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Tianli Wang , Biru Cao * , Ang Li

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Economic Policy Uncertainty's Spatial Spillover Impacts on Green Economy Efficiency

Tianli Wang, Biru Cao *and Ang Li

School of Finance and Taxation, Capital University of Economics and Business, Beijing 100070, China
* Correspondence: biru_cao@foxmail.com

Abstract: Green economy has emerged as a significant pillar of sustainable development in the current global context, and the unpredictability of economic policy has progressively garnered the interest of businesses and government officials as one of the obstacles they must confront. This paper examines how uncertainty in the green economy impacts the green economy's efficacy. The research concentrates on how changes in a particular region can result in geospatial diffusion (spatial spillover), which is a form of spatial spillover wherein the uncertainty of the green economy can impact its efficacy. This paper examines the policy formulation and current state of the green economy across various regions, as well as the diffusion of economic policy uncertainty across geographical areas and the subsequent impact on the green economy's status quo. There is a negative correlation between economic policy uncertainty and green economy efficacy, according to research. There is a spatial spillover effect between economic policy uncertainty and the efficacy of the green economy. Regional variations exist in the impact of economic policy uncertainty on the efficacy of the green economy. The findings indicate that the implementation of AI has a more substantial beneficial effect on carbon emissions. An increase in carbon dioxide emissions poses a growing challenge for the industrial sector in its pursuit of carbon neutrality.

Keywords: economic policy uncertainty; green economic efficiency; spatial durbin modelSpatial moran index

1. Introduction

The urgency surrounding social and economic requirements for sustainable development and environmental protection has escalated in tandem with the growth of the green economy in recent years. This trend mirrors international endeavors to implement policy interventions that address pressing concerns including resource scarcity and climate change[1]. However, at the same time, uncertainty of economic policies is constantly increasing, especially in international relations and domestic politics, which together shape the pattern of the economic environment [2].

As a result, it is impossible to overlook how uncertain economic policy affects the effectiveness of the green economy. The uncertainty surrounding international collaboration, regulatory changes, and government policy decisions may have a significant impact on the growth and innovation of the green sectors. These factors can also diffuse and propagate across multiple geo-spaces, leading to the formation of a "spatial spillover" effect [3]. This effect may result in disparities in green economic efficiency between locations, which has sparked widespread interest among policymakers, entrepreneurs, and researchers [4]. Thus, investigating the connection between green economy efficacy and economic policy uncertainty is a crucial focus of modern global economics.

A growing number of academics have shifted their attention to studying green economic efficiency in response to the growing number of environmental crises. Green economic efficiency was largely defined and several measuring techniques were investigated in the early literature. Then, a plethora of studies started to zero in on the ways in which different variables impact green economy efficiency [5]. One of the most important ways to encourage the growth of a green economy is through environmental policies. For example, Shuai & Fan (2020) [6] pointed out that strict environmental regulations can encourage enterprises to carry out technological transformation and green innovation, thereby improving resource utilization efficiency and reducing pollution emissions.

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From a tax policy standpoint, it is believed that implementing a fair environmental tax and charge system can motivate businesses to adopt production methods that are more environmentally sustainable [7]. Technological innovation is recognized as a significant catalyst for advancing green economic efficiency, alongside environmental policies. For example, Zhang (2020) [8] found through empirical analysis that technological progress can significantly improve resource utilization efficiency and reduce pollution emissions.

This paper incorporates geographical geographic aspects into empirical analysis by utilizing the economic policy uncertainty among provinces in China. The text explores the regional variations in geographical spillovers and then examines the processes via which these impacts impact green economic efficiency and spatial spillovers. Simultaneously, this study examines the dissemination of policy uncertainty across different geographical regions and its influence on green economic efficiency. It aims to offer policy makers a more solid foundation for decision-making and contribute to the establishment of a more sustainable framework. An effective economic system offers pragmatic recommendations and policy guidelines to attain long-lasting economic growth.

2. Literature Review

This uncertainty may stem from the decision-making process of policy makers, the long-term impact of policies, political turmoil, changes in international economic relations, and other factors [9]. Economic policy uncertainty may manifest as unclear policy objectives, frequent changes in regulations, and uncertainty in policy predictions. In the context of a green economy, government environmental protection policies, energy policies, and carbon emission policies may be affected by uncertainty, thereby affecting the behavior of enterprises, investors, and consumers [10]. Al-Thaqeb et al. (2022) [11] provided a preliminary definition of economic policy uncertainty in his classic work, viewing it as the decision-maker's uncertainty perception of future policy direction and implementation methods. Following that, researchers like Beckmann & Czudaj (2017) [12] effectively assessed the degree of uncertainty in economic policies within a country or region by creating measures like the Policy Uncertainty Index. These tools offer practical methods for future study to measure and examine the influence of uncertainty.

