The Impact of "Carbon Peak and Carbon Neutrality" Policy on Automobile Industry

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ABSTRACT
Under the background of carbon peak and carbon neutrality, China's new energy vehicles usher in development opportunities. This paper mainly discusses the impact of the Carbon peak and neutrality policy on the automobile industry by combining qualitative and quantitative analysis. By analyzing the contemporary and traditional automobiles, this paper carries out data visualization and trend analysis through Python and plot functions to show the impact of the "Carbon peak and neutrality" policy on the data of pure new energy and traditional automobiles. Then the samples are divided into treated group and control group. The double difference (did) research method is used to compare and analyze the data before and after the implementation of the policy to study the net impact of the policy. By comparing and analyzing the trend changes before and after the policy, this paper forecasts the future development of the automobile industry and puts forward countermeasures and suggestions for development. The study of this paper will comprehensively promote the development of a low-carbon economy in the automobile industry, help achieve the goal of "dual carbon", and drive the rapid growth of China's automobile export.

Keywords: *Pure new energy automobiles, Traditional automobiles, "Carbon peak and carbon neutrality" policy*

1. INTRODUCTION

1.1. Research background

China's economy has changed from the primary stage of rapid growth to high-quality development. It is urgent to adjust the energy structure and industrial layout. Energy supply and demand, environmental carrying capacity, and ecology face severe challenges. In the automobile industry, the "Carbon peak and carbon neutrality" policy proposes that the carbon emission of the automobile industry will be 30% lower than the peak in 2035 and the new energy vehicles will account for 50% of the total sales of new vehicles. "New energy, networking, and intelligence" has become the automobile industry's development trend and general trend. Implementing the "double carbon" policy will promote the overall transformation of the automotive industry and bring substantial fluctuations to the development of existing industries. So what is the impact of implementing the "double carbon" policy on the development of the automobile industry? How to evaluate this impact? What improvement suggestions should be put forward for the existing policies based on the impact assessment? These studies are relatively rare. This paper will answer the above questions in detail and fill the gap.

Various domestic and foreign papers emphasize the impact of the carbon peak and neutrality policy on the automobile industry. The review of 50 articles related to the automobile industry under carbon peak and neutrality policy can be divided into two categories. The first category is started from the main body of the policy. Most of the papers from the first category discuss the impact from the macro angle and analyze it in combination with current events and news hotspots rather than building the econometric model to analyze[1-2]. The papers from the second category generally analyze a particular field of the automobile industry by establishing a game model related to the main participants of the automobile industry[3-4].

1.2 Research framework

This paper filled the gap by combining qualitative and quantitative analysis. The quantitative part starts from the automobile stock data from a new perspective and uses DID model to analyze. In the qualitative part, the stock

data of automobile companies is used as a direct database for analysis and research, which is used to put forward forecasts and suggestions for the development of the automotive industry in the future. Most of the literature analyzes the automobile industry rather than refining and classifying automobile enterprises and conducting strategic research. After thinking and summarizing the previous papers, this paper makes a more in-depth and detailed treatment.

2. LITERATURE AND POLICY REVIEW

2.1. Programmatic documents of "Carbon peak and neutrality" policy

"The guiding opinions on accelerating the establishment and improvement of a green and low-carbon circular development economic system" [5] (hereinafter referred to as the "opinions") and "the notice of the State Council on Printing and distributing the action plans for reaching the peak by 2030"[6] (hereinafter referred to as the "plans") are two programmatic documents of the "Carbon peak and neutrality" policy. The "Opinions" highlights the concept of guiding the implementation of the "Carbon peak and neutrality "policy and takes the green concept as the guide of social development. It puts forward the three-stage development goals of 2025, 2030, and 2060. Meanwhile, it gives the overall layout of implementing the "Carbon peak and neutrality" goal and task from the overall layout, industrial structure change, and low-carbon transportation. Energy-related activities run through the comprehensive green strategy and low-carbon transformation of the social economy. They mainly gave comprehensive policy guidance from six aspects: energy supply, energy consumption, energy technology, energy system and mechanism, statistical energy monitoring and international energy cooperation, and practice the new energy security strategy through specific actions of green and low-carbon transformation of energy.

