Research on the Heterogeneous impacts of Dual-credit Policy on the Innovation Performance of Upstream, Midstream and Downstream Enterprises of New Energy Vehicles Energy Vehicles

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Abstract. Taking 55 A-share listed enterprises of new energy vehicle as the research object, this paper analyzes the disparity of the influence of dual-credit policy on the innovation performance of the upstream, midstream and downstream enterprises by using the Interrupted Time Series Method. The results show that, there is disparity in the influence of the dual-credit policy on the innovation performance of upstream, midstream and downstream enterprises of NEVs. There also exists disparity in the influence of the dual-credit policy on the pure technical efficiency, scale efficiency and comprehensive efficiency of innovation performance. The dual-credit policy should formulate corresponding innovation assessment rules for upstream and midstream enterprises and give corresponding support measures to midstream enterprises. In addition, relevant promotion policies should be implemented, such as accelerating the construction of charging piles. Enterprises should also continuously improve their own capabilities to gain competitive advantages in the market.

Keywords: Dual-credit policy; New energy vehicles; Innovation performance; Industry chain

1 Introduction

With the drawbacks of the subsidy policy of the new energy automobile industry becoming more prominent, the government released the dual-credit policy in 2017. While promoting the development of new energy vehicle industry, the dual-credit policy has also exposed many problems, such as insufficient promotion of new energy-saving technologies and imbalance between supply and demand of credits. The dual-credit policy needs to be revised to adapt to the new energy vehicle industry, so it is of great significance to study the implementation effect and influence path of the policy[1]. The Development Plan for New Energy Vehicle Industry (2021-2035) proposes to improve the technological innovation level of new energy vehicle enterprises and realize the division of labor and benefit sharing among enterprises in the industry chain. Therefore, it is of strong practical significance to study the impacts of the dual-credit policy on the

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innovation performance of new energy vehicle enterprises. At the same time, the study of the differential impacts of the dual-credit policy on the innovation performance of enterprises in the industry chain can also further adjust the dual-credit policy.

At present, there are different views in foreign studies on the impacts of the credits management policy on automobile enterprises, and some scholars believe that the credits management policy can promote the innovation of automobile enterprises[5,6]. However, there are still some scholars who believe that there are flaws in the implementation of ZEV credits policy[7,8]. The research on the impacts of dual-credit policy on new energy vehicle enterprises in domestic studies mainly includes: the impacts of dual-credit policy on new energy vehicle downstream enterprises[1,2,3,4], the problems in the industrial chain of new energy vehicles[9,10], and the synergy between the dual-credit policy and other policies.[11] By combing the relevant literature, this paper finds that scholars pay more attention to the downstream enterprises in the research on the impacts of dual-credit policy on new energy vehicle enterprises, and seldom mention the upstream and midstream vehicle enterprises. Moreover, there are relatively few studies on the impacts of the dual-credit policy on the innovation performance of new energy vehicle enterprises. The number of applied patents are mostly used to measure innovation performance[12], without comprehensively considering the innovation input and output. Therefore, this paper selects the upstream, midstream and downstream enterprises in China's new energy automobile industry during the period of 2010-2021 as the research object to study the differential impacts of the dual-credit policy on the innovation performance of the upstream, midstream and downstream enterprises in the new energy industry.

Considering that the dual-credit policy is directly applied to the downstream enterprises of new energy vehicles as well as the differences among the enterprises in the new energy vehicle industry chain[3], This paper puts forward the hypothesis that there is disparity in the impacts of the dual-credit policy on the upstream, midstream and downstream enterprises of new energy vehicles.

2 Model and data description

2.1 Data sample

The enterprise data used in this paper comes from Wind database and CNRDS database. Data of 55 A-share listed companies of new energy vehicles from 2010 to 2021 are selected in this paper.

