Valuation of PV Enterprises Based on Residual Income Model--Taking Longi Green Energy as an Example

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Abstract. Under the current background of increasing global environmental problems, the development of photovoltaic (PV) industry has increasingly attracted the attention of countries all over the world, and how to scientifically and reasonably assess the value of PV enterprises is an important issue in China's capital market. By combining the characteristics of photovoltaic enterprises themselves, this paper chooses to adopt the residual income method as the basic model, and applies the DuPont analysis method and the mutation level method to make the corresponding model improvement in order to improve the accuracy of the valuation results. Compared with the actual value, the deviation rate is only 1.2%, which is a small error, proving that the improved model can reflect the intrinsic value of PV enterprises more accurately and provide investors with more accurate value reference.

Keywords: Photovoltaic firms; Residual income model; DuPont analysis; Mutation series metho.

1 Introduction

In 2023, under the double driving force of "double carbon policy" and global energy crisis, China's PV whole industrial chain ushered in high growth and became one of the "new three" foreign trade exports. 2023 China's PV product exports reached 245.3 billion U.S. dollars. Among them, the export amount of monocrystalline silicon slices, battery slices, modules, inverters were 5.409 billion U.S. dollars, 4.159 billion U.S. dollars, 39.624 billion U.S. dollars and 9.96 billion U.S. dollars. Although the price of PV industry chain experienced a sharp decline in 2023, it did not hinder the rapid development of PV industry. from January to November 2023, the investment completion of PV projects reached 320.9 billion yuan, up 60.5% year-on-year, and this data further confirms that the PV industry attracts a large amount of capital inflow, and the investors' firm confidence in the potential of this industry's sustained growth. At the same time, there are more than 30 PV companies lined up for IPO in the capital market, reflecting the market's strong interest in this field.

The photovoltaic industry is characterized by a high degree of head aggregation, high value of intangible assets, and unstable cash flow, etc[1]. Traditional relative value

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methods such as the price-earnings ratio method and the price-net ratio method are of limited application in the value assessment of photovoltaic enterprises due to the problem of difficulty in finding comparable enterprises[2]. In contrast, absolute value assessment methods, especially the free cash flow method and residual income method, do not need to compare other enterprises, and are more appropriate and effective in the value assessment of the PV industry where the Matthew effect is obvious. However, the free cash flow method has higher requirements for the prediction of future cash flow, and the unstable cash flow of the PV industry makes the prediction results of the free cash flow method have a large error[3], while the residual income method utilizes publicly available financial data for the value assessment, and the assessment results will be more accurate. Based on the above reasons, this paper chooses the residual income method to assess the value of photovoltaic enterprises, and introduces the DuPont analysis system and the market-to-book ratio to modify the residual income model. Further, in order to solve the problem that non-financial factors are not considered in the model, this paper will utilize the mutation level method to correct the final results.

2 Derivation and Improvement of the Residual Income Model

The basic principle of the residual income model is that a firm is considered to be earning positive residual income only if it earns a net profit in excess of the compensation demanded by its shareholders, and that firms that want to increase their overall value do not do so by virtue of profit distributions, but rather from the residual value created by the firm. The value of equity equals the sum of the book value of net assets at the beginning of the period and the discounted future residual income. The specific formula is shown below:

$$V = BV_0 + \sum_{t=1}^{\infty} \frac{RI_t}{(1+R_e)^t} \tag{1}$$

Where V is the stock value of the enterprise on the base date, BV_0 is the book value of net assets in the base period, RIt is the residual income in period t, Re is the required rate of compensation demanded by the shareholders, and t stands for a certain period of time, and usually the longer the forecasting period, the worse the valuation accuracy.

2.1 Shortcomings of the Residual Income Model

Compared with other valuation methods, the residual income model more fully utilizes the various information in the financial statements, which makes the value assessment more comprehensive and adequate, and at the same time reduces the degree of reliance on subjective forecasts. Xu, Jianling, Zhu, Guanghuan and Zhang, Xiangyue (2023) demonstrate that the residual income model has better applicability to firms that specialize in specialties[4]. However, in light of the characteristics of the PV industry today, there are still many shortcomings.

(1) The residual income model inappropriately assumes that the enterprise will continue to operate for a long time[5], while the photovoltaic industry is affected by the

reality of the market competition, the vast majority of enterprises are difficult to achieve continuous operation, and the indefinite prediction of the residual income is not in line with the actual situation. Therefore, it is necessary to make certain improvements to the residual income model on the issue of continuity.

(2) Residual income is difficult to predict. Whether the residual income model can be accurately applied mainly depends on whether the residual income can be accurately estimated. From the perspective of the market outlook of the PV industry, the performance of PV enterprises has been affected by a variety of aspects from the increase in trade barriers to PV exports, large fluctuations in the cost of silicon, the retreat of the national subsidy policy, and the intensification of competition within the industry[6]. Therefore, for the prediction of residual income in the future period, the single indicator of residual income should be disassembled to improve the accuracy of the prediction results.

(3) The residual income model is mainly based on the enterprise's financial indicators, while the importance of non-financial factors such as R & D investment, human resources, policy support and so on is relatively weak[7]. However, in the operation and development of photovoltaic enterprises, the impact of non-financial factors on enterprise value creation cannot be ignored, and how to incorporate non-financial factors into the calculation needs further exploration.