Economic policy uncertainty has several repercussions. The correlation between economic policy uncertainty and corporate investment is substantial. Feng & Chen (2018) [13] contend that in the presence of significant policy uncertainty, companies may choose to delay or abandon investment plans in order to await more definitive policy signals. This change in investment behavior could potentially have an adverse effect on overall macroeconomic growth. The volatility of economic policy will affect enterprise innovation [14].

When confronted with uncertainty in economic policies, businesses may decrease their investment in innovation endeavors. This is because innovation often requires a significant amount of time to yield profits and is heavily impacted by policy decisions. This could potentially result in a deceleration of technical advancement and a decrease in the country's competitiveness. A major driver of economic growth in many nations, business exports are affected by economic policy uncertainty [15].

However, as a result of increased uncertainty in external markets, businesses may reduce exports when policy uncertainty rises. Exports may decline as a result, which could have an impact on the nation's economic growth [16]. Uncertainty regarding economic policy can also influence market reactions. A rise in uncertainty may prompt investors to curtail their investments, thereby resulting in a decline in the liquidity of the capital market [17]. Additionally, consumer confidence could potentially decline, resulting in a reduction in consumer demand. International trading partners may react negatively to the unpredictability of economic policies; in extreme cases, it may even result in trade conflicts or investment competition, which would only serve to heighten the uncertainty of the global economy [18].

Prior to examining the influence of economic policy uncertainty on the efficiency of the green economy, it is imperative to elucidate the definition and techniques used to quantify green economy efficiency. The concept of green economy efficiency refers to the capacity to attain economic growth

while limiting the negative impact on the environment [19]. The primary objective is to attain the sustainable utilization of resources, foster the growth of the environmental protection sector, and finally realize a mutually beneficial outcome for both the economy and the environment. To measure the effectiveness of the green economy, researchers utilize a range of indicators from the domains of economics and environmental science. These indicators, such as ecological footprint and carbon emission intensity, provide a comprehensive assessment of the overall performance of the green economy [20-21].

The concept of green economy efficiency pertains to the pursuit of economic growth while minimizing the negative effects on the environment [22]. This notion encompasses enhancing resource utilization efficiency, minimizing waste and pollution emissions, and advocating for the adoption of renewable energy and sustainable industrial techniques. The efficacy of the green economy encompasses not only the harmonization of economic progress and environmental preservation, but also necessitates the inclusion of social fairness and long-term viability. Over the past few decades, the global economy has undergone remarkable expansion. However, this expansion has frequently been accompanied by the excessive utilization of environmental resources and the degradation of the ecological environment [23]. The conventional economic development paradigm has become unsustainable, prompting countries to shift towards the path of green development. The notion of green economy efficiency, which is now growing, focuses on the simultaneous achievement of economic growth and the reduction of environmental effect [24]. The focus of this approach extends beyond economic gains and also highlights the importance of achieving a peaceful cohabitation between the environment, society, and economy [25]. Hence, it is highly significant, both in theory and practice, to investigate the elements that influence the efficiency of the green economy in order to advance global sustainable development [26].

In light of the escalating global environmental crises, the pursuit of a green economy has emerged as a shared objective among governments and businesses worldwide. The efficiency of the green economy is a crucial indicator for assessing the amount of development in this sector, and it is influenced by a variety of factors. Examining these influential aspects not only enhances comprehension of the inherent principles governing the advancement of the green economy, but also offers valuable guidance for policymakers and businesses, hence carrying substantial theoretical and practical implications [27].

Over the past few years, both local and international experts have performed thorough research on the various aspects that influence the effectiveness of the green economy. Environmental policy is widely recognized as a crucial driver for the advancement of the green economy. According to Miao et al. (2017), stringent environmental restrictions can serve as a catalyst for firms to develop innovative green technology, leading to enhanced economic efficiency [28]. Peng et al. (2021) argued that implementing a well-designed environmental tax and charge system can incentivize firms to enhance their efficiency in utilizing resources, as viewed through the lens of tax policy [29]. In their study, Phan et al. (2021) discovered that environmental policies exert a notable and favorable influence on the efficiency of the green economy. Stringent environmental rules and tax policies might incentivize firms to augment their investment in environmental conservation and enhance their efficiency in resource consumption [30].

Technological innovation is considered a significant catalyst for enhancing the efficiency of the green economy, alongside environmental policies [31]. For instance, Sun et al. (2022) discovered through empirical analysis that technical advancements can greatly enhance the efficiency of the green economy, particularly in high-tech sectors [32]. In a similar vein, Sun et al. (2017) highlighted that technology innovation has the potential to encourage businesses to embrace greener manufacturing practices, thereby enhancing overall economic efficacy. Technological innovation is the primary contributing component [33]. Enterprises can achieve a reduction in energy consumption and emissions, as well as an improvement in production efficiency and resource usage, by introducing and developing new technologies autonomously.

