Urban Green Sustainable Development

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The role of government support in sustainable urban development has always been a research topic of scholars, but research focusing on the relationship between government innovation support and urban green sustainable development is still relatively rare. China's innovative city pilot policy (ICPP) to represent the innovation support provided by the government and address the interaction mechanism and the spatial spillover effect of China's innovative city pilot policy (ICPP), green technology innovation (GTI), and green sustainable development performance (GSDP) with the support of the mediating effect model and the spatial econometric model.

government innovation support innovative city pilot policy

1. Introduction

Improving human well-being, protecting the environment, and promoting sustainable development through green development are key 2030 Global Sustainable Development goals [1]. However, China's economic growth has brought with it serious problems such as high energy consumption, high emissions, and high pollution, and the ecological environment has been severely damaged [2][3]. In this case, in order to meet the people's yearning for a better life, adhering to green development has become an inevitable choice for China's sustainable development. The realization of green development is an important driving force for promoting the process of China's ecological civilization construction and maintaining the sustainable development of China's economy and society [4]. At the same time, green sustainable development is also an important part of building a modern economic development system. In the process of China's economic transformation from high-speed growth to high-quality development, green sustainable development is the fundamental policy to solve the problem of environmental pollution, and a key step in the promotion of the coordinated evolution of high-quality development and ecological environment protection [5][6]. Nowadays, green sustainable development is not only an important issue concerning government and society but also a hot topic focused on by many scholars.

The concept of green sustainable development has been put forward based on critiques of the traditional development model. For example, Daly and Cobb [7] think that green sustainable development is an economic development mode that does not lead to unsustainable economic development due to the depletion of natural resources, and the green development model is conducive to solving the problems of low energy utilization efficiency and ecological environment pollution in economic development. On this basis, Giddings et al. [8] proposed that green sustainable development is generally represented by the intersection of environment, society, and economy. Therefore, green sustainable development should ensure that while the economy is growing rapidly, the ecological environment is also significantly improved, and people can enjoy high-quality living conditions.

Scholars have attained rich research achievements on the current situation and problems of China's green sustainable development. For example, Zeng and Bi. [9] measured and analyzed the condition of China's green sustainable development at the provincial level, and they argue that China's green sustainable development requires steady progress before it can feed back into economic growth. Wang et al. [10] evaluated the green sustainable development level of nine cities in the Pearl River Delta and found that the green sustainable development work in these nine cities had made some progress, but there were still some shortcomings in energy savings and emissions reduction. In addition, He et al. [11] believe that China's industrial development has not yet fully met the requirements of green sustainable development, and how to measure the performance of green sustainable development should be the focus of current research. Conceptually, green sustainable development performance (GSDP) is the measurement of the completion and implementation efficiency of urban green sustainable development. Measurement methods include the AHP method, principal component analysis, entropy weight method, and data envelope analysis (DEA) [12]. In recent years, the use of DEA to measure GSDP has become a mainstream trend in academia. In particular, the SBM directional distance function incorporates undesired outputs such as environmental pollution, avoiding the defect that traditional DEA only considers economic output [13].

The city is the basic space carrier for human beings to engage in economic activities, and it is also because of the influence of people's production and lives that urban industrial pollution, domestic waste, and locomotive exhaust gas and other environmental problems are becoming increasingly serious. Therefore, the city has become an important focus for strengthening pollution prevention and promoting green development. Many scholars have found that technological innovation has a positive effect on sustainable urban development [14][15], especially the increasingly prominent role of green technology innovation in environmental pollution control [16]. Green technology innovation (GTI) is an innovation that can both bring benefits to enterprises and reduce adverse impacts on the environment. It includes technological innovations in energy conservation, pollution prevention, waste recycling, green product design, and environmental management [17]. Therefore, in order to promote the process of urban green sustainable development, central and local governments have issued relevant policies to support the development of urban innovation activities and the construction of innovation systems [5][13][18]. In 2008, Shenzhen took the lead in implementing the innovative city pilot policy (ICPP). Since then, the Chinese government has promulgated the "Guiding Opinions on Promoting the Pilot Work of Innovative Cities" and the "Guidelines for Building an Innovative City" beginning in 2010 and 2016, respectively, which further clarifies the goals and implementation plans of the ICPP. As of 2022, a total of 103 cities have entered the ICPP pilot list, and the ICPP has now become a representative government innovation support policy in China. The ICPP refers to the policy exploration of carrying out urban innovation activities and improving urban innovation ability under the support of the government so that pilot cities can develop into innovative cities with strong independent innovation abilities with scientific and technological support and which play a leading role [19]. In the process of implementing the pilot policy for innovative cities, studies have tried to bring the concept of eco-city into the category of innovative city construction and to explore the urban green sustainable development mode of achieving economic sustainability and natural ecological health by giving play to the positive role of urban innovation in environmental protection [20][21][22]. Thus, under a policy background of the innovative city pilot project, will government innovation support

positively affect urban green sustainable development? If so, what is the transmission mechanism of this effect? At present, the existing research does not provide a definite answer.