2.2 Improvements to the Residual Income Model

Determine the Growth Stage Model in Conjunction with the Life Cycle Principle. Due to the reality, there is no enterprise that can operate forever, and combined with the life cycle theory, photovoltaic enterprises are in the life cycle of the characteristics of the growth period, the enterprise prediction period is divided into two parts of the period of rapid growth and stable growth period, which to some extent improve the original residual income model, the formula is shown below.

$$V = BV_0 + \sum_{t=1}^{T} \frac{RI_t}{(1+R_e)^t} + \frac{CV_T}{(1+R_e)^T} \tag{2}$$

CV_T represents the present value of residual earnings after the forecast period discounted to period T. If $CV_T = 0$,then it means that the firm does not earn any residual income after the forecast period. If $CV_T = \frac{RI_t}{R_e}$, then the residual income after the forecast is constant, and if $CV_T = \frac{RI_t}{R_e - g}$, g is the growth rate of retained earnings, then the firm's residual earnings are expected to rise steadily after the forecast period.

Incorporation of Price-To-Book Ratios

When applying the residual income model, the growth rate of residual income g is difficult to predict and has a strong subjective nature, and the change of residual income is closely related to the efficiency of the producer and the management and operation ability. Therefore, the P/E ratio analysis is introduced to increase the accuracy of the valuation results[8].

Since the present value of the residual income after the forecast period discounted to period T is equal to the expected end-of-period enterprise share price less the expected end-of-period book value of equity, it is

$$CV_T = P_T - BV_T \tag{3}$$

Bringing the above results into the basic form of the residual income method leads to the following equation:

$$V = BV_0 + \sum_{t=1}^{T} \frac{RI_t}{(1+R_e)^t} + \frac{P_T - BV_T}{(1+R_e)^T} \tag{4}$$

$$V = BV_0 + \sum_{t=1}^{T} \frac{RI_t}{(1+R_e)^t} + \frac{\left(\frac{P_T}{BV_T} - 1\right) BV_T}{(1+R_e)^T} \tag{5}$$

Where P_T /BV_T is the price-to-book ratio. If the price-to-book ratio is greater than one, it means that the company is still able to create value in the future, its market value is higher than its book value, and it still has potential for growth. If the P/E ratio is equal to one, it means that the company is unable to create value in the future and there is no excess return. If the P/E ratio is less than one, it means that the enterprise has a low capacity to continue to consume value.

Incorporation of the DuPont Analysis System.

Through DuPont analysis, the return on net assets can be disassembled into three parts: net sales margin, total asset turnover and equity multiplier, which greatly enriches the connotation of the residual income from the three dimensions of sales capacity, management capacity and capital structure, and more intuitively reflects the relevant influencing factors of the enterprise's value, thus improving the accuracy and rationality of the solid valuation, with the formula as follows:

$$ROE = \frac{NI_t}{BV_{t-1}} = \frac{NI_t}{A_{t-1}} \cdot \frac{A_{t-1}}{BV_{t-1}} = \frac{NI_t}{S_t} \cdot \frac{S_t}{A_{t-1}} \cdot \frac{A_{t-1}}{BV_{t-1}} = MOS_t . ATO_t . EM_{t-1} \tag{6}$$

Of which.A_{t-1} is total assets at the beginning of the period, andS_t is the sales revenue, andMOS_t is the net sales margin, theMOS_t is the total asset turnover ratio, andEM_{t-1} denotes the equity multiplier at the beginning of the period. The derivation can be continued from the above equation:

$$BV_{t-1} = \frac{NI_t}{ROE} = \frac{S_t . MOS_t}{MOS_t . ATO_t . EM_{t-1}} = \frac{S_t}{ATO_t . EM_{t-1}} \tag{7}$$

In summary, the following formula is derived by combining the decomposition of the forecast of residual income into the forecast of net operating margin, total asset turnover and equity multiplier in the DuPont analysis system.

$$RIt = St \times (MOSt \times ATOt \times EMt - 1 - Re)/(ATOt \times EMt - 1) \tag{8}$$

Bringing the above equation into Eq. 4 derived from the price-to-book ratio, the valuation model for the current improved residual income can be derived as:

$$V = BV_0 + \sum_{t=1}^{T} \frac{S_t \cdot (MOS_t \cdot ATO_t \cdot EM_{t-1} - R_e) / (ATO_t \cdot EM_{t-1})}{(1+R_e)^t} + \frac{(\frac{P_T}{BV_T} - 1)\, BV_T}{(1+R_e)^T} \quad (9)$$

Using the improved residual income model to evaluate the entire shareholders' equity of LONGi Green Energy can verify the feasibility of the application of this evaluation method in the PV industry, and help the external investors of the enterprise to better evaluate the status quo of the different enterprises in the PV industry, and to reasonably allocate the funds for investment at the same time. It can also help PV business managers to have a deeper grasp of the company, thus promoting the development of the enterprise and ultimately maximizing the value of the enterprise[9].

Incorporation of the Mutation Level Method.

