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The regional economic impacts of NEV development

Guangdong Province, China

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Abstract: Environmental issues have become a major concern for all over the world. In recent years, various developments in the field of new energy have been greatly supported to reduce carbon emissions and environmental pollution. Based on the background of the rapid development of the new energy vehicle industry in China since 2017, this study explores how the development of New Energy Vehicles affects regional economic changes in Guangdong Province, China, by collecting data from 11 categories in this region between 2017 and 2021, while standardizing the setup of these data and applying econometric modeling and data analysis methods. The data and results proved the hypothesis proposed in this study that the development of the NEV industry will promote regional economic progress. This provides an important argument for the introduction of the new energy vehicle industry to promote economic development in less developed regions and also bridges the gap of past research on this area. However, like some of the past studies in this area, the results and research process of this study are limited by the constraints of regional short-term data, so it is hoped that a richer data panel will complement the findings of this study in the future.

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List of Abbreviations

CAAM - China Association of Automobile Manufacturers

CAS - Chinese Academy of Sciences

ECI - Economic Composite Index

GDP - Gross domestic product

HDI - Human Development Index

MIIT - Ministry of Industry and Information Technology

NBS - National Bureau of Statistics of China

NCI - New Energy Vehicle Composite Index

NDRC - National Development and Reform Commission

NEV - New Energy Vehicle

PEV - Pure Electric Vehicle

R&D - Research & Development

TIITB - Tianjin Industrial and Information Technology Bureau

UN – United Nations

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1. Introduction

1.1 Background

In recent years, with the continuous development and advancement of human industry, a large amount of greenhouse gases has been emitted as a result of human activities, and the rate of climate change is more rapid than ever before. The main cause of climate change is the burning of fossil fuels such as coal, oil, and gas (United Nations). As the urgency of the knock-on effects of climate change and the energy crisis grows ever more acute, the United Nations has included addressing climate issues as one of its sustainable development goals. At the same time, governments around the world are actively looking for clean energy alternatives. Among them, the rapid rise of the new energy vehicle industry in the last decade has brought about significant changes in the global automotive industry, while also actively promoting aspects such as environmentally friendly travel and energy technology advancement (Zimm, 2021). The new energy vehicle (NEV) industry, powered primarily by electric and hybrid technologies, offers a key way to reduce carbon emissions and ameliorate climate change. The industry's unprecedented innovation is attracting a great deal of attention.

The impact of the rapid development of the new energy vehicle industry covers many aspects. In addition to the environmental benefits of reducing carbon emissions and improving air quality, a World Bank report noted that the new energy vehicle industry can also have a significant economic impact, particularly in developing countries (World Bank, 2022). Expanding on this, intra-industry production and distribution can stimulate future economic growth, create jobs, attract investment, and drive technological innovation. In addition, some of the literature suggests that the sectoral chain reaction could extend to more relevant areas such as battery manufacturing, charging infrastructure, digital technology, and so on. The interconnectedness of these sectors can also provide very comprehensive coverage of developments and have far-reaching impacts on the regional economy.

As the largest industrialized economy and the world's largest carbon emitter, China has been actively seeking and adopting policies to reduce its carbon emissions, while also striving to develop a sustainable economy (Chinese government, 2021). As proposed by the Chinese government at the 75th session of the United Nations General Assembly, the "dual carbon goal" is to achieve a carbon peak by 2030 and carbon neutrality by 2060. Focusing on the development of the new energy vehicle industry is one of the most important ways to achieve the "dual carbon goals" (Yang and Ge, 2022). Therefore, China has introduced a large number of policies to promote the development of the new energy vehicle industry (Zhang, Ma, & Yong, 2019). China has now become the world's largest producer and seller of new energy vehicles, and based on statistics from recent years it can be found to be a world leader in the

areas of production, sales, and technological development. This shift towards promoting new energy vehicles is not only a direct response to environmental demands but also an attempt to secure a position of strength in the global economic order.

However, due to the rapid development of the new energy vehicle industry is currently in its early stages, academic research on new energy vehicles is still lacking to a certain extent in many perspectives. More attention has been paid to the environmental aspects of the new energy vehicle industry, with a large number of studies discussing the role of new energy vehicles in reducing emissions. In the field of economic development, most studies focus on the impact of changes in the job market and new government policies on various industries. However, many of these studies are too large in scope and too general in terms of the regions and industries involved and do not explore in detail the economic benefits brought about by the rapid development of this new industry. In addition, the data used in some of the literature is also relatively old, with some of the data taken as of 2018 and some as of 2019. However, China's production and sales of new energy vehicles appear to have increased significantly from 17,500 and 17,600 units in 2013 to more than one million units in 2018. But in fact, the production and sales figures exploded from 2020 onwards.

In 2020, China's new energy vehicle production and sales amounted to 1,366,000 and 1,367,000 units (NDRC, 2021). The figures are 3,545,000 and 3,521,000 units in 2021 respectively (TIITB, 2022). By 2022, China's new energy vehicle production exceeded 7 million units, while sales reached 6.887 million units (NDRC, 2023). At the same time, industries related to new energy vehicles are also developing rapidly. According to statistics, the registration of new energy vehicle-related enterprises jumped from 43,000 in 2019 to 172,700 in 2021 and reached 243,000 in 2022 (MIIT, 2023). Therefore, there is still a certain degree of research gap regarding the impact of the rapid development of the new energy vehicle industry in recent years.

1.2 Research Question

Although the new energy vehicle industry has gained a great deal of attention, and existing research has explored many aspects of the new energy vehicle industry, there is still limited understanding of the specific economic impacts of the rapid development of the industry, particularly at the regional economic level.

Therefore, the research topic of this study is:

Whether the rapid development of the new energy vehicle industry will have a significant impact on regional economic development and planning.

This study aims to empirically test this proposition from multiple perspectives in the context of China, focusing on regions where the new energy vehicle industry is well developed and concentrated. Therefore, Guangdong Province in China will be chosen as the focus area of this study. It should be explained that Guangdong Province in China is chosen mainly because it ranks first in China in terms of both economic size and population size. At the same time, Guangdong Province is also one of the best regions in China for the development of the new energy vehicle industry. In addition, as an economically developed coastal city, its economic diversification and inclusiveness are also important advantages for the future development of the emerging field.