The Yangtze River Delta urban agglomeration is one of the most developed regions in China. However, due to the influence of the extensive development mode and the long-term natural ecology of the Yangtze River, the environmental pollution phenomenon is relatively serious, and the overall level of ecological efficiency is low [20][23]. At the same time, the Yangtze River Delta region is also the backbone of China's technological innovation. With the support of national policies, the Yangtze River Delta urban agglomeration is the area with the highest intensity of implementation of the ICPP.

2. Urban Green Sustainable Development

Green sustainable development is a concept that carefully considers the economic, social, and environmental impacts of development; thus, it is vital to establish a reasonable evaluation index system to measure and analyze green development performance. From the literature research, most scholars made improvements based on existing achievements. Among them, the economic, social, environmental, and institutional four-system framework model constructed by the United Nations Commission on Sustainable Development is a more comprehensive evaluation index system for GSDP at this stage. In addition, many scholars are also actively carrying out research on green economic accounting and green development capacity measurement such as Vogtlander et al. [24], Moussiopoulos et al. [25], and Kim et al. [26]. Other scholars have focused on methods to realize green sustainable development. For example, Li et al. [27] not only established a theoretical framework but also formulated an implementation mechanism for the current status and problems of China's green sustainable development. Other scholars take the influencing factors of green sustainable development as their research topic such as environmental regulation [21], green organizational identity [28], the constraints of haze [29], financial agglomeration [30], and the high-tech industrial scale [23]. According to the research objects, most scholars conduct empirical research at the national level [27][31], provincial level [9][29], and industrial level [32][33]. It was found that empirical research based at the urban level is relatively rare, and the research on the condition and influencing factors of GSDP need to be further supplemented.

How to rely on innovation to drive green sustainable development is a hot issue in academic circles. As is known, technological innovation not only requires sufficient R&D personnel and funding but also requires a good innovation milieu to ensure the orderly development of scientific and technological innovation activities [34]. Innovation milieu is a multidimensional concept that not only includes the complex network relationships among the innovation subjects but also the systematic institutional arrangement [35]. The innovation system theory believes that regional market, culture, system, and other innovation environment factors play an important role in the agglomeration of innovation elements. Especially, the government's investment in innovation activities and policy support (such as macroeconomic policy, science and technology policy, and industrial policy) are an important source of power to promote technological innovation [36], and the innovation absorption and application capabilities of different regions will also directly affect the agglomeration level of local innovation elements [37]. In addition, research on the geography of innovation has found that spatial or geographic proximity has a significant impact on

technological innovation [35][38][39][40]. Therefore, the government should try to create a good innovation environment for local cities and drive the innovation capacity of surrounding cities through the spatial spillover effect, which is crucial for realizing regional sustainable development.

In recent years, the role of the government in the construction of regional innovation systems has gradually been paid increasing attention by scholars. Most of them found that government innovation support is conducive to promoting regional innovation capabilities [41][42][43]. In China, the construction of an innovative country is not only the government's strategic goal but also includes the fundamental policy support provided by the government. In the process of innovative country construction, the implementation of the ICPP is through typical government innovation support. Innovative city refers to a city whose development is mainly driven by innovative elements, such as technology, knowledge, manpower, culture, and system, and plays a leading role for other cities in the region. In the related research on innovative cities, researchers found that there were two main expressions regarding innovative city [44][45]: one is "the creative city" and the other is "the innovation city". There is a difference between creativity and innovation: one emphasizes the development of ideas and the other puts these ideas into practice. Therefore, the former emphasizes solutions to complex urban problems by proposing creative methods, while the latter emphasizes the application of innovative methods to solve complex problems in urban development [46]. In the research on the construction of innovative cities in China, scholars mostly define the concept of innovative cities based on the driving force of "innovation" elements for urban development [47]. The elements of an innovative city mainly include innovation resources, innovation subject, innovation milieu, and innovation achievement [46]. Among them, innovation achievement is the direct embodiment of urban innovation ability [32]. Some scholars have also pointed out that the achievement of urban innovation is mainly carried out by innovation subjects, such as enterprises, universities, and research institutes, in a positive innovation milieu so as to transform the urban innovation resources into output that is conducive to the release of urban innovation [48][49].

Thus far, the existing literature lacks a systematic theoretical interpretation of the impact of government innovation support on green and sustainable development. The theoretical basis closely related to this topic is the impact of innovation on the ecological environment, and most scholars support the view that innovation can promote the ecological environment. For example, Roy [50] argued that in national economic development, scientific and technological innovation is the only way to promote the country from an industrial society to an ecological society. Bryan [51] emphasized the adaptability of the innovation milieu among the public. He believed that a positive innovation milieu was a strong aspect in helping the ecological environment achieve sustainability. The research by Charmondusit et al. [52] showed that a positive innovation atmosphere has a promoting impact on ecological efficiency, which is conducive to improving sustainable development and cleaner production. In addition, some studies found that innovation is conducive to reducing haze pollution and improving environmental quality [53][54]. On this basis, many scholars have gradually extended their focus to the impact of technological innovation on ecological economy or green sustainable development. Ehresman [55] integrated relevant concepts related to green sustainable development in the existing research based on the perspective of environmental justice and found that there was a positive correlation between national innovation capacity and green development performance. Feng et al. [33] showed that technological innovation had a positive impact on the quality of urban development and was conducive to improving the green and sustainable development of cities.

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