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EDITED BY
Diogo Ferraz,
Universidade Federal de Ouro Preto, Brazil

REVIEWED BY
Yawei Qi,
Jiangxi University of Finance and Economics, China
Lele Qin,
Hebei University of Science and Technology, China
Khoa Bui Thanh,
Industrial University of Ho Chi Minh City, Vietnam

*CORRESPONDENCE
Lina Han,
hanlina@gdufe.edu.cn

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# Empirical analysis of the role of new energy transition in promoting china's economy

Xiaofei Liu[1,2,3], Jingcheng Li[1,2,3], Lina Han[4]* and Biao Zhou[5]

[1]National Academy of Economic Security, Beijing Jiaotong University, Beijing, China, [2]Beijing Laboratory of National Economic Security Early-warning Engineering, Beijing Jiaotong University, Beijing, China, [3]Postdoctoral Programme of China Centre for Industrial Security Research, Beijing Jiaotong University, Beijing, China, [4]School of Public Finance and Taxation, Guangdong University of Finance and Economics, Guangzhou, China, [5]School of Economics and Management Beijing Information Science and Technology University, Beijing, China

In order to accelerate the development of new energy industry and social economy, this paper presents an empirical analysis of the role of new energy transformation in promoting China's economy. On the basis of analyzing the concept and types of new energy, the necessity of transformation and upgrading of new energy industry is discussed. The new energy consumption data from 2010 to 2020 and China's GDP data are selected as the basic data, and the MS-VAR model is used as the base model for the empirical analysis. The model combines the Markov zone transition model and the autoregressive model, which is suitable for analyzing non-linear problems. The results of the empirical analysis show that the new energy transition is an important way to promote new energy consumption, and it plays a role in promoting the balanced development of China's economic growth. Combining the results of the empirical analysis, this paper gives suggestions related to the new energy transition from the institutional, economic and technological perspectives.

KEYWORDS

**new energy transition, Chinese economy, facilitation, empirical analysis, autoregressive model, MS-VAR model C.I.C.: F260 Document ID: A**

## Introduction

China's energy industry is facing the defects of low energy utilization rate and poor energy structure, and the optimization of energy industry structure is urgent (Li et al., 2020). The vigorous development of new energy and the improvement of China's economy through new energy transformation are of great significance to promote China's economic development (Bai et al., 2020). The new energy industry is characterized by long capital recovery period and large investment scale, and vigorous development of new energy industry and promotion of new energy transformation require the support of government and financial related policies. The government can encourage the development of new energy industry by means of tax exemptions and other means. The development of new energy is inseparable from the support of science and technology, the development and use of new energy by the world's research scholars,

many countries for the development of new energy technology, the formulation of relevant policies, so that the scale of new energy production is increasing, expanding the use of new energy.

The development of new energy industry is facing a rare opportunity. New energy can not only improve the ecological environment for human survival in China, but also play an important role in promoting the sustainable development of China's economy (Fang et al., 2021). The new energy industry has an obvious driving effect on China's employment environment (Zeng, 2021). At present, many countries have significantly increased their support for the new energy industry, which has largely promoted the further development of the new energy industry.

Based on the above analysis, this paper analyzes the role of new energy transition in promoting China's economy.

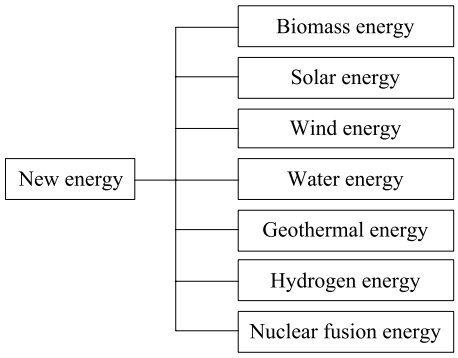


FIGURE 1
Classification of new energy.

## Literature review

The current stage of China's economic development emphasizes the irreversibility as well as the long-term nature of economic development. Under the pace of the new economic normal development, China's economic changes are gradually stabilizing. The government has developed relevant macro-control instruments for China's economic development. At the stage of development of the new economic normal, China's energy industry is severely impacted and there are profound changes in the development of energy industry (Chen and Zhang, 2021). In order to establish a reasonable energy industry structure in a short period of time, the adjustment strategy of energy industry structure should be actively developed for economic development (Wang and Sun, 2021).

At present, many researchers and scholars have studied the relationship between new energy technologies and economic development. For example, Zhang et al. studied the relationship between new energy sources and the environment and the economy (Zhang and Liang, 2021) and found that: the development of new energy sources plays an important role in protecting the ecological environment and promoting economic development; Suo et al.(2020) studied the impact of China's economic development on the transition of clean energy production under different conditions and found that: economic development can promote the transition of clean energy production.

The above traditional studies have verified that there is a significant correlation between new energy development and the Chinese economy, but they have not used new energy transition as the object to analyze its role in promoting the economy, and lack of non-linear analysis of the data. Therefore, in order to further explore the relationship between new energy and China's economy, this study verifies the promotion effect of new energy transition on China's economy through the results of empirical analysis, and provides an effective theoretical basis for China's new energy transition and promoting China's economic development.

## Method design

### New energy concept and classification

New energy refers to renewable and clean energy, new energy uses renewable energy to improve the pollution of the environment from traditional energy sources. Renewable energy is characterized by sustainable development, as well as the protection of the ecological environment. Compared to traditional energy sources, new energy sources mainly include the following characteristics.