1.3 Research Purpose

As the new energy automobile industry is in the early stage of development all over the world. However, it has received a great deal of attention for the use of new energy sources and for the development of new technologies to advance the traditional automotive industry. At the same time, the development of this industry involves knowledge and technological advances in many high-tech fields, while its potential sustainability offers many opportunities to address labor employment, traditional industrial transformation, and environmental concerns. In addition, this study is of great significance from a policy perspective. It helps governments understand the economic impact of the new energy vehicle industry and provides important insights for improving industrial policies, employment programs, and regional development strategies. By comprehensively analyzing the impact of the new energy vehicle industry on the regional economy, this study can also help provide a strong, evidence-based case base for other sectors of the new energy industry. Meanwhile, it will give governments a broader perspective on policymaking to address environmental issues.

At the same time, from an academic perspective, this study contributes to the existing literature on the economic impact of the new energy sector. Much of the literature focuses mainly on new energy generation such as wind and solar. And drawing research in new energy towards the new energy vehicle industry, could fill the current research gap in this rapidly growing sector and provide insights into the economic impact of the emerging industry. In addition, understanding the economic impact of the new energy vehicle industry could provide valuable lessons as many countries endeavor to reduce carbon emissions and promote sustainable growth. Although this study is China-focused, its findings can contribute to global discussions on clean energy, sustainable development, and green economy, and can provide a research template for countries or regions that are developing new energy vehicle industries, both in terms of potential impacts on regional economic development and the technological and knowledge advances they bring, which can lead to empirical analysis for socio-economic development.

1.4 Thesis Outline

The remainder of this paper will consist of Chapter 2, which reviews and analyses the existing relevant literature, including previous studies on the current state of China's new energy vehicle industry, the current state of economic and industrial development in China's Guangdong Province, and the relationship between the industry and the regional economy. Chapter 3 introduces the theoretical analysis framework that will be used in this study and explains the applicability of the theory to this study. Chapter 4 will describe the design of the study, the collection of data types, and the use of the methodology. The chapter 5 will present and explain the analytical process and the findings of the analysis, as well as the limitations of the process. The final section will summarize the full paper and make appropriate recommendations for further research on the relevant elements in the future.

2. Literature Review

2.1 China's new energy vehicle industry

2.1.1 Overview

As the world's largest import and export trading country, China has ranked first in the world in terms of automobile production and sales for 14 consecutive years (MIIT, 2023). Among them, China's new energy vehicle (NEV) industry has seen rapid development in recent years. In China, NEVs mainly include pure electric vehicles (PEVs), plug-in hybrid (including add-on) vehicles, and fuel cell vehicles (MIIT, 2020). With the growing concern for climate issues around the world, the new energy vehicle industry has received extra attention around the world. Many policies and capital from governments have been gradually invested in this field. Especially in the past 10 years or so, China's new energy vehicle industry has seen unprecedented rapid development.

In 2009, the Chinese government launched the "Ten Cities, One Thousand Vehicles Project", which started the development of new energy vehicles in China. The program aimed to launch 1,000 new energy vehicles in each of the 10 cities in a short period, year by year, through substantial government financial subsidies (MIIT, 2013). According to data from the end of 2012, the 25 cities in the initial phase of policy promotion had an average of 1,096 new energy vehicles per city. It seems that this data has completed the government's expectations, but after checking the data, according to the policy to get the promotion of most of the new energy vehicles is more concentrated in Beijing, Shenzhen, and Hangzhou and a few large-scale cities, many cities with new energy vehicles and the expected plan is far from, for example, in the city of Tangshan at that time, the new energy vehicle ownership is less than 50 units. So the new energy vehicle industry in the Chinese market is very difficult in the

early stage of development. In 2013, China's new energy vehicle production was 17,500 units and 17,600 units. In comparison, in the United States and Europe during the same period, the sales of new energy vehicles reached 96,000 units and 74,000 units respectively (MIIT, 2023). As a result, sales of new energy vehicles in China are insignificant compared to the country's huge economic market and spending power. One of the biggest obstacles to this situation is consumer concerns about charging facilities. According to statistics, by the end of 2013, the Chinese government had built only 400 charging stations, while the United States had more than 20,000 charging stations in the same year. As a result, this lack of convenience makes traditional fuel vehicles the preferred choice for the Chinese consumer market. But China's dismal production and sales of new energy vehicles began to change the following year.

In 2014, the government continued to promote related policies and subsidies. At the same time, Tesla Motors, a U.S.-based new-energy vehicle company, began to enter the Chinese market and proposed to build a manufacturing plant in China. In addition, the Chinese government also strengthened the construction and promotion of charging infrastructure. With the combination of the above factors, China's new energy vehicle production and sales volume in 2014 were 78,500 and 74,800 respectively, an increase of more than 400% compared with the previous year. The number of registrations of companies related to the new energy vehicle industry also doubled to 10,100 (MIIT, 2023). And with the government's broader push for related policies and subsidies, coupled with the rapid establishment and development of various industries related to new energy vehicles, China's new energy vehicle production and sales volume both exceeded 1 million units in 2018. By 2021, production and sales reached 3.545 million units and 3.521 million units. This figure even reached 7.058 million and 6.887 million units by the end of 2022. This figure has exceeded 60% of the global market share in 2022. At the same time, the number of new energy vehicle-related enterprise registrations has reached nearly 250,000 (MIIT, 2023). As a result, China has the world's largest share of new energy vehicles and is also the largest producer and seller of new energy vehicles.

2.1.2 Relevant Policies and Regulations

According to the production and sales figures of new energy vehicles in China, the new energy vehicle industry has achieved unprecedented rapid development in about 10 years, and the industry's development has already achieved certain results. One of the most important factors contributing to the success of the new energy vehicle industry in China is the Chinese government's continuous promotion of related policies and subsidies. The Chinese government has implemented subsidies or purchase tax exemptions in various regions through annual central financial subsidies, in addition to subsidies for charging infrastructure and exemptions from traffic restrictions by some local governments. These supports have provided a very significant boost to the new energy vehicle industry (Lin & Wu, 2017).

