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EDITED BY
Mariarosaria Lombardi,
University of Foggia, Italy

REVIEWED BY
Guoxiang Li,
Nanjing Normal University, China
Bright Obuobi,
Nanjing Forestry University, China

*CORRESPONDENCE
Kaiyi Song,
497202408@qq.com

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# Carbon reduction effects of government digital attention

Rong Hu[1] and Kaiyi Song[2]*

[1]School of Air Transportation and Engineering, Nanjing University of Aeronautics and Astronautics Jincheng College, Nanjing, Jiangsu, China, [2]School of Business, Nanjing Xiaozhuang University, Nanjing, China

In the digital economy era, increasing government's adoption and attention to digital technology is not only conducive to accelerating the improvement of governance capacity, but also an important measure to achieve green economic development. This paper uses text analysis to measure the government digital attention at the city level, and then uses panel data econometric models to estimate the impact of government digital attention on carbon emissions reduction. The findings reveal that government digital attention can significantly reduce carbon dioxide emissions by improving the government's low-carbon governance, strengthening the public's low-carbon attention, and encouraging the enterprises' low-carbon transformation. Further, government digital attention mainly reduces carbon dioxide from direct energy consumption, transportation and electricity product. The carbon reduction effect of government digital attention is also affected by degree of marketization, and the high degree of marketization helps to reinforce the effect. Moreover, there is spatial heterogeneity in the effect, it is more significant in the eastern region. Our conclusions are then of important implications for promoting China's carbon dioxide reduction and achieving high-quality sustainable development.

KEYWORDS

**government digital attention, carbon reduction, low-carbon governance, public concern, enterprise low-carbon transformation**

## 1 Introduction

In the face of increasingly serious environmental and climate issues, the Chinese government has made achieving carbon reduction an important aspect of promoting high-quality economic development in recent years. In 2020, the Chinese government proposed at the 75th United Nations General Assembly: "China will increase its nationally determined contributions, adopt more effective policies and measures, strive to peak carbon dioxide emissions before 2030, and strive to achieve carbon neutrality before 2060".[1] This has also become an important goal constraint for China's low-carbon transformation at present.

Especially after entering the digital economy era, with the popularization of technologies such as the Internet of Things, cloud computing, and big data, the Chinese government attaches great importance to applying digital technology to social governance and high-quality economic development. The *14th Five Year Plan* clearly

1 Originating from the speech of Chinese President Xi Jinping at the 75th General Debate of the United Nations General Assembly on 20 September 2020.

pointed out that accelerating digital development, building a digital China, and promoting deep integration of digital technology and real economy.[2] The government is increasingly valuing the application of digital technology and placing greater emphasis on it in order to better rely on digital technology to enhance governance capabilities and help the economy and society achieve low-carbon transformation. For example, on 26 October 2021, China issued the *Action Plan for Peaking Carbon Emissions Before 2030*, which clearly stated the need to promote the integration of digital, intelligent, green and integrated development. More importantly, government digital attention can not only optimize its own carbon reduction policies, but also help improve the carbon footprint of micro subjects, including the public low-carbon concern and enterprise low-carbon transformation.

Specifically, the application of digital technology in governance helps to improve the government's access to more economic information (Li and Yue, 2025), strengthen its supervision of enterprise carbon emissions, and achieve low-carbon governance. Government digital attention has diversified social governance channels and opened up channels for expressing public environmental demands (Yuan et al., 2023), enhanced public attention to low-carbon initiatives. Besides, the allocation of enterprise attention is closely linked to government actions. Government digital attention will achieve proactive induction, guiding enterprises to pay attention to the government's carbon reduction policies, thereby incentivizing enterprises to achieve low-carbon transformation.

Exploring the influencing factors of carbon reduction has always been one of the important fields concerned by the academic. The explanation based on data enabling attributes in the new era has become a very important entry point. More and more scholars have discussed the factors affecting the carbon emissions from the economic development, energy structure, industrial structure, technological progress, population size, green finance, etc. (Rahman et al., 2022; Danish et al., 2019; Zhang et al., 2025). For China during the transition period, the government plays a direct or indirect role in promoting regional sustainable development and carbon emissions (Xian et al., 2025). However, previous studies have not paid attention to how the government's attention to digital technology affects regional carbon emissions reduction after entering the digital economy era. This paper is based on attention theory and examines the impact mechanism and effect of government digital attention on regional carbon reduction within the tripartite framework of government-public-enterprise.

This paper may have the following two marginal contributions. (1) This paper is based on the background of government governance in the digital economy era, and from the perspective of government digital attention, focuses on exploring the impact of government digital attention on carbon reduction. This may help to gain a more comprehensive understanding of low-carbon governance strategies in the digital economy era and provide more perspectives for studying the key factors affecting low-carbon development. (2) This paper focuses on the three main entities of government, public, and enterprises in low-carbon development, and examines the impact mechanism of government digital attention on carbon reduction from three aspects: government low-carbon governance, public low-carbon attention, and enterprise low-carbon transformation. It examines the promoting role of government attention to digital technology in fulfilling governance responsibilities, authorizing multi-party governance, and optimizing corporate attention allocation. This also helps to gain a more comprehensive understanding of the pathways through which government digital attention affects regional carbon emissions.

The following is arranged as follows: The second part is literature review; The third part is the mechanism analysis; The fourth part is empirical analysis, constructing the econometric model and introducing the data selection as well as variable construction. The fifth part is the analysis and discussion of estimation results. The sixth part is extended analysis; Finally, we summarize the above conclusions and draw policy implications.

## 2 Literature review

Government digital attention can be understood as government's concern about the application of digital technology and the development of digital economy. The academic research on concepts such as government digitization, digital government generally revolves around three aspects: enabling elements, process reengineering, and transformation goals. In terms of enabling elements, the scholars generally agreed that government digitalization takes digital technology as governance means, digital space as governance field, and data itself as governance (Chen and Liu, 2022; Luna-Reyes and Gil-Garcia, 2014; Luca et al., 2021; Hamish et al., 2021). In terms of process reengineering, it can be simply defined as the use of digital technology by government organizations to implement their governance processes. Lee et al. (2016) proposed that digital government should not be limited to breakthroughs at the technical level. More importantly, it should achieve overall governance by integrating institutional functions and reengineering work processes. In terms of transformation goals, digital government should realize digitalization, intelligence and precision of government services (Guo and Lin, 2022), effectively coordinate the relationship between government, market, and society (Mergel et al., 2019), and provide government services to stakeholders of a country.

