emissions per unit of output value of 680 tons/100 million yuan, and credit loan ratio of 55%. The 2019–2024 industry averages are 4.8%, 2.3 times/year, 820 tons/100 million yuan, and 41.5%, respectively.

(2) Adjustment item calculation: the adjustment to the proportion of green investment is: $0.273 \times (7.2\% - 4.8\%)$ = 0.00655, representing a positive adjustment of 0.655%. Capital turnover ratio adjustment: $0.246 \times (2.6 - 2.3)$ = 0.0738, representing a positive adjustment of 7.38%; Carbon emission adjustment per unit output: $-0.198 \times (680-820)/820 \approx -0.198 \times (-0.1707) = 0.0338$, representing a positive adjustment of 3.38% (because carbon emissions are lower than the industry average, the negative indicator makes a positive contribution). Adjustment of the proportion of credit loans: $0.162 \times (55\% - 41.5\%)$ = 0.02187, representing a positive adjustment of 2.187%.

(3) Revised valuation calculation:

Total adjustment factor = 1 + 0.655% + 7.38% + 3.38% + 2.187% ≈ 1.13602;

The revised valuation is approximately RMB 5.98 billion × 1.13602 ≈ RMB 6.79 billion.

Case Conclusion : The deviation between the revised valuation (RMB 6.79 billion) and the actual market value of Bayi Steel (RMB 6.847 billion) is merely 0.8%, significantly lower than the 14.3% deviation of the traditional PB model. This directly verifies the accuracy of the revised model in practical applications, especially for companies with green incremental businesses, where the improvement in valuation accuracy is significant.

3.4 Analysis of the Coordination Mechanism of Core Indicators

Further analysis employing grouped regression and interaction term testing identified a significant synergistic effect between the green dimension and the financial dimension indicators, specifically manifested as follows:

(1) Synergy between Green Investment and Capital Efficiency : Sample companies were divided into a "high-efficiency group" (>2.5 times/year) and a "low-efficiency group" (<2.0 times/year) based on capital turnover rate. Results showed that in the high-efficiency group, every 1 percentage point increase in the green investment ratio

boosted the valuation premium by 2.1% (p<0.01); in the low-efficiency group, the same increase in green investment only yielded a 1.2% valuation premium (p<0.05), representing a 42.9% reduction in the premium effect. Taking Shagang Co., Ltd. as an example, in 2024, its green investment proportion increased from 5.1% to 7.8% (an increase of 2.7 percentage points), while its capital turnover rate increased from 2.4 times/year to 2.7 times/year (entering the high-efficiency group). This ultimately result in a valuation premium of 18% , 95.7% higher than the average premium of the low-efficiency group (9.2%) during the same period [6], confirming the amplifying effect of the synergy between the two on value release.

(2) Synergy between carbon emissions and credit financing : For "low-carbon" enterprises with carbon emissions per unit output value below 700 tons/100 million yuan, a 10 percentage point increase in credit loans ratio result in a 3.2% increase in valuation premium (p<0.01); for "high-carbon" enterprises with carbon emissions above 900 tons/100 million yuan, the same increase in credit loans only brings a 1.5% valuation premium (p<0.1), indicating a statistically significant difference. This is because low-carbon enterprises are more likely to obtain policy support and capital market recognition, making the positive transmission of improved creditworthiness to valuation more seamless. Data from the 2024 China Carbon Trading Market shows that the approval rate for green loans for low-carbon enterprises (89%) is 43.5% higher than that of medium-carbon enterprises (62%), and their financing costs are 1.2 percentage points lower [7], further strengthening the synergistic logic of "low-carbon attributes, credit advantages, and valuation improvement."

In summary, the core indicators do not affect valuation in isolation, instead, they drive corporate value growth through a synergies chain: "green transformation optimizes asset quality, capital efficiency improves profitability, and credit advantages reduce financing costs." This also provides mechanism-level support for subsequent practical recommendations.

4. Practical Implications of the Research Results

Implications for businesses : Green transformation should be advanced in conjunction with capital management. Green investment alone (e.g., a company's green investment accounts for 8% but its capital turnover rate is only 1.8 times/year) is insufficient to maximize corporate value. Enterprises need to improve capital efficiency through inventory optimization (e.g., controlling inventory turnover days within 35 days), accounts receivable factoring and other measures., Meanwhile, they should strengthen credit building (e.g., striving for credit loans to account for more than 45%), forging a value enhancement path of "green and finance" synergy.

Implications for the capital market : Investors need to establish a multi-dimensional valuation logic integrating "green" and "financial" factors to avoid investment misjudgments caused by relying solely on the PB ratio. For example, valuation expectations can be appropriately raised for companies with a green investment ratio exceeding 6% and a capital turnover rate above 2.5 times/year. Securities firms and fund companies can incorporate revised models into their investment research tools and publish green valuation reports for the steel industry, guiding market pricing logic towards "long-term value."

5. Conclusion

This study starts with the valuation distortion of Chinese steel companies amid the dual-carbon goals. Through a three-stage quantitative framework of "core indicator screening, weight calculation, and valuation correction," a targeted valuation correction model is constructed and validated. The main conclusions are as follows:

(1) Traditional PB models, by neglecting differences in green transformation value and capital efficiency, exhibit an average valuation deviation of 14.3% for Chinese steel companies, failing to adapt to shifts in industry's value logic under the dual-carbon policy .

(2) The core valuation indicators are the green investment ratio (27.3%), capital turnover rate (24.6%), carbon emissions per unit of output (19.8%), and credit loans ratio (16.2%), which collectively explain 87.9% of valuation fluctuations. Moreover, the dominant role of green dimension indicators highlights the characteristics of the Chinese market.

(3) The corrected model reduces valuation error to within 1%, with RMSE 31.25% lower than traditional PB model. Case studies and synergistic mechanism analysis further confirm the accuracy and practicality of the model.

(4) The core indicators drive value growth through a "green + finance" synergy mechanism. Enterprises need to optimize green transformation and financial management simultaneously to maximize the value potential under the dual-carbon policy.

The study is limited by its sample coverage, incomplete indicators, and lack of model dynamism. Future research will expand the sample and indicators, upgrade the model with dynamic techniques, and explore applications in corporate M&A and green bond pricing.

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