The Chinese government's policy planning for the new energy vehicle industry can be traced back to the early 21st century. In 2009, China's Ministry of Finance, Ministry of Science and Technology, Development and Reform Commission, and Ministry of Industry and Information held a conference in Beijing on the promotion of new energy vehicles on a pilot basis, and for the first time listed the new energy vehicle industry as a development goal. The following year, the new energy vehicle industry was clearly defined as a strategic emerging industry (Zhang, Ma, & Yong, 2019). Since then, the Chinese government has implemented a series of policy promotion frameworks to support and promote the development of the new energy vehicle industry. Within this policy framework, it can be divided into two main areas:

- direct policy support

The Chinese government has issued dozens of policies on the development of the new energy vehicle industry over the past 10 years or so. Among them, more than 20 government departments and dozens of levels of development are involved. These policies contain for example:

The "Ten Cities, One Thousand Vehicles" project in 2009.
The New Energy Vehicle Industry Development Plan (2012-2020) in 2012.
The “Made in China 2025” in 2015
The " Dual-Credit" policy in 2017.
The New Energy Vehicle Industry Development Plan (2021-2035) in 2020.

- Policy-relevant subsidies and incentives:

In addition to the direct promulgation of policies, the government also provides financial subsidies and non-monetary incentives to the new energy vehicle industry.

First, the government has implemented a series of policies on vehicle purchase subsidies. These purchase subsidies not only directly subsidize the manufacturers of new energy vehicles, but also reduce the purchase tax for consumers. These subsidies have greatly boosted market supply and demand, which has been a key factor in the rapid growth of new energy vehicle production and sales in the Chinese market year after year. In addition, these subsidies have greatly reduced the human and material capital associated with production Research and development (R&D) for new energy vehicle manufacturers, which has promoted industrial development and technological innovation (MIIT, 2023).

Second, many non-monetary forms of incentives have also been implemented. For example, in some cities with a large population base, vehicle purchases are limited by the number of vehicles photographed. But owners of new energy vehicles will not be affected in this regard. In addition, the establishment and promotion of some vehicle charging infrastructures are also heavily subsidized and incentivized (MIIT, 2023).

In summary, the Chinese government has enacted a series of policies and regulations to promote the development of the new energy vehicle industry, ranging from direct financial incentives to regulations that create a favorable environment for the adoption of new energy vehicles. These policies have greatly contributed to the rapid development and success of China's new energy vehicle industry.

2.2 Guangdong Province, China

Guangdong Province in China is located in the southern coastal region of China, with Guangzhou as its capital. It was the first province in China to realize foreign trade and introduce Western culture and technology under the "reform and opening up" policy introduced by the Chinese government in the last century and has since been one of the largest in China. Since then, the province has been one of the largest in China, with a GDP of 129,118,858,000,000 Yuan in 2022, ranking first in China for the 33rd consecutive year (Guangdong Government, 2023).

Guangdong Province's economy is due to its coastal location. In 2022, the province's total import and export trade value was 8.31 trillion yuan, ranking first in China for 37 consecutive years. At the same time, Guangdong Province has become China's most important manufacturing base and import/export trade center, driven by the Chinese government's "Pearl River Delta Economic Zone" policy. In February 2023, the Guangdong Provincial Department of Commerce released a report on the region's top ten strategic pillar industries and top ten strategic emerging industries It can be seen that the provincial government is constantly transforming and upgrading the region's economic structure. As a result, the development of high-tech and emerging industries has been heavily favored. The new energy vehicle (NEV) industry has become one of the top ten strategic pillar industries in the region (Guangdong Government, 2020).

Development of NEV Industry in Guangdong Province

In 2022, Guangdong province produced more than 1.3 million new energy vehicles, a year-on-year increase of 140 percent, accounting for about one-fifth of the country's total output. As the region with the largest automobile production and sales in China, Guangdong is home to two automakers, BYD and GAC, as well as leading companies in the new energy vehicle industry, whose annual revenue together exceeds nearly 900 billion yuan. At the same time, the region is also home to new forces in new energy vehicles such as Xiaopeng and Huawei Automobile (MIIT, 2023).

In addition, Guangdong Province has many supply chain industries related to new energy vehicles.

In terms of lithium batteries (including energy storage batteries), Guangdong Province has dozens of related enterprises. These include lithium battery companies with annual revenues of tens of billions of yuan, such as Brunp Recycle, GEM, and BTR.

In addition, CATL, the world's leading battery maker, is also cooperating with local automakers in Guangdong, such as BYD, to provide high-quality batteries for new energy vehicles (MIIT, 2023).

In terms of charging infrastructure, as of September 2022, Guangdong Province has the largest charging network for new energy vehicles in China. It contains about 350,000 public charging posts and about 20,000 charging stations. This is three times the number of public charging piles in the entire United States. While the Guangdong government continues to invest in expanding the charging infrastructure for new energy vehicles, it also provides subsidies to public organizations and individuals for the construction of charging stations. The convenient charging environment has greatly contributed to the development of new energy vehicles and related industries (MIIT, 2023).

In terms of Research and Development, Guangdong is an important center for R&D in China's new energy vehicle industry. Leading universities and institutions such as the South China University of Technology and the Guangdong Energy Research Institute are deeply involved in research projects aimed at advancing new energy vehicle technology. This, coupled with the province's strength in information technology and electronics, makes it a leader in areas such as autonomous driving and connected car technology (MIIT, 2023).

Impact on related industries

The rapid development of Guangdong's new energy vehicle industry has had a knock-on effect on many related industries. A report from the securities industry shows that the rapid development of the new energy vehicle industry is demonstrating demand for metals such as lithium, cobalt, and nickel, which are key components in the production of batteries. Meanwhile, the logistics industry is also benefiting from the development of the new energy vehicle industry, with more and more logistics companies opting for electric vans and trucks to reduce costs and avoid carbon emissions. In addition, the development of the new energy vehicle industry has led to the development of the province's software strength and data analysis industry. Modern electric vehicles are equipped with many sensors and electronic control units that generate large amounts of data (She et al., 2019). This has opened the way for software companies to develop applications that can interpret this data to improve vehicle performance and user experience. In addition, as the sales of new energy vehicles grow year on year, the related service industry is also developing vigorously as a result.

In summary, the development of Guangdong's new energy vehicle industry is very closely integrated with the province's economic situation. The implementation of relevant government policies and the continuous progress of technology has not only made Guangdong an important participant in China's new energy vehicle industry but

also driven the development of related industries and stimulated the development of the regional economy.

2.3 Previous research on the NEV industry

The NEV industry, as a rapidly developing emerging industry in recent years, has received very great attention.

From the perspective of regional economic development, most of the new energy vehicle enterprises are established in the newly developed areas of various cities, which contain many high-tech enterprises and universities, in addition, the government also provides economic policy support for these areas, which makes these areas in need of the real economy to promote the economic growth of the region. Therefore, the development of a new energy automobile industry and regional economic development are mutually beneficial (Yu and Jiang, 2020).