Furthermore, market size, industrial structure, and international trade are regarded as significant determinants of green economy efficiency. Altenburg and Rodrik (2017) [34] posit that the

advancement of the green economy can be facilitated through industrial structure adjustment, with a particular emphasis on how a greater proportion of services-oriented sectors can mitigate energy consumption and emissions. The advancement of the service sector significantly enhances the efficacy of the green economy, while the decline in the share of industries characterized by high energy consumption and pollution is advantageous for the enhancement of green economy efficiency. According to Liang et al. (2021) [35], international trade influences the efficacy of the green economy in two ways: International trade has the potential to facilitate resource sharing and technology transmission. However, an excessive dependence on exports could result in resource overconsumption and heightened environmental stress. Uncertainty surrounds the effect of international trade on the efficacy of the green economy.

IScholars from both within and outside the country have undertaken substantial research on the green economy and spatial spillover effect in recent years. Prior research concentrated on elucidating the concept, operation, and extent of spatial spillover. As research progresses, an increasing number of academics are focusing on the significance of the spatial spillover effect in the context of the green economy. According to the findings of Shen et al. (2021) [36], the implementation of green technology innovations in a given area not only stimulates the economic growth of that region but also positively influences the neighboring areas via technology diffusion and additional mechanisms. Wang et al. (2021) [37] underscored the spatial spillover effect of green investment, contending that through the investment transmission mechanism, green investment in a region can not only stimulate local employment and economic expansion, but also generate a favorable spillover effect on neighboring areas.

Spatial spillover is a term used to describe the consequential effects of economic activities or policy choices that occur in one region on adjacent regions (Feng et al., 2022) [38]. Uncertainty regarding economic policy can affect one region within the context of a green economy, but its effects can also extend to neighboring regions. The potential consequences of this spatial spillover effect on green technology innovation, green investment, and carbon emission control are substantial (Qi et al., 2022) [39]. The economic connections between regions are becoming more interconnected in the era of globalization, and the progress made in one region frequently influences the progress made in others. Numerous policies and economic activities, particularly in the context of the green economy, have cascading effects on neighboring regions [40]. Due to this characteristic of spatial spillover, economic policy ambiguity in one region may have a ripple effect on other regions as well. Consequently, investigating the spillover influence on the green economy is both substantive and pragmatically significant. In addition to enhancing comprehension of the internal mechanisms governing green economic development, it can furnish decision makers with a practical reference point for advancing coordinated, sustainable, and environmentally friendly development across diverse regions (Li et al., 2022) [41].

The following constitutes academic research on the space spillover effect: The influence of the space spillover effect and innovations in ecological technology. Regional green technology innovation is influenced not only by local R&D investment and technology accumulation, but also by technology diffusion in neighboring regions, according to Peng et al. (2021) [42]. This diffusion of innovation across regions enhances the technological sophistication and capacity for innovation throughout the entire area, thereby fostering the growth of the green economy. The spatial spillover effect and the environmental investment's consequences. According to a study by Taghizadeh Hesary and Yoshino (2019) [43], green investment in a given region not only stimulates economic growth and local employment, but also exerts a favorable residual effect on neighboring areas via the investment transmission mechanism. An illustration of this is how regional investments in green energy initiatives can foster cooperation and investment from neighboring regions, thereby promoting the growth of green industries throughout the region. The influence of the spatial spillover effect on the regulation of carbon emissions (He et al., 2019) [44].

The findings of Du et al. (2022) [45] demonstrate that endeavors to control carbon emissions in a specific area not only lead to a decrease in local carbon emissions, but also exert a beneficial influence on carbon emission control in adjacent regions. This is mostly attributed to the widespread

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distribution and exchange of environmental conservation technology and knowledge throughout different geographical areas.

3. Research Hypotheses

Al Thaqeb et al. (2022) [46] demonstrated that economic policy uncertainty has the potential to cause enterprises to postpone investment choices, thereby impacting economic growth. The uncertainty surrounding economic policies might impact the prices and limitations of funding for businesses (Xu, 2020) [47], thereby influencing their performance and value (Bhattacharya et al., 2017) [48]. Furthermore, researchers have examined the influence of economic policy uncertainty on corporate technology innovation (Danish et al., 2020) [49] and discovered that economic policy uncertainty can impede corporate technological innovation endeavors.

Regarding the green economy, researchers have mostly examined the elements that influence it and the methodologies used to evaluate it. Wu et al. (2020) [50] examined how environmental rules affect green economic efficiency and discovered that these restrictions encourage businesses to implement environmental protection technology, leading to an improvement in green economic efficiency. Furthermore, researchers have examined how firm features, technological innovation, and management innovation affect green economic efficiency at the enterprise level (Gaspara atos et al., 2017) [51].