There is also a close relationship between the "Plans" and the "Opinions". As a step decomposition of the opinions in the "Carbon peak" stage, the "Plans" formulates specific action implementation for various industries and fields as well as joint carbon reduction. It can guarantee plans in terms of scientific and technological support, energy security, carbon sink capacity, fiscal and financial price policies. A series of documents have established a policy system of "Carbon peak and carbon neutralization" with clear objectives, reasonable division of labor, decisive measures, and orderly connection. The "Plans" puts forward the "top ten actions of carbon peak". The primary task of the "Plans" is the transformation to green and low carbon energy, which reflects the importance of the overall deployment of the opinions on building an energy system. By taking the protection of national energy and economic development as the bottom line, the plans give the critical tasks of the "Carbon peak" action from three aspects. They include carbon reduction in energy supply and consumption, carbon reduction in key energy fields, and coordinated carbon reduction through multiple measures.

The research is based on the "Plans" and the "Opinions" objectives. The "plans" reflected the policy of "Carbon peak" went through the whole process and all aspects of economic and social development. In addition, these plans focus on implementing the green and low-carbon transformation of energy, energy conservation, and carbon reduction and efficiency action, carbon peak action in the industrial field, carbon peak action of urban and rural construction, green and low-carbon action of transportation, action of the circular economy.

Relevant contents have been put forward in the "Opinions": the goal is to optimize the industrial structure, energy structure significantly, and transportation structure, continuously improve the green level of infrastructure, continuously improve the level of cleaner production. Adopting more rational allocation of energy resources greatly improves the utilization efficiency, continuously reducing the total emission of major pollutants, considerably reducing the intensity of carbon emission, and constantly improving the ecological environment.

By 2025, The market-oriented green technology innovation system will be perfect. By 2035, key industries' energy and resource utilization efficiency and products will reach the advanced international level.

In addition, carbon emissions will drop steadily after reaching the peak, the ecological environment will fundamentally improve, and the goal of building a Beautiful China will be achieved. Their goals coincide with the sustainable development of green energy conservation and pay attention to the impact on the environment. Therefore, as the research background, these two documents can provide the influencing factors of the general environment for the development trend of the automobile industry and then make a detailed analysis combined with the background, which adds a strong theoretical basis to this research.

2.2. Effectiveness and significance brought by "Carbon peak and neutrality" policy

On April 16, 2020, "the key points for the standardization of new energy automobiles in 2020" pointed out that automobiles should actively respond to the "Carbon peak and neutrality" goal in all aspects. These aspects, such as driving safety, mileage, and power performance, realize the transformation of green and low-carbon targets and the rapid development of the economy. As for new energy automobiles, the statistical analysis data of the China Automobile Association shows

that the production and sales of automobiles reached 26.082 million and 26.275 million, respectively, as of December 2021, with a year-on-year increase of 3.4% and 3.8%. In terms of sales volume, the growth rates of sales volume from 2018 to 2021 were - 2.8%, - 8.2%, and - 1.9%, respectively, and positive growth in 2021. Among them, the sales volume of new energy automobiles reached 3.521 million, a year-on-year increase of 157%, representing the main driving growth force. In December 2021, new energy automobiles' monthly production and sales exceeded 500,000, maintaining ultra-high-speed development.[7]