Existing studies have basically held a positive attitude towards the role of digital government in improving the social governance. Digital government can promote information disclosure (Sohail et al., 2020), citizens' participation in government affairs and the development of accountability system, which will help transform government functions (Yang et al., 2024), and build a service-oriented government (Han and Zhang, 2024). Government digitalization can ensure a stable, orderly and vibrant society by enabling multiple entities to participate in social governance, thus improving the quality of governance (Xing and Yao, 2022). In addition, many scholars' research has focused on the impact of digital government, including the technological innovation (Li et al., 2023), manufacturing productivity (Yu et al., 2025), enterprises'

2 *Outline of the 14th Five Year Plan for National Economic and Social Development of the People's Republic of China and the Long-Range Objectives by 2035*. www.gov.cn.

intelligent transformation (Zhang and Zhang, 2025) and digital transformation (Li and Yue, 2025). Currently, there is little research on the impact of government digitization on the natural environment and sustainable development. Castro and Lopes (2022) proposed that digital government is conducive to efficient resource management, so it can help improve the current use of natural resources. Destek et al. (2024) found that digitalization of the public sector can reduce resource rich countries' dependence on natural resources. Tang et al. (2025) also verified the positive impact of digital government construction on the improvement of enterprise energy efficiency based on empirical research in China, and Jiang et al. (2024) also reached a relatively consistent conclusion in their study.

Carbon dioxide emissions mainly come from the production and consumption behavior of human society. The production and consumption in the reproduction cycle play a decisive role in carbon dioxide emissions. For a long time, China's industrial development has been mainly driven by the secondary industry, which has not only promoted rapid economic growth but also led to a rapid increase in energy consumption that mainly relies on fossil fuels, resulting in a significant increase in carbon emissions. When *per capita* GDP exceeds a certain threshold, people's attention to environmentally sustainable development will prompt them to take measures to reduce carbon dioxide emissions (Wang et al., 2024). However, for China, which is currently in a transitional period, scholars tend to study the main factors affecting carbon emissions from the perspective of government or institutions (Yang et al., 2022). Under the socialist market economy system with Chinese characteristics, the government plays an important role in economy operation. Through the mutual cooperation between various levels of government and the combination of policy tools, it generates important expectations and guidance for the economic behavior of market micro entities, changes their carbon footprint. Some studies believed that China's fiscal decentralization distorts the incentive mechanisms of local governments, leading to excessive use of fossil fuels for short-term economic performance and resulting in severe carbon emissions (Zhao et al., 2023). However, the results of Cai et al. (2025) shown that fiscal decentralization significantly aids carbon reduction, but stronger environmental regulations have not effectively slowed emission growth, creating a "green paradox."

In recent years, with the rapid development of the digital economy, some studies have also examined the government digital attention and its impact effects. For example, the study by Zhang et al. (2024) found that government attention to digital technology can promote regional digital economic development; Li and Yue (2025) also found that government digital attention promotes digital economy output efficiency through data openness mechanism and data flow mechanism. However, previous literature still lacks research on the relationship between government digital attention and carbon reduction. In fact, the government attention to the digital economy and digital technology can help promote low-carbon governance, stimulate low-carbon transformation of enterprises, and also influence public low-carbon attention, thereby reducing regional carbon emissions. Neglecting this factor will inevitably hinder the investigation of the main factors of regional carbon emissions, especially for us to explore how the improvement of government governance capacity affects carbon reduction in the digital economy.

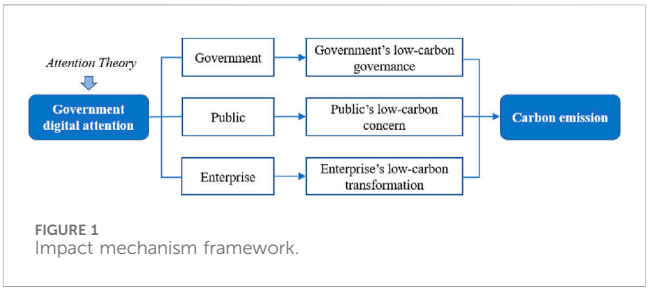


FIGURE 1
Impact mechanism framework.

## 3 Influence mechanism analysis

Attention theory provides a good explanatory framework for examining the impact of government digital attention on carbon dioxide emissions. In government decision-making, the attention of decision-makers is often seen as a scarce resource. The allocation of attention by the government demonstrates the importance placed on specific affairs, guiding the focus of attention of social entities (enterprises, residents). In the era of digital economy, government digital attention reflects the government's inclusion of digital economy development into the decision-making agenda (such as reflecting digital economy and digital technology in government work reports), emphasizing the use of digital technology to achieve social governance. This not only affects the efficiency of government governance, but also affects production and consumption activities in the economy, such as green economy and carbon dioxide emissions.

The carbon emissions in the real economy mainly come from production and consumption activities, involving three main entities: government, public, and enterprises. On the one hand, as the macro-regulator, various policies promulgated by the government will affect the behavior of micro-subjects and change their carbon footprint. Moreover, as a part of the huge national machine, the carbon emissions generated by the government's own operation cannot be ignored. On the other hand, public life generates carbon dioxide emissions through transportation and heat consumption, accounting for a relatively large proportion of the total carbon emissions in China. In addition, the energy input of China's manufacturing enterprises is still mainly concentrated in fossil fuels, which generates a large amount of carbon emissions. Government digital attention will have a certain impact on the government, the public and enterprises. It will promote carbon reduction from three aspects: government low-carbon governance, the public low-carbon concern and enterprise low-carbon transformation, as shown in Figure 1.

### 3.1 Government low-carbon governance

Government digital attention can help the government integrate various information resources using digital technology. This helps to better identify green violations, strengthen government green governance, and promote carbon reduction. Specifically, government digital attention will increase the utilization of digital technology and promote the digital transformation of the government itself (Peng et al., 2024). On the one hand, traditional government is often restricted by problems such as

small information volume and blurred sources of information. There is a "blind area" of low-carbon governance, resulting in the government's inability to fully identify social events that violate carbon emissions. The government uses digital technologies such as the Internet to collect and process environmental behavior data of more microeconomic entities, promote information sharing, and provide guarantee for the government to accurately identify carbon emission violations (Bayat and Kawalek, 2023). On the other hand, digital information systems can be used to monitor government workflows and expose corrupt practices, greatly strengthening the hierarchical accountability within the state apparatus (Shim and Eom, 2008); Moreover, in the application of digital technology, the disclosure of government governance information also helps to strengthen the supervision of civil society and media over the government, leading to an increase in external diagonal accountability (Agostino et al., 2021). The strengthening of the accountability system has changed the traditional situation of chaotic and decentralized governance, and effectively implemented environmental protection issues. Effectively controlling the "black box" operation of enterprises, social organizations, and other organizations in the context of excessive carbon emissions also helps the government achieve low-carbon governance.