In order to take the influence of non-financial models into account, this paper draws on Song Yinghui and Yuan Zhonghua (2024) [10]and incorporates the mutation level method in the model. Since non-financial data are usually confidential and not publicly available, it is difficult to obtain them, so this paper determines the weights of financial factors in enterprise value through the mutation level method, and then combines with the improved residual income model to indirectly derive the value of PV enterprises that comprehensively consider non-financial factors. The mutation level method uses mutation theory and fuzzy mathematics to combine the mutation fuzzy affiliation function, and then by the normalization formula for the integrated quantitative operation, normalized to a parameter, so as to evaluate the target for sorting analysis. The model is used to correct the influence brought by the non-financial factors of the company to make the calculation results more accurate and reduce the generation of evaluation errors. The formula is as follows:

$$V_A = V/A \quad (10)$$

V_A is the value of the firm's specialized and new medical business taking into account both financial and non-financial factors, V is the value of the firm assessed according to the residual income model, and A is the weight given to the financial factors determined according to the mutation level method.

3 LONGi Green Energy Case Study

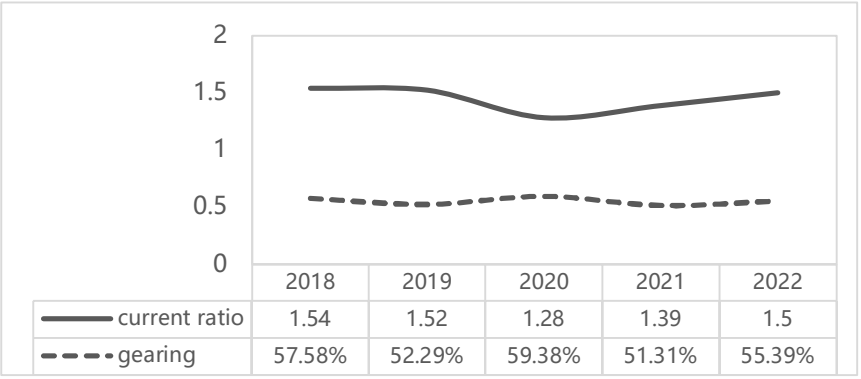
3.1 LONGi Green Energy Company Profile

LONGi Green Energy is a global photovoltaic company founded in February 2000 under the full name of LONGi Green Energy Technology Co. The company's main business covers the research, development, manufacturing and sales of semiconductor materials (such as monocrystalline silicon rods and monocrystalline silicon wafers), electronic components, solar cells, green hydrogen and other products, the development of photovoltaic power plants and a series of other businesses. Nowadays, LONGi Green Energy takes silicon wafers and batteries as the core of its business, which covers the whole industry chain upstream and downstream, and in recent years, it has become the

world's largest monocrystalline silicon wafers and components dominant, as well as the integrated leader in manufacturing silicon rods to components. In the PV industry chain, LONGi Green Energy enjoys an important position.

Analysis of Solvency Capacity.

As can be seen from Figure 1, the current ratio of LONGi Green Energy fluctuates up and down from 1.3 to 1.5, and its fluctuation is not large. In the photovoltaic manufacturing enterprises, non-current assets account for a large proportion of total assets, so the current ratio is low within a reasonable range, while the ratio of the year-on-year decline followed by a year-on-year increase is more due to the increase in current liabilities such as accounts payable, notes payable, etc., coupled with the year-on-year increase in sales revenue, which also indicates the enhancement of LONGi Green Energy's financial management capabilities, as well as the improvement of the bargaining power in the industry chain. From the perspective of long-term solvency, LONGi Green Energy's gearing ratio is stabilized at a reasonable range of 51% to 60%. To summarize. LONGi Green Energy's financial status is relatively good, and it has reasonably balanced the risks and benefits brought by financial leverage.



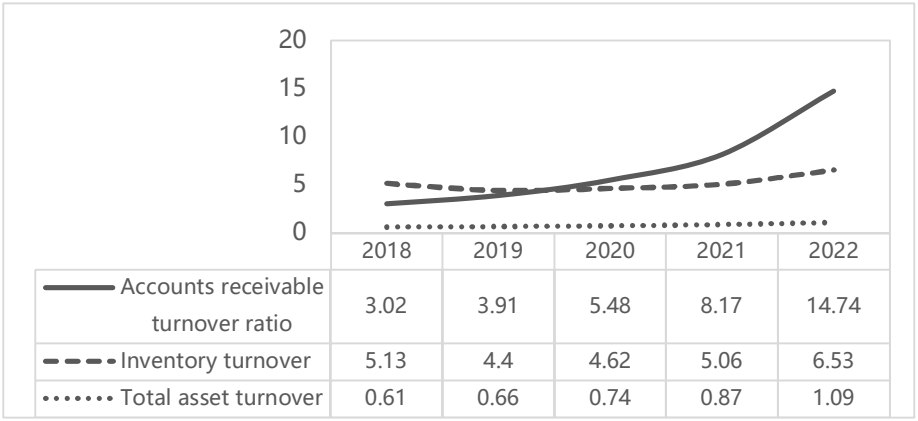
	2018	2019	2020	2021	2022
current ratio	1.54	1.52	1.28	1.39	1.5
gearing	57.58%	52.29%	59.38%	51.31%	55.39%

Fig. 1. Solvency Analysis of LONGi Green Energy

Analysis of Operating Capacity.