Most automobile enterprises plan to realize "Carbon neutrality" by 2050. A few enterprises even advance to 2040, such as Volvo and General motors. Mercedes Benz announced that they want to realize "Carbon neutrality" in 2039. Nissan Motor Company said that it planned to realize 100% electric drive in the core new models, including the Chinese market, in the early 2030s and transform the factory with innovative technology to introduce the "Nissan smart factory" into major factories in the world. By 2030, the carbon dioxide emission of Nissan plants will be reduced by 40% contrast to 2019. In addition, Nissan is still trying to build a comprehensive new energy vehicle ecosystem, optimizing the use of new energy vehicle batteries, improving energy management, and the recycling mode of reprocessing, recycling, resale, and reuse of vehicle batteries. As the profit leaders of new energy automobiles, SAIC Motor, Ningde times, and great wall motor have formulated characteristic development policies in response to the "Carbon peak and neutrality" policy. For example, SAIC Group announced that SAIC Group will achieve global sales of more than 2.7 million new energy automobiles, accounting for no less than 32% of SAIC's total vehicle sales by 2025. At the same time, SAIC also said that they will strive to realize a high-quality "Carbon peak" target by 2025. Even if the output continues to increase, SAIC's total carbon emissions must also continue to decline until the goal of "carbon neutralization" is realized. It indicates that most automobile industries have responded to the guidance of the "Carbon peak and neutrality" policy.

3. METHOD

3.1. Data selection

Select 164 current automobile manufacturing enterprises, take the quarter as the time nodes to classify and collect the automobile manufacturing stocks with the index of the six years before and one year after implementing the "Carbon peak and neutrality" policy from January 1, 2014 to September 2031. Take profits, liabilities, and total assets index of the stocks as the indicators, at the meantime, classify the automobiles by pure new energy and traditional car industries.

3.2. Data analysis

Thi paper uses Python for trend analysis and then uses the Plot function to visualize the tendency of the 3 indexes of the stocks (total asset, total benefits, and total liability). Moreover, this paper compares the figures before and after the "Carbon peak and neutrality" policy by analyzing the changes of pure new energy and traditional vehicle data.

4. RESULT

4.1. Visualizing the data by applying the Plot function

Use Python for trend analysis and then visualize the tendency of the 3 indexes of the stocks (total asset, total benefits, and total liability) by using the Plot function. Compare the figures before and after the "Carbon peak and neutrality" policy by analyzing the changes of pure new energy and traditional vehicle data.

4.2. Application of DID model

From the formula as below (1), Y_{it} is explicit data du is a grouped virtual variable. If the individual i is affected by the policy implementation, the individual i belongs to the treated group, and the corresponding value du is 1. If the individual is not affected by the policy implementation, the individual i belongs to the control group, and the corresponding value du is 0. dt is a dummy variable of policy implementation. dt is 0 before policy implementation and 1 after policy implementation. $du * dt$ is the interaction term between grouped dummy variables and policy implementation dummy variables. Its coefficient a_3 reflects the net effect of policy implementation (as shown in table 1) and ϵ_{it} is the bias term used to correct the deviation.

Table 1 The effect of policy implementation

Styles	Before the policy	After the policy	Difference
Treated group	$a_0 + a_1$	$a_0 + a_1 + a_2 + a_3$	$a_2 + a_3$
Control group	a_0	$a_0 + a_2$	a_2
Difference	a_1	$a_1 + a_3$	(DID result)

Before applying the DID model to evaluate the impact of policy, we need to do the significance testing of the control group and the treated group. The most effective method to test whether there is a significant difference between the two data groups is the comparison test method. The comparison test method we use in this paper is the t-test method. The objective of using a t-test is to verify whether each independent variable can be defined

as an essential factor affecting the dependent variable. We use the following formula to construct statistics (2).

From the formula, β_j is the estimated value of the j coefficient of the linear regression model; β_j is the assumed value in the original assumption 0; $se(\beta_j)$ Is the standard error of regression coefficient and the corresponding calculation formula is as follows (3).

It indicates that $\sum \epsilon_i^2$ is the sum of squares of errors and c_{jj} is the j element on the diagonal of the matrix. It also shows that the greater value of T reflected the greater difference of sample mean.

After we obtain the statistics of the samples, we can use the following calculation method to calculate the significance estimation of the sample (4).