Meanwhile, the new energy vehicle industry is having a profound impact on the industrial and economic structure of China, which attaches great importance to the development of the industry and has introduced a large number of policies to promote the production and sales of new energy vehicles (Zhang, Ma, & Yong, 2019). The findings show that government policies, infrastructure penetration, and demographic factors are strongly associated with the sales of new energy vehicles (Wang et al., 2020). Policies, as one of the most important driving factors of economic development, can also affect regional economic development in many ways. For example, under the guidance of relevant policies, the environmental protection driven by the new energy vehicle industry can create a good ecological background for the regional economic environment Yu and Jiang, 2020). With the promotion of new energy vehicles, some studies have proved that there will be a significant change in the emissions of SO2 and NOx (Li et al., 2019). At the same time, it has been argued that appropriate government regulatory policies for the new energy vehicle industry are very favorable to the development of the industry, and that appropriate cap-and-trade regulation can provide greater impetus to green innovation (Lyu et al., 2023). From an employment perspective, the China Energy Foundation released a report in 2022 analyzing the impacts of the "electrification" transition of China's automotive industry and the employment environment. There is a wealth of existing and projected data that suggests that the number of people and types of jobs in the new energy automotive industry is expanding as the industry grows. At the same time, many vocational colleges and universities have opened an increasing variety and size of new automotive majors in recent years (CAS, 2022). These large numbers of new energy automotive industry-related labor forces with potential growth trends can undoubtedly drive the long-term development of the industry while bringing higher benefits to the regional economy. In addition to this, studies have highlighted that intelligent transformation can drive innovation in the technological development of new energy vehicle-related companies (Han, Jiang & Liu, 2023).

In addition, some studies have also shown that the maturity of new energy vehicle technology, technology judgement standards and R&D funding is one of the important factors driving the sustainable development of the new energy vehicle industry (Ren, 2018). The development of the new energy vehicle industry will also lead to the continuous progress of scientific research technology, which will become one of the important boosts for regional economic development.

2.4 Literature gaps

However, although the existing literature gives much research findings and data support the economic impacts caused by the new energy vehicle industry. However, most of the research is currently focused on the national level, with little attention paid to regional impacts. However, according to the data, a large number of new energy vehicle industries are established in more developed regions, so if less developed regions want to drive regional economic development through the introduction of investment in new energy vehicle industry and other emerging industries, the current research does not give it enough theoretical support, and there is a research gap in the theory.

In addition, because the new energy automobile industry is in the early stage of development, there is a certain degree of restriction on the data that can be collected. At the same time, according to the production and sales volume of new energy vehicles, it can be observed that from the beginning of 2017 to the present, the development of the new energy automobile industry is more rapid than in any previous period, however, a lot of literature on this aspect of the research and data review still stays in a few years ago, and the results of the analysis can no longer keep up with the speed of the new energy vehicle development in recent years. Therefore, there exists a certain degree of gap in this area.

3. Theoretical Framework

This study focuses on the topic of how the rapid development of emerging industries affects regional economic performance. The rapid development of emerging industries is often accompanied by a great deal of technological innovation and policy support. Therefore, Endogenous growth theory is undoubtedly suitable as the theoretical framework of this study.

Endogenous growth theory suggests that economic development is largely created by internal factors such as technological innovation, advances in knowledge and investment in human capital (Martin and Sunley, 1998). The theory emphasizes the importance of these internal factors in driving economic development, which is different from the neoclassical growth theory which argues that external factors make

economic growth. In some studies, the theoretical view supported by neoclassical growth theory fails to explain how some countries grow faster than others, especially in East Asia, given similar rates of savings and investment (Krueger, 1995). In contrast, technological innovation, and investment in knowledge, which are the focus of endogenous growth theory, can explain some of the reasons for economic growth, thus compensating for the research shortcomings of neoclassical growth theory.

Endogenous growth theory is particularly suitable for exploring the impact of the new energy vehicle industry on regional economic development in this study for several key reasons.

The first is the applicability of the two theories: the core of the Endogenous Growth Theory is to attribute the causes of economic growth mainly to internal factors rather than external factors. The development of the new energy automobile industry is essentially a progression of innovation and knowledge, which is in line with the Endogenous growth theory. For example, advances in new energy vehicles, such as electric vehicles or hydrogen fuel cell vehicles, represent major innovations in vehicle drive technology. At the same time, the industry focuses on R&D for items such as power supplies and motors, a different perspective on R&D from the traditional automotive industry, which is full of knowledge and technological advancement. The rapid development of new energy vehicle technology has led to a high level of knowledge creation and innovation. Through R&D, new processes, products and applications are constantly being discovered and implemented to drive the industry forward. These technological advances can improve production efficiency, create more economic value with the same resources, and directly contribute to regional economic growth.

In addition, the importance of human capital as mentioned by the theory is one of the key perspectives applicable to this study. Although the perspective that this study focuses on is the development of the new energy vehicle industry itself, it does not involve investment in human capital such as education. But the fact is that a highly skilled and educated labor force is an important factor in driving innovation and technological progress in the industry (Martin & Sunley, 1998). Therefore, investment in education and training is critical to the growth of the industry. Increased investment in human capital contributes positively to regional economic development by increasing productivity and creating an environment conducive to sustained innovation and growth.

In addition to this, endogenous growth theory provides the concept of increasing returns to scale (List & Zhou, 2007). Unlike the traditional growth theory that assumes diminishing returns to capital. In the context of this study, the application of new knowledge and technology may lead to more efficient production processes, which increase the elasticity of returns. As the industry grows and knowledge and expertise continue to accumulate over time, the cost of production of new energy

vehicles may decline, accompanied by an increase in production, thus driving further growth in the industry and even the regional economy.

On the other hand, endogenous growth theory provides a framework for understanding the structural impact of the new energy vehicle industry on the regional economy. The development of the industry can encourage the growth of numerous related sectors, including battery production, charging infrastructure and vehicle maintenance services. This structural change can have a wide-ranging impact on regional economic development, affecting employment levels, income distribution, and even the region's more macro-level development perspective, as the continued advancement of these industries continues to provide each other with room for growth and the formation of new industrial centers. And all these factors are directly in line with the basic principles of endogenous growth theory.