2.2 Interrupted Time Series Regression Model

In this paper, we construct a segmented regression model for interrupted time series, while taking into account the existence of lag effects in policy, which is expressed as:

$$Y_{ij,t} = \beta_{0j} + \beta_1 time + \beta_2 X_{2016} + \beta_3 L.\text{policy} + \beta_4 Xt_{2016} + \text{Control}_{it} + \varepsilon_{it} \quad (1)$$

In equation (1), Yij,t is the type j of innovation performance of the i new energy automobile enterprise at time t. Controlit is the control variable and εit is the error term.

The coefficientβ1 is the level of change in innovation performance of new energy vehicle enterprises before the policy implementation; the coefficientβ2 is the level of change in innovation performance of enterprises after the policy implementation; the coefficientβ3 is the level of change in innovation performance of enterprises one period after the policy implementation lag; and the coefficientβ4 is the tendency of the change in innovation performance of enterprises before and after the policy implementation.

2.3 Variable selection

Explanatory variables: time denotes the time point t from 2010; X_{2016} denotes whether the dual-credit policy is implemented or not, taking the value of 0 or 1; L.policy denotes the lagged effect of the policy; X_{t2016} denotes the time after the policy is implemented.

Explained variable: innovation performance. This paper chooses the DEA-BCC model to assess the innovation performance of new energy vehicle enterprises, and the output indicators in the model are intangible asset scale and patent numbers. The input indicators are R&D expenditure and R&D investment intensity.

Control variables: this paper refers to other scholars to include government grants and tax incentives as control variables external to the enterprise[1]. In addition, considering the internal operation of the enterprise will also affect the innovation performance of the enterprise. Therefore, this paper includes the enterprise's operating income, enterprise size, profitability, asset-liability ratio, property right nature, and enterprise age into the internal control variables.

3 Empirical results and analytical discussion

3.1 Descriptive statistical results

Outliers were handled prior to descriptive statistics (samples that were below the 1% and above the 99% were replaced with threshold values) to avoid the effect of extreme values. The results of descriptive statistics in this paper are shown in Table 1. In order to ensure the smoothness of the data to make the estimation results more convincing, this paper also uses the LLC, IPS, Fisher-PP and ADF tests, and the panel data are basically significant at the 1% level after the test, therefore, the panel data are all smooth data.

Table 1. Descriptive statistics results

Variable	Size	average	variance	min	max
RDexp	490	19.156	1.652	13.969	23.748
Strength	490	.052	.037	0	.356
Patent Apply	490	4.547	1.597	1.163	7.847
Intang assets	490	19.656	1.665	14.108	23.563
OE	490	.739	.074	.513	1
VE	490	.787	.07	.65	1

SE	490	.939	.041	.709	1
Etr	490	17.513	2.21	10.513	21.478
Subs	490	17.516	1.811	12.612	21.789
Re	490	22.334	1.653	18.974	27.218
Kg	490	.286	.452	0	1
Fz	490	49.408	19.533	7.976	95.605
Size	490	22.916	1.429	20.253	26.961
Gpr	490	21.112	11.394	-14.033	55.494
Sj	490	11.033	7.036	1	26

3.2 Analysis of the impacts of the dual-credit policy on the Heterogeneity of Innovation Performance of Overall New Energy Vehicle Upstream, Midstream and Downstream Enterprises