(1) New energy sources are extremely abundant in different kinds of resources, and new energy sources have renewable characteristics and can be used continuously by human beings with a high degree of sustainability.
(2) New energy sources have lower energy density and need to utilize a larger spatial area.
(3) New energy sources are extremely widely distributed and can be developed and utilized in a decentralized manner (Sherman et al., 2020).
(4) New energy sources are less destructive to the ecological environment.
(5) New energy sources are influenced by time and environment, and their functions are fluctuating and intermittent (Erreygers et al., 2020), so they cannot be used continuously.

The specific classification of new energy is shown in Figure 1.

As can be seen in Figure 1, new energy sources mainly include hydro, solar and wind, biomass, geothermal, hydrogen

and fusion energy. New energy sources differ in the material resources they contain at different levels of technology and at different times. Along with the continuous development and utilization of new energy technology, new energy technology has gradually matured and the development of new energy industry has been gradually improved (Liu et al., 2021).

China has abundant new energy reserves and huge market potential for new energy development.

(1) Water energy

China has abundant hydro energy resources, and the south-central and southwestern regions of China contain abundant hydro energy. The use of hydro energy resources as power generation resources has become an important trend in the development of new energy sources (Lin et al., 2021). China ranks among the leading countries in the world in terms of hydroelectric power generation capacity. China's hydro energy resources still contain a large potential.

(2) Solar energy

Solar energy is an important new energy source that uses the energy of solar radiation as an energy source (Cui et al., 2022). Solar energy is a clean and renewable energy source and is the most abundant resource. The high content of solar energy resources has exceeded all the renewable energy sources currently available to humans. The sustainability of solar energy is poor, and solar energy is less stable as the energy magnitude changes significantly with time and location. China's solar energy development and utilization is relatively short, but China's solar energy technology is developing rapidly, and currently China's solar energy technology has a wide development space and good development prospects.

(3) Wind energy

Wind energy is an important clean energy source available to human beings, and offshore wind energy is the main source of wind energy development in China, which has abundant offshore wind energy. China's wind energy technology is developing rapidly, and wind energy has huge room for development in the new energy market.

(4) Biomass energy

Biomass is the energy provided by living plants in nature, which use biomass as a medium to store solar energy and is a renewable energy source. It is calculated that the energy stored in biomass is two times larger than the total world energy consumption. The first energy sources used in human history were biomass, and before the second half of the 19th century, the energy sources used by humans were mainly fuelwood.

The current more effective use of biomass energy are: ① biogas production. Mainly the use of urban and rural organic waste, straw, water, human and animal manure, through anaerobic digestion to produce combustible gas methane for living and production; ② use of biomass to make alcohol. In the current world energy structure, the proportion of biomass energy is insignificant.

(5) Geothermal energy

Geothermal energy is the natural heat extracted from the Earth's crust. This energy comes from molten rock in the Earth's interior and exists in the form of heat, which is the energy that causes volcanic eruptions and earthquakes.

The temperature of the Earth's interior can reach 7,000°C, but at a depth of 80–100 metric miles, the temperature drops from 650 to 1,200°C. The heat is transferred closer to the surface through the flow of groundwater and the influx of lava to the crust 1–5 km above the surface. The hot lava heats up the nearby groundwater, which eventually seeps out of the ground. The easiest and most cost-effective way to use geothermal energy is to tap directly into these heat sources and extract their energy.

(6) Hydrogen energy

Hydrogen, which is found mainly in its chemical form on Earth, is the most widely distributed substance in the universe, and it constitutes 75% of the mass of the universe and is a secondary energy source. Hydrogen energy has the potential to become a pivotal energy source on the world energy stage in the 21st century, and the technology of hydrogen production, storage, transportation, and application will become a focus of much attention in the 21st century. The product of hydrogen combustion is water, which is the cleanest energy source in the world. It is resource-rich and sustainable.

(7) Nuclear fusion energy

Nuclear fusion is a form of nuclear reaction in which nuclei of small masses, mainly deuterium or tritium, fuse with each other at ultra-high temperatures and pressures to produce new, heavier nuclei, accompanied by a huge release of energy. The nuclei of atoms contain enormous amounts of energy, and changes in the nuclei of atoms (from one type of nucleus to another) are often accompanied by a release of energy.

Nuclear energy is divided into fission energy, which has been used by mankind to generate electricity, and fission reactors, which have very limited reserves of nuclear fuel and not only produce powerful radiation that can harm humans, but the disposal of radioactive nuclear waste has also been one of the main challenges.

## Analysis of the development status of the new energy industry

With the adjustment of industrial structure and the increasingly strict demand for energy, the low-carbon economic development model will gradually replace the traditional high-pollution development model, and the new energy industry will be a strategic industry to drive economic growth, optimize industrial structure and break the energy bottleneck constraints in the future. However, the development of new energy industry requires high research and development costs, and has a certain scientific and technological content, and from experiments to actual production will face many constraints.

Among them, wind power, as the most widely used and fastest growing new energy generation technology, has achieved large-scale development and application worldwide. Currently, in China, wind power accounts for 13% of the country's total power supply capacity, and for more than a decade wind power has played an increasing role in the country's power supply. At present, China's installed wind power grid capacity surpassed 300 million megawatts, and for 12 consecutive years ranked first in the world.