Finally, the role of policy decisions on economic growth, as emphasized by endogenous growth theory, can be seen in the new energy vehicle industry, where known studies have concluded that government policy is an important factor in driving the rapid development of new energy vehicles, such as the Chinese government's policies of subsidizing car purchases and attracting new energy vehicle manufacturers to build factories in China. This can have a significant impact on the development of the industry, both from a short-term and long-term perspective. Therefore, the endogenous growth theory as a research framework can help this study to explore how these policies stimulate or inhibit the growth of the new energy vehicle industry, and thus get relevant information on how they affect regional economic development.

In summary, endogenous growth theory provides a suitable and comprehensive theoretical framework for analyzing how the development of the new energy vehicle industry affects regional economic development. Its emphasis on the roles of innovation, knowledge, human capital, incremental returns to scale, and policy decisions is highly compatible with the development characteristics of the new energy automobile industry, and therefore this theory is chosen as the analytical framework for this study.

4. Data and Method

This section will introduce the data and methodology relevant to the study and will begin with the design of the overall research process in the context of Endogenous growth theory. This will be followed by a description of the type of data selected and how it will be processed. The research methods that will be used in the analysis process are then also presented. Finally, a summary of the relevant limitations is given.

4.1 Research Design

Firstly, this study came up with a hypothesis based on Endogenous growth theory and the research topic:
The rapid development of the NEV Industry will have a positive impact on the regional economy.

To verify this hypothesis, and because Guangdong Province is currently the most developed region in China's new energy vehicle industry, the industry-related data have a very high degree of persuasiveness. Therefore, this study selects this region as the object of analysis and collects relevant data within this region. Meanwhile, since the new energy vehicle industry is in the emerging development stage in China and the world, this study sets the data collection period from 2017 to 2021 and focuses on the impact of the rapid development of the new energy vehicle industry on the regional economic development before and after the change.

In addition, this study, in the context of Endogenous growth theory, takes many indicators that can measure the performance of the regional economy as the dependent variables, and many indicators that can measure the level of development of the new energy automobile industry as the independent variables. In addition, a set of control variables are included in the study to explain the factors that may affect the independent and dependent variables. The inclusion of these variables will ensure a more nuanced isolation of the relationship between the growth of the new energy vehicle industry and the regional economy.

Meanwhile, Endogenous growth theory, the theoretical backbone of this study, provides a perspective for understanding how internal factors such as scientific and technological progress and technological innovation affect economic growth. This theory is particularly important considering the nature of the automotive industry, where innovation and technological progress are among the key drivers of its rapid growth. Therefore, in the above context, this study also develops a theory-based model, which provides a theoretical support base for the data in question. At the same time, with the help of SPSS software, the relevant variables are analyzed through multiple regression and other means, which can clearly present the relationship between the variables and also explain the strength of the impact of each variable on the regional economic development aspects.

In conclusion, the research design adopted in this paper provides a comprehensive framework for examining the impact of the development of the new energy vehicle industry on the regional economy. The use of selected relevant variables, coupled with appropriate theoretical underpinnings and data analysis methods, is expected to generate insights that contribute to the body of knowledge in this area. However, whilst this design process is a well-thought-out design, there are still some potential

limitations and therefore this study will describe and summarize the potential limitations of each component.

4.2 Data

4.2.1 Data collection

Definition of regional economic performance (dependent variable)

The purpose of this study is to measure regional economic changes, but since the performance of regional economies is diverse and complex, to measure the level of regional economic development, this study collected six different categories of data to measure the regional economy. These include GDP, GDP per capita, average wage, employment, trade surplus volume, and HDI.

Table 1: Definitional items for regional economic performance

GDP	employment
GDP per capita	trade surplus volume
average wage	HDI

However, it is important to note that the six economic development feedback data selected in the table above have different units, so to reduce the impact of different units of measurement, and to facilitate the process of analyzing the data afterwards. In this study, the data will be standardized for each category, this is to ensure that the variables in all categories are within the same range interval and to obtain meaningful combination results. The formula for data standardization is as follows:

$V = （R-M）/ d$

In this formula,
V represents the standardized transformed scores for each variable
R represents the raw data for each variable
M represents the mean of each variable
d represents the standard deviation of each variable

After standardizing these six variables, the study created a composite index that could feed back on the performance of the economy through the following formula.

Economic Composite Index（ECI） $=（W_1*V_1）+（W_2*V_2）+，…，+（W_6*V_6）$

Here,
W is the weight share of different categories

V is the standardized score for different categories of data

However, it should be noted that to avoid subjectivity in the analysis process and results, W_1-W_6 in this formula will be set to the same weight share by default.

Definition of NEV Industry development (dependent variable)

Within the theoretical framework based on Endogenous growth theory, this study collects data on relevant categories from the perspective of innovation and knowledge technology development. At the same time, it was considered that some of the categories of data might lead to potential multicollinearity problems during the ensuing multiple regression analyses. Therefore, after several screenings to remove some highly correlated data categories, the following three categories of data were identified to measure the development of the new energy vehicle industry from the perspective of technology and knowledge innovation. These include the ratio of new energy vehicle production to total vehicle production, the number of public charging piles, and the number of new energy vehicle patent applications.

Table 2: Definitional items for NEV Industry development

the ratio of NEV production to total vehicle production
the number of public charging piles
the number of new energy vehicle patent applications

At the same time, this study also makes a comprehensive determination of these three variables, adopting the same treatment process as that of the dependent variable data, and also using the data standardization formula and the composite index establishment formula, and finally arrives at the independent variable that can measure the level of development of new energy vehicles - the NEV Composite Index (NCI).

Control variables

In the process of analyzing the data for both the independent and dependent variables, it is also necessary to consider some potential factors that may affect the relationship between them. Therefore, two types of data were selected as control variables in this study. They are the total revenue of the automotive industry and the ratio of R&D investment in the automotive industry.

