Stock Price Fluctuations of Listed Companies in the Photovoltaic Energy Industry

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Abstract-As climate problems and environmental crises intensively, renewable and clean energy have attracted widespread attention. Contemporarily, with the break out of Russian-Ukrainian conflict, the major financial assets fluctuate accordingly and the energy sector is no exception. This paper analyzes the impact of traditional energy prices and the current Russian-Ukrainian conflict on the revenue of the photovoltaic industry. This paper selects the listed companies in the A-share photovoltaic industry as investigation sample. For traditional energy prices, we select the WTI crude oil futures and coke futures prices to calculate the photovoltaic energy and its correlation coefficient. According to the analysis, different crude oil prices have different effects on enterprises, there is no significant correlation between them. On the contrary, the Russia-Ukraine incident had a positive effect on photovoltaic companies. These results shed light on industry investment analysis for high volatility situations.

Keywords-Traditional Energy; Russia-Ukraine Conflict; Photovoltaic industry; Stock Volatility

1 INTRODUCTION

Energy is an important basic substance for the development of human civilization. With the intensification of climate crisis and environmental problems, solar energy, as a renewable, clean and environmentally friendly energy source, has received extensive international attention. With the awareness of sustainable development gaining popularity all over the world, the scale of comprehensive utilization of photovoltaic power generation in the world has expanded rapidly, the technology has been continuously developed. Besides, the cost has been significantly reduced, showing a good development prospect. Many countries regard photovoltaic power generation as a key new industry. Photovoltaic power generation is more widely used. Between 2001 and 2017, the photovoltaic industry developed at an astonishing rate. The total installed capacity in the world has risen from 1.250GW to 304.300GW, with a compound annual growth rate of 40.98%. China's photovoltaic industry is also showing unprecedented development charm. It has established factories in more than 20 countries or regions around the world, and its products are exported to nearly 200 countries and regions, becoming a strategic new industry with international core competitiveness in China [1].

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Nowadays, the tension in Russia and Ukraine has continued to intensify, which affects the changes in the financial market. The world is always paying attention to the situation, and the prices of major financial assets fluctuate dramatically, especially the oil price. It is reported that the oil price since 2008 is about to hit a new high. The price of light sweet crude oil futures for April delivery on the New York Mercantile Exchange rose $8.04 to close at 127.44 US dollars / barrel; London Brent crude oil futures for delivery in May rose 8.42 US dollars to close at 131.63 US dollars / barrel, about to exceed 140 US dollars / barrel in 2008 [2]. The conflict between Russia and Ukraine not only affects oil prices, but also affects the prices of many energy sources. On February 28th, LME copper futures rose 0.1% to close at $9,883.50 per ton etc. [3].

With the rapid development of the photovoltaic industry, the stocks of photovoltaic companies have also experienced twists and turns, and the future and stock trends of photovoltaic companies have often caused heated discussions. Since the "13th Five-Year Plan", the development of the photovoltaic power generation industry has been hindered by many constraints, but it is very in line with the requirements of new energy security, reliability and green economy. Therefore, after the "14th Five-Year Plan", under the correct guidance of the photovoltaic industry, its healthy development prospects Hopeful, the future is promising [4]. When considering that the photovoltaic industry will have a good development prospect, this paper studies its stock market factors. New energy is often closely related to traditional energy. Therefore, this paper adopts the method of calculating correlation to detect the degree of influence, and the development of photovoltaic industry is inseparable from the outbreak of the Russian-Ukrainian war has obviously affected the price of metal energy futures and some traditional energy prices. This paper uses data processing to calculate the volatility of the stock market during the outbreak of the war and the excess rate of return to study the degree of correlation between the two. The rest part of the paper is organized as follows. The Sec. II will summarize the previous literatures to present the research routine for this paper. Subsequently, the Sec. III will introduce the data origination and research models. Afterwards, the result will be demonstrated in the Sec. IV with explanations accordingly. Eventually, a brief summary is given in Sec. V.