As countries continue to develop new technologies and develop new materials, reduce the cost of solar power generation, its quality continues to improve, especially in terms of conversion efficiency performance is particularly outstanding. Solar photovoltaic power generation system in China due to the late start, especially in the development, production of solar cells is still lagging behind the international level, the overall performance of low yield, the application is not wide, the product range is not rich and diverse, the level of technology is not developed at this stage. But after years of development, solar thermal technology is becoming more and more perfect, the application field is becoming more and more extensive, solar energy applications are most common and one of the most rapid development of the industry is solar collector.

China has many rivers and is relatively rich in hydro energy resources compared to other resources. However, by the end of 2013, China's installed hydropower capacity was only 290 million kilowatts, with a power generation capacity of 180 million kilowatts, accounting for 29.6% of the total technically exploitable capacity of China's entire hydropower resources. It can be seen that China's hydropower generation can be improved with more space, and the level of power generation development does not match with the stock of hydropower resources.

At this stage, there are more resources suitable for small hydroelectric power stations in China, and the utilization of small power stations below 500,000 can be developed as the focus of China's hydroelectric power resources. In terms of economic renewable green energy alternative to carbon-based energy generation security and peaking mobility, hydroelectric power generation is superior to other green energy sources and should be developed with great priority.

In terms of nuclear energy, China has started a new round of nuclear power construction peak since 2015, with an average annual start-up rate of five to six nuclear power units estimated to add about 100 billion yuan of nuclear power investment per year, of which nuclear island equipment accounts for about 20 billion yuan, and is expected to show year-on-year growth. Through national policy support, China still has a lot of space in nuclear power development.

## The necessity of transformation and upgrading of new energy industry

China's new energy industry has obvious competitive advantages in the international arena. The development of technological innovation in the new energy industry and the national policy support for the new energy industry are the driving force for the development of the new energy industry. China has realized the role of new energy industry in promoting economic development in recent years, and has put forward the important strategic idea of optimizing energy structure, paying attention to the utilization of new energy and other clean technologies, and improving the utilization rate of new energy such as solar energy and wind power (Kang et al., 2020). Along with the continuous development of the new energy industry, the cost of photovoltaic has decreased, and the state has put forward many encouraging policies for the development of new energy, and new energy sources such as solar energy have shown explosive growth rates. At present, the PV industry in China's new energy industry includes two types of distributed PV and terrestrial power plants. China has formulated many policies to promote wind power energy in the new energy industry, which has become an important part of the new energy industry to promote industrial development. China's new energy industry has poor technological innovation and energy structure surplus defects, new energy still has a broad market development space.

In view of the development status of China's new energy industry, it is known that the necessity of transformation and upgrading of China's new energy industry is as follows.

### Improve the current situation of overcapacity in new energy industry segments

There is an obvious overcapacity in many traditional industries in China, and there is also overcapacity in the rapidly developing new energy industry. The government has set many supportive policies for the development of new energy industries, and some enterprises have invested massively in new energy industries for their own corporate interests (Zheng et al., 2018), and many enterprises have entered the new energy automobile industry and photovoltaic industry in China. The new energy industry, as an emerging industry, is supported by many national policies, but in terms of technology, there are still large barriers.

The new energy industry is an industry with high technological content, which has been effective in stimulating economic growth and reducing environmental pollution (Chen et al., 2021). However, many Chinese enterprises do not have the

high technology level to meet the development of new energy industry, and some of them only have the manufacturing capacity, which does not enhance the competitiveness of new energy industry. At present, many enterprises expand their market development space by reducing the cost of new energy products, which does not provide a good living environment for new energy enterprises and causes new energy enterprises to enter a vicious circle and overcapacity. The capacity utilization rate of China's new energy industry is low, and there is a large number of solar and wind power equipment utilization rate is low.

The development of new energy industry is closely related to government support, and because many people have realized the importance of new energy industry in recent years, the government has formulated more support policies for new energy industry, and too many support policies have caused false prosperity in new energy industry (Lu et al., 2022). In recent years, many Chinese enterprises spend a lot of time and money to build solar photovoltaic industrial park, some local governments for the insolvent enterprises, but still developed a corresponding support policy, resulting in the government's support policy for the new energy industry, resulting in excessive waste of resources.

### Improving technological innovation restrictiveness

Technological innovation is the core of the development of the new energy industry. China's new energy industry has generally adopted foreign technologies until recent years, when the number of new energy patent applications in China has risen. China's new energy industry should vigorously develop new energy innovation technologies. There are fewer new energy companies using original innovative technologies. There are still obvious limitations in China's technology accumulation in the new energy industry, and the lack of innovative technology as support for the development of the new energy industry has hindered the further development of the new energy industry.

### New energy industry is difficult to connect to the grid and has a high market development space

The market development of China's new energy industry still has a lot of room for development, and some new energy enterprises choose the export method as a way to develop the new energy industry. The effective demand for new energy products in China's domestic market is insufficient, and the production capacity of the new energy industry cannot meet the development needs of the industry, resulting in the new energy industry not being able to play its proper advantage. Therefore, although China has developed a large number of policies to support the new energy industry, the new energy industry still does not have a competitive advantage. China's new energy industry development process, although can meet the installed capacity needs, but the new energy can not meet the grid demand. The main reason is that there are technical barriers to grid integration between new energy power plants and distribution grids, and there are still obvious limitations to the technology of integrating new energy into the grid. The power generation effect of new energy into the distribution network is not ideal, which may cause serious waste of resources. The main reasons why new energy cannot be connected to the grid include new energy transmission channels, new energy operation subsidies and market space. Through the upgrading and transformation of the new energy industry, we can solve the problem of new energy grid connection difficulties and broaden the market development space of the new energy industry.