Table 3: Items for Control variables

the total revenue of the automotive industry
the ratio of R&D investment in the automotive industry

4.2.2 The rationality of selected variables

First, on the dependent variable.
Since regional economic changes are very macro-expression, it is necessary to make a comprehensive assessment of the development of the regional economy from multiple perspectives. In this study, GDP and GDP per capita are considered first. These two types of data are often used as indicators of regional economy and living standards. Because Guangdong Province in China has a very large population base and a high proportion of migrant workers, this study also considers the average wage to get a clearer picture of the standard of living of the average worker in the region. Regarding the acquisition of average wage data, this study evaluates the average wage values of urban non-private enterprises and private enterprises together. At the same time, the number of employed people can also provide feedback on the labor market situation in the region, and at the same time can be used as a basis for judging the productivity of the economy. In addition, this study also considers the trade surplus, of Guangdong Province, as a major production and export province, its trade volume is always in surplus, so the change of trade surplus statistics can be used as a feedback indicator of production capacity, but also indicates the competitiveness strength of the region's industries. Finally, the HDI is also considered. Although the HDI is not a direct economic measure, the three perspectives it contains can provide a more comprehensive analysis of a region's development.

Second, about the choice of independent variables.
The first perspective that this study focuses on is the ratio of new energy vehicle production to total vehicle production. Although the sales volume of new energy vehicles can provide more intuitive feedback on the changes in the development of the industry, the ratio of new energy vehicle production to total vehicle production can measure the penetration of new energy vehicles in the market. Changes in the data can provide feedback on the bias of the industry's development and the popularity of new energy vehicles, which represents more factors such as technological progress, policy stimulus, and market preference. In addition, the number of public charging piles constructed provides feedback on the market for new energy vehicles and the degree of improvement of the corresponding infrastructure facilities. A higher number of public charging piles represents a higher level of private and public sector investment, which also represents the government's support for the development of the new energy vehicle industry. Finally, this study considers the number of patent applications related to new energy vehicles. This can be used as a strong judgement indicator of the level of innovation and technological development of the new energy

vehicle industry. These patents cover a wide range of fields such as batteries, energy, charging, materials, etc., and represent the degree of development of the industry's related scientific and technological level.

In addition to this, Endogenous growth theory mentions that investment in human capital is also one of the key factors that contribute to economic development. However, this study decided not to consider collecting data related to human capital investment in this industry. Firstly, the main purpose of this study is to understand how the rapid development of the new energy automobile industry affects regional economic performance. Among other things, a large amount of information indicates that the rapid development of the new energy automobile industry is more influenced by policy investment and technological innovation. The role of human capital investment in it is not clear. Secondly, given that the new energy automobile industry is an emerging industry that has just begun to develop, a lot of relevant data is limited. At the same time, the definitional scope involved in human capital investment is too ambitious, while the measurement of this investment often involves examining factors such as industry-specific education and job training. However, these data are difficult to isolate at the provincial level. Moreover, the technical and employment training statistics involved in the new energy automobile industry are difficult to collect as a stand-alone industry, and most of the relevant data cover the automobile industry. Therefore, under these limitations, this study considers excluding human capital investment as an independent variable. It should be noted, however, that these independent variables mentioned above provide a comprehensive overview and description of the development of the new energy vehicle industry from multiple perspectives, and their impact on regional economic performance is the focus of this study. Therefore, this study considers it reasonable to exclude human capital investment from the consideration of independent variables. However, as the new energy vehicle industry will continue to mature and develop and the role of human capital may change, it is possible to explore research in this area in the future.

Finally, it is about the choice of control variables. Since the role of control variables is to measure additional variables other than the independent variable that may affect the dependent variable. Therefore, this study firstly chose the total income variable of the automobile industry, and since new energy vehicles are part of the automobile industry, it makes sense to control the impact of a wider set on regional economic development, which can help to measure the impact of new energy vehicles more accurately on economic development. In addition, the proportion of total investment in the automotive industry provides feedback on the attractiveness of the industry's development, and controlling for this variable can help to differentiate between the impact of general investment in the automotive industry and the impact of the development of new energy vehicles. Therefore, both control variables can filter out the impact of the overall huge automotive industry and the related investment intensity. It helps this study to assess the impact of the development of the new energy vehicle industry more accurately on regional economic change.

4.2.3 Data sources

All the above types of data are secondary data. Except for some data from the Chinese government and relevant research literature, data on the new energy vehicle industry and human capital, etc. are from the China Automotive Industry Yearbook and the China Urban Statistics Yearbook. Both data sources are highly authoritative. All the data come from the statistical departments of various national departments.

The China Urban Statistics Yearbook is compiled by the National Bureau of Statistics of China (NBS), a government organization directly under the State Council of China. Each year, an edition is published based on the size of each city, covering population, employment, public health, education, urban construction, and other social statistics. However, due to the size of China and the large number of cities in the country, some remote or underdeveloped areas may not be fully covered or may not be guaranteed to be completely accurate. However, this study focuses on the most developed provinces in China, so the data in this region are guaranteed to be complete and authoritative.

The China Automotive Industry Yearbook is compiled by the Ministry of Industry and Information Technology of China and the China Association of Automobile Manufacturers (CAAM). And CAAM covers all enterprises and governmental units related to the automotive industry in China. Like the City Yearbook, the Automotive Industry Yearbook is published annually in a new edition, which provides detailed information on the development of China's automotive industry, including production, sales, imports, and exports, and a wide range of data on each automotive enterprise. Over the years, this yearbook, like other kinds of yearbooks, has become one of the main reliable data sources for industries to conduct relevant research. It should be noted, however, that some of the data in the automotive industry yearbook come from the annual reports of automotive companies, so there may be a difference in the degree of scrutiny of the type of report by different companies. However, none of the automotive-related data collected in this study involves individual automotive enterprises or manufacturers, so the integrity and authority of the data can be guaranteed.

4.3 Method

In this study, quantitative research methods will be used within the framework of Endogenous growth theory to develop relevant analytical models. SPSS software is also used to execute the relevant analytical tools.

4.3.1 Model setting

In the endogenous growth theory, internal factors such as technological innovation and knowledge advancement are considered to be important factors affecting economic development. Therefore, in the setup of the model will be considered for each dependent variable expressed as a function related to the independent and control variables, thus resulting in the research model:

$$Y=a+\beta_1 X+\beta_2 C_1+\beta_3 C_2+e$$

Among them:
Y is the dependent variable (composite index of regional economic performance)
a is the Y-axis intercept
X is the independent variable (New Energy Vehicle Industry Development Measurement Index)
C_1, and C_2 are control variables
β_1, β_2, and β_3 are the coefficients of the independent variables, representing the individual regression coefficients associated with each independent and control variable
e represents the error value

It is important to explain that,
a as the Y-axis intercept represents the basic level of regional economic development
β_1, β_2, and β_3 coefficients represent the changes that may occur in the dependent and control variables when there is a one-unit change in their respective counterpart variables.
e as the error value represents the amount of random variation in Y that cannot be explained by a change in an independent variable such as X.