Table 2. Heterogeneity analysis of interrupted time series analysis

	Upstream			Midstream			Downstream		
Variables	**TE**	**SE**	**OE**	**TE**	**SE**	**OE**	**TE**	**SE**	**OE**
_t	0.002	-0.001	-0.004*	-0.003	0.004**	0.001	0.003	0.002	0.004*
	(0.440)	(-0.128)	(-1.706)	(-0.985)	(2.367)	(0.734)	(1.246)	(1.257)	(1.783)
_x2016	0.027***	0.034***	0.061***	0.042***	0.024***	0.061***	0.041***	0.031***	0.064***
	(4.830)	(3.007)	(6.746)	(7.809)	(3.950)	(7.915)	(3.591)	(5.537)	(5.590)
_x_t2016	-0.003	0.003	0.002	0.001	-0.005**	-0.004	0.001	-0.010***	-0.006*
	(-1.347)	(0.825)	(0.634)	(0.665)	(-2.429)	(-1.490)	(0.214)	(-4.910)	(-1.790)
L. Policy	0.039***	0.016	0.049***	0.028***	0.026***	0.048***	0.039***	0.032***	0.063***
	(7.321)	(1.335)	(4.757)	(5.945)	(4.463)	(5.992)	(3.103)	(5.424)	(4.706)
Etr	-0.002**	0.011***	0.006***	-0.011***	0.003**	-0.005***	0.007***	-0.001	0.004***
	(-1.989)	(4.975)	(4.937)	(-9.564)	(2.528)	(-2.760)	(3.316)	(-0.465)	(2.617)
Subs	0.000	0.004**	0.010***	-0.006***	-0.001	0.009***	0.008***	0.001	0.010***
	(0.116)	(2.384)	(10.932)	(-3.403)	(-0.325)	(4.716)	(3.726)	(1.050)	(6.911)
Re	-0.006	-0.015	-0.013**	-0.012***	-0.002	-0.020***	-0.013*	-0.004	-0.011*

	(-1.143)	(-1.490)	(-2.339)	(-2.674)	(-0.349)	(-3.051)	(-1.663)	(-0.820)	(-1.828)
Kg	-0.017	0.019	-0.011				0.003	0.012*	0.009*
	(-0.521)	(0.558)	(-0.811)				(0.305)	(1.687)	(1.843)
Fz	0.000	-0.001**	0.000	-0.001***	0.000**	0.000	-0.000*	-0.000	-0.000
	(0.937)	(-2.434)	(0.015)	(-3.529)	(2.286)	(0.353)	(-1.793)	(-0.449)	(-1.641)
Size	0.001	0.030***	0.010	0.035***	-0.008	0.015**	0.020**	-0.014**	0.003
	(0.121)	(2.584)	(1.467)	(6.994)	(-1.500)	(2.106)	(2.079)	(-2.300)	(0.464)
Gpr	-0.000	0.000	0.000	-0.001***	0.001***	-0.001**	-0.000	0.000	-0.000
	(-0.900)	(0.059)	(1.068)	(-5.279)	(4.769)	(-2.195)	(-0.777)	(1.192)	(-0.497)
Sj	-0.001	0.000	0.001	0.002	-0.000	0.000	-0.000	0.000	-0.000
	(-0.136)	(0.033)	(0.900)	(0.815)	(-0.124)	(0.057)	(-0.569)	(0.574)	(-0.728)
Constant	1.035***	-0.814***	-0.777***	1.793***	0.847***	0.357**	-0.809***	1.224***	-0.534***
	(7.276)	(-4.122)	(-8.001)	(11.705)	(6.363)	(2.411)	(-5.895)	(11.541)	(-6.338)
Observations	101	101	101	155	155	155	171	171	171
Number of CompanyID	14	14	14	20	20	20	20	20	20

Note: ① *** p<0.1, ** p<0.05, * p<0.1, t-statistic values in parentheses; ② Yue Bo Power time series discontinuity can not participate in the regression, so the number of enterprises in the upstream enterprise data results in the number of enterprises is 14; ③ property rights nature of the variable in the middle of the river because of the problem of covariance was removed by automatic omission.

From the **Tab. 2**, we can see the outcome. The heterogeneity test is mainly conducted by group regression to regression analysis of new energy upstream, midstream and downstream enterprises respectively. By comparing the policy impacts coefficients of upstream, midstream and downstream enterprises, it can be concluded that the dual-credit policy has the greatest impacts on the innovation performance of the downstream enterprises of new energy vehicles, followed by the midstream enterprises, and finally the upstream enterprises. The relatively large difference between the policy impacts coefficients of upstream and downstream enterprises reflects that there are large differences in the impacts of the dual-credit policy on the innovative performance of each enterprise in the new energy industry chain link, which proves that the hypothesis is valid.