## Empirical analysis

### Factor decomposition method

There are significant differences in the characteristics of different types of new energy production, and the new energy transition has a significant impact on the intensity of new energy consumption. The factor decomposition method was chosen to analyze the impact of new energy transition on the intensity of new energy consumption, which is an important reflection of China's economy. Factor decomposition method is an important method to decompose the impact of variables related to new energy transition on new energy consumption using mathematical methods, and the decomposition result corresponds to the influencing factors.

Decompose the expression for the intensity of new energy consumption as follows.

$$e = \frac{E}{H} = \sum_{i=1}^{2} e_i h_i \tag{1}$$

In Eq. 1, $E$ and $H$ represent the total new energy consumption and the GDP of the Chinese economy, respectively, and $e_i$ and $h_i$ represent the energy consumption intensity of the new energy type $i$ and the ratio of the output value of the new energy type to the GDP, respectively.

Eq. 1 shows that energy consumption intensity can reflect the energy utilization rate of different types of new energy sources, and new energy industry structure can reflect the ratio of different types of new energy output in the GDP of the Chinese economy. Therefore when analyzing the contribution of new energy transition to the Chinese economy. It is important to analyze the utilization efficiency of different energy sources in the new energy industry and the changes in the structure of the new energy industry (Su et al., 2021). Further decomposition of the new energy consumption intensity changes to obtain the expression of the impact share of the new energy industry structural transformation is as follows.

$$A = \frac{\sum_{i=1}^{2} e_i^{n-1}\left(h_i^n - h_i^{n-1}\right)}{\sum_{i=1}^{2} e_i^n h_i^n - e_i^{n-1} h_i^{n-1}} \tag{2}$$

The expression for the impact share of new energy utilization efficiency is as follows.

$$B = \frac{\sum_{i=1}^{2}(e_i^n - e_i^{n-1})h_i^n}{\sum_{i=1}^{2}e_i^n h_i^n - e_i^{n-1}h_i^{n-1}} \tag{3}$$

In the above formula, $e_i^n$ and $e_i^{n-1}$ represent the energy consumption intensity of the new energy industry in $i$ $n$ and $n-1$, respectively; $h_i^n$ and $h_i^{n-1}$ represent the ratio of the output value of the new energy industry $i$ in $n$ and $n-1$, respectively, to the GDP of the Chinese economy. When the impact share of new energy industry transformation and the impact share of new energy utilization efficiency are both positive, it means that the impact share of new energy industry transformation and new energy utilization efficiency change in the same direction as the intensity of new energy consumption; when the impact share of new energy industry transformation or the impact share of new energy utilization efficiency is negative, it means that the impact share of new energy industry transformation and new energy utilization efficiency change in the opposite direction as the intensity of new energy consumption. When the share of impact of new energy industry transformation or the share of impact of new energy utilization efficiency is negative, it means that the force of new energy industry transformation and new energy utilization efficiency changes inversely with new energy consumption intensity (Pols, 2020).

## Building the markov-switching vector autoregressive model

The MS-VAR model is selected as the empirical analysis model to analyze the study of the role of new energy transition on the promotion of China's economy, which is based on the VAR model and applied to study the relationship between different variables. Since many time series variables of new energy transition and China's economic promotion have nonlinear characteristics, the Markov zone transition vector with nonlinear characteristics is applied to the autoregressive VAR model to achieve a good combination of Markov zone transition model and autoregressive model.

The model can be applied to study the changes of variables in different time series when influenced by different zone system changes. The zone system is a potential variable in the study of new energy transition and China's economic development, and the model needs to meet the realistic characteristics of China's economy, and the model should meet the dynamic influence process of the interaction between the new energy transition and China's economic development.

A vector autoregressive model VAR of order $P$ is created as follows.

$$y_t = v + D_1 y_{t-1} + \cdots + D_p y_{t-p} + vo_t \tag{4}$$

In Eq. 4, $t$ and $y_t$ denote the sample size and $k$ dimensional vector, respectively; $v$ and $D_i$ denote the constants and the matrix of coefficients to be determined, respectively, and $o_t$ denotes the regression parameters.

Eq. 4, which is the intercept form of the empirical analysis model established using the steady-state Gaussian VAR model, converts Eq. 1 into a mean-adjusted form, which yields the following expression.

$$y_t - o = D_1(y_{t-1} - o) + \cdots + D_p(y_{t-p} - o) + vo_t \tag{5}$$

In Eq. 5, $o = (I_k - \sum_{j=1}^{p} D_j)^{-1} v$ represents the $k \times 1$ dimensional mean of the vector. $y_t$

When the time series vector $y_t$ is an observable vector, the potential data is generated using the unobservable zone-based variable $s_t$. Let the zonal variable $s_t$ consist of a Markov chain of discrete states and the discrete time of the $M$ zonal system, the transformation probability expression of the zonal variable $s_t$ can be obtained as follows.

$$p_{ij} = \Pr(s_{t+1} = j | s_t = i) \tag{6}$$

In Eq. 6, $\forall i, j \in (1, 2, \cdots, M)$, $\sum_{j=1}^{M} p_{ij} = 1$.

The Markov process for the zone system transition probabilities is expressed using the matrix form as follows.

$$p = \begin{bmatrix} p_{11} & \cdots & p_{1M} \\ \vdots & \ddots & \vdots \\ p_{M1} & \cdots & p_{MM} \end{bmatrix} \tag{7}$$

Through the above process, the mean-adjusted formal expression of the VAR model is obtained as follows.

$$\begin{aligned} y_t - o(s_t) &= D_1(s_t)(y_{t-1} - vo(s_{t-1})) + \cdots \\ &+ D_p(s_t)(y_{t-p} - vo(s_{t-p})) + vo_t \end{aligned} \tag{8}$$

Equation 8, $o_t \sim NID[0, \sum(s_t)]$, $o(s_t)$, $D_1(s_t)$, $D_p(s_t)$, $\sum(s_t)$ are represented by the parameters $o$, $D_1$, $D_p$, $\sum$ for the implemented zone system $s_t$ dependent variable parameter functions, the existence of expressions as follows.

$$o(s_t) = \begin{cases} o_1 & (s_t = 1) \\ \vdots & \\ o_M & (s_t = M) \end{cases} \tag{9}$$

Equation 8 is used to show the observable variables of the new energy transition as well as China's economic promotion role when there is a jump in the mean value. The observable variables mainly include the jump case as well as the sudden change case, and the expressions for the existence of the smoothing mode are as follows

$$y_t = v(s_t) + D_1(s_t) y_{t-1} + \cdots + D_p(s_t) y_{t-p} + vo_t \tag{10}$$

TABLE 1 New energy consumption.

| Year | Total energy consumption/(10,000 tons of standard coal) | The proportion of new energy/% | New energy consumption/(10,000 tons of standard coal) | GDP/ (100 million yuan) |
|---|---|---|---|---|
| 2010 | 335,846 | 8.5 | 28546.91 | 72645.8 |
| 2011 | 415,865 | 9.8 | 40754.77 | 79854.5 |
| 2012 | 535,184 | 10.3 | 55123.952 | 89451.5 |
| 2013 | 615,284 | 11.5 | 70757.66 | 99541.5 |
| 2014 | 689,451 | 11.9 | 82044.669 | 102645.5 |
| 2015 | 725,468 | 12.5 | 90683.5 | 112546.5 |
| 2016 | 798,541 | 13.5 | 107803.035 | 126485.4 |
| 2017 | 856,451 | 15.7 | 134462.807 | 135467.5 |
| 2018 | 905,418 | 16.8 | 152110.224 | 145264.8 |
| 2019 | 954,235 | 18.5 | 176533.475 | 156485.1 |
| 2020 | 978,541 | 19.5 | 190815.495 | 168451.6 |

Equations 8, 10, obtained using the above process, are two different forms of the MS-VAR model constructed to study the role of new energy transition in promoting the Chinese economy. Equations 8, 10 can reflect the different processes when there is a shift in variables, respectively. Respectively, reflecting the differential dynamic adjustment patterns of observable variables after the zone system change. Equation 8 as well as Equation 10 rely on the adjustment of the mean as well as the intercept term, respectively. Through the above process, it can be seen that the mean adjustment method as well as the intercept term adjustment are used to study the effect of new energy transition on China's economic promotion, showing a slow smoothing process as well as an abrupt change, respectively.

The established MS-VAR model is solved by selecting the maximized likelihood function, and the parameters of the established MS-VAR model are obtained by iterative calculation, while the parameters in the established autoregressive model and the transfer probabilities in the interval system that cannot be observed using Markov chains can be obtained.

The results of the study of the relationship between the new energy transition and China's economic development also vary with the differences in the study area and the study population, as well as with the differences in the selected sample intervals. The relationship between new energy and China's economic growth is non-linear (Lean and Lee, 2022). The traditional linear model cannot be used to study the relationship between the two, and the established MS-VAR model is applied to study the non-linear issue of the promotion of new energy transformation to the Chinese economy, and to clarify the dynamic development of the relationship between new energy transformation and economic growth with high validity.

## Results of the empirical analysis and discussion

Considering the availability of data for empirical analysis, the new energy consumption data from 2010–2020 and China's GDP data were selected as the data for empirical analysis, and the impact of two new energy transition changes on the intensity of new energy consumption during the 11 years were selected as the object of analysis. All the data are obtained from China Industry Information Network and China Statistical Yearbook, in which the consumption of new energy such as solar energy and wind energy is taken as the data base.

The new energy consumption from 2010–2020 is shown in Table 1.

The new energy consumption data and GDP data in Table 1 were logarithmically processed, and the obtained new energy consumption and GDP logarithmic trend graphs are shown in Figure 2.

By looking at Figure 2, it can be seen that China's new energy consumption and GDP data show an increasing trend year by year for the 11 years from 2010 to 2020. Based on the slope of the line segment, it can be seen that this year-to-year upward trend is more balanced, so it can be assumed that China's new energy consumption and GDP have steadily increased during these 11 years.

The results of the logarization of the new energy consumption intensity data for 2010–2020 are shown in 3.

The results of the new energy consumption intensity treatment in Figure 3 show that 2013–2014 and 2017–2018 are two important periods of the new energy transition, in which there is a more rapid increase in the new energy consumption intensity. And after the new energy transition, the intensity of new energy consumption increased sharply and then leveled off gradually. Therefore, the experimental results shown in Figure 3 verify that the

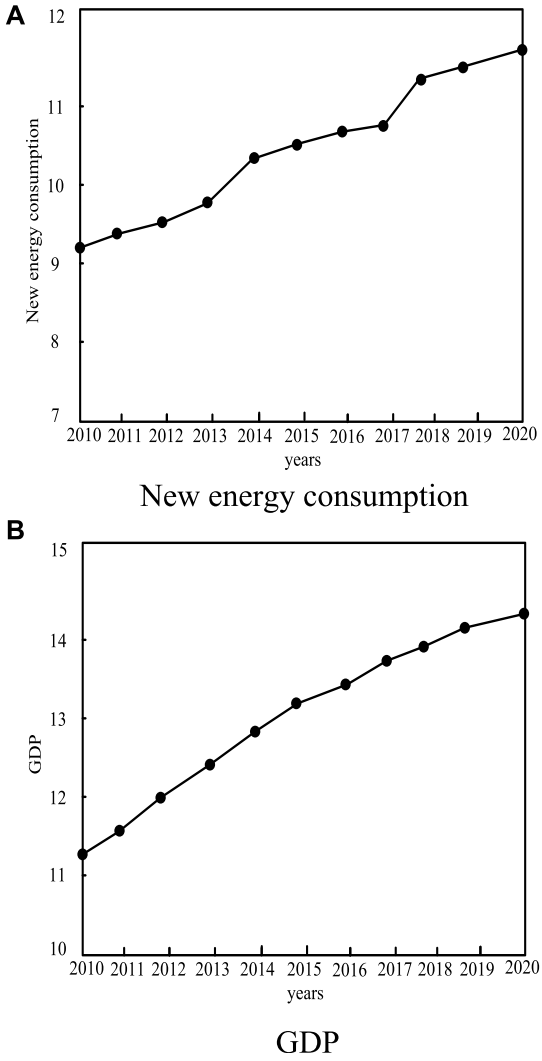


FIGURE 2
The logarithmic trend of new energy consumption and GDP.

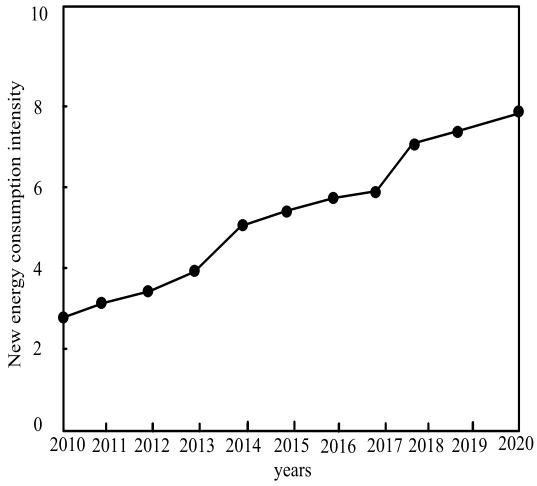


FIGURE 3
New energy consumption intensity.

new energy transition can increase the intensity of new energy consumption.

The relationship between the new energy transition and energy consumption intensity was obtained using the factor decomposition method as shown in Table 2.

The results in Table 2 show that the energy consumption intensity during 2010–2020 is higher than the efficiency share of new energy obtained through factor decomposition, indicating that the main reason for the increase in new energy consumption intensity is the structural share of new energy. The efficiency share and structural share of new energy consumption intensity in Table 2 fluctuate significantly, and the efficiency share of new energy is negative in 2013 as well as in 2017, when the structural share of new energy increases significantly, mainly because the new energy transition has increased the consumption intensity of new energy, and the main reason for the increase of new energy consumption intensity in China is the increase of the structural share of new energy. In 2020, the difference between the efficiency share and the structural share of new energy is small, indicating that the structural adjustment of the new energy industry and the efficiency of new energy utilization have stabilized in 2020, which has the same effect on the intensity of new energy consumption in China.

The impact of new energy transition on energy consumption intensity is analyzed by factor decomposition method, and the analysis results show that the effect of new energy differential structure transition on energy consumption intensity is higher than the effect of new energy utilization efficiency on energy consumption intensity enhancement. When the utilization efficiency of new energy is improved, the consumption intensity of new energy is reduced. The impact of new energy transition on energy consumption intensity has different effects in different periods. The new energy transition process should pay attention to the impact of energy utilization efficiency improvement on energy consumption intensity. In order to promote China's economic development, the transformation process of China's new energy industry should improve energy utilization efficiency, develop new processes and new technologies in the new energy industry, improve the management level of the new energy industry through scientific and technological innovation and other strategies, pay attention to the optimization and upgrading of the structure of the new energy industry, improve the consumption intensity of new energy through the transformation of the new energy industry, and promote China's further development of China's economy.