4.3.2 Analytical method

In this study, SPSS software will be used as a quantitative data analysis tool. This software is highly robust and at the same time can provide ease of assistance in performing complex statistical analysis processes. The SPSS software was chosen for the multiple linear regression analysis of the variables of interest mainly because it can help to describe the relationship between the dependent variable and multiple independent variables (including control variables), which can objectively measure the causal relationship between the independent variables and the dependent variable and has high predictive robustness of the results. It is also well suited to the context of the endogenous growth theory framework used in this study, which views technological change and industrial development as endogenous variables that affect economic growth.

After importing the data for each variable into SPSS and building the regression model, this study will first check the assumptions of linearity, independence, homoskedasticity, and normality, which are critical to the reliability of the regression model. If these assumptions are violated, appropriate corrective measures will be taken. Also, SPSS provides us with output containing the R-squared value, which measures the proportion of variance in the dependent variable that can be predicted from the independent variable. In addition, we will also receive the individual regression coefficients (β1, β2, and β3) and their p-values, indicating the statistical significance of each variable in the model.

The focus of attention of the study is β1, which represents the change in Y (regional economic performance) resulting from a unit change in X (development of new energy automobile industry) while other variables remain constant. The significant positive β1 verifies our hypothesis, indicating that the development of the new energy vehicle industry has a positive impact on regional economic development.

Finally, the residual or error term (e) in our model represents the difference between the actual and predicted values of the dependent variable. By analyzing this, we can understand variations in the data that our model cannot explain.

In summary, the analytical method we have chosen is to use a linear regression model in SPSS, which allows us to quantitatively measure the impact of the development of the new energy automobile industry on regional economic performance, taking into account the relevant control variables. The advantage of this method lies in its ability to provide strong support for the research hypotheses through clear explanations, reliable predictions, and applicability to the theoretical framework of the study.

4.4 Limitations

Data limitations

Firstly, as the new energy vehicle industry is in the early stage of development, it is difficult to obtain sufficient years of relevant data to support the research process. At the same time, as the new energy vehicle industry is part of the automotive industry, much data related to new energy vehicles cannot be extracted separately. Also, because of the independence of regional policies and investment norms, many of the types of data involved in measuring the new energy vehicle industry cannot necessarily be extracted in all regions.

Secondly, regarding the data extraction aspect of this study. In this study, both dependent and independent variables were standardized, and index measure formulas were constructed to replace the complexity and variety of variable types. Although

this can help in the subsequent data analysis stage, and also avoid the high similarity of some data types and some potential effects caused by different data units, the choice of data types is still subjective to a certain extent. The choice of control variables also has the same potential impact. In addition, due to the short development time of the emerging industry, it is very difficult to obtain many data types, so it is not possible to cover enough perspectives to fully analyze the research hypotheses in this study, while future research can avoid this problem based on a large amount of panel data.

Method limitations

Firstly, the method of multiple regression analysis through SPSS used in this study, although it can reveal the correlation between the variables of interest and draw conclusive inferences about the expected hypothesis. However, an absolute causal relationship cannot be fully derived from the correlations involved. In addition, the quality of analysis in this research method depends on the diversity and coverage of the data, so different types of data will probably bias the research model to varying degrees. In addition, although SPSS can be operated simply to obtain many useful analyses and data, it lacks many features such as ridge regression. This limitation may have an impact on the accuracy and completeness of the analysis process. Future research can take these perspectives and use more advanced analysis methods and more diverse data sets to avoid the occurrence of the above limitations.

5. Empirical Analysis

5.1 Analysis results

relevance analysis

After the correlation analysis of the independent variable (NCI) and the dependent variable (Regional ECI) as well as the two control variables, we get Table 4. First of all, we can see that the Pearson Correlation between the independent variable and the dependent variable is 0.981, that is to say, it shows that there is a very strong positive correlation between the two, and at the same time, the p-value is 0.003, which is much smaller than the value of 0.05, so it can be shown that the correlation is statistically significant. In addition, the Pearson Correlation between the other two control variables and the dependent variable is 0.93 and 0.948 respectively, which indicates that these two variables also have a strong positive correlation with the regional economic development index, and the p-value is less than 0.05, which indicates that the correlation is also statistically significant. The overall data can be concluded that there is a significant positive correlation between all the variables.

Table 4: Correlations

		ECI	NCI	Total revenue	investment
ECI	Pearson Correlation	1	.981**	.930*	.948*
	Sig. (2-tailed)		0.003	0.022	0.014
	N	5	5	5	5
NCI	Pearson Correlation	.981**	1	.954*	.886*
	Sig. (2-tailed)	0.003		0.012	0.046
	N	5	5	5	5
Total revenue	Pearson Correlation	.930*	.954*	1	.899*
	Sig. (2-tailed)	0.022	0.012		0.038
	N	5	5	5	5
investment	Pearson Correlation	.948*	.886*	.899*	1
	Sig. (2-tailed)	0.014	0.046	0.038	
	N	5	5	5	5

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

multiple regression analysis

Firstly, the model summary shows the first important data of the findings, the R-value is 1.000, which shows that there is a perfect positive correlation between the predictor variables of the model and the dependent variable. The R-squared value is 1. This shows that our model explains everything around the mean value of the dependent variable, i.e. the Economic Composite Index (ECI). This is supported by the fact that the adjusted R-squared value is also 1. This shows that our independent variables can perfectly predict the dependent variable even after adjusting the number of predictor variables in the model. Also, the error value of the model estimate (0.007376) is very low indicating that the prediction is very accurate.

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1	1	0.007376

a. Predictors: (Constant), investment, NCI, Total revenue

Secondly, the ANOVA table obtained from the analysis was used to analyze the differences between the group means and their associated procedures. The results of the analysis indicate that the regression model is statistically significant, as indicated by a p-value of 0.001. a p-value of <0.005 indicates that all regression coefficients are unlikely to be zero, i.e., that there are predictor variables that will affect the dependent

variable, which passes the statistical significance test. Meanwhile, the F-statistic provides another strong indication of this relationship and it can be found that F-statistic = 966386.84, this higher figure indicates that the model has a better fit to the data than the model without predictor variables and that the model has a high level of robustness in explaining the variance of the dependent variable. The importance of our model is further supported by the remaining higher figures for each of the data, which indicates that the model explains a large amount of variation in the dependent variable.