When the possibility of the samples is located in the confidence interval of $(-t_{\alpha/2}, t_{\alpha/2})$ (in which α is the confidence degree), the explicit confidence degree does not need to be set in the DID model. We can obtain the specific value of T by the above method and μ works as a constant. Generally, we take the average value.

$$Y_{it} = a_0 + a_1 du + a_2 dt + a_3 du * dt + \epsilon_{it} Y_{it} \quad (1)$$

$$t = \frac{\widehat{\beta}_j - \beta_j}{se(\beta_j)} \sim t(n-p-1) \quad (2)$$

$$se(\beta_j) = \sqrt{c_{jj} \frac{\sum \epsilon_i^2}{n-p-1}} \quad (3)$$

$$p(|\overline{X} + \mu| > |t + \mu|) \quad (4)$$

4.3. Validation of policies

Figures 1, 2, and 3 reflect the index data of new energy and traditional vehicle enterprises from three different perspectives: total asset, total debt, and total profits, respectively. It indicates that the contrast from the period before and after the policy shows that the assets and liabilities index of the stocks of significant automobile enterprises increased steadily. There was no huge fluctuation before and after the policy node.

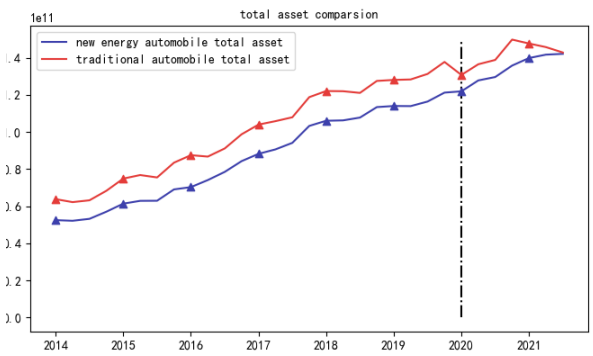

Figure 1 A comparison of total asset

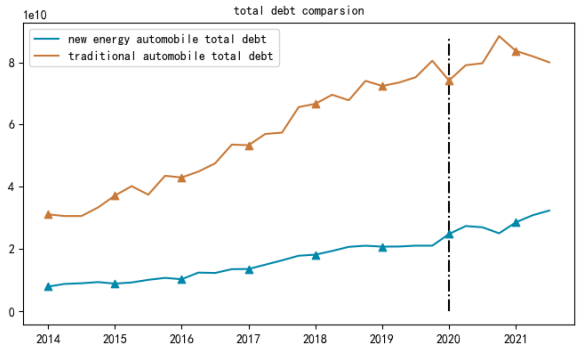

Figure 2 A comparison of total debt

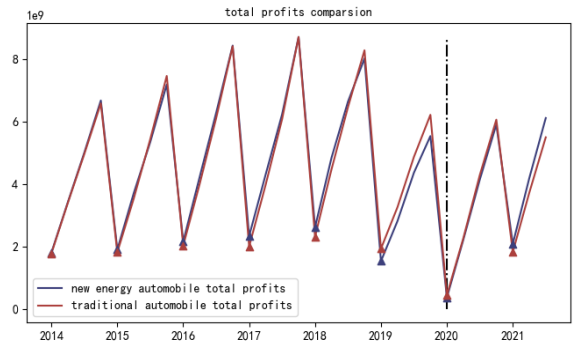

Figure 3 A comparison of total profits

The quantitative value of total asset and debt of traditional automobile enterprises are much higher than those of new energy automobile enterprises. The new energy and traditional automobile industry repeatedly fluctuated in profit indicators. New energy gradually caught up with the value of the traditional automobile industry and significantly exceeded the traditional automobile industry after the "Carbon peak and neutrality" policy. It indicates that the "Carbon peak and neutrality" policy significantly develops the new energy automobile industry. The target of realizing carbon reduction and green development has become a new direction of the automobile industry.