In addition, as a large national organizational system, the carbon dioxide generated by the operation of the government itself accounts for an indispensable part of carbon emissions. Low carbon governance by the government can effectively guide energy conservation and emission reduction within government departments. More importantly, low-carbon governance by the government can release positive environmental signals, enabling businesses and the public to optimize their own behavior and reduce carbon emissions in production and consumption. Therefore, the following hypothesis is proposed in this paper:

**Hypothesis 1.** Government digital attention helps to achieve low-carbon governance and promote carbon reduction.

## 3.2 Public low-carbon concern

Government digital attention can encourage more social entities to participate in social governance, raise public awareness of low-carbon environmental protection, and motivate them to reduce carbon emissions. Due to the single perspective and limited subject of traditional government decision-making, single-center government intervention cannot fundamentally solve externality problems. Many carbon reduction policies do not resonate well in society, resulting in low governance efficiency and slow progress of carbon emission reduction. Government digital attention will strengthen the use of modern information technology and form a structured innovation in digital governance, which can help lower the threshold of public participation in governance, and achieve cooperate working (Xing and Yao, 2022). While ensuring the effectiveness of decision-making, it helps strengthen the public's awareness of environmental protection and then realize the public's low-carbon concern. In addition, digital governance is conducive to improving governance transparency and strengthening internal and external accountability. This will motivate the government to shift its focus to providing public services to the public and form a common interest with the public. While the public has environmental rights, it also enhances environmental awareness and forms an inherent driving force for carbon reduction (Zhao et al., 2023). More importantly, as a populous country, the proportion of carbon emissions generated by the public to total emissions continues to rise with the improvement of living standards (Yuan et al., 2024). The public's concern to low-carbon will effectively control the carbon emissions caused by lifestyle and economic activities, thereby promoting carbon reduction. Therefore, the following hypothesis is proposed in this paper:

**Hypothesis 2.** Government digital attention can guide public low-carbon concerns, thereby helping to promote carbon reduction.

## 3.3 Enterprise low-carbon transformation

Government digital attention can optimize the allocation of enterprise attention through "active induction", promote enterprise innovation and improve production methods, and achieve low-carbon transformation. On the one hand, the measures taken by the government to achieve established social goals are a prominent background for the allocation of corporate attention, as these measures are crucial to the operation of enterprises (Nambisan et al., 2019). Enterprises identify business opportunities by evaluating changes in government policies (Tuggle et al., 2010), and develop targeted development plans accordingly. Government digital attention not only promotes the process of government digital transformation, but also helps to reduce the distance between the government and enterprises, and reduce the difficulty for enterprises to understand policies. When the government releases policies related to environmental protection, enterprises will closely monitor information related to the environment, generating motivation for low-carbon transformation. The government ultimately achieves "initiative guidance" (Wang et al., 2022). On the other hand, if a balance is struck between low-carbon transformation and economic growth, the economic risks of transformation failure will greatly reduce the initiative of enterprises in low-carbon transformation. The government's focus on digital technology enables the full utilization of data empowerment attributes and unleashes the vitality of the digital economy. By integrating data resources and optimizing government services, the government creates a more fair and high-quality market environment for market entities, which is conducive to attracting external resources (Eklinder-Frick and Åge, 2017). This to some extent reduces the rent-seeking costs of enterprises, enhances their profit margins and levels, and provides financial support for technological innovation (Peng et al., 2024), thereby facilitating the improvement of production models and achieving green transformation. As the main body of market economy, the low-carbon transformation of enterprises represents the transformation of the overall production mode of society, which is crucial for China to achieve carbon peak. Therefore, the following hypothesis is proposed in this paper:

**Hypothesis 3.** Government digital attention can help promote the low-carbon transformation of enterprises, thereby promoting carbon reduction in cities.

# 4 Empirical analysis

## 4.1 Econometric model construction

Considering that econometric models can help better identify causal relationships between different variables, this paper constructs a panel data econometric model as shown in Formula 1 with the city's carbon emissions as the dependent variable and the degree of government digital attention as the independent variable, to empirically examine the impact of government digital attention on carbon reduction. The panel data used is data from 246 cities in China from 2006 to 2018.

$$Carbon_{it} = \alpha_0 + \beta Digital\_Government_{it} + \gamma_m X_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (1)$$

In Formula 1, $i$ and $t$ represent region and year respectively; *Carbon* represents the carbon emissions of the city. In this paper, carbon emissions generated by electricity, gas and liquefied petroleum gas, transportation and heat consumption are added together to get the carbon emission amount of the city. $\alpha$ is the constant term; *Digital_Government* is the core independent variable, indicating the degree of government digital attention; $\beta$ is the corresponding estimated coefficient, indicating the effect of government digital attention on carbon emissions; $X$ represents the control variables that may affect carbon dioxide emissions. $\gamma$ is the corresponding estimated coefficient. It is worth noting that when using panel data that includes time and region dimensions, it is necessary to consider the impact of unobservable features in time and region on the estimation results. These features may not change over time or region, but are related to the dependent variable. Therefore, the model constructed is a two-way fixed effects model that includes time ($\lambda$) and city ($\mu$), which can effectively control the influence of unobservable factors; and $\varepsilon$ is a random error term.

## 4.2 Index election

### 4.2.1 Carbon dioxide emissions

In this paper, it is believed that regional carbon emissions include not only carbon emissions generated by direct energy consumption (such as gas and liquefied petroleum gas, etc.), but also carbon emissions generated by transportation, as well as carbon emissions generated by electricity and heat consumption.

(1) Carbon emissions from direct consumption of energy such as coal gas and liquefied petroleum gas are measured according to the baseline method (carbon emission conversion factor) provided by the *IPCC Guidelines for National Greenhouse Gas Inventories*', combined with the scale of energy consumption of prefecture-level cities (data sourced from the *China City Statistical Yearbook*).

(2) We use the various energy scales consumed by the transportation sector published in the *China Statistical Yearbook* to calculate the energy consumption per unit of passenger and freight traffic of different transportation modes. Then we the calculate transportation energy consumption and carbon emission of each city by combining the passenger and freight traffic of various transportation modes in the *China City Statistical Yearbook*.

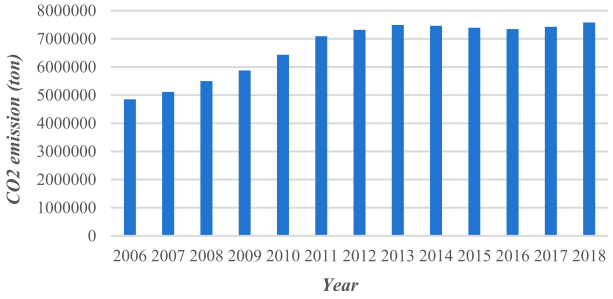


FIGURE 2
China's carbon dioxide emissions (unit: ton).

(3) Carbon emissions of each city's electric energy consumption is equivalent to baseline emission factor of power grid released by six regional power grids in North China, Northeast China, East China, Central China, Northwest China and South China over the past years multiplied by the city's electric energy consumption.

(4) Carbon emissions from urban heat energy consumption are mainly generated by the raw coal consumed in the heating process of the boiler room. The minimum standard of thermal efficiency of coal-fired industrial boilers stipulated in *GB/T152317-2009 Energy-saving Monitoring of Coal-fired Industrial Boilers* is between 65% and 78%. In addition, since China's current central heating boilers are mainly small and medium-sized coal-fired boilers, the thermal efficiency value of 70% is used to calculate. The average low calorific value of raw coal is 20,908 kJ/kg. The amount of raw coal needed can be calculated by using heat supply, thermal efficiency and heat coefficient of raw coal. Then converting raw coal into standard coal coefficient (0.7143 kg of standard coal/per kg), the amount of energy consumed by central heating can be calculated. Finally, according to the IPCC method, the carbon emission coefficient per kilogram of coal is 2.53 kg CO2/kg, and the carbon emissions generated by central heating in various cities are calculated using the amount of raw coal consumed for heat energy.