As can be seen from Figure 2, LONGi Green Energy's accounts receivable turnover ratio maintains a high rate of growth, which indicates that LONGi Green Energy's discourse in its upstream and downstream supply chain is increasing, its accounts receivable management ability is gradually rising, and LONGi Green Energy has optimized the company's business structure: it has increased the proportion of sales in the wafer business compared with the module business; and it has increased the proportion of overseas business compared with the domestic business. These two optimizations have shortened the recovery period of the company's accounts receivable and improved its turnover rate. LONGi Green Energy's total asset turnover ratio showed a slow upward trend, which indicates that LONGi Green Energy's operation level of the company's

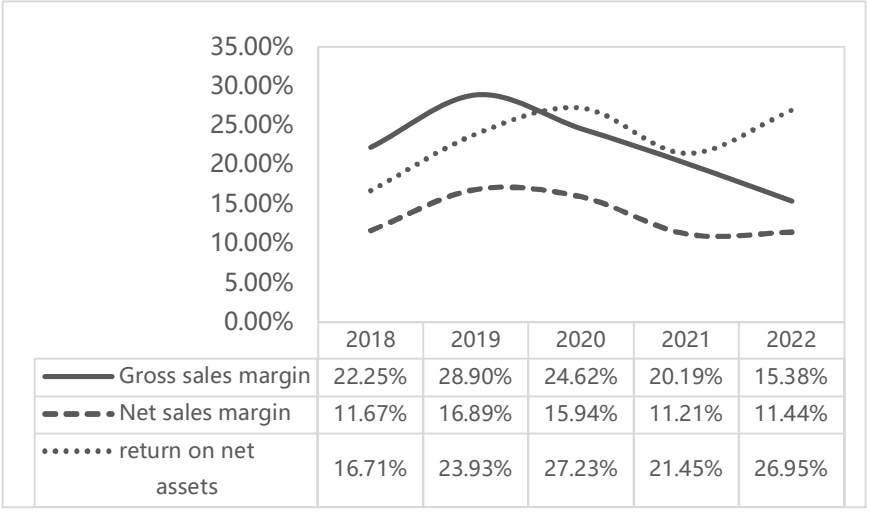
overall assets is steadily increasing. While the inventory turnover ratio showed a downward trend from 2018 to 2019, but in combination with LONGi Green Energy's production capacity in the corresponding years, the declining inventory turnover ratio has a significant relationship with the increasing product output year by year, the continuous expansion of the company's scale and the increasing demand for monocrystalline silicon in the market have made the company reasonably expand the amount of inventory, and due to the impact of the New Crown Epidemic as well as raw material price And due to the impact of the new crown epidemic and rising raw material prices, the company has increased the amount of inventory safety reserves, these factors have led to a decline in its inventory turnover rate.



	2018	2019	2020	2021	2022
Accounts receivable turnover ratio	3.02	3.91	5.48	8.17	14.74
Inventory turnover	5.13	4.4	4.62	5.06	6.53
Total asset turnover	0.61	0.66	0.74	0.87	1.09

Fig. 2. Analysis of LONGi Green Energy's Operating Capacity

Analysis of Profitability Capacity.



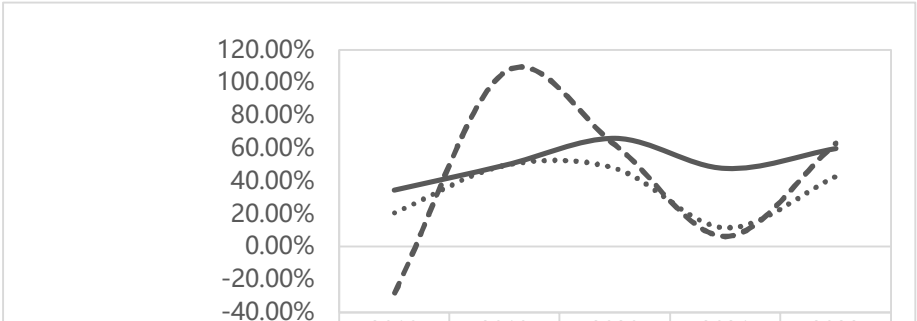
	2018	2019	2020	2021	2022
Gross sales margin	22.25%	28.90%	24.62%	20.19%	15.38%
Net sales margin	11.67%	16.89%	15.94%	11.21%	11.44%
return on net assets	16.71%	23.93%	27.23%	21.45%	26.95%

Fig. 3. LONGi Green Energy Profitability Indicators

As can be seen from Figure 3, the profitability of LONGi Green Energy is considerably affected by the policy environment. With the continuous development of the PV industry, the state implemented a new policy in 2018, which reduced the policy subsidies of the PV industry, and due to the decline in international market demand, which led to the lower profitability index of LONGi Green Energy in 2018. However, in 2019, LONGi Green Energy actively develops overseas markets and implements the globalization strategy, and the negative impact of the previous year's policy has been reduced so that its core profitability indicators have increased. And from 2020 onwards, with the decline in the economic environment caused by the outbreak of the new crown epidemic, the jamming of the industrial chain and the work stoppages that occur from time to time make its indicators remain in a depressed state.

Analysis of Growth Capacity.