Tables 2, 3, and 4 can analyze them in-depth from three different perspectives: total profits, total debt and total asset. Although the DID model can greatly bring endogenous advantages of policy evaluation, it must pass the parallel trend test. It requires that the total factor productivity of enterprises in the control group and the treatment group have the same change trend before being impacted by the policy. Therefore, a parallel trend test is made. Through the t-test method, it can be verified that the P values of the three indicators are significantly greater than 0.05, which indicates the continuity of data. It represents that the three indicators of assets, liabilities, and profits meet the experimental method of double difference. The trend of the three indicators in control and treated groups is also relatively consistent, which means there is no significant difference. The P-value of total profit and assets is large, indicating that the policy is also greatly affected.

Table 2. Summary of DID model results (Total profits)

Time	Item	Effect of value Total profit	The standard deviation	*t*	*p*
Before	Control Treated Diff (T – C)	4755264858 4755354486 89628.271	631311765	0	0.998
After	Control Treated Diff (T – C)	3573228473 3442650368 -130578105	1168962243	-0.112	0.911
	Diff-in-Diff	-130667734	1328543289	-0.098	0.922

Table 3. Summary of DID model results (Total debt)

Time	Item	Effect of value Total liabilities	The standard deviation	*t*	*p*
Before	Control Treated Diff (T – C)	14474944732 53592746838 39117802106	3147621028	12.428	0
After	Control Treated Diff (T – C)	27980662020 81028397983 53047735963	5828261628	9.102	0
	Diff-in-Diff	13929933857	6623907588	2.103	0.04

Table 4. Summary of DID model results (Total asset)

Time	Item	Effect of value Total assets	The standard deviation	*t*	*p*
Before	Control Treated Diff (T – C)	85622919351 99523842204 13900922854	6300522530	2.206	0.031
After	Control Treated Diff (T – C)	134222663150 141853562349 7630899198	11666300796	0.654	0.516
	Diff-in-Diff	-6270023655	13258927498	-0.473	0.638

From Table 2, 3, and 4, we can conclude that when p is larger, the samples of the control group and treated groups' samples are more significant. The DID model generally takes 0.01 as the threshold of P. When p > 0.01, we believe that the samples of the control group and the treated group meet the requirement of the significance hypothesis. Through the visualization trend using the Plot function, we can easily see the changes of stock indexes of major automobile enterprises before and after the policy. In order to verify the impact of the policy, we ignore the endogenous influencing factors and use the DID model for analysis. DID model has the advantage of overcoming endogenous influence and has the function of effectively estimating policy effect. The "Carbon peak and neutrality" policy constitutes a double difference model as a quasi-natural experiment. The first level of the difference comes from the distinction between vehicle types: new energy automobiles and traditional automobiles. The second level of the difference comes from the year difference. Set control group as 0, treated as 1, pure new energy as the control group, and traditional as the control group. 154 traditional automobiles and 75 new energy automobiles were selected. Before policy (from January 3014 to September 3030) set 0. After the policy (from September 30 to December 3031) set 1. The interaction is reflected in the Difference-in-Difference.

We found that the diff affects the value of the total profit was 89638.371 and showed significance (P > 0.01) before the implementation of the policy, which means that the data of the treated group and the control group were similar before the implementation of the policy. We can also know that the total profit of the treated group is higher than that of the control group. The total profit of traditional automobiles is higher than that of new energy automobiles.

After implementing the policy, the diff affect value of the total profit is -130667733.533, which means that the policy has had a noticeable impact. Combined with the trend chart, we know that the rising trend of the treated group's total assets, total liabilities, and total profit has been gentle. In contrast, the total profit of the control group has exceeded the total profit of the treated group in the middle of 2021.

We can conclude that the "Carbon peak and neutrality" policy has hit the rising range of profits of the treated group. Traditional automobiles show a slowly rising trend, while the overall rising range of the control group, new energy automobiles, shows a thriving trend.