On this basis, this paper sums up the above four types of carbon dioxide emissions, and obtains the carbon dioxide emissions of each city. Figure 2 depicts the temporal trend of CO2 emissions at the city level in China from 2006 to 2018. It can be observed that during the study period, China's CO2 emissions still showed a certain increasing trend. However, after 2012, this growth trend stopped and China's carbon dioxide emissions entered a stable stage, indicating that the corresponding carbon emission control policies have achieved positive results.

### 4.2.2 Government digital attention

This paper mainly adopts the method of text mining to quantify the text information in the government work report, so as to measure the government digital attention. In China, the work report of a local government is an important document that reflects its work priorities and focus of attention, and is one of

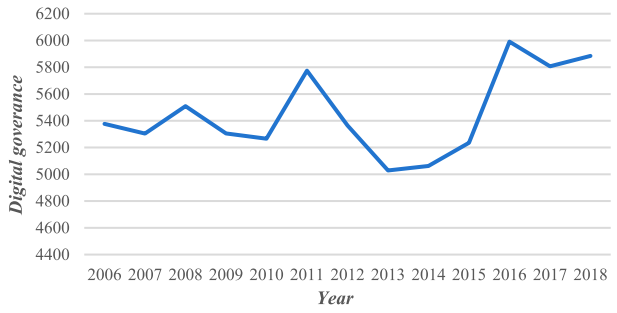


FIGURE 3
Digital attention of governments.

the most authoritative guidelines for the work of local governments. Based on the availability of data, we obtained the terms of digital application concern and digital technology concern from the government work reports of 246 cities in China from 2006 to 2018. The initial text data are sourced from government portal websites of every city.

On the whole, government digital attention is reflected in the degree to which the government pays attention to and uses digital technology in governing economic activities. The keywords related to digital technology in the government work report include *B2B, B2C, C2B, O2O, NFC payment, industrial digitalization, third-party payment, industrial Internet, Internet finance, Internet medical care, financial technology, open banking, quantitative finance, rural big data cloud platform, rural big data, data center, digital service system, digital supply chain, digital finance, digital economy, digital agriculture, digital RMB, Internet of things, online entertainment, unmanned farming, unmanned cars, unmanned retail, unmanned agriculture, unmanned banking, information industry, mobile Internet, mobile payment, government service platform, government application system, smart city, smart agriculture, smart village, smart medical care, smart pension, smart storage, smart wear, smart grid, smart supply chain, intelligent environmental protection, intelligent computing, intelligent home, intelligent transportation, intelligent customer service, intelligent energy, autonomous driving*, etc.

We used computer crawling technology to crawl these keywords in the government work report, and added them up by city and year to obtain the total frequency of government digital attention. Then, we compared it with the total frequency of words in the government work report to obtain the index of local government digital attention. Figure 3 depicts the level of digital attention of Chinese prefecture level municipal governments from 2006 to 2018. It can be observed that during the inspection period, the government continuously strengthened its focus on digital technology and digital economy.

### 4.2.3 Control variable

To further improve the accuracy of the estimates, we also controlled some other factors that may affect regional carbon emissions, including: (1) regional economic development (*Economy*). The measurement indicator used is the *per capita* income level of the city, which is the ratio of the city's gross domestic product to the total population. (2) The opening of the city (*Open*). The measurement index adopted is the actual amount of foreign capital utilized by cities during the investigation period. (3) Urban Innovation (*Patent*). We mainly use the number of city patent applications granted to measure it. (4) Industrial structure (*Second_rate*). We use the proportion of the total output value of the city's secondary industry to GDP to measure the urban industrial structure. (5) Fiscal decentralization (*Fiscal*). Based on the perspective of fiscal revenue decentralization, the *per capita* local fiscal revenue/(*per capita* local fiscal revenue + *per capita* central fiscal revenue) at the provincial level is used to measure fiscal decentralization. (6) Educational development (*Education*). We use the number of college and undergraduate students in each city to measure it. (7) Environmental governance (*Governance*). We choose the industrial pollution control investment of each city as a measure of the degree of environmental regulation. (8) Internet development (*Internet*). This paper selects the number of Internet broadband access users in each prefecture-level city to measure the level of Internet development. The data for the control variables mentioned above are all sourced from the *China City Statistical Yearbook*. Table 1 reports descriptive statistical results for the above variables.

## 4.3 Analysis and discussion of estimated results

### 4.3.1 Estimated results of the benchmark regression model

We estimated the econometric model shown in Formula 1 using Stata 17 software, and the estimation results were obtained as shown in columns (1) - (6) of Table 2. Column (1) shows the results without control variables and fixed effects, the Column (2) shows the results without control variables and with time fixed effects, and the Column (3) shows the results without control variables and with city and time fixed effects; the Column (4) shows the results with control variables but without any fixed effects; Column (5) shows the results with control variables and time fixed effects; Column (6) shows the results after adding control variables and fixed effects of time and city. According to the estimated results shown in column (6), the influence coefficient of the government digital attention on carbon emissions is significantly negative, indicating that the government's attention on the digital technology is conducive to promoting carbon dioxide emission reduction, which is consistent with the expectation.

### 4.3.2 Endogeneity tests

#### 4.3.2.1 Instrumental variable method

To avoid endogeneity estimation bias caused by potential causal relationships, we used instrumental variable method to estimate the model shown in Formula 1. We subtract the average government digital attention index of all cities within the same province from the government digital attention index of city *i* for year *t*, and take the third power of the difference as the instrumental variable for the degree of government digital attention. The advantage of this method is that it can utilize the information contained in the heteroscedasticity of errors without relying on external variables. Columns (1) and (2) in Table 3 represent the estimated results for the first and second stage respectively. It can be found that the *Cragg-Donald Wald F Statistic* is 3052.26, which is larger than the

TABLE 1 Descriptive statistics of variables.

| Variable name | Observations | Mean | sd | Minimum | Maximum |
|---|---|---|---|---|---|
| Digital Governance | 2,920 | 8.5601 | 0.4417 | 0.6931 | 9.7044 |
| Carbon | 2,925 | 5.9677 | 1.1185 | 2.1437 | 9.1895 |
| Economy | 2,925 | 10.4173 | 0.7276 | 8.1312 | 15.6718 |
| Open | 2,925 | 9.7423 | 2.0451 | 0.0000 | 14.1520 |
| Patent | 2,925 | 6.8112 | 1.8777 | 1.6094 | 12.1521 |
| Second_rate | 2,920 | 3.8896 | 0.2859 | 0.0000 | 6.3428 |
| Fiscal | 2,920 | 0.4977 | 0.2713 | 0.0544 | 8.3902 |
| Education | 2,925 | 10.3779 | 1.5630 | 0.0000 | 13.9108 |
| Governance | 2,925 | 12.2330 | 0.7973 | 8.1786 | 14.1637 |
| Internet | 2,925 | 12.8910 | 1.0880 | 9.2104 | 15.8567 |

Note: The above variables are logarithmically processed except for the proportional variables.

TABLE 2 Results of baseline regression model.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Constant | 4.0625*** (10.15) | 4.0498*** (10.07) | 7.3381*** (53.86) | −3.1178*** (−6.55) | −6.9078*** (−14.98) | 5.7098*** (14.02) |
| Digital_Governance | 0.2228*** (4.77) | 0.1835*** (3.92) | −0.0236* (−1.83) | −0.0253 (−0.85) | −0.0164 (−0.60) | −0.0250** (−2.02) |
| Economy | | | | 0.3884*** (13.64) | 0.7458*** (24.83) | 0.0553* (1.87) |
| Open | | | | 0.0326*** (3.41) | −0.0342*** (−3.73) | 0.0072 (1.01) |
| Patent | | | | −0.1098*** (−6.24) | −0.1789*** (−10.87) | −0.1207*** (−9.20) |
| Second_rate | | | | 0.2326*** (4.87) | 0.0528 (1.18) | 0.0538** (2.20) |
| Fiscal | | | | 0.8899*** (14.64) | 0.2170*** (3.48) | 0.0504*** (2.60) |
| Education | | | | −0.1477*** (−12.50) | −0.0803*** (−7.24) | −0.0314*** (−3.36) |
| Governance | | | | −0.0861*** (−4.77) | −0.0770*** (−4.49) | −0.0279** (−2.14) |
| Internet | | | | 0.0198 (0.73) | 0.2426*** (9.12) | −0.0245 (−1.33) |
| Observations | 2,920 | 2,920 | 2,920 | 2,911 | 2,911 | 2,911 |
| City Fixed Effect | No | No | Yes | No | No | Yes |
| Time Fixed Effect | No | Yes | Yes | No | Yes | Yes |
| R-square | 0.0077 | 0.0322 | 0.9435 | 0.6072 | 0.6771 | 0.9475 |

Note: *, ** and *** are significant at 10%, 5% and 1% levels respected; The value in parents indicates the *t* value.

critical value of 10% bias in *Stock-Yogo weak ID test*, so the null hypothesis that the instrumental variable is a weak instrumental variable is rejected. In addition, the estimation coefficient of instrumental variables in the first stage is significant at the 1%, and it can be judged that there is no weak instrumental variable problem. In the results of the second stage shown in column (2), the effect of government digital attention on carbon dioxide emissions is still significantly negative, which is also consistent with the results of the benchmark regression above.

#### 4.3.2.2 Controlling the joint fixed effect

The fixed effects on time and region were added to the benchmark regression model to control for the influence of unobservable features at the time and region levels. However, some important factors may still be missed, which will lead to the endogenous bias of the estimation results. Here, we will further control for the time-region joint fixed effects to reduce the interference of unobservable features that vary simultaneously with time and region on the estimation results. The estimated results considering the joint fixed effect are shown in column (3) of Table 3. The results also show that the effect of government digital attention on carbon dioxide emissions is significantly negative.

### 4.3.3 Robustness tests

#### 4.3.3.1 Replacing the measurement method of carbon dioxide

To verify the robustness of the benchmark regression model, we use the following two methods to replace the dependent variable in

TABLE 3 Results of endogeneity tests.

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | 8.3647*** (40.96) | −6.7846*** (−12.36) | 5.5732*** (3.46) |
| Digital_Governance | | −0.0169** (−2.43) | −0.0245* (−1.98) |
| IVaverage3 | 0.0239*** (55.25) | | |
| Control Variables | Yes | Yes | Yes |
| Observations | 2,730 | 2,730 | 2,911 |
| City Fixed Effect | Yes | Yes | Yes |
| Time Fixed Effect | Yes | Yes | Yes |
| City-Time Joint Fixed Effect | No | No | Yes |
| R-square | | 0.6673 | 0.9476 |
| Cragg-Donald Wald F statistic | 3052.26 | | |

TABLE 4 Robustness test results.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Constant | 2.6977*** (5.89) | 0.1016*** (10.72) | 15.7869*** (150.20) | 6.3577*** (10.23) | 5.7097*** (8.33) | 5.7098*** (7.08) |
| Digital_Governance | −0.0258* (−1.76) | −0.0003** (−2.03) | −0.0037*** (−3.16) | −0.0006*** (−2.67) | −0.0250** (−2.06) | −0.0250** (−2.53) |
| Control Variables | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Observations | 2,911 | 2,911 | 2,911 | 1,573 | 2,911 | 2,911 |
| City Fixed Effect | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Time Fixed Effect | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| R-square | 0.7332 | 0.8295 | 0.9944 | 0.9629 | 0.9475 | 0.9475 |

Formula 1. On the one hand, selecting the carbon dioxide emissions per unit of GDP and *per capita* carbon dioxide emissions per unit of GDP as alternative indicators to exclude the influence of economic aggregate. The estimated results are shown in columns (1) and (2) of Table 4; On the other hand, we selected the carbon dioxide emission data observed by the satellite as an alternative index, and the estimated results are shown in column (3) of Table 4. It can be seen from the estimated results that no matter what measurement index is used, the coefficients are significantly negative, and our estimation results have good robustness.

#### 4.3.3.2 Replacing the measurement method of government digital attention

Here, *National Pulse Network Government Index* is selected as an alternative indicator to measure the degree of government digital attention. The estimated results are shown in column (4) of Table 4. It can be seen that the new digital government index has a significant negative impact on carbon dioxide emissions.

#### 4.3.3.3 Using clustering robust standard error

Considering that our panel data may have structural features at the same city or province level, we used robust standard errors for city and province clustering in estimating the econometric model of Formula 1 to improve the robustness and accuracy of the estimation results. The estimated results are shown in columns (5) and (6) of Table 4. We can observe that the influence coefficient of government digital attention degree on carbon dioxide emissions is still significantly negative, and our estimation results are robust.

## 4.4 Impact mechanism tests

This paper has pointed out that the influence path of government digital attention on carbon dioxide emission mainly includes three aspects: government digital attention may boost government low-carbon governance, enhance the public's low-carbon attention, and promote enterprise low-carbon transformation. Here, we will continue to use econometric models to empirically test these potential impact mechanisms. Specifically, we used a two-step mediation effect model. That is, on the basis of Formula 1, we further constructed an econometric model as shown in Formula 2:

$$Mechanism_{it} = \alpha_0 + \beta Digital\_Government_{it} + \gamma_m X_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (2)$$

In Formula 2, *Mechanism* represents mechanism variables (including government low-carbon governance, public low-

TABLE 5 Test results of impact mechanism.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Constant | −7.0134*** (−5.64) | 2.0586** (2.45) | 2.0027*** (3.38) | 1.9784*** (3.95) |
| Digital_Governance | 0.1185** (2.26) | 0.1460* (1.95) | 0.2829*** (3.80) | −0.0260* (−1.71) |
| Control Variables | *Yes* | *Yes* | *Yes* | *Yes* |
| Observations | 2,911 | 1826 | 1826 | 2,911 |
| City Fixed Effect | *Yes* | *Yes* | *Yes* | *Yes* |
| Time Fixed Effect | *Yes* | *Yes* | *Yes* | *Yes* |
| R-square | 0.5049 | 0.6729 | 0.5948 | 0.9399 |

carbon attention, and enterprise low-carbon transformation). The meanings of other variables are consistent with Formula 1. In terms of the mechanism variables, firstly, we selected the number of environmental protection administrative punishment cases in each city to measure the government's low-carbon governance. The estimated results of government digital attention degree on government's low-carbon governance are shown in column (1) of Table 5. Secondly, in terms of public concern about low carbon, we used *low carbon* and *carbon dioxide* as keywords to calculate the *Baidu Index* from 2011 to 2018 as indicator[3]. The estimated results of government digital attention on public low-carbon concern are shown in columns (2) and (3) of Table 5; Thirdly, for low-carbon transformation of enterprises, considering the availability of data at the city level, we converted the total gas consumption, liquefied petroleum gas consumption and electricity consumption of the whole society into coal volume and sum it up. We then calculated the ratio of coal consumption and added value of the secondary industry in China, and chose this index to measure the enterprises' low-carbon transformation. The smaller the index is, the better the low-carbon transformation effect of the enterprise is. The estimated results are shown in column (4) of Table 5.

It can be seen from the estimated results that government digital attention has a significant positive impact on government's low-carbon governance, indicating that the higher the government digital attention, the better its low-carbon governance performance. It is consistent with the statement of Hypothesis 1. According to the results in column (2) and (3), government digital attention has a significant positive impact on public's low-carbon concern. Government digital attention can enable multiple subjects to participate in governance and transmit positive signals to strengthen the public's awareness of carbon emission reduction, which is consistent with Hypothesis 2. Moreover, the results in column (4) show that government digital attention has a negative impact on the coal consumption of enterprises, the higher the government's digital attention, the lower the proportion of coal consumption of enterprises. Government digital attention can promote the low-carbon transformation of enterprises, this also confirms the Hypothesis 3.

3 Baidu index was officially released in 2011. We lack the data from 2006 to 2010 here.

## 4.5 Extended analysis

### 4.5.1 Heterogeneity of carbon dioxide emission sources

In fact, all aspects of social production and life will produce a certain amount of carbon dioxide emissions, which is also reflected in the measurement method of carbon dioxide in this paper. On the one hand, due to the high cost of clean energy, fossil fuels such as coal gas, natural gas, and liquefied petroleum gas remain the main fuels for industrial production today. This has led to high carbon dioxide emissions from transportation and coal-fired power generation, making it an important area for low-carbon governance in China. The government will actively increase its attention and use of digital technology, strengthen low-carbon governance and public concern in these fields, so as to effectively reduce carbon dioxide emissions in these areas. On the other hand, for the carbon dioxide generated by urban heat energy, these mainly come from the energy consumption generated by the heating of small boiler rooms in the city in order to meet people's daily life. In China, these thermal energy supplies that are closely related to people's lives cannot be reduced in the short term. Government digital attention may not be able to have a direct impact on carbon dioxide in these areas.

In this paper, carbon dioxide emissions are divided into three aspects: carbon dioxide from direct energy consumption and transportation, carbon dioxide from electric energy consumption and carbon dioxide from heat consumption. The impact of government digital attention on them are estimated respectively, so as to identify the heterogeneity. The estimated results are shown in columns (1), (2) and (3) of Table 6.

As can be seen from the estimated results, government digital attention has significant negative effects on carbon dioxide from direct energy consumption and transportation, and electric energy consumption. It indicates that carbon dioxide generated by direct energy consumption and transportation, and electric energy consumption are important areas of governance. According to the estimated results shown in column (3), the estimated coefficient between government digital attention and carbon dioxide from heat consumption is still not significant at the 10%, indicating that government digital attention cannot have a direct effect on carbon dioxide from heat consumption in the short term. The results are consistent with our expectations.

TABLE 6 Heterogeneity results of carbon dioxide emissions sources.

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | 1.1281** (1.97) | 5.6224*** (12.31) | 6.1605*** (7.49) |
| Digital_Governance | −0.0011** (−2.06) | −0.0338** (−2.43) | 0.0100 (0.40) |
| Control Variables | *Yes* | *Yes* | *Yes* |
| Observations | 2,911 | 2,911 | 2,911 |
| City Fixed Effect | *Yes* | *Yes* | *Yes* |
| Time Fixed Effect | *Yes* | *Yes* | *Yes* |
| R-square | 0.9274 | 0.9358 | 0.9407 |

### 4.5.2 Impact of the marketization

The degree of marketization determines the regional resource allocation efficiency to a large extent, which may have an impact on carbon emission reduction effect of government digital attention. Especially for China, which is in the period of economic transformation, if the government controls too many resources and excessively intervenes in the behavior of market players, market competition cannot be played. This will not only cause the government to lose the impetus for digital transformation, but also lead to many high-pollution, high-energy-consuming enterprises unable to withdraw from the market. This then will certainly reduce the impact of government digital attention on carbon dioxide reduction.

Based on this, this paper will identify the impact of government digital attention on carbon dioxide emission reduction under different marketization degrees. We used the index of the degree of marketization (*Market*) of China's provinces, and divided the samples into high degree of marketization and low degree of marketization according to the median, so as to investigate the impact of government digital attention on carbon dioxide emission reduction in different samples respectively. The final results are shown in columns (1) and (2) of Table 7. Moreover, we also adopted the method in the form of interaction terms to incorporate the interaction terms of government digital attention and marketization degree index into the model. The estimated results are shown in column (3).

As can be seen from Table 7, in areas with a high degree of marketization, government digital attention has a significant negative effect on carbon dioxide emissions. While in areas with a low degree of marketization, the impact of government digital attention is not significant. The degree of marketization does indeed affect the carbon reduction effect of government digital attention. According to the results shown in column (3), the estimated coefficient of the interaction term is significantly negative, indicating that the degree of marketization can positively regulate the government digital attention and carbon dioxide emission reduction.

### 4.5.3 The impact of regional heterogeneity

Due to the comprehensive influence of historical factors, geographical environment and policy factors, China's regional economic and social development presents a typical spatial gradient pattern. There are significant spatial differences in economic development level and governance capacity in eastern, central and western regions. On the one hand, the difference in economic development often determines the difference in the decision-making orientation of local governments. The development of digital economy in the eastern region is relatively high, and the government attaches more importance to the application of digital technology. The government is more willing and capable of using digital technology for governance. On the other hand, the eastern region has a dense population distribution and a huge manufacturing volume, facing more serious carbon emission problems. Hence, their urgency of low-carbon transition is relatively high. We believe that government digital attention may have a significant impact on carbon emission reduction in the eastern region, but not in the central and western regions.

We identified regional heterogeneity by separately estimating the impact of government digital attention on carbon dioxide emissions reduction in the eastern, central, and western regions. The results are shown in Table 8, where columns (1), (2) and (3) represent the estimated results for the eastern, central and western regions respectively.

As for the estimation results of spatial heterogeneity shown in Table 8, government digital attention has a significant positive impact on carbon dioxide emission reduction in the eastern region, while the effect in the central and western regions are not significant. It verifies the existence of spatial heterogeneity of carbon dioxide emission reduction influenced by government digital attention, which is consistent with our expectation.

TABLE 7 Results of considering the regional marketization.

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | 6.3231*** (11.46) | 4.4879*** (6.33) | 5.7397*** (14.08) |
| Digital_Governance | −0.1400*** (−2.59) | −0.0101 (−0.76) | −0.0399** (−2.36) |
| Digital_Governance × Market | | | −0.0018** (−2.29) |
| Control Variables | *Yes* | *Yes* | *Yes* |
| Observations | 1,618 | 1,293 | 2,911 |
| City Fixed Effect | *Yes* | *Yes* | *Yes* |
| Time Fixed Effect | *Yes* | *Yes* | *Yes* |
| R-square | 0.9634 | 0.9665 | 0.9475 |

TABLE 8 Results of regional heterogeneity.

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | 4.0729*** (4.47) | 6.5136*** (11.27) | 4.5831*** (4.92) |
| Digital_Governance | −0.0864*** (−2.69) | −0.0027 (−0.20) | −0.0138 (−0.46) |
| Control Variables | Yes | Yes | Yes |
| Observations | 961 | 1,179 | 771 |
| City Fixed Effect | Yes | Yes | Yes |
| Time Fixed Effect | Yes | Yes | Yes |
| R-square | 0.9559 | 0.9507 | 0.9232 |

## 5 Conclusion and policy implications

This paper is based on attention theory and examines the impact of government digital attention on regional carbon reduction within the framework of government-public-enterprise. The following conclusions have been drawn: (1) During the study period, government digital attention has a significant negative impact on carbon dioxide emissions, indicating that the government attention to digital technology can further promote carbon dioxide emission reduction in the region. (2) Results of the impact mechanism test show that government digital attention can improve the government's low-carbon governance, strengthen the public's low-carbon attention, and encourage enterprises' low-carbon transformation. (3) Government digital attention has a significant negative effect on carbon dioxide from direct energy consumption, and transportation, electric energy consumption, but has no significant effect on the carbon dioxide from heat energy consumption. The degree of marketization helps to strengthen the carbon reduction effect of government digital attention. The effect of government digital attention on carbon dioxide emissions in the eastern region is significantly negative, while the effect in the central and western regions are not significant.

The policy implications of this research conclusion are as follows: (1) The government should accelerate the popularization of digital technologies such as the Internet of things, cloud computing, and big data, increase attention to digital technologies, promote government digital transformation, and enhance the digital governance capabilities. That is, the government should pay more attention to digital technology in the future work. They should give full play to the functions of the Internet of things, sensors and other public data collection, establish governance databases and data cockpits, providing guarantees for integrating data resources and accurately identifying carbon violations. In addition, the construction of digital government should be accelerated. On the one hand, by providing the public with more convenient and information-based services, the public can improve their trust in government decision-making and participation in joint decision-making, so as to lay the foundation for the public's low-carbon concern. On the other hand, we can improve the digital economy policy and optimize the business environment, so as to stimulate the motivation of enterprises' low-carbon transformation. (2) It is necessary to further dredge the transmission channels of government's digital attention to promote carbon dioxide emission reduction through government low-carbon governance, public low-carbon attention and enterprise low-carbon transformation. Specifically, government can establish a digital file management system, promote digital examination and approval system, establish a digital assessment and evaluation platform. Government can also establish digital platforms so that the public can participate in government decision-making anytime and anywhere. Through data opening and sharing, the public can understand the work of the government. (3) Government can disclose relevant ecological civilization information to enterprises, such as environmental monitoring data, environmental protection policies, environmental impact assessment reports, etc. At the same time, government can strengthen digital publicity and education, conveying government intentions and policy connotations to enterprises through digital media. It will help guide enterprises to allocate attention to ecological civilization, and improve their responsibility awareness in ecological civilization.

This article has made many attempts and extensions to the research on the carbon reduction effect of government digital attention, but it cannot be denied that there are also certain shortcomings. The government's digital attention reflects its emphasis on the development of the digital economy and the use of digital technology in decision-making, which is both a broad concept and highly subjective. This article mainly extracts the frequency of words related to digital technology from government work reports to identify the government's digital concerns. Although this has good applicability in China, it still cannot reflect all the content of the government's digital concerns, such as the actual adoption and investment of digital technology by the government, which may also have an impact on carbon reduction in the economy. In the future, we will continue to expand our research on the connotation of government digital attention, in order to have a more comprehensive understanding of the new models and impact effects of government governance in the digital economy era.

## 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

RH: Formal Analysis, Funding acquisition, Investigation, Writing–review and editing. KS: Conceptualization, Data curation, Methodology, Funding acquisition, Writing–original draft.

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## 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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## References

Agostino, D., Saliterer, I., and Steccolini, I. (2021). Digitalization, accounting and accountability: a literature review and reflections on future research in public services. *Financial Account. Manag.* 38 (2), 152–176. doi:10.1111/faam.12301

Bayat, A., and Kawalek, P. (2023). Digitization and urban governance: the city as a reflection of its data infrastructure. *Int. Rev. Adm. Sci.* 89 (1), 21–38. doi:10.1177/00208523211033205

Cai, Z., Ding, X., Zhou, Z., Han, A., Yu, S., Yang, X., et al. (2025). Fiscal decentralization's impact on carbon emissions and its interactions with environmental regulations, economic development, and industrialization: evidence from 288 cities in China. *Environ. Impact Assess. Rev.* 110, 107681. doi:10.1016/j.eiar.2024.107681

Castro, C., and Lopes, C. (2022). Digital government and sustainable development. *J. Knowl. Econ.* 13, 880–903. doi:10.1007/s13132-021-00749-2

Chen, R., and Liu, D. C. (2022). Research on the innovation path of government digital transformation under the new development pattern of 'double cycle'. *Reform Econ. Syst.* (1), 28–34. (in Chinese).

Danish, B. M. A., Mahmood, N., and Zhang, J. W. (2019). Effect of natural resources, renewable energy and economic development on CO2 emissions in BRICS countries. *Sci. Total Environ.* 678, 632–638. doi:10.1016/j.scitotenv.2019.05.028

Destek, M. A., Hossain, M. R., Manga, M., and Destek, G. (2024). Can digital government reduce the resource dependency? Evidence from method of moments quantile technique. *Resour. Policy* 99, 105426. doi:10.1016/j.resourpol.2024.105426

Eklinder-Frick, J., and Åge, L. J. (2017). Perspectives on regional innovation policy: from new economic geography towards the IMP approach. *Ind. Mark. Manag.* 61, 81–92. doi:10.1016/j.indmarman.2016.07.005

Gil-Garcia, J. R., Helbig, N., and Ojo, A. (2014). Being smart: emerging technologies and innovation in the public sector. *Gov. Inf. Q.* 31, 11–I8. doi:10.1016/j.giq.2014.09.001

Guo, Y. F., and Lin, B. (2022). Influencing factors and multiple paths of construction ability of digital government: qualitative comparative analysis based on 31 Chinese provinces. *Procedia Comput. Sci.* 199, 1213–1220. doi:10.1016/j.procs.2022.01.154

Hamish, S., Aaron, G., Valtteri, K., Michelle, R., and Val, H. (2021). Mechanisms of service ecosystem emergence: exploring the case of public sector digital transformation. *J. Bus. Res.* 137, 100–115. doi:10.1016/j.jbusres.2021.08.008

Han, F., and Zhang, D. (2024). Government digitalization and its influence on government functions transformation adopting a Structural Functionalism perspective: evidence from county-level governments in China. *Heliyon* 17 (10), e37267. doi:10.1016/j.heliyon.2024.e37267