The correlation between economic policy uncertainty and the effectiveness of the green economy has gained significant attention in recent academic study. Several scholars have presented data that supports the anticipated inverse relationship between economic policy uncertainty and green economic efficiency. They have conducted thorough examinations of pertinent literature. For instance, Drobetz et al. (2018) [52] discovered that elevated levels of economic policy uncertainty can result in decreased investment in green technology and environmental innovation by enterprises. This is because they face difficulties in making long-term decisions within an uncertain policy setting. This indecisiveness could result in a decline in the effectiveness of the sustainable economy.

The correlation between economic policy uncertainty and the efficiency of the green economy is not coincidental. Amidst an unpredictable policy landscape, businesses and investors tend to exercise greater caution and find it challenging to anticipate the future trajectory of policy evolution. Consequently, investment in the green economy sector may face limitations. These consequences might be observed as a reluctance to embrace environmentally-friendly technologies, decreased funding for environmental advancements, and postponements in sustainable development initiatives. Georgeson et al. (2017) [53] conducted an analysis using economic data from several countries. They discovered a noteworthy inverse relationship between elevated levels of economic policy uncertainty and green economic efficiency. Evidence indicates that policy uncertainty might cause firms to be reluctant to invest in green technologies and innovation. This is because they face difficulties in anticipating the regulatory landscape, which can impact their long-term strategies in the realm of sustainable development. Furthermore, the perspective is reinforced by the research conducted by Sun et al. (2017) [54]. The study examined the influence of policy uncertainty on the green energy sector and discovered a detrimental relationship between heightened policy uncertainty and reduced investment and innovation by renewable energy firms. This implies that when faced with high levels of uncertainty in policy, enterprises may choose a more cautious approach towards green economy projects, resulting in a decline in efficiency.

Multiple independent research have consistently found substantial evidence supporting the notion that there is an anticipated inverse relationship between economic policy uncertainty and green economic efficiency. These research findings establish a robust theoretical and empirical foundation for our comprehensive examination of this correlation. The presence of economic policy uncertainty, characterized by the frequent alterations in government policies, ambiguous rules, and swings in tax policies, frequently exerts a detrimental influence on the macroeconomy. The policy uncertainty can have a detrimental impact on the efficiency of the green economy, resulting in a negative effect. Rising economic policy uncertainty can cause a decline in investment, research, and innovation within the green economy sector. This, in turn, can lead to higher capital costs and

reduced market confidence, ultimately diminishing the overall effectiveness of the green economy. The initial assumption posits that the anticipated impact of economic policy uncertainty on green economic efficiency is adverse. To summarize, the following hypothesis is put up.

H1: The effect of economic policy uncertainty on green economic efficiency is negatively correlated.

Liow et al. (2018)[25] highlighted that uncertainty in one location might be transferred to other regions via supply chain and industrial connections. This offers us a specific theoretical foundation for comprehending the spatial dissemination of economic policy uncertainty. The presence of economic policy uncertainty in a certain region may result in a sense of caution among firms and investors, leading to a reduction in the allocation of funds towards green economy projects (Beckmann & Czudaj, 2017) [55]. The influence of this phenomenon is not just confined to regions with policy uncertainty, but can also propagate to neighboring places via industrial networks and economic interdependencies. This transmission mechanism may encompass both upstream and downstream firms within the supply chain, as well as foster industrial cooperation connections and facilitate trade and investment between different locations.

According to Chi & Li (2017) [56], economic policy uncertainty frequently causes businesses and investors to be hesitant in participating in green economy projects. Yu et al. (2021) [57] found that enterprises may be deterred from investing in green technology and environmental innovation due to significant policy uncertainty. This is because they face difficulties in anticipating the future direction of policy development. This cautious demeanor may not just be evident in domains of policy ambiguity, but may also disseminate to adjacent sectors via supply chains and economic linkages.

Several empirical research offer data that confirms the regional spillover effects of economic policy uncertainty. Huang & Luk (2020) [58] discovered, by examining provincial panel data in China, that policy uncertainty affects the economic performance of a region directly and also spreads to surrounding regions through trade and investment. The spillover effect amplifies the impact of economic policy uncertainty across different geographical areas. Additionally, certain research have investigated the spatial transfer effects arising from the environmental aspect. According to Li et al. (2022) [59], China's ambiguous environmental regulations might spread to neighboring areas through the network of environmental protection sectors in a region. This can have an impact on investments in innovative green technologies and environmental governance. This provides additional evidence for the perspective that there is a regional diffusion of the impact of uncertainty in environmental policy.

Furthermore, certain research have specifically examined the influence of geographical spillover effects on the attainment of sustainable development goals. Kwilinski et al. (2023) [60] discovered that policy uncertainty in a specific area can impact the progress of sustainable development by influencing economic relationships both inside and beyond the region. This implies that the ambiguity surrounding economic policies not only impacts the environmental effectiveness of the local region, but can also have indirect consequences on the broader objectives of sustainable development. Policy uncertainty in a region can impact neighboring places, leading to changes in its green economic efficiency. When the policy landscape in a particular location becomes more unpredictable, neighboring areas may also experience this uncertainty, leading to comparable policy unpredictability and thus impacting their green economic effectiveness.

The geographical spillover impact of economic policy uncertainty on green economic efficiency might have two consequences. To begin, spillover effects, or the spillover impacts of policy uncertainty, may be dispersed in a variety of ways. For example, if regulatory uncertainty in one location causes a decline in green investment by enterprises in that region, other regions in the supply chain that have commercial relations with that region may also be impacted. This might raise concern in surrounding areas, decreasing investment in the green economy (Trung, 2019) [61]. Second, competitive policies: If one area implements unstable policies, other regions may be obliged to follow suit in order to remain competitive. This will extend policy uncertainty across areas, reducing the

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efficiency of the green economy (Al Thaqeb & Algharabali, 2019) [62]. In conclusion, the following hypothesis is advanced.

H2: There is a spatial spillover effect of economic policy uncertainty on green economic efficiency.

The efficacy of green economy initiatives varies across regions of eastern, central, and western China as a result of resource distribution, policy environment, and industrial structure. This heterogeneity is a result of economic policy uncertainty (Chen et al., 2020) [63]. The variation in policy environments across various areas might significantly contribute to the observed heterogeneity. The government's dedication to fostering environmentally sustainable economic development, together with the reliability and uniformity of policies, will greatly influence the unpredictability of economic policies. Certain areas may choose to implement more proactive policy measures to reduce the effect of uncertainty, while others may have more difficulties as a result of policy swings.

Policy implementation disparities: Governments across various areas may exhibit divergent policy agendas and exert dissimilar efforts in executing them. Eastern areas tend to have higher levels of income and are therefore more likely to embrace green policies due to their greater capacity to support environmental conservation and sustainable growth. The central and western areas may experience economic development demands, prompting the government to prioritize the advancement of traditional industries. The variations in policy execution will have diverse effects on the efficiency of the green economy (Beraja et al., 2019) [64].

Resource allocation: Various locations in China possess distinct natural resources, including wind energy, solar energy, and water resources. The government may facilitate the development of environmentally-friendly industries that align with the region's resource advantages. Hence, the presence of economic policy uncertainty might result in ambiguity about the allocation of resources, thereby impacting the efficiency of green economic practices (Adams et al., 2020) [65].

Industrial structure varies by location, with some places depending more on polluting businesses, while others may concentrate more on clean energy and environmental protection sectors. Policy uncertainty will have an influence on these industrial structures, reducing the efficiency of the green economy (Hu & Yan, 2021) [66]. In conclusion, the following hypothesis is advanced.

H3: The influence of economic policy uncertainty on the efficacy of green economies differs among regions.

4. Discussion

4.1. Spatial Moran Index

To analyze the spatial and geographical relationship between the two variables, we quantify the Moran's I index of global economic policy uncertainty and green economy efficiency from 2007 to 2017 using the economic distance matrix. The results of the survey are presented in Table 1. The Moran's I indices of global green economy efficiency and economic policy uncertainty are both positive and satisfy the 10% significance test, as shown in Table 1. Clearly, provinces have exhibited spatial agglomeration characteristics over the past decade with regard to economic policy uncertainty and green economy efficacy.

Table 1. Moran Index of Economic Policy Uncertainty and Green Economic Efficiency Space in 30 Provinces from 2007 to 2017.

Economic policy uncertainty			Green economic efficiency		
Year	Moran's I	P-value	Year	Moran's I	P-value
2007	0.104*	0.074	2007	0.241***	0.005
2008	0.165**	0.013	2008	0.253***	0.004
2009	0.160**	0.032	2009	0.299***	0.001
2010	0.157**	0.034	2010	0.253***	0.004

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2011	0.175**	0.013	2011	0.207**	0.012
2012	0.117*	0.061	2012	0.214***	0.010
2013	0.172***	0.010	2013	0.228***	0.007
2014	0.135*	0.053	2014	0.120*	0.074
2015	0.156**	0.035	2015	0.158**	0.036
2016	0.147**	0.042	2016	0.178**	0.023
2017	0.173**	0.011	2017	0.120*	0.074

According to the findings presented in Table 1, the Moran's I values for green economy efficiency and economic policy uncertainty across 30 provinces from 2007 to 2017 are both greater than zero and statistically significant at the 1% level. Consequently, a spatial agglomeration effect was observed during the test period, suggesting that the digital divide and industrial structure modernization are spatially correlated. H1 is therefore validated.

5. Empirical Result Analysis

An analysis was conducted using Stata 15.1 to examine the relationship between economic policy uncertainty, green economic efficiency, and control variables across 30 provinces, cities, and autonomous areas of China. Spatial econometric models primarily consist of three types: spatial lag models (SAR), spatial error models (SEM), and spatial Durbin models (SDM). Thus, disregarding geographical correlation, Hausman's findings rejected the null hypothesis with a 5% level of significance, leading to the selection of a fixed effects model for regression. Furthermore, given the unique and diverse features of each province and city in the research sample, a regression model with both time and spatial double fixed effects was used. The precise outcomes are shown in Table 2. The Spatial Durbin Model (SDM) was chosen for further investigation by comparing the corrected R^2 and maximum likelihood estimate findings, based on the Ansenlin criteria.

Table 2. Green Economic Efficiency Indicator System.

Indicator system	Production energy efficiency indicators	The ratio of energy consumption to output
		Renewable energy ratio
	Carbon emission efficiency indicators	Carbon emissions per unit of GDP
		Carbon emissions per unit energy consumption
	Resource utilization efficiency indicators	Raw material utilization efficiency
		Utilization rate of renewable resources
	Ecosystem protection and restoration	Nature Reserve Area
		Water quality
		soil quality
		Forest coverage rate
	Social Inclusiveness	unemployment rate
		Universal education and vocational training
	Innovation and technological progress	Investment in clean technology research and development
		Popularity rate of clean technology application

According to the results in Table 3, it can be seen that the goodness of fit of this model is 0.412, indicating the rationality of model construction and control variable selection. At the same time, the direct effect of economic policy uncertainty on green economic efficiency is -0.011 and meets the significance test at the 5% level. Due to the uncertainty of economic policies, enterprises and individuals may hesitate to make investment decisions, thereby delaying or canceling investment in green industries, reducing the development speed and efficiency of green economy. At the same time, the spatial lag effect of economic policy uncertainty is -0.030 for the quality of economic growth. Through a significance test at the 10% level, it can be considered that economic policy uncertainty will lead to a decrease in consumer and business confidence, thereby reducing demand for green

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products and services. The green economy in surrounding areas usually requires market demand support. If consumers and businesses are uncertain about the economic outlook, They may reduce the demand for green products or delay purchasing decisions, thereby affecting the development of the green economy in the surrounding areas, verifying hypothesis 1.

Furthermore, spillover effects arise from the collective impact of economic policy uncertainty and its influencing elements. It can be shown that government involvement, economic development level, technical advancement, and environmental restrictions have a favorable influence on the efficiency of China's green economy, whereas urbanization level, urbanization rate, and marketization level have a negative impact. The direct effects of various influencing factors exhibit substantial disparities, suggesting that variations in capital levels and development among different provinces give rise to the primary causes of the divergent formation directions, namely the "resource diffusion" and "factor siphon" effects.

Table 3. Spatial Durbin Model.

Variable	Estimated results
Economic policy uncertainty	-0.011**
Government intervention	-0.252*
Economic development level	0.412***
Urbanization level	-0.098*
Technical progress	0.001**
Energy consumption structure	5.389*
Environmental regulations	0.233*
ϱ	-0.030
Log-likelihood ： 226.0446	
Individual effects: Control	
Time Effect: Control	
Sample size: 330	

Table 4 demonstrates that the spatial lag component of the SDM model, denoted as ϱ, is observable. Positively passing the significance test at the 10% level suggests that the green development efficiency of different provinces in China is significantly influenced by nearby areas, potentially resulting in bias in the computation of estimate coefficients. Hence, the examination of the correlation between economic policy uncertainty and green economic efficiency necessitates the use of advanced regression techniques rather than conventional regression alone. Building upon the methodology proposed by LeSage and Pace [67], we employed partial differential estimation to decompose the variables. This allowed us to determine the direct and indirect effects of the spatial Durbin model, thereby elucidating the impact of economic policy uncertainty and other influencing factors on the efficiency of the local green economy. Additionally, we investigated the spillover effects on neighboring areas. Kindly see Table 3 for more information.

Economic policy uncertainty has a direct impact on green economic efficiency of -0.027, which is considerably negative at the 5% level, and an indirect effect of -0.019, which is significantly negative at the 10% level. This suggests that economic policy uncertainty not only impedes the local area's green economic efficiency, but also impedes the development of green economic efficiency in nearby provinces. The reason for this is because the ambiguity of economic policies makes it harder for businesses to foresee the future market environment and policy direction, raising investment risk and diminishing investment certainty. Furthermore, policy changes may expose businesses to differing tax, regulatory, and subsidy policies, raising operational risks. Furthermore, regulatory uncertainty makes financial institutions wary of giving financing assistance, making it difficult for green firms to receive low-cost funding assistance, eventually impeding the growth of local green economic efficiency.