2 LITERATURE REVIEW

The war between Russia and Ukraine, which broke out on February 24, 2022, shocked the world and severely shook global financial markets. Although many experts remind the crisis between Russia and Ukraine [5], Politicians and economists are unprepared for a sudden war. The war intensifies the dilemma facing monetary policy makers since it will add to inflation but weaken growth and damage consumer and business confidence [6]. Inflation which is already ravaging most global economies is steadily rising due to the sharp increase in oil, natural gas, and food prices just a few days into this crisis [7].

It’s obviously that the escalating war between Russia and Ukraine threatens global energy security and financial flows, with implications for the global investment landscape and geopolitics. In particular, the global energy and security order will be restructured. Studies suggest that the war could change the energy structure in Europe [8]. At the very least, Europe has finally realized that it cannot remain so fatally dependent on Russian energy commodities. It will need to further diversify its suppliers, while strengthening the role of renewables, including nuclear energy and in the event of an emergency, using less environmentally friendly coal-fired power plants for which domestic fuel can be provided [9].

The war influences the energy market severely, as Russia is the world's largest energy exporter. The transportation component of the consumer price index rose in the month of the invasion due to shortage of energy and fuel supplies which led to a rise in the price of gasoline for transportation in the Euro Area [10]. Some papers illustrate that the trends in the natural gas sector development in South East Europe, to evaluate whether and how the role of the Russian natural gas supplies in the region’s energy security has changed and to examine what measures have been taken for the security of natural gas supplies in the region over the years [11]. Thus, the oil and gas market at war is delicate and complex, we focus on this research gap.

Previous studies focused on the impact of the war on western countries and EU countries, but ignored the negative impact on China's economy, as the world economy is closely linked. Even though some articles argue the trade and relationship between China and Russia, they all ignore the impacts on Chinese energy market and structure.

We could not consider the impact of war to China economy the same as the European Union. Political and economic rapprochement is taking place between Russia and China in a number of fields: energy, arms production, trade in national currencies and strategic projects in transport and supporting infrastructure [12].

In particular, the other’s researches ignore the influence on China's photovoltaic energy industry. As photovoltaic power generation is the most widely used power generation method except traditional energy, and China is in a critical period of transition from non-clean energy to clean energy. The development in the photovoltaic industry is directly reflected in the stock market, though the index of global stock markets plunged on the day of invasion [10].

Table 1 The analysis of industry chain

The chain of production	Upstream companies	Middle companies	Downstream companies	Matching companies	Comprehensive enterprise
Main business	production of polysilicon material, silicon, etc	Production of batteries, battery components, etc	Construction and operation of photovoltaic power station	silicon production equipment, photovoltaic glass, relay, inverter,etc	full or semi-industrial chain

Related companies	Longji shares Orient tantalum industry Poetic chemical ordos Have good technology Fine work of science and technology The new material Draco photoelectric Central co Minjiang river water and electricity Jiangsu sunshine YouYan silicon shares The British force,	Million crystal photoelectric Sail share Hengdian east magnetic Antai technology Silver star energy Photoelectric co Vosges shares	Spaceflight electromechanical Variety co Rio tinto nissin can Change especially electrician The east - In the science and technology Icahn technology sunflower	Star science and technology Fine work of science and technology Draco photoelectric Mr Shares The big group Avic sanxin Jin jing science and technology The hing technology Sun power Xinda new material Secco roth The amalekites, Beijing express co.	Spaceflight electromechanical Tianwei change bao Rio tinto nissin can Change especially electrician The east - Sea embellish photovoltaic In the science and technology Icahn technology South bo A sunflower ST super day
The number od companies	13	7	8	13	11

3 METHODOLOGY

3.1 Data

Financial data of this paper is collected from Tongda, photovoltaic industry related a-share listed companies are from the phoenix net PV concept of finance and economics plate. In order to make the research more targeted, according to previous classification method, 38 PV business companies are divided into the upstream, middle and downstream enterprises and supporting facilities and comprehensive enterprise. Table. 1 lists the industry chain detailly.

