Digital Economy, Waste Treatment and Urban Waste

Subjects: Economics

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Waste management has always been an integral part of urban governance, and in the post-pandemic era, the choice of waste disposal methods has become a focal point of public attention. While there is existing literature pointing to new waste disposal methods, such as the conversion of biomass-derived polymers into functional biochar materials through pyrolysis, according to the Chinese Urban Statistical Yearbook, there are currently two primary waste disposal methods: landfill disposal and incineration.

Keywords: digital economy ; waste management ; DEA ; investment efficiency

1. Introduction

The exponential growth of the digital economy is bringing about unprecedented transformations in our everyday lives. However, along with the convenience and innovation it brings, this rapid advancement also presents its own set of challenges. One such challenge is the alarming increase in urban domestic waste. The growth of the digital economy has spurred consumption, which in turn has led to a rise in urban domestic waste. It's worth noting that digital shopping and traditional offline economic activities generate different types of waste (Bai et al. [1]). Digital shopping often results in electronic waste, such as old electronic devices and packaging materials, whereas traditional offline shopping may generate more organic waste and paper trash (Liang and Li [2]). According to the China Internet Development Report 2023 [3] and the China Urban Statistics Yearbook 2022 [4], the scale of China's digital economy and the volume of urban waste disposal are increasing. **Figure 1** illustrates an upward trend in both the digital economy and total waste treatment from 2017 to 2021. However, researchers observed a decrease in waste processing volume in 2020. This decline can be attributed to the global outbreak of the pandemic, which resulted in a significant reduction in offline economic activities. As the pandemic spread, traditional offline shopping and brick-and-mortar store operations were severely restricted, leading to a shift in consumer behavior. The reduction in these economic activities resulted in a decrease in consumption to some extent, thereby reducing the demand for manufacturing industries such as disposable packaging materials and electronic products. Specifically, the digital economy surged from approximately 29 trillion RMB in 2017 to around 40 trillion RMB in 2021, marking a notable growth of 37.93%. Simultaneously, waste treatment increased from about 200 million tons to approximately 300 million tons, indicating a significant growth of 47.78%. Hence, the surge in urban domestic waste resulting from the expansion of the digital economy imposes a pressing dilemma to be addressed.

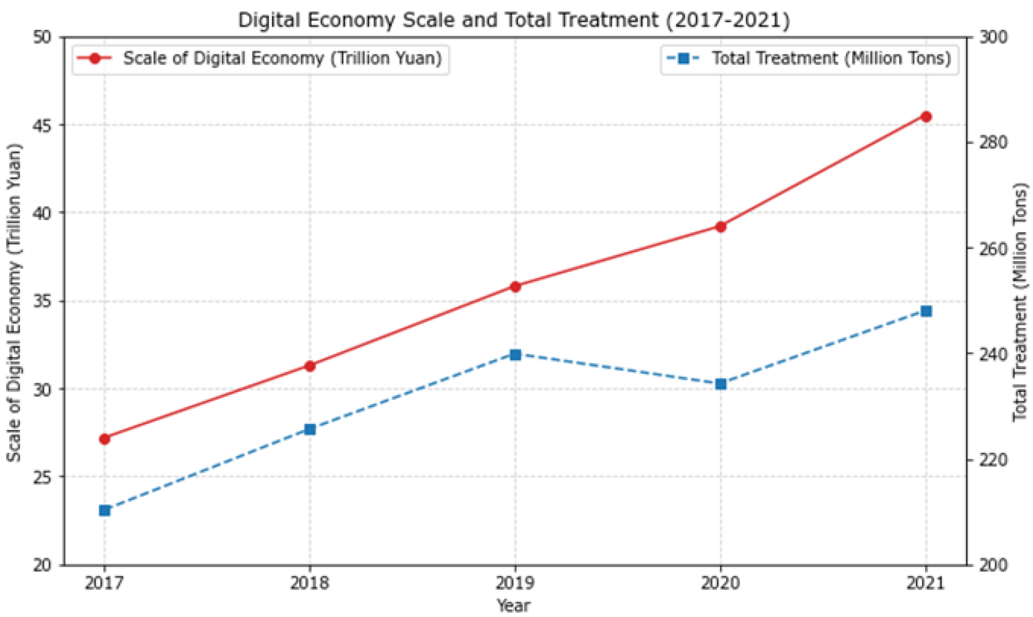

Figure 1. