Research on the Risk Premium and Growth Opportunities of the Chinese Green Energy Industry
——Based on CAPM and Mean-variance Analysis

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Abstract

At present, the development of green energy industry is receiving more and more attention in China. This paper uses mathematical statistics and economic analysis to explore the law of green economic development and improve the ability to avoid risks. Considering the high-risk premium as a signal of the high price volatility of the green energy stock leads to a conclusion that the green energy investment is risky. CAPM and mean-variance analysis are effective to measure the industry risk premium that works on the data from the past performance of the green energy portfolio. Using CAPM and mean-variance analysis can help us understand the risk premium and growth opportunities of Chinese green energy industry more concretely. As the results show that the beta of the risk premium of the green energy industry is 0.976, thus the industry risk premium is approximately 5.48% at the end of 2021. Policy factors are mentioned to help the further estimate of the industry risk premium.

Keywords: *Risk premium, Green energy, Supply chain, Risk factors*

1. Introduction

During the last decades, the importance of long-term sustainability of economic growth and global environmental issues has been an unprecedented emphasis by both academics, corporations, and government bodies. The main driver of rising attention on the environment implied that the pressures resulted in the implicit changes of corporate objectives formed by media, government, and civil society under the climate changes, thus accelerating the climate transition, which leads to beneficial influences on the natural world and future generation. An increasing number of institutional investors across the globe are therefore motivated to make investment decisions based on the environmental care of projects. The Chinese government has shown its distinctive goals on carbon dioxide peaking and carbon neutrality that the consumption of non-fossil fuel or green energy will be over 25% of total energy consumption and the total volume of wind and solar electricity generation will be over 1.2 billion KWs until the year 2030.

In China, the green energy markets constitute the three main sectors, which are the electronic vehicle, wind, and photovoltaic power industries. The stock index of these sectors has experienced dramatic growth from the year 2020 to 2021, which is approximately 208% on average at least. Hence the high expected return of green stocks is attractive to investors while the risks are taken.

There is a risk premium under the assumptions of risk-aversion of people and uncertainty, which could be defined as the excessive return of taking risks. The measurement of industry risk premium is vitally imperative for investors who are looking for comparing the risk premium of individual security to its industry risk premium. It is also helpful to further study specific factors about the difference between the risk premium of the entire industry and individual stock. Then the lower risk is expectable due to the improved effectiveness of diversification of the portfolio. This essay examines the industry risk premium of green energy stocks and key factors which are contributing to the price volatility of green energy stocks in China. Then the growth opportunities for the green energy market in a foreseeable future will also be developed in the latter part of the essay. To determine the risk premium of the green energy industry, this essay employs the mean-variance analysis, CAPM, and factor model in our analysis of risk premium and growth opportunities.

G. Vilas Bhau et al. (Eds.): MSEA 2022, ACSR 101, pp. 763–769, 2023.
https://doi.org/10.2991/978-94-6463-042-8_109

2. Literature review

Since Modern portfolio theory (MPT) or mean-variance analysis (1) was first introduced by Harry M. Markowitz in his 1952 essay *Portfolio selection* [1], the main insight is how an individual security's risks(σ_i) and returns ($E(R_i)$) contribute to the portfolio's total risks (σ_p^2) and returns ($E(R_p)$). The importance of diversification is therefore mentioned by Markowitz's model that the return of a portfolio can be maximized at a given level of risks by holding diversified security. Because the risks can be hedged with a combination of weights (w_i)between assets with negative correlation.

$$E(R_p) = \sum_i w_i E(R_i)$$

$$\sigma_p^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w \quad (1)$$

William F. Sharpe, as one of the initial inventors, then developed the Capital Asset Pricing Model (CAPM) (2) in his book *Portfolio Theory and Capital Markets (1970)*, which is given the measure of expected return ($E(R)$) consists of both systematic and unsystematic risks [2-4]. His findings also showed that the investment performance should be risk-adjusted, where the $R_{market}$is defined as the market return and $R_{risk-free}$ is the risk-free rate, such as T-bill or government bond. The sensitivity of the return of an individual asset with the market return (β) plays a key role in determining the risk premium of risky security. Meanwhile, his invention so-called Sharpe ratio act as a measure of return of assets with given risks that are still utilized by a myriad of investors [5].

$$E(R) = R_{risk-free} + \beta(R_{market} - R_{risk-free}) \quad (2)$$

$$\text{Sharpe ratio} = \frac{r_P - r_F}{\sigma_P} \quad (3)$$

Arbitrage Pricing Theory is another milestone in asset pricing and measuring the risk premium that was proposed by the economist Stephen Ross in 1976 [6,7]. The specific factor-based beta (β_j) was introduced in terms of the sensitivities of different factors owned by assets. F_j is the difference between actual and expected returns. And the noise (ε) is a diversifiable factor that is affected by the specific stock.

$$r_j = E(R) + \beta_1 F_1 + \beta_2 F_2 + \cdots + \beta_j F_j + \varepsilon \quad (4)$$

Furthermore, the asset pricing measure of the Three-Factor Model (3) has been developed by Eugene Fama and Kenneth French in 1990, who are the professors at University of Chicago, that expand the one market variable of CAPM by adding the factors of size risk (SMB) and value risk (HML) in the model [8,9]. The result of their observation is that the small stocks with a high book-to-market ratio tend to outperform the stock of big firms. Carhart's four-factor model (1997) was an addition to the three-factor model that applied the momentum factor for the pricing model [10]. In 2015, the model has been another extent by Fama and French from three-factor to five factors so that the probability factor and the investment factor can be measured [11].

$$r = R_f + \beta_1(R_m - R_f) + \beta_2(SMB) + \beta_3(HML) + \varepsilon (5)$$

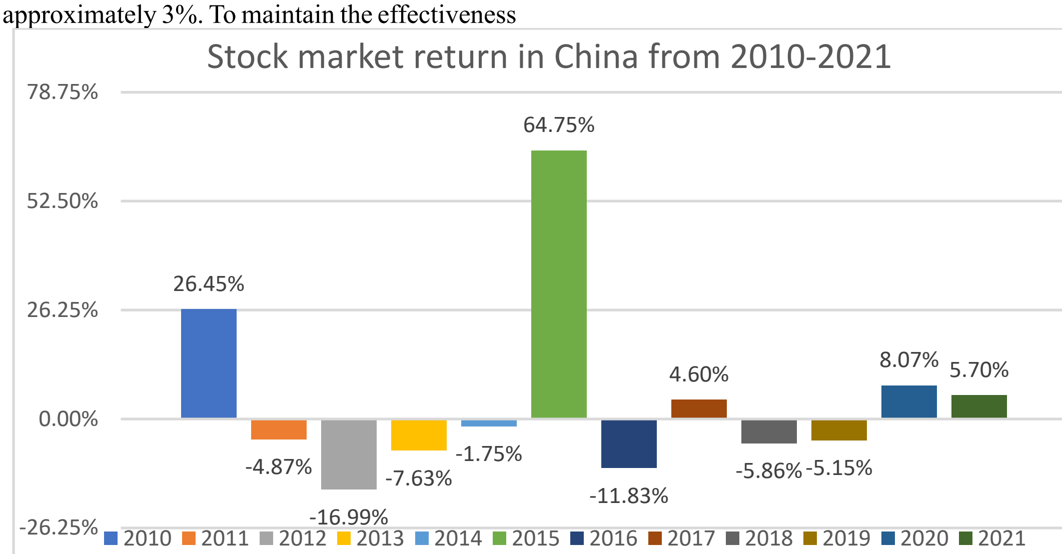
Moreover, the main factors contribute to risk premium that has been identified by the literature of Damodaran (2011), including economic factors, the risk aversion of investors, the quality of information, liquidity, the risk of catastrophe events, and the irrational behavior in the market [12,13]. However, there is one more important factor having an imperative influence on the equity risk premium of green energy listed companies in China, which could be the instructive policy proposed by the government. And the following analysis of this essay will also quote other core factors to make forecasts of market growth.

However, there is little study on the risk premium of an entire industry from the previous works of literature. This essay will attempt to explore more ways in this field which is specifically based on the green energy industry in China.

3. Analysis and Discussions

To measure the industry risk premium of green energy, the beta act as a key indicator to determine the systematic risks of the green energy industry so that the relevant supply chains of different sectors should be clarified. The green energy market in China is composed of three main sub-sectors, including wind power, electronic vehicle (EV), and photovoltaic (PV) industries. The wind power industry constitutes firms that manufacture components of the whole power generator specializing in different parts such as blades, towers, generators, turbines, and operation. EV industry can be divided into the upstream which specialized in the exploitation of raw material from mineral resources, and the middle-stream works on the production of Lithium batteries and other relevant intermediate components, then the complete vehicle and accessory manufacturers are the downstream part of the chain. In terms of the PV industry, the upstream of the supply chain conducts the production of raw materials of silicon and further processed products. Then the middle part of the chain could be the production of components of PV power stations such as PV glass and EVA. Last, the downstream of the PV industry is the PV power station which can be applied to the provision of electricity, solar charge, and grid-connected power generation. The national energy administration state that the installed base of wind and solar power generator in China has risen to 300.15 million kW and 282 million kW by the end of 2021 as 2.6 times larger than in the USA, acting as the largest market of these two renewable energies across the globe.

Due to the high reliance of the development of Chinese renewable energy on policy supports, either the easiness of obtaining a car license plate or financial subsidies, the green energy industry can be defined as a policy-based industry in general. In other words, the measurement of risk premium in the green energy industry is interrelated to this critical factor, besides from the primary determinants of beta (cyclist of revenue, operating leverage, and financial leverage) that contribute to the expected return and success of the investment by the capital gain of security. According to the policy plan for emission reduction in China, it is important to note that the carbon dioxide peaking will be reached until the year 2030 based on an increase in consumption of non-fossil fuel from 16% in 2020 to 25% by 2030, aiming to diminish 65% of carbon dioxide emissions per unit of GDP from the level of 2005. Assuming that this expected goal can be achieved in 2030, then the Beta can be determined by implementing the expected return of the market, and the risk-free rate could be treated as the interest rate of China's government bond which is approximately 3%. To maintain the effectiveness of data, as the figure 1 indicate that the market rate of return should be defined as the average return of the Chinese stock market from the year 2015 to 2021 (8.61%) in that the return rate before this date may not be useful for the current financial market. As the below chart indicates that the average return between 2014 and 2015 has a significant increase contributing to the higher market return in general. It appears that the main cause of the high return in China's stock market could be the intensive media spread and soaring level of aggregate leverage in a nationwide range in 2015. On the one hand, the media multiplied the good news from the stock market that encourages the involvement of the public to buy risky security. On the other hand, most investors in the Chinese financial market have been leveraged to maximize their return from investment and hence ignoring the risks of gearing. However, in the middle of the dramatic year, the huge down of the stock index crushed the confidence and arrogancy of Chinese investors until the actions to rescue the market from government and financial institutions.



Source: Trading economics

Figure 1: Stock market return in China from 2010-2021

Application of the CAPM model in the measurement of risk premium leads to the below results:

$$E(R) = R_{risk-free} + \beta(R_{market} - R_{risk-free})$$

$$Riskpremium = \beta(R_M - R_F)$$

The current beta of the green energy industry in China is 0.976 which is based on the performance of several portfolios of mutual funds in terms of variance and covariance, these funds are concentrating on the investment in the green energy industry in China, including Huaxia Energy Innovation Fund, Nongyin Green Energy Theme Fund, and Huijin Low Carbon Pioneer Fund.

Table 1: the best performance of the green energy portfolio in 2020 and part of 2021

	The Best Stock Fund in the nearest year	**The Best Stock Fund in the year 2020**	**The Best Hybrid Fund in the nearest year**
Fund manager	**Zheng Zeming**	**Lu Bin**	**Zhao Yi**
Funds	Huaxia Energy Innovation Fund	Huijin Low Carbon Pioneer Fund	Nongyin Green Energy Theme Fund
Entire period of actual operation/years	4	2.1	4.2

Beta in a nearest year	1.02	0.82	0.95
Alpha in a nearest year	18.40%	17.80%	20.44%
Return rate in a nearest year	153.09%	128.42%	158.33%

Source: Wind

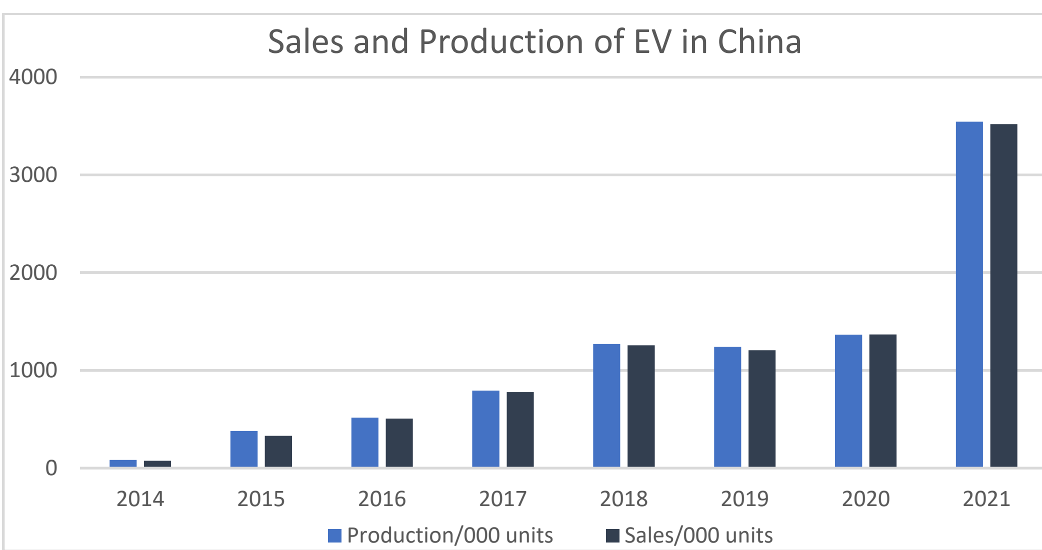
Table 2: the beta of the green energy fund managers in the year 2020 and part of 2021

Time Interval	**Market performance**	**Return rate of CSI New Energy Index (%)**	**Beta of Zheng Zeming**	**Beta of Zhao Yi**	**Beta of Lu Bin**
2021.3.10-2021.5.31	Bull	21.11	0.93	0.98	0.7
2021.2.11-2021.3.9	Bear	-21.79	0.85	0.86	0.71
2021.1.8-2021.2.10	Fluctuation	1.12	0.95	0.84	0.74
2020.12.4-2021.1.7	Bull	40.05	0.93	0.76	0.81
2020.7.14-2020.12.3	Bull	12.58	0.92	0.92	0.96
2020.3.24-2020.7.13	Bull	55.89	1.06	1.04	1.21
2020.2.26-2020.3.23	Bear	-24.48	1.1	1.05	1.15
2020.1.1-2020.2.25	Bull	23.59	1.14	1.05	0.98

Source: Wind

The risk premium of the green energy industry is therefore approximately 5.48%. This result represents that the risks and expected returns of investment in the renewable energy industry are relatively high compared to other industries in China. The main drivers behind the risk premium of assets should be concerned with whether the expectation of futuristic growth in the green energy industry can be fulfilled.

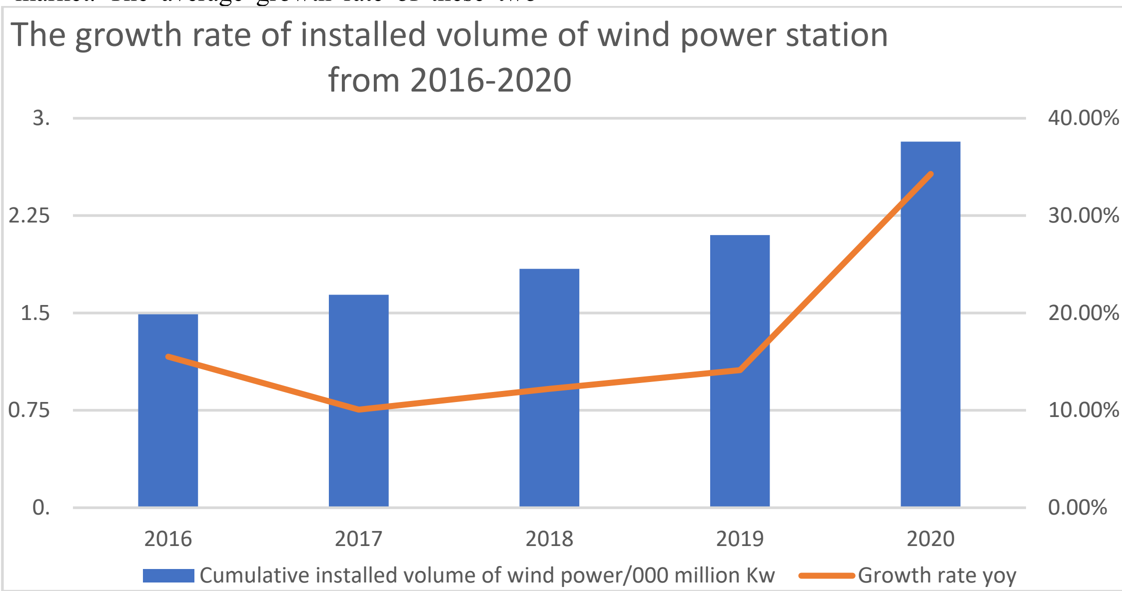
The growth rate of the green energy industry in the past five years has proved the capacity to return above the market level. According to figure 2, it appears that the sales and production of EVs have been a substantial growth during the last 7 years from 84000 units of production and 75000 units of sales in 2014, to 1.366 million of production and 1.367 million of sales. In addition, the estimated sales of EVs in 2021 are likely to be near approximately 3.4 million units which is a considerable increase compared to the year 2020. Predictably, the EV market will have a huge potential for growth in the next five years resulting from the entire substitution of traditional fossil fuel vehicles.



Source: China Association of Automobile Manufacturer

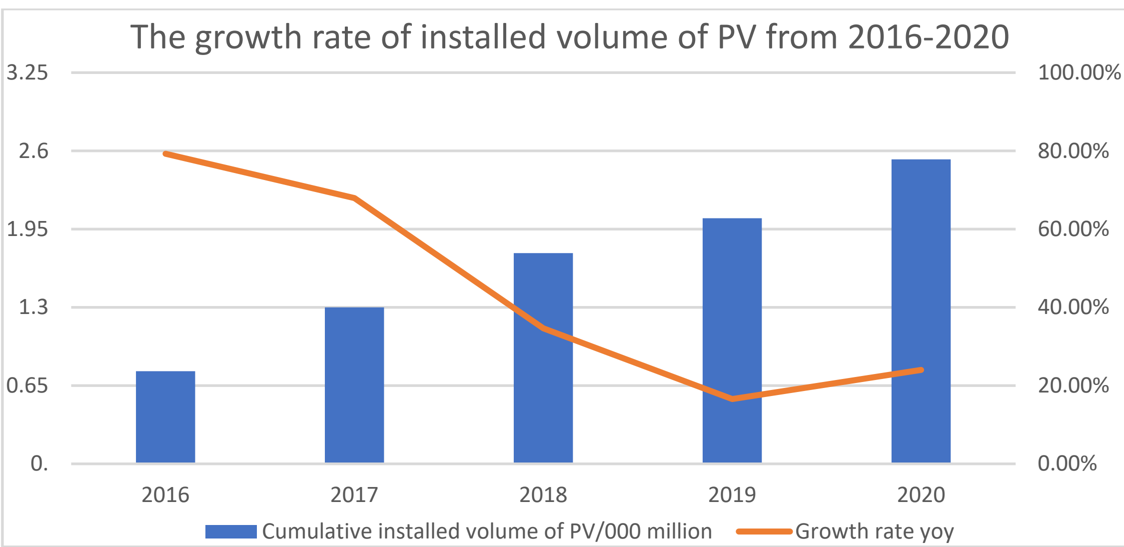
Figure 2: the sales and production of EVs in China from 2014 to 2020

The growing demand for renewable energy also contributes to the development of wind power and PV which play a key role in the supply side of the renewable energy market. The average growth rate of these two markets is separately 44.49% and 17.24% annually in the last five years and the further growth rate will remain constant to complete the policy goal in 2030.



Source: National Energy Administration of China

Figure 3: The growth rate of installed volume of the wind power stations from 2016-2020



Source: Sohu

Figure 4: The growth rate of installed volume of PV from 2016-2020

Meanwhile, some investors' skepticism about the potential growth opportunities of this industry has also been constantly voicing that there is a market bubble or the current price is already above the upper limit of its actual worth. However, in my humble opinion, the transformation from traditional fossil fuel to renewable energy will be a globally inevitable trend in the future so that the industry and its technology are still evolving within a rapid growth stage. Technical progress could be the underlying driver of growth that contribute to the improved efficiency of production and exploitation of energy.

4. Conclusion & Limitations

Overall, this essay has examined the risk premium of the green energy industry by Mean-variance analysis and CAPM which is relatively high compared to the risky security of other industries in China. The utmost underpinned factor driving the growth of the green energy market could be the policy plan for the reduction of carbon dioxide emissions. PV, EV, and wind power sectors are bearing significant responsibilities for the policy goal so that the majority of the public listed company from these sectors have been a soaring growth during the last few years and the growth opportunities are still available in the next decade until the complete transformation from uses of fossil fuel energy to renewable energy. The challenges of climate change should be emphasized from both internal corporate governance and external intervention of government, media, and civil society so that the protection of the environment can be maximized through the coordination between the public and institutions.

The methodology utilized in the risk measurement is limited due to the finite size of the sample, and standard errors of results based on CAPM as a result of uncertainty which is also mentioned by Eugene Fama and Kenneth French. However, improvements will be made in the further research of the industry risk premium and the growth opportunities of the green energy market in China.

References

[1] Markowitz, H. M., & Todd, G. P. (2000). *Mean-variance analysis in portfolio choice and capital markets* (Vol. 66). John Wiley & Sons.

[2] Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *The journal of finance*, *19*(3), pp: 425-442.

[3] Sharpe, W. F. (1963). A simplified model for portfolio analysis. *Management science*, *9*(2), pp: 277-293.

[4] Sharpe, W. F. (1966). Mutual fund performance. *The Journal of business*, *39*(1), pp: 119-138.

[5] Sharpe, W. F. (1994). The sharpe ratio. *Journal of portfolio management*, *21*(1), pp: 49-58.

[6] Ross, S. A. (1978). The current status of the capital asset pricing model (CAPM). *The Journal of Finance*, *33*(3), pp: 885-901.

[7] Roll, R., & Ross, S. A. (1980). An empirical investigation of the arbitrage pricing theory. *The journal of finance*, *35*(5), pp: 1073-1103.

[8] Fama, E. F., & French, K. R. (1997). Industry costs of equity. *Journal of financial economics*, *43*(2), pp: 153-193.

[9] Fama, E. F., & French, K. R. (2012). Size, value, and momentum in international stock returns. *Journal of financial economics*, *105*(3), pp: 457-472.

[10] Carhart, M.M., (1997). On persistence in mutual fund performance. The Journal of finance, 52(1), pp.57-82.

[11] Fama, E.F. and French, K.R., (2015). A five-factor asset pricing model. *Journal of financial economics*, *116*(1), pp.1-22.

[12] Damodaran, A. (2012). *Investment valuation: Tools and techniques for determining the value of any asset* (Vol. 666). John Wiley & Sons.

[13] Damodaran, A. (2011). Equity Risk Premiums (ERP): Determinants. *Estimation and Implications–The*.