Jiang, Z., Yuan, C., and Xu, J. (2024). The impact of digital government on energy sustainability: empirical evidence from prefecture-level cities in China. *Technol. Forecast. Soc. Change* 209, 123776. doi:10.1016/j.techfore.2024.123776

Lee, J. N., Ham, J., and Choi, B. (2016). Effect of government data openness on a knowledge-based economy. *Procedia Comput. Sci.* 91, 158–167. doi:10.1016/j.procs.2016.07.053

Li, E., Chen, Q., Zhang, X., and Zhang, C. (2023). Digital government development, local governments' attention distribution and enterprise total factor productivity: evidence from China. *Sustainability* 15, 2472. doi:10.3390/su15032472

Li, X., and Yue, S. J. (2025). Does the government digital attention improve China's digital economy output efficiency: accelerator or inhibitor. *Econ. Analysis Policy* 85, 607–625. doi:10.1016/j.eap.2024.12.020

Luca, T., Marijn, J., Michele, B., and Giuliano, N. (2021). Digital government transformation: a structural equation modelling analysis of driving and impeding factors. *Int. J. Inf. Manag.* 60, 102356. doi:10.1016/j.ijinfomgt.2021.102356

Luna-Reyes, L. F., and Gil-Garcia, J. R. (2014). Digital government transformation and internet portals: the co-evolution of technology, organizations, and institutions. *Gov. Inf. Q.* 31 (4), 545–555. doi:10.1016/j.giq.2014.08.001

Mergel, I., Noella, E., and Nathalie, H. (2019). Defining digital transformation: results from expert interviews. *Gov. Inf. Q.* 36 (4), 101385. doi:10.1016/j.giq.2019.06.002

Nambisan, S., Wright, M., and Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: progress, challenges and key themes. *Res. Policy* 48 (8), 103773. doi:10.1016/j.respol.2019.03.018

Peng, Z., Huang, Y., Liu, L., Xu, W., and Qian, X. (2024). How government digital attention alleviates enterprise financing constraints: an enterprise digitalization perspective. *Finance Res. Lett.* 67, 105883. doi:10.1016/j.frl.2024.105883

Rahman, M. M., Sultana, N., and Velayutham, E. (2022). Renewable energy, energy intensity and carbon reduction: experience of large emerging economies. *Renew. Energy* 184, 252–265. doi:10.1016/j.renene.2021.11.068

Shim, D. C., and Eom, T. H. (2008). E-government and anti-corruption: empirical analysis of international data. *Int. J. Public Adm.* 31 (3), 298–316. doi:10.1080/01900690701590553

Sohail, R. C., Hu, G. W., Si, W. F., and Pasha, A. T. (2020). Synthesizing e-government maturity model: a public value paradigm towards digital Pakistan. *Transforming Gov. People Process Policy* 14 (3), 495–522. doi:10.1108/tg-11-2019-0110

Tang, J., Li, W., Hu, J., and Ren, Y. (2025). Can government digital transformation improve corporate energy efficiency in resource-based cities? *Energy Econ.* 141, 108043. doi:10.1016/j.eneco.2024.108043

Tuggle, C. S., Sirmon, D. G., Reutzel, C. R., and Bierman, L. (2010). Commanding board of director attention: investigating how organizational performance and CEO duality affect board members' attention to monitoring. *Strategic Manag. J.* 31 (9), 946–968. doi:10.1002/smj.847

Wang, Q., Ren, F., and Li, R. (2024). Exploring the impact of geopolitics on the environmental Kuznets curve research. *Sustain. Dev.* 32 (3), 1700–1722. doi:10.1002/sd.2743

Wang, X. C., Li, Y., Tian, L. W., and Hou, Y. (2022). Government digital initiatives and firm digital innovation: evidence from China. *Technovation* 119, 102545. doi:10.1016/j.technovation.2022.102545

Xian, Y., Wang, H., Zhang, Z., Yang, Y., and Zhong, Y. (2025). Driving factors and reduction paths dynamic simulation optimization of carbon dioxide emissions in China's construction industry under the perspective of dual carbon targets. *Environ. Impact Assess. Rev.* 112, 107789. doi:10.1016/j.eiar.2024.107789

Xing, Q., and Yao, W. (2022). Digital governance and its benchmarking college talent training under the rural revitalization in China: a case study of Yixian County (China). *Public Health* 10, 984427. doi:10.3389/fpubh.2022.984427

Yang, C., Gu, M., and Albitar, K. (2024). Government in the digital age: exploring the impact of digital transformation on governmental efficiency. *Technol. Forecast. Soc. Change* 208, 123722. doi:10.1016/j.techfore.2024.123722

Yang, X., Wang, J., Cao, J., Ren, S., Ran, Q., and Wu, H. (2022). The spatial spillover effect of urban sprawl and fiscal decentralization on air pollution: evidence from 269 cities in China. *Empir. Econ.* 63, 847–875. doi:10.1007/s00181-021-02151-y

Yu, C., Gao, D., and Sun, H. (2025). The impact of digital government services on manufacturing productivity: China's pilot city insights. *Finance Res. Lett.* 73, 106600. doi:10.1016/j.frl.2024.106600

Yuan, B., Zhong, Y. P., Li, S. S., and Zhao, Y. H. (2024). The degree of population aging and living carbon emissions: evidence from China. *J. Environ. Manag.* 353, 120185. doi:10.1016/j.jenvman.2024.120185

Yuan, Y. P., Dwivedi, Y. K., Tan, G. W., Cham, T. H., Ooi, K. B., Aw, E. C., et al. (2023). Government digital transformation: understanding the role of government social media. *Gov. Inf. Q.* 40 (1), 101775. doi:10.1016/j.giq.2022.101775

Zhang, C., Wang, C., Jin, H., Xu, M., Balezentis, T., and Agnusdei, L. (2025). The impact of green finance on energy transition and carbon emission targets: exploring the double threshold and spatial spillover effects among the regions. *Struct. Change Econ. Dyn.* 73, 1–10. doi:10.1016/j.strueco.2024.12.012

Zhang, K., Cao, B., Guo, Z., Li, R., and Li, L. (2024). Research on the impact of government attention on the digital economy of Chinese provinces. *Innovation Green Dev.* 3 (2), 100118. doi:10.1016/j.igd.2023.100118

Zhang, L., and Zhang, X. (2025). Impact of digital government construction on the intelligent transformation of enterprises: evidence from China. *Technol. Forecast. Soc. Change* 210, 123787. doi:10.1016/j.techfore.2024.123787

Zhao, B., Wang, K., and Xu, R. (2023). Fiscal decentralization, industrial structure upgrading, and carbon emissions: evidence from China. *Environ. Sci. Pollut. Res.* 30, 39210–39222. doi:10.1007/s11356-022-24971-w

Zhao, S. L., Teng, L. J., Vincent, E. A., and Hu, H. (2023). Impacts of digital government on regional eco-innovation: moderating role of dual environmental regulations. *Technol. Forecast. Soc. Change* 196, 122842. doi:10.1016/j.techfore.2023.122842