As can be seen in Figure 4, LONGi Green Energy's operating income has always maintained a high level of growth, but due to the impact of the new policy in 2017 and the decline in market demand, it has made its net profit growth rate negative. In addition, due to the surge of upstream materials starting in 2021, it also made LONGi Green Energy's net profit growth rate drop significantly, but there is no major fluctuation in upstream demand, and considering that the price of upstream materials will eventually return to a reasonable trend of price changes, we expect that LONGi Green Energy's net profit will grow normally in the future. Overall, as a leading enterprise in the PV industry, LONGi Green Energy, under the environment of rapid development of the industry, its solvency and operating ability is outstanding, and profitability with the changes in the industry to show cyclical fluctuations, so that LONGi Green Energy's development prospects are considered to be relatively good.



	2018	2019	2020	2021	2022
Revenue growth rate	34.38%	49.62%	65.92%	47.68%	60.03%
Net profit growth rate	-28.24%	106.40%	61.99%	6.24%	63.02%
Total asset growth rate	20.60%	49.53%	47.77%	11.53%	42.79%

Fig. 4. LONGi Green Energy Growth Capacity Indicators

Based on the above analysis of LONGi Green Energy's solvency, operating ability, profitability and growth ability, it can be seen that LONGi Green Energy's financial performance has been good in recent years, which is in line with the applicable conditions of good operating condition, good financial condition, possessing the trend of continuous operation, and at least five years of historical performance required by the residual income model.

3.2 Prediction of Various Parameters of LONGi Green Energy

The prediction of the residual income method needs to be supported by reasonable data, and this paper provides a simple and reasonable prediction of the parameters of LONGi Green Energy through the average value method, regression analysis method and other methods.

Sales Revenue Forecast.
In this article, the sales data of Longi Green Energy from 2013 to 2022 is obtained from wind data terminal. It is shown in the table 1.

Table 1. 2013-2022 Sales Revenue of LONGi Green Energy

Year	2013	2014	2015	2016	2017
Sales revenue (billions)	22.80	36.80	59.47	115.31	163.62
Year	2018	2019	2020	2021	2022
Sales revenue (billions)	219.88	328.97	545.83	809.32	1289.98

It can be seen that the sales revenue of LONGi Green Energy presents a trend of increasing year by year, and the proportion of increase has been expanding year by year, so regression analysis is carried out to predict the subsequent sales revenue from 2022 to 2024.

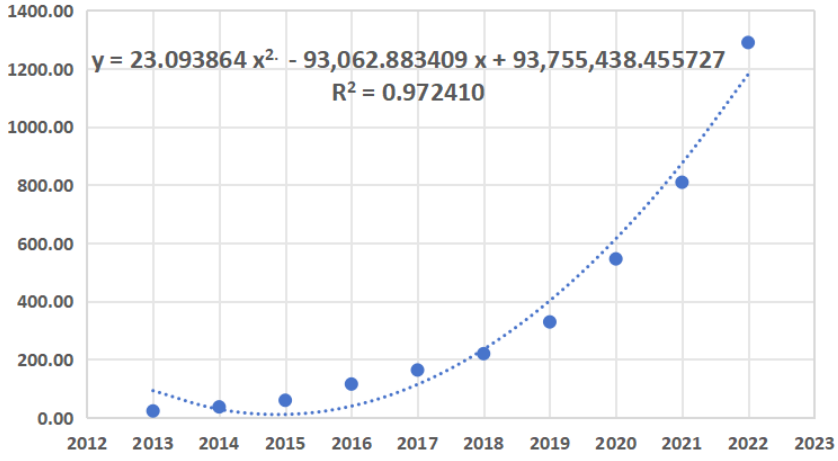


Fig. 5. Polynomial fit of sales revenue

In this paper, the exponential regression, linear regression and polynomial regression curves of its sales revenue are plotted and analyzed for the goodness of fit, and the polynomial regression curve is finally found to have the best fit. The formula and table are shown in Figure 5, and since R^2 equal to 0.97241, it can be seen that the fit is thought to be high.

Bringing the years into the equation works out that the estimated sales for 2023 are 1533.46, the estimated sales for 2024 are 1931.46, and the estimated sales for 2025 are 2375.61.

P/E Ratio Forecast.

The price-to-book ratio is an indicator that measures the relationship between a company's market value and its book value (net worth), which can help determine how much the market capitalization deviates from the net worth. Due to the new energy industry, including PV companies, receiving greater policy support from 2020 onwards (e.g., NDRC Price [2020] No. 511, "Notice of the National Development and Reform Commission on Matters Relating to the Policy on Feed-in Tariffs for Photovoltaic Power Generation for the Year 2020") as well as investors' benign expectation judgment on the industry as well as on the company, resulting in an abnormal rise in LONGiGreen's share price in 2020 and 2021, leading to an abnormal P/E ratio in those two years. The price-to-book ratios of these two years are also abnormal, so this paper excludes the abnormal data of 2020 and 2021, and chooses the average value of 3.88 of the remaining years as the price-to-book ratio of LONGi Green Energy for the forecast period from 2023 to 2025.

Forecasts of Net Sales Margin, Total Asset Turnover and Equity Multiplier.

LONGi Green Energy's net sales margin, total asset turnover and equity multiplier from 2013 to 2022 are shown in the table 2.