From the perspective of pure technical efficiency of innovation performance, the dual-credit policy has a stronger impacts on the innovation performance of midstream and downstream enterprises of new energy vehicles, and a weaker impacts on the innovation performance of upstream enterprises. In addition, by observing the impacts coefficients of government subsidies and tax incentives, it can be seen that the dual-credit policy will help to overcome the shortcomings of government subsidies and tax incentives that are difficult to improve the level of industrial technological development, and stimulate new energy vehicle enterprises to innovate.

From the perspective of scale efficiency of innovation performance, the coefficients of the impacts of the dual-credit policy on the innovation performance of midstream and downstream enterprises are positive, and all of them are significant at the 1% confidence level. Meanwhile, combined with the descriptive statistics, the innovation scale efficiency values of midstream and downstream enterprises are all less than 1, which also indicates that the innovation scale efficiency of enterprises is in the stage of increasing returns to scale. Therefore, the implementation of the dual-credit policy is favorable to the midstream and downstream enterprises to improve the innovation scale efficiency, and the enterprises can increase the efficiency by expanding the innovation scale.

From the perspective of comprehensive efficiency of innovation performance, the impacts of dual-credit policy on automobile performance of upstream, midstream and downstream enterprises are all significantly positive, and the difference of the impacts on enterprises on the industrial chain in the period of policy implementation is smaller, which indicates that the impacts on innovation performance of all enterprises on the industrial chain in the period of policy implementation is more synchronized. By observing the trend of innovation performance of enterprises before and after the implementation of the policy, the dual-credit policy has a negative impacts on the innovation performance of upstream, midstream and downstream enterprises. These effects can be attributed to the policy environment. In recent years, the government has continuously adjusted the policies and policy tools of the new energy automobile industry, and the subsidy slopes have reduced the innovation initiative of new energy vehicle enterprises. The follow-up role of the dual-credit policy needs to be further refined and improved.

3.3 Robustness Tests

In order to investigate the stability of the findings of this paper, this paper uses four methods to conduct robustness tests, namely, the variable substitution method, adjusting sample period, introducing the lagged period of the explanatory variables, and adding two control variables. Finally, the direction of the coefficients of the key variables remains unchanged after the change. The significance is still established and is consistent with the previous conclusions.

4 Conclusions

4.1 Main conclusions

1. The dual-credit policy is conducive to improving the innovation performance of new energy vehicle enterprises as a whole, and there is a lag effect in the impacts of the policy.

2. The impacts of the dual-credit policy on the innovation performance of upstream, midstream and downstream enterprises of new energy vehicles varies and is highly differentiated. Specifically, the dual-credit policy has the greatest impacts on the innovation performance of downstream enterprises of new energy vehicles, followed by midstream enterprises, and finally upstream enterprises.

3. There are differential impacts of the dual-credit policy on the pure technical efficiency, scale efficiency, and comprehensive efficiency of the innovation performance of upstream, midstream, and downstream enterprises of new energy vehicles.

4.2 Recommendations

1. The government should consider the differences in the impacts of the dual-credit policy on enterprises in the new energy automobile industry chain, and formulate relevant regulations on innovation assessment for upstream enterprises. Secondly, the innovation performance of midstream enterprises is weakly affected by the dual-credit policy, and the government should consider improving the technological innovation capability of midstream enterprises. Finally, for downstream enterprises, the government should take into account the situation of the credits trading market, constantly adjusting the credits compliance value and carry-over ratio, controlling the credits trading price within a reasonable range and standardizing the credits trading process.

2. The dual-credit policy should be supplemented by other relevant policies. First, the government needs to accelerate the construction of charging piles for new energy vehicles. Secondly, it should fully implement preferential policies for parking, charging and highway toll reduction for new energy vehicles. Finally, the government can also consider setting up a credits storage and loan mechanism in the dual-credit trading market, giving car companies more flexible ways to trade credits.

3. New energy vehicle enterprises should also continue to improve themselves. Firstly, new energy vehicle enterprises should continuously adjust and optimize their innovation input and output structure. Secondly, new energy vehicle enterprises should improve their resource allocation capacity and resource utilization efficiency, and gradually improve the level of innovation output under the established innovation input.

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