In terms of indirect consequences, the growth of green economies in neighboring regions often requires foreign finance in addition to local capital accumulation. However, economic policy uncertainty can cause investors to be concerned about market prospects and transfer funds to other

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regions or industries, reducing investment in green projects in adjacent areas and resulting in a decrease in the efficiency of green economy in adjacent areas. Uncertainties in economic policies may cause consumers' income expectations to fall, causing them to be more cautious when acquiring products and services and to pay more attention to pricing and cost-effectiveness. This consumption behavior will reduce the demand for green products, and companies will often reduce their investment and R&D in green technology. It will also suppress the development of green economy in adjacent areas of the region, thereby impeding the improvement of green economy efficiency, confirming hypothesis 2.

Table 4. Spatial Durbin Decomposition.

Variable	Direct effect	Indirect effect	Total effect
Economic policy uncertainty	-0.027**	-0.019*	-0.047**
government intervention	-0.139**	1.291*	1.151***
Economic development level	0.356*	-0.952**	-0.595*
Urbanization level	0.165**	1.141*	1.307**
technical progress	0.017**	0.193**	0.210*
energy consumption structure	4.609*	-14.011*	-9.401*
Environmental regulations	0.337**	-1.298	-.9608*

There is a notable disparity in economic policy uncertainty across various locations. The eastern and central areas have a substantial direct beneficial influence on the efficiency of the green economy, while the western region has a detrimental impact. Both the eastern and western regions have an adverse indirect effect, however the center region has a favorable impact. For starters, the eastern area depends on sophisticated technology and plentiful resources as a major driving factor in China's economic growth. In an unpredictable economic policy climate, businesses will constantly seek new innovation and commercial prospects, as well as better modify and adapt to economic policy uncertainty. Furthermore, the eastern area government will take a more active role in encouraging green economic growth, such as by boosting fiscal investment. Encouragement of green innovation investment creates a more relaxed external environment for boosting green economy efficiency.

Nevertheless, the majority of the eastern regions are part of economically prosperous areas, and their growth is reliant on external factors. Uncertainty in economic policies in specific provinces in the eastern region might have negative effects on investment, market confidence, and resource flow in neighboring regions. This can hinder the growth of green economy in such areas and impede the enhancement of green economic efficiency.

Furthermore, economic policy uncertainty in the central region can have both direct and indirect effects, with the latter exhibiting a positive promoting effect. This suggests that enterprises operating in the region will be motivated to enhance their research and development efforts, accelerate innovation, and concentrate on the implementation and transformation of green technologies as a means to accommodate fluctuations in market demand. Simultaneously, the extensive implementation of green technologies will assist businesses in enhancing the efficiency of resource utilization, decreasing production costs, and enhancing product quality, thereby contributing to a reduction in pollution emissions and a subsequent enhancement in green economic efficiency. Furthermore, this favourable advancement will generate spillover effects, motivating neighboring regions to collectively attain effective growth in green economic efficiency. The limited advancement of green economy development is ultimately attributable to the relatively low economic level and the disparity in infrastructure and technological development in the western region. Furthermore, the formulation of green economy development policies by local governments is invariably impacted by economic policy uncertainty. This leads to inadequate support and guidance, which impedes the enhancement of efficiency in the local green economy and causes it to lag behind. Furthermore, its limited technological and infrastructure capabilities further restrict the progress of green economy initiatives.

In conclusion, the western region shows a direct effect of economic policy uncertainty of -0.154, which is significant at the 1% level. This suggests that local governments' ability to support and guide

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green economic development is impacted by uncertainty as well, which could hinder the improvement of green economy. Because conventional manufacturing and resource-based businesses form the backbone of the western region's economy, there is a very simple framework in place when it comes to spillover effects. Green economy efficiency in surrounding provinces may be hindered by a lack of an industrial basis and this uncertainty, leading to negative spillovers. Overall, it is clear that green economic efficiency is impacted by economic policy uncertainty, which supports hypothesis 3.