Table 2. 2013-2022 Total Asset Turnover, Net Sales Margin, Equity Multiplier for LONGi Green Energy

Year	Total Asset Turnover	Net Sales Margin	Equity Multiplier
2013	0.48	3.17%	1.57
2014	0.66	8.11%	1.98
2015	0.71	8.76%	1.81
2016	0.78	13.45%	1.90
2017	0.63	21.66%	2.31
2018	0.61	11.76%	2.36
2019	0.66	16.89%	2.10
2020	0.74	15.94%	2.46
2021	0.87	11.21%	2.05
2022	1.09	11.44%	2.24

By analyzing the above data, it can be concluded:

(1) Net sales interest rate: the ratio as a whole shows a fluctuating upward trend, while the data for 2016-2022 is higher on average compared to the data for 2013-2015,

while the data for 2017 is more abnormal, which is because LONGi Green Energy has continued to expand its scale, reduce the cost of photovoltaic power generation, and give full play to its technological leadership and good cost control ability, which has increased the mono-crystalline silicon wafer sales volume and market share, resulting in a significant increase in LONGi Green Energy's operating income and net profit attributable to the parent company, so we only select the average value of 13.45% of the 2018-2022 data as the value of LONGi Green Energy's net sales margin for the forecast period of 2023-2025.

(2) Total Asset Turnover Ratio: this ratio shows a trend of steady increase year by year, while the data of 2013-2014 is lower on average compared to the data of 2014-2022, this is due to the fact that LONGi Green Energy acquired Leaf PV Technology Co. Ltd. in 2014, expanding the production capacity of batteries, modules, etc., and successfully creating an integrated production capacity, so that the increase in the company's total assets and sales revenue, the This in turn led to an increase in the total asset turnover ratio, so we selected the average value of the data from 2014-2022, 0.71, as the value of LONGi Green Energy's total asset turnover ratio for the forecast period of 2023-2025.

(3) Equity multiplier: the ratio also shows a steady upward trend, while the data for 2014-2022 is higher on average compared to the data for 2013, this is due to the fact that Leaf PV Technology Co. was included in the scope of consolidation in 2014, which made the total assets of LONGi Green Energy to be increased, and thus the equity multiplier grows in tandem, so we choose the 2014-2022 data's average value of 2.12 as the value of LONGi Green Energy's equity multiplier for the forecast period of 2022-2024.

Cost of Equity Capital Forecast.

In this paper, the capital asset pricing (CAPM) model is used to measure the cost of equity capital. The specific formula is shown below:

$$R = Rf + \beta(Rm - Rf) \tag{11}$$

Where R denotes the cost of equity capital, Rf represents the risk-free rate, βdenotes the systematic risk coefficient, and Rm -Rf denotes the risk premium of the market. In this paper, we refer to the yield to maturity of 10-year treasury bonds at the valuation base date of 3.14% as the risk-free interest rate; while the expected Rm of the market portfolio is calculated with reference to the average of the annualized rate of the CSI 300 Composite Index for the period from 2017 to 2022 to obtain 8.30%, so the predicted value of the risk premium of the market is 5.16%;3 β represents the degree of sensitivity of the common stock to changes in the overall rate of return of the stock market, and also represents the systematic risk of the asset relative to the entire market, this paper by querying the Wind database to obtain the average value of βof LONGi Green Energy from 2017 to 2022 is 1.01. From the above formula, we can calculate that the cost of equity capital of LONGi Green Energy is 8.35%. The forecast data of each parameter of Longi Green Energy is shown in the table 3.

Table 3. Forecast of LONGi Green Energy's indicators for 2023-2024

Forecast year	2023	2024	2025
Revenue from main operations (billions)	1533.46	1931.46	2375.61
Net Sales Margin	13.45%	13.45%	13.45%
Total Asset Turnover	0.71	0.71	0.71
Equity Multiplier	2.12	2.12	2.12
Cost of equity capital	8.35%	8.35%	8.35%
P/E	3.88	3.88	3.88

4 Enterprise Value Assessment of LONGi Green Energy based on Residual Income Model

4.1 Assessment of Enterprise Value during the Expected Period

The valuation base date of this paper is December 31, 2022, and by checking the book value of owner's equity in the 2022 financial statements of LONGi Green Energy, it can be determined that the book value of net assets of LONGi Green Energy in the base period is BV_0 =62.254 billion.

According to the formula of residual income, the data in the table can be brought into the following formula to get the residual income in the forecast period, and then discounted to the base date to get the enterprise value in the forecast period.

$$\sum_{t=1}^{T} \frac{S_t \cdot (MOS_t \cdot ATO_t \cdot EM_{t-1} - R_e) / (ATO_t \cdot EM_{t-1})}{(1+R_e)^t} \tag{12}$$

Table 4. Calculation of the discounted present value of Longi Green Energy 2023-2025 (in billions)

Year	Total Asset Turnover	Net Sales Margin	Equity Multiplier	Sales revenue	Residual income	Discount rate	Discounted value
2023	0.71	13.95%	2.12	1533.46	128.850	1.084	118.920
2024	0.71	13.95%	2.12	1931.46	162.292	1.174	138.239
2025	0.71	13.95%	2.12	2375.61	199.612	1.272	156.928
(grand) total							414.087

By analyzing and calculating the above data you can get the enterprise value of LONGEVITY GREEN ENERGY for the definite expected period as 41,408.7 million, as shown in Table 4.

4.2 Assessment of Enterprise Value beyond the Expected Period

For data after the expected period, i.e., after 2025, this paper applies the derived following equation in conjunction with the price-to-book ratio.

$$V_T = \frac{(\frac{P_T}{BV_T} - 1)\ BV_T}{(1+R_e)^T} \tag{13}$$

Substituting the previously obtained forecast values for 2025 into the above formula, we can get the value of Longi Green Energy after the clear expectation period is 234.884 billion yuan. Therefore, the projected enterprise value of Longi Green Energy in the base period 2022 is the sum of the enterprise value in the base period, the enterprise value in the expected period and the enterprise value after the expected period, i.e. 338.547 billion Yuan.

4.3 Evaluation of the Improved Residual Gains Model

This paper adopts the appraisal method of comparing the appraisal results with the market value on the appraisal reference date, and verifies the validity of the residual income model based on the rate of difference between the appraisal results and the prevailing market price. The valuation error is within 20%, which is reasonable.

According to the disclosure of LONGi Green Energy's financial statements, as of December 31, 2022, the value of LONGi Green Energy's total shareholders' equity is 359.375 billion yuan, with a deviation rate of approximately 5.8%, which is within a reasonable range of error. This further demonstrates the accuracy of the valuation results and the validity of the Improved Upper and Earnings Model.

4.4 Introduction of the Mutation Level Method

Introduction of the Mutation Level Method.
In reality, the operation of an enterprise does not only depend on financial factors, but also affected by many non-financial factors, such as the enterprise's innovation ability, learning ability, management ability, and development ability, etc. However, it is difficult to obtain the information of non-financial factors due to the fact that they are internal information of the enterprise. Therefore, this paper introduces the mutation level method to determine the weight of financial factors in enterprise value, and then combines the improved residual value model to obtain the valuation results considering both financial and non-financial factors, so as to improve the accuracy of the valuation results.

In this paper, we will analyze the financial factor indicators of LONGi Green Energy from four aspects: growth capacity, solvency capacity, Operating capacity and profitability capacity, and its specific evaluation indicators are shown in the table 5.

Table 5. Indicators for valuing photovoltaic enterprises

Level 1 indicators	Level 2 indicators	Level 3 indicators
Financial factors	Growth capacity	Total asset growth rate
		Net profit growth rate
		Growth rate of revenue from main operations
	Solvency capacity	Current ratio
		Gearing ratio
	Operating capacity	Accounts receivable turnover ratio
		Inventory turnover ratio
		Total asset turnover ratio
	Profitability capacity	Net sales margin
		Return on net assets

The mutation level method first calculates the weights of the three-level indicators using the coefficient of variation method for the selected indicators and ranks them according to the weights of the indicators. Afterwards, the indicators are standardized, and finally the normalization formula is used to calculate the third-level indicator data, and at the same time, whether the three-level indicators are complementary or not, the complementary indicators take the average value, and the non-complementary indicators take the minimum value according to the principle of "taking the smallest value out of the big", and the mutation value of the second-level indicators is calculated, and similarly, the second-level data is finally obtained by the first-level financial weights. Similarly, the data of the second level will be used to obtain the financial weight of the first level.

Application of the Mutation Level Method.

(1) Ranking of Tertiary Indicators.
This paper obtained the mean and standard deviation of each index of LONGi Green Energy from 2017 to 2022 through wind, flush and other platforms, calculated the coefficient of variation of each coefficient through the mean and standard deviation, and finally found the weight of each coefficient respectively through the coefficient of variation, and sorted each tertiary index with letters within the secondary indexes according to its weight.

(2) Standardization of Tertiary Indicators.
Normalization in the mutation level method means subtracting the data for each tertiary indicator for each year from the minimum value of all data for that tertiary indicator from 2017 to 2022, and dividing the resulting figure by the difference between the maximum and minimum values for that tertiary indicator from 2017 to 2022.

Let a be the minimum value of a tertiary indicator from 2017 to 2022, b be the maximum value of that tertiary indicator from 2017 to 2022, and x be the value of that tertiary indicator for that year, then the formula can be expressed as:

$$(x - a)/(b - a) \tag{14}$$

(3) Calculation of Internal Complementarity of Secondary Indicators.
This step is intended to analyze the complementarity between the tertiary indicators within the secondary indicators. For example, in the development capability, the correlation coefficients of the growth rate of total assets and net profit, and the growth rate of total assets and the growth rate of main business income, and the growth rate of net profit and the growth rate of main business income between 2017 and 2022 are calculated respectively. After that, the average value of the three is taken, and if the value is greater than 0.5, it means that there is complementarity between the three-level indicators. In this paper, the growth rate of total assets, the growth rate of net profit and the growth rate of main business income in the development ability are abbreviated as A1, A2 and A3, and the three-level indicators of solvency, current ratio and gearing ratio, are abbreviated as B1 and B2, and so on.

Finally, the CORREL function in the EXCELL table was used to calculate the correlation between the three levels of indicators The results of the correlation calculations are shown in the table 6.