Both new energy transition and Chinese economy belong to macro variables, and the time series of macro variables show non-stationary characteristics, and new energy transition and Chinese economy show a fixed upward or downward trend along

TABLE 2 Decomposition results of energy consumption intensity factors.

| Year | New energy efficiency share | New energy structure share |
|---|---|---|
| 2010 | 0.1352 | 0.8648 |
| 2011 | 0.0352 | 0.9648 |
| 2012 | 0.0352 | 0.9648 |
| 2013 | −0.2541 | 1.2541 |
| 2014 | 0.2845 | 0.7155 |
| 2015 | 0.2546 | 0.7454 |
| 2016 | 0.1025 | 0.8975 |
| 2017 | −0.0512 | 1.0512 |
| 2018 | 0.0234 | 0.9766 |
| 2019 | 0.3152 | 0.6848 |
| 2020 | 0.5846 | 0.4154 |

TABLE 3 Stationarity test results.

| Inspection index | First order difference | | Second order difference | |
|---|---|---|---|---|
| | GDP | New energy consumption | GDP | New energy consumption |
| 1% standard threshold | −3.5612 | −3.5612 | −3.6151 | −3.6151 |
| 5% standard threshold | −2.8546 | −2.8546 | −2.8951 | −2.8951 |
| 15% Standard Threshold | −2.5164 | −2.5164 | −2.5342 | −2.5342 |
| ADF test value | −5.8456 | −5.6484 | −6.1584 | −8.4645 |
| Test result | Smooth | Smooth | Smooth | Smooth |

with the development of time series. In order to obtain a good empirical analysis, the series of each variable needs to be analyzed for smoothness. When the time series data do not pass the smoothness test, the model constructed has good fitting effect, but too much spurious information is presented in the time series, so the results obtained cannot reflect the actual development trend of new energy transition and Chinese economy, and the credibility of the conclusion is low. When using the time series of each variable for the econometric analysis of the new energy transition as well as the Chinese economy, the smoothness of the time series was tested. The ADF unit root method was chosen to test the smoothness of the time series of the new energy transition's contribution to the Chinese economy. To calibrate the smoothness analysis problem of Chinese economy as well as new energy consumption, the lag length of the default ADF method is 0. The results of the smoothness test of the time series are obtained as shown in Table 3.

The experimental results in Table 3 show that the results of testing the smoothness of the time series using the ADF method show that the first-order difference series of GDP and new energy consumption set up in this study are smooth at different significance levels. The validation is applied to the empirical analysis of the promotion effect of new energy transformation on China's economy, and the constructed model has high validity and can be applied to the empirical analysis of the promotion effect of new energy transformation on China's economy. The experimental results in Table 3 show that China's new energy transition plays a facilitating role for China's economic growth in the long-run equilibrium.

The results of the correlation coefficient matrix of the three variables of new energy, energy consumption intensity and GDP under different zone systems using the constructed model are shown in Table 4.

The experimental results in Table 4 show that the correlation coefficients between the three variables of new energy, energy consumption intensity and GDP are all high under different zone systems, and the correlation coefficient between new energy and energy consumption intensity is positive, and the correlation coefficient between energy consumption and GDP is also positive. The experimental results in Table 4 show that the constructed model can clearly and intuitively demonstrate the relationship between the new energy transition and GDP, and can effectively analyze the role of the new energy transition in promoting the Chinese economy. Continuing the analysis of the results in Table 4, the impact of new energy consumption on the Chinese economy is greater, and the growth of the Chinese economy is influenced by new energy consumption, and when new energy consumption grows, GNP grows. The experimental results in Table 4 visually show that the new energy transition is an important way to promote new energy consumption and verify that the new energy transition has a catalytic effect on the Chinese economy.

TABLE 4 Correlation coefficient matrix.

| | | New energy | Energy consumption intensity | GDP |
|---|---|---|---|---|
| Zone 1 | New energy | 1 | 0.7561 | 0.8615 |
| | Energy consumption intensity | 0.7561 | 1 | 0.7841 |
| | GDP | 0.8615 | 0.7841 | 1 |
| Zone 2 | New energy | 1 | 0.6875 | 0.7841 |
| | Energy consumption intensity | 0.6875 | 1 | 0.8054 |
| | GDP | 0.7841 | 0.8054 | 1 |

TABLE 5 Causality check.

| Assumption | New energy transition is the reason for GDP growth | GDP growth is the reason for the new energy transition |
|---|---|---|
| F statistic | 0.0254 | 0.3512 |
| *p* value | 0.0054 | 0.0064 |
| Critical result | Agree | Agree |
| Conclusion | New energy transition is the reason for GDP growth | GDP growth is the reason for the new energy transition |

In order to further verify the relationship between the new energy transformation on the Chinese economy, the model of this paper is used to test the causal relationship between the new energy transformation on the promotion of the Chinese economy using the causality test method, and the test results are shown in Table 5.

According to the results shown in Table 5, it can be seen that there is a double positive causality between new energy transition and economic growth at 10% significance level, not only new energy transition can promote economic growth, but also economic growth can stimulate new energy transition.

## Suggestions to promote the development of new energy

In order to promote the further development of the new energy industry and to promote China's economic development through the new energy transformation, this study proposes policy recommendations to promote the development of the new energy industry from the institutional and economic perspectives, respectively.

### Institutional perspective

At present, more and more countries and regions pay attention to the development of new energy industry. Our government has also clearly put forward the goal of "carbon peaking" by 2030 and "carbon neutral" by 2060, which has also greatly promoted the development of new energy industry.