3.2 Model

The method used in this paper is the event study method. The estimation window selected is from 90 trading days to 11 trading days before the policy announcement (-90, -11), and the window period is selected from emergency to 18 trading days after the emergency (0,18). This paper mainly uses CAPM model to estimate the excess return rate of the company and the industry. According to the market model method to calculate the daily stock yield:

$$r_{i,t-1} = \alpha_i + \beta_i r_{m,t-1} + \varepsilon_i \tag{1}$$

where $r_{i,t-1}$ is the daily rate of return of i company in the estimation period, $r_{m,t-1}$ is the daily rate of return of the market in the estimation period. The least square method is used to estimate the intercept $\alpha_i$and slope β_i of the CAPM model. The yield rate of 10-year treasury bonds is taken as the risk-free rate of return. Then the yield rate of the window period obtained by model regression is inserted into the equation to obtain the assumed normal rate of return of the event window, and then the actual stock return rate of the event window is subtracted from the estimated normal rate of return, so that we obtain the excess return rate of the i stock:

$$AR_{i,t} = r_{i,t} - \hat{a}_i\hat{\beta}_i r_{m,t} \tag{2}$$

Here, $r_{i,t-1}$is the daily rate of return of i company in the estimation period, $r_{m,t-1}$ is the daily rate of return of the market in the estimation period, $r_{i,t}$ is the daily rate of return of i company in the event window, $r_{m,t}$is the daily rate of return of the market in the event window, and $AR_{i,t}$is the excess rate of return of i company in the event window.

Based on the daily excess return rate of each company, the cumulative daily excess return rate of the photovoltaic industry, the average cumulative excess return rate of the industry and the average daily excess return rate of the industry are calculated as follows:

$$CAR_t = \Sigma_i AR_{i,t} \tag{3}$$

$$CAAR = \frac{1}{N}\sum_{i=1}^{N} CAR_{i,t} \tag{4}$$

$$AAR_t = \frac{1}{N}\sum_{i=1}^{N} AR_{i,t} \tag{5}$$

Here, CAR_t is the cumulative daily excess return rate of the photovoltaic industry. $CAAR$ is the average cumulative excess return rate of the industry. AAR_t is the average daily excess return rate of the industry.

The industry average excess return rate is tested by relevant hypothesis, and its test statistics follow the T-distribution with the n-1 degree of freedom. The return rate of WTI fuel futures and coke futures from January 1, 2019 to December 31, 2021 and the average return rates of the stock price of 38 photovoltaic enterprises are selected to calculate the correlation coefficient of the two arrays, as follows

$$r = \frac{E\left[\left(\boldsymbol{x} - E(\boldsymbol{x})\right)\left(\boldsymbol{y} - E(\boldsymbol{y})\right)\right]}{\sqrt{|\boldsymbol{x} - E(\boldsymbol{x})|^2}\sqrt{|\boldsymbol{y} - E(\boldsymbol{y})|^2}} \tag{6}$$

Here, r represents the correlation between the crude oil futures price and the average stock price of photovoltaic market within the selected interval. The stronger the correlation is, the result is closer to 1; the weaker the correlation is, the result is closer to 0. Fig. 1 and Table. 2 present the price trend of average yield and other features