Table 6. Complementarity results table

A1-A2	0.92	
A1-A3	0.20	
A2-A3	0.27	
average value	0.46	non-complementary relationship
B1-B2	0.22	non-complementary relationship
C1-C2	0.24	
C1-C3	0.97	
C2-C3	0.24	
average value	0.48	non-complementary relationship
D1-D2	0.71	complementary relationship

As can be seen from the above table, the correlation coefficient of development capacity and solvency is less than 0.5 as a non-complementary relationship, while the correlation coefficient of operating capacity and profitability is greater than 0.5 as a complementary relationship.

(4) Normalization of Tertiary Indicators.

There are three different categories of normalization formulas which are cusp mutation, swallowtail mutation and butterfly mutation. Their formulas are respectively:

Normalization formula for cusp-type mutations:$X_a = a^{\frac{1}{2}}$, the $X_b = b^{\frac{1}{3}}$

The normalization formula for a swallowtail mutation:$X_a = a^{\frac{1}{2}}$, the $X_b = b^{\frac{1}{3}}$,$X_c = c^{\frac{1}{4}}$

Normalized formula for butterfly mutations:$X_a = a^{\frac{1}{2}}$, the $X_b = b^{\frac{1}{3}}$,$X_c = c^{\frac{1}{4}}$, $X_d = d^{\frac{1}{5}}$

Since the development capacity and operational capacity have three three-level indicators respectively, they are dovetail-type mutations, and similarly, the solvency and profitability have two three-level indicators respectively, so they are all cusp-type mutations. Among them, a, b and c in the above formula are the standardized data arranged in the calculation table according to the weights of the three-level indicators.

If a secondary indicator is complementary, the average of each of the above X-values is taken, and if it is non-complementary, the minimum value is calculated.

For example, a dovetail mutation with a non-complementary development capacity, a is the growth rate of net profit, b is the growth rate of total assets, and c is the growth rate of main business income, which is normalized by calculating the year'sX_a,X_b,$X_c$and take the smallest of these values. Solvency is a non-complementary cusp-type mutation, which is normalized by calculating the corresponding year's X_a and X_b and take the smallest of these values.

In contrast to its counterpart, the operating capacity is the complementary swallowtail mutation, calculated for the corresponding year of its X_a , the X_b and take the average. X_c and take its average, and profitability is the complementary spiked mutation,

which is calculated for its corresponding year of X_a andX_b and take its average value can be. The calculation results are shown in the table 7.

Table 7. Table of normalization calculations

Level 1 indicators	Level 2 indicators	Weights	Rank
Financial factors	Growth capacity	23.3%	C
	Solvency capacity	24.7%	B
	Operating capacity	37.1%	A
	Profitability capacity	14.8%	D

Finally, the coefficient of variation method was used to find and rank the weights of the normalized secondary indicators.

(5) Calculation of the Weighting of Financial Factors.

Same as the above calculations, development capacity, solvency, operating capacity, and profitability are complementary dovetailed mutations brought into the dovetailed mutation formula, i.e: $X_a = a^{\frac{1}{2}}$, and $X_b = b^{\frac{1}{3}}$, and $X_c = c^{\frac{1}{4}}$.

Find 2017 through 2022 each year X_a that X_b, X_c, X_d and take the average to roughly estimate the weight of financial factors from 2017 to 2022. Finally, find the approximate weight of the financial factors of the company in the year 2022 as 93.1%.

(6) Adjustment and Evaluation of Results.

In the previous calculation, this paper estimated the company value in 2022 is about 338.547 billion, and the actual 3593.75 difference of about 5.8%, after the introduction of the mutation level method, it is concluded that the enterprise value of LONGi Green Energy when considering financial and non-financial factors is 338.547/0.931, and the result is about 3636.38, and the actual result is only a difference of 1.2%, which shortens the error by nearly 4.6% error, the effect is remarkable.

5 Conclusion

Using the residual income model to assess the value of PV companies can circumvent the industry's own comparable companies, difficult to find, difficult to predict cash flow and dividends, high non-systematic risk of the assessment of the difficult problem, can be a good reflection of the company for shareholders to create excess earnings, help investors understand the company's true financial position and intrinsic value.

But even so, the residual income model itself still has deficiencies. This paper incorporates the life cycle principle to improve the improper assumption in the original formula that a company can exist forever. At the same time, the inclusion of the price-to-book ratio and DuPont analysis system to make secondary improvements to the residual income model, so that this paper can analyze LONGi Green Energy more comprehensively from a more comprehensive and detailed point of view. Finally, the calculation model of the mutation level method is incorporated, through which the impact of the

company's non-financial factors is corrected, making the calculation results more accurate and reducing the generation of assessment errors.

This paper takes the photovoltaic enterprise--Longi Green Energy as the research object, based on the improved residual income model, the value of Longi Green Energy enterprise is assessed to be 309.925 billion in the clear expectation period, and compared with the value of the total shareholders' equity of 359.375 billion on December 31, 2022, the deviation rate is 5.8%, and the error is within the reasonable range. This demonstrates the accuracy of the valuation results and the effectiveness of the improved residual income model. Finally, by combining the mutation level method and considering both financial and non-financial factors, the adjusted estimate is 3626.38, with an error of only 1.2%, a reduction of 4.6%, proving that the revised model has a higher explanatory and predictive ability.

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