The development of the new energy industry cannot be separated from the guiding role of the government, and the government occupies an important position in the development process of the new energy industry. In order to use the new energy transformation to promote economic development, our government should develop strong policy support and escort the development of new energy industry from the perspective of the system.

The government can develop a new energy industry-related policy system as well as a supporting system to support new energy enterprises to vigorously develop the new energy industry through tax incentives and other financial policies. From the long-term planning of promoting the development of new energy, a perfect new energy management system with clear responsibilities can be established through macro-control. In order to promote the healthy development of the regional economy, cross-departmental and cross-regional coordination can be carried out to provide the basis for good transmission of electric energy and ensure the full utilization of energy, and promote further development of social economy through the full utilization of new energy.

In addition, the government should develop a perfect transformation mechanism for the technical achievements of the new energy industry to enhance the industrialization level of new energy in different regions. The government

should encourage relevant enterprises to continuously innovate new energy equipment and new energy technology, establish new energy-related technologies and products with independent intellectual property rights, and provide a good foundation for the transformation of China's new energy industry. The government should develop relevant incentive strategies in terms of taxation and finance to provide a new environment for the good development of new energy technologies.

The change in the structure of the new energy industry is also affected by the financial investment. Therefore, in order to support the transformation of the new energy industry, the government needs to develop relevant support for new energy enterprises in response to the development of new energy. Maximize to meet the funding needs of the new energy industry and promote new energy enterprises to achieve further development through technology development. The development of new energy enterprises requires long-term investment in R&D funds and technology. The stability and transparency of government policies for the development of new energy industry can help maintain the long-term investment in R&D of new energy enterprises. Through the government's strategy for the new energy industry, it can meet the market development needs of new energy enterprises, reduce the investment risks of new energy enterprises, and encourage more enterprises to invest in the new energy industry.

## Economic perspective

At present, China's economic development maintains a high energy consumption and high emission development method, in order to better promote China's economic development through new energy transformation, it is necessary to change the current sloppy economic growth mode, and adjusting the energy industry structure is an effective measure.

China should take low-carbon economy as an important goal of new energy transformation and adhere to the path of sustainable development of energy. Vigorously support low-carbon industries, enhance the competitiveness of new energy products in the energy market, and increase the proportion of new energy technologies in conventional energy. It should raise the threshold of new energy enterprises in the energy market, make low-carbon economy an important goal of China's economic development, promote China's economic development through new energy transformation, and realize the optimization of the industrial structure of China's new energy economy.

China's new energy industry has developed rapidly in recent years, but the share of new energy consumption in energy consumption is still relatively small. At present, the main sales method of Chinese new energy products is still export. Therefore, when developing new energy industry, we should actively learn from the successful new energy development experience of advanced countries, adjust the consumption structure of new energy economy, and guarantee the sustainable development of energy industry by diversifying energy consumption.

## Technical perspective

The new energy industry needs to rely on technology as a development support. In the process of new energy industry development, it is necessary to maintain a strong core competitive ability, so the development of new energy cannot be separated from the investment in science and technology.

At present, many countries invest a lot of money in new energy industry, and actively carry out research and development of new energy-related technologies to improve the level of technological development of new energy industry. Compared with other industries, the new energy industry in China is relatively late in development, China's development of new energy industry, need to increase the investment in technology. Through the new energy technology level investment, change the situation of China's new energy development is too backward.

In addition to the introduction of advanced new energy technologies, China should also strengthen the level of research and development in the field of new energy, increase the cost reduction of new energy technologies and improve the production efficiency of new energy technologies, and combine the introduced new energy technologies with the results of independent research and development. The basic research of new energy in China is characterized by high risk and high investment. When developing new energy industry in China, the level of R&D of new energy needs to be fully considered when developing China's energy development strategy and creating a favorable development environment for the development of new energy in China through long-term planning.

# Conclusion

The new energy industry is a new industry in China, and the development of new energy in China is not perfect, which hinders the promotion of the new energy industry to China's economic development. The development of new energy industry needs to invest a lot of money to purchase equipment as well as develop technology, and new energy development increases the burden of the country. China should transform the new energy industry through new energy transformation, vigorously develop mature solar, wind and other new energy technologies, and use mature new energy technologies to achieve the transformation of the new energy industry and promote China's economic development. Fully analyze the cost components of new energy, clarify the impact of new energy development on China's economy, and use the

research results as an important basis for the government to make relevant policies based on new energy.

For the role of new energy transition in promoting China's economy, this study uses the MS-VAR model as the empirical analysis model and completes the nonlinear analysis by combining the Markov zone transition model with the autoregressive model. In the empirical part, the new energy consumption data and Chinese GDP data from 2010 to 2020 are selected as the basic data, and it is found that the new energy transition plays a role in promoting China's economic growth in the long-term equilibrium. However, due to the constraints of research time and other conditions, there are certain shortcomings in this paper's research. Regional development imbalance is the basic condition of China, therefore, the economic promotion effect of new energy transition for different regions must be different. However, this issue has not been studied in depth in this paper. In the future, on the basis of this paper, we will further analyze the economic promotion effect of new energy transition on different regions.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication. All four authors were involved in building the framework and searching for information during the conception of the article, and the first author did the main work of writing the paper.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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