Table 5. Effect decomposition of spatial Durbin models in different regions.

variable	Eastern region		Central region		Western Region	
Economic policy uncertainty	Direct effect	Indirect effect	Direct effect	Indirect effect	Direct effect	Indirect effect
government intervention	0.317*	-0.022*	0.034*	0.111	0.154***	-0.121**
Economic development level	-0.941**	0.264*	-0.257**	0.613*	-0.827**	-0.452*
Urbanization level	0.798*	-0.168**	0.026*	-0.721*	0.781*	0.457**
technical progress	0.858**	-0.270*	-0.494**	-2.240*	-2.036*	0.660**
energy consumption structure	0.021*	0.032**	0.037*	0.041*	0.037*	0.041**
Environmental regulations	28.006*	7.326*	2.994**	0.033	2.994*	0.033*
variable	0.988*	0.889*	1.786**	4.676*	1.786*	4.676*

A steadily developing feature is shown by China's green economic efficiency as a result of the tight relationship between the spatial spillover effect and intense economic growth. Concurrently, taking into account that in 2013, the State Council released the "Opinions on Accelerating the Development of Energy Conservation and Environmental Protection Industries," which emphasized the significance of energy conservation and environmental protection issues and clarified the responsibilities of increasing domestic demand, stabilizing growth, and making structural adjustments, the goal is to utilize the development of these industries to promote the upgrading of industrial structure and the low-carbon transformation of development mode. Thus, separate conversations were held for the 2007–2012 and 2013–2017 study periods (Table 6) to assess the geographical spillover effects of economic policy uncertainty on green economic efficiency across various time periods.

The findings indicate that the impact of economic policy uncertainty on the effectiveness of China's green economy varies in various study periods, both directly and indirectly. From 2007 to 2012, the overall impact of green economy efficiency was detrimental, both directly and indirectly. Between 2013 and 2017, there was a negative direct impact and a favorable indirect advantage. Throughout the research period, the world economy saw a decline as a result of the onset of a severe global financial crisis. China has implemented assertive monetary and fiscal policies in order to mitigate the impact of the economic crisis.

Nevertheless, the presence of policy ambiguity creates a sense of uncertainty for firms in the investment environment. Consequently, this uncertainty diminishes their desire to invest in new projects and technologies, so hindering the enhancement of green economic efficiency. Furthermore, throughout the financial crisis, the government has augmented its backing for conventional sectors, so exerting further pressure on the advancement of green industries and impeding the enhancement of green economic efficacy in adjacent regions. The indirect impact seen from 2013 to 2017 was both positive and statistically significant at a 5% significance level. Policy uncertainty leads to the redistribution of production components between areas. Investors are actively looking for fresh investment options, and nearby regions with promising development prospects are expected to receive a greater influx of high-quality resources, therefore stimulating economic growth in those areas.

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Table 6. SDM Effect Decomposition Results at Different Periods.

	Time period/ year	Policy uncertainty	Government intervention	Level of economic development	Urbanization level	Technological advances	Energy consumption structure	Environmental regulation
Total effect	2011—2015	-0.134*	1.328*	-0.707*	1.052**	0.298*	-2.076**	-1.115*
Direct effects	2016—2020	0.017*	0.682*	-0.354**	0.510*	0.207*	-4.362*	-0.477*
Indirect effects	2011—2015	-0.019**	-0.306**	0.457*	0.386*	0.022**	7.674*	0.278*
Total effect	2016—2020	-0.028*	0.033*	0.254*	-0.001	0.013	6.195*	0.630*
Direct effects	2011—2015	-0.115*	1.634**	-1.165*	0.665*	0.276*	-9.752**	-1.432**
	2016—2020	0.046**	0.648*	-0.609**	0.511**	0.194*	-10.557*	-1.108*

6. Conclusions

This research utilizes the geographical Durbin model to investigate the variables that influence the efficiency of the green economy, based on the uncertainty data of China's regional economic policies spanning from 2007 to 2017. The conclusion may be summarized as follows.

Factors such as environmental policies, technological innovation, industrial structure, international trade, and market size affect the efficiency of green economy to varying degrees. In order to further promote the development of green economy, the government should strengthen the formulation and implementation of environmental policies; Enterprises should increase investment in technological innovation; Simultaneously adjusting industrial structure, making rational use of international trade opportunities, and expanding market size. Future research can further explore the impact mechanism and response strategies of heterogeneity in different countries, industries, and enterprise sizes on green economic efficiency.

The spatial spillover effect plays an important role in the green economy. In order to further promote the development of green economy and achieve regional coordinated development, the government should strengthen policy coordination and regional cooperation, promote the dissemination and sharing of green technology and experience; Simultaneously increasing green investment and encouraging enterprises to innovate in green technologies; And strengthen carbon emission control and environmental supervision, promoting the transformation of the entire region towards a green, low-carbon, and sustainable development model. Future research can further explore the underlying mechanisms, influencing factors, and policy implications of spatial spillover effects; Simultaneously combining emerging green technologies and industrial models, study the ways and effects of spatial spillover effects in new economic forms. In addition, conducting research on cross-border cooperation is also one of the important directions for future exploration, in order to better understand the role and impact of global spatial spillover effects in the development of green economy. Through these in-depth studies and analyses, we can provide more targeted

recommendations and methods for policy-making, promoting sustainable development of the global economy.

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