Table 6: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	157.722	3	52.574	966386.84	.001[b]
	Residual	0	1	0		
	Total	157.722	4			

a. Dependent Variable: ECI

b. Predictors: (Constant), investment, NCI, Total revenue

In addition, when focusing on the Coefficients results, the study found that:
The intercept in the model is 5.084 while the t-value is 37.441 and the Sig value is $0.017 < 0.05$.
The independent variable passed the statistical significance test with a β of 1.563, a t of 450.35, and a Sig value of $0.001 < 0.05$. This indicates that, with other factors remaining unchanged, for every unit increase in the new energy vehicle development index, the economic development index increases by 1.563 units. This result provides strong evidence for the hypothesis that the development of the new energy vehicle industry promotes regional economic development.

The standardized coefficients (Beta values) provide a measure of the contribution of each variable in the model. The New Energy Vehicle Composite Index (.902) and Total Investment (.451) have a significant positive effect on ECI, implying that these two variables have a substantial contribution to regional economic development. However, total income with a beta value of -0.337 seems to have a negative impact on ECI. This could be due to many factors, perhaps due to the shift in focus of new energy vehicles undermining the positive economic impact of the traditional automotive sector, which warrants further exploration.

The first control variable (total car revenue) passed the statistical significance test with a β of -0.003, a t of -158.776 and a Sig value of 0.004 less than 0.05. It shows that total revenue shows a statistically significant negative correlation with the economic development index. It also means that an increase of one unit in total auto income leads to a decrease of 0.003 units in the economic development index. This result seems counterintuitive since the general expectation is that an increase in gross revenues would be positively correlated with regional economic development.

However, this could be due to many factors, such as overexpansion of the automotive industry and attracting investment from other industries that are more important drivers of economic growth.

The second control variable (proportion of R&D investment) has a β of 10.481, a t of 329.027, and a Sig value of 0.002 less than 0.05, which passes the statistical significance test. This means that the proportion of R&D investment in the automobile industry shows a statistically significant positive relationship with the economic development index. And while other variables remain constant, for every unit increase in the proportion of R&D investment, the economic development index increases by 10.481 units. This result is in line with economic theory because investment usually stimulates continuous economic growth by increasing production, creating jobs, and promoting consumption.

Table 7: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.084	0.136		37.441	0.017
	NCI	1.563	0.003	0.902	450.35	0.001
	Total revenue	-0.003	0	-0.337	-158.776	0.004
	investment	10.481	0.032	0.451	329.027	0.002

a. Dependent Variable: ECI

In summary, this study provides strong evidence for the hypothesis that the rapid development of the new energy vehicle industry promotes regional economic development. It illustrates a strong and highly significant relationship between the development of new energy vehicles, total investment in the automotive industry, and regional economic development.

5.2 Limitation

Although the conclusions drawn support the hypotheses presented above and provide insights and measures of the impact of new energy vehicle development on regional economic development, there are some potential limitations in the results of the analysis that need to be considered, which may play a role in the general applicability of the study's findings.

First, the R-squared and adjusted R-squared values are 1. Such a perfect positive correlation also signals the possibility of overfitting. Overfitting occurs when the model is too complex, such as having too many parameters relative to the number of observations, overfitting occurs. This may indicate that we may have inadvertently merged noise from the data into our model rather than the true underlying pattern.

Therefore, future research could prevent potential overfitting and ensure the generalizability of the model through further analyses or the use of other more relevant data.

Second, the negative correlation between gross motor vehicle income and the dependent variable suggests that increases in gross income tend to lead to decreases in measures of economic development. This result seems counterintuitive, as the general expectation for this is often a positive correlation. However, this anomaly could be due to many factors, in addition to those mentioned above. It could also be due to the potential impact of the definition of the ECI or the fact that the model may include confounding variables or unforeseen industry dynamics that were not accounted for. Therefore, future research could do more to explain this phenomenon from these perspectives.

Also, while total investment and total income are reasonable control variables, there may be other variables that can influence regional economic development. These may include education levels, infrastructure, existing industries, political stability, and so on. Failure to consider these variables may introduce omitted variable bias, where the error term of the model is correlated with the dependent variable, leading to biased and inconsistent parameter estimates.

In summary, future research could improve these limitations by incorporating a wider variety of control variables, further exploring the relationship with total income, and seeking to validate newly formed indices. In addition, techniques for detecting and correcting overfitting (e.g. cross-validation or regularization) may help to ensure that the predictive power of the model is accurate and generalizable.

6. Conclusion

Based on the background of the rapid development of new energy vehicles in China since 2017, this study explores the link between the new energy vehicle industry and regional economic changes by collecting 11 relevant data within the Guangdong Province region. After analyzing the data through econometric modeling and data analysis, the conclusions drawn support the hypothesis mentioned in this study: the development of the NEV industry can promote regional economic progress.

This conclusion provides theoretical support and data basis for the introduction of the NEV industry in less developed regions to promote regional economic development. At the same time, this study can also provide clearer development suggestions for policymakers in regions with new energy vehicle industries.

These include: First, the promotion of new energy vehicles can bring about a better natural and economic environment at the same time. Second, the innovation and

technological progress brought about by the development of the new energy vehicle industry can serve as a foundation for the future development of the region. Third, government policy support is one of the biggest drivers for the development of new energy vehicles and related industries, so the government can be based on this conclusion carry out macro-control and economic transformation of different regional development plans, especially for regions with a foundation of heavy industry but currently underdeveloped economies, such as the northeastern provinces of China, which have a history of heavy industry and a large number of local laborers. Therefore, the development of new energy vehicles and related industries can be one of the most important ways to promote the economic development of the region.

However, it is worth noting that since the NEV industry is in the early stage of development, the results of the analyses are limited by the short-term data, while the SPSS software also has some limitations for performing more data and analysis methods. Therefore, for future research directions, this study suggests, firstly, taking advantage of more adequate data time points and a wider range of data types in the future, as well as expanding the scope of the study to cover as much as possible the area of two or more provinces and incorporating comparisons of data from different areas to validate the applicability of the conclusions. Secondly, more complex analyses could also be used and more validation methods could be incorporated to avoid potential impact issues such as multiple covariance that may exist with some data types. In addition, limited by the current statistics on human capital related to the NEV industry, the conclusions can be made more convincing in the future by investigating enough human capital data to include this influence factor in the analysis process.

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