5. STRATEGY AND DISCUSSION

5.1 Prediction of future development of automobile industry

The visual presentation and analysis of the above data indicate that the new energy vehicle market has great potential and will gradually become a new outlet for the development of the automotive industry. The profits of the traditional automobile industry have not decreased due to the policy and even show an upward trend. It is easy to see that the traditional automobile industry will adapt to the new market and create a new development strategy after implementing the policy. With the introduction of various national support policies for new

energy automobiles, the gradual improvement of consumers' awareness of new energy automobiles and the continuous improvement of public charging facilities will usher in a high-speed period of their development. Therefore, under the "Carbon peak and neutrality" policy, new energy automobiles will become the main force and lead the development of the whole automobile industry. At the same time, the traditional automobile industry will also adapt to the new development strategy and will remain the backbone of the automobile market.[8]

5.2 Suggestions for "Carbon peak and neutrality" policy

Advance the layout of the economic model of the "post-carbon peak" era. After the carbon peak, it isn't easy to increase the emission of fossil fuels, which will have a far-reaching impact on the energy industry, energy trading, and other aspects. As a developing country, China is particularly affected. China's carbon peak in 2030 means that China has found a new track to develop clean energy, and fossil energy will no longer grow. In this way, China's development will not be limited by fossil energy after 2023 but also have the potential to continue to maintain a high development speed and narrow the gap with the United States and other developed countries. The improvement of clean energy and energy efficiency is a new economic development model that China should consider at this stage.

The "Carbon peak and neutrality" goal is a systematic change project involving all aspects through the gradual and systematic implementation of policies and the smooth implementation of policies. By starting from the top-level design and step-by-step implementation, the overall national goal can be decomposed into regional development goals step by step. The overall national economic goal can be decomposed into sub-industry goals: break down the long-term objectives into specific objectives in the short and medium-term and pay attention to the coordination and cooperation among regions, industries, short, medium, and long term.[9]

Coal should not be banned completely, and we should vigorously improve the utilization efficiency of coal. China's coal production accounts for about 50% of the world and once became the largest country in the world. In 2020, coal accounted for 57% of China's energy consumption structure and played a mainstay role in energy supply. It is expected that after the carbon peak is achieved in 2030, the proportion of coal in China's energy consumption will decline, but it will still be the most critical energy type. Therefore, improving the utilization efficiency of coal should also be put on the agenda.

While improving the utilization efficiency of coal, we should also consider the basic issue of energy security. In realizing the "Carbon peak and neutrality" goal, we need to attach great importance to energy security. At the same time, energy security cannot bypass the potential role of China's main energy - coal. China's own mature and huge coal industry should be used as the basic anchor of China's energy security. China's overall energy preparation and emergency mechanism should be established, especially retaining and storing sufficient coal production and power generation facilities.[10]

Continuously maintain the market competitiveness of non-fossil energy. A key to achieving the goal of Carbon peak and neutrality is to replace fossil energy with non-fossil energy gradually. As the development of the fossil energy industry chain has more than 200 years, its application technology is mature and has relatively obvious market competitiveness. At the same time, the pressure to achieve the dual carbon goal will also force the global demand for fossil energy to decrease, resulting in a stable or even downward trend in the price of fossil energy in the long run. Therefore, the cost of using fossil energy will maintain a certain market competitive advantage. In this case, in order to promote the vigorous use of non-fossil energy, we should increase investment and subsidies, encourage the continuous and rapid improvement of production efficiency and cost reduction of non-fossil energy, so as to effectively promote the replacement of fossil energy and achieve the Carbon peak and neutrality goal.

6. CONCLUSION

With the continuous development and expansion of the automobile industry in recent years, the sales volume has maintained the global forefront. China's auto market still has room for sustainable development and total vehicle volume improvement. After setting the goal of "dual carbon", The development of China's automobile industry will inevitably move towards the route of a low-carbon economy.

In this paper, the quantitative part from a new perspective, starting from the automobile inventory data, using DID model for analysis. In the qualitative part, the inventory data of automobile enterprises are analyzed and studied as a direct database, and the future development of the automobile industry is forecasted and suggested.

Through secondary data such as industry reports and literature, this paper discusses the impact of the Carbon peak and policy on the automobile industry. Because of the lack of first-hand data, we can conduct field research and issue questionnaires to investigate the automobile industry data in the future so that the analysis results will be more real and reliable.

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