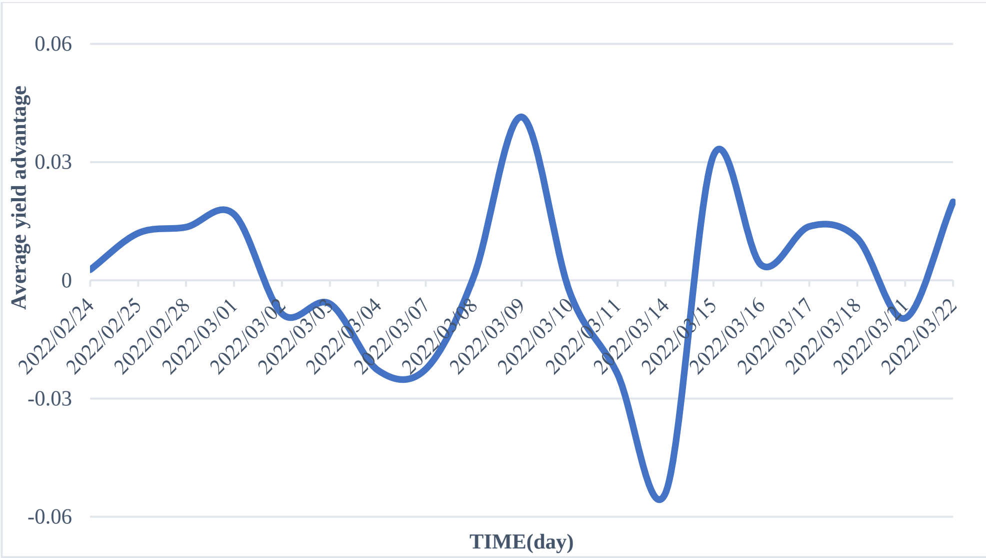

Figure 1. Average yield advantage in window phase.

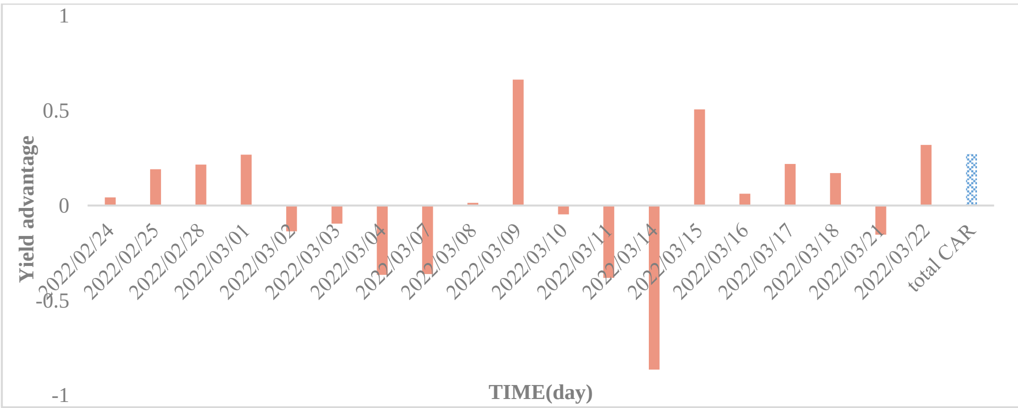

Figure 2. Yield advantage in window phase

Table 2 The average daily excess return rate of photovoltaic industry after the outbreak of "Russia-Ukraine conflict (AAR)

Date	AAR (%)	t	Sig (P)
2022/02/24	0.27	0.77	0.451
2022/02/25	1.2	1.81	0.090
2022/02/28	1.3	2.96	0.010
2022/03/01	1.7	2.92	0.010
2022/03/02	-0.85	-2.11	0.052
2022/03/03	-0.59	-0.78	0.448
2022/03/04	-2.3	-3.44	0.004

2022/03/07	-2.2	-3.29	0.005
2022/03/08	0.09	0.16	0.874
2022/03/09	4.1	6.46	0.000
2022/03/10	-0.29	-0.47	0.642
2022/03/11	-2.4	-4.99	0.000
2022/03/14	-5.3	-11.6	0.000
2022/03/15	3.2	8.05	0.000
2022/03/16	0.39	0.60	0.555
2022/03/17	1.37	1.46	0.165
2022/03/18	1.07	1.96	0.068
2022/03/21	-0.96	-2.47	0.026
2022/03/22	1.99	2.74	0.015

Table 3 The correlation of coke futures yield and photovoltaic energy related enterprises

	The average rate of return in photovoltaic industry	The rate of return in coke futures yield
The average rate of return in photovoltaic industry	1.000 (0.000***)	0.053 (0.458)
The rate of return in coke futures yield	0.053 (0.458)	1.000 (0.000***)

***, **, * present the significance level of 1%,5% and 10%

Table 4 The correlation of fuel futures yield and photovoltaic energy relate enterprises

	The average rate of return in photovoltaic industry	The rate of return in fuel futures yield
The average rate of return in photovoltaic industry	1.000 (0.000***)	-0.077 (0.279)
The rate of return in fuel futures yield	-0.077 (0.279)	1.000 (0.000***)

***, **, * present the significance level of 1%,5% and 10%

4 RESULTS & DISCUSSION

As shown in Table. 2 and Fig. 1, we can find there was a CAR and obvious T-test on 11 trading days out of 18 trading days, and then we can conclude "the event in Russia and Ukraine" had a positive influence on photovoltaic energy industry. As illustrated in Fig. 2, photovoltaic energy industry got the CAAR with 0.089% in window period. It's proven after adding daily CAR.

Seen from Table. 3 that the coke future's rate of return and photovoltaic energy industry companies is not strongly correlated but positively correlated. As summarized in Table. 4, the WTI fuel is same as it but has a negative correlation. After this analysis, there was not a strongly correlated between the new energy, similar to photovoltaic energy and traditional energy, but it was also weakly alternative with the fuel. We believe photovoltaic energy has great potential.

As a matter of fact, this paper has some drawbacks and defects. To be more specific, the sample we selected in this paper is too small, which only has special significance for this policy, i.e., might not be enough to draw general conclusions. Moreover, the event is not sudden, and the market has already made a prediction, which has led to the failure to reach an ideal conclusion.

5 CONCLUSION

In summary, this paper investigates A-share 38 listed companies in the photovoltaic industry. Specifically, based on CAPM model, the estimated value of each stock is analyzed in terms of excess return. As a consequence, the yield returns were indeed found during the conflict between Russia and Ukraine. Besides, it is found that photovoltaic (PV) energy has to substitute for traditional fossil energy. Especially because of the conflict between Russia and Ukraine, European countries are considering reducing their dependence on Russian gas and oil and developing new energy such as solar energy.

In the future, according to our analysis Photovoltaic industry will develop more and more rapidly. Photovoltaic industry is an important emerging enterprise in China, and it is a strategic industry that may gain a leading advantage. Based on the current situation, the government said that would continue to promote the sustainable, healthy and high-quality development of China's photovoltaic industry. In the future, the scale of China's photovoltaic industry will continue to expand, but also to intelligent upgrade. Current photovoltaic power installed capacity in China has been continuously expanding, and the electricity generation also obviously increased year by year. Contemporarily, China’s low carbon, energy conservation and environmental protection policy and trend are based on the development of PV in the previous scale expands gradually. On this basis, the standardization of the PV industry will also tend to be stricter, combining the intelligent, promote the innovation of intelligent photovoltaic. Besides, the photovoltaic industry is expected to become intelligent and, driven by policy, technology will improve and the generation cost of the system will be reduced for the state-of-art products and facilities. Photovoltaic industry is still a hot industry, macro situation, many have been clearly put forward environmental protection measures, e.g., green energy from the point of demand, around 150 countries worldwide have the condition to develop solar power. Therefore, the global solar photovoltaic power generation demand growth is strong, with the shrinking of traditional energy and the cost to reduce gradually, photovoltaic power generation obvious advantages, we're going to see strong growth.

According to this result, the analysis of PV is phased since the uncertainty of the world's fossil energy producing countries, which has spurred the growth of photovoltaic energy. The number of industries is limited, hence researchers ought to obtain more accurate results from this model. Meanwhile, we hope that researchers can pay more attention about PV. These results provide a reference and guideline to the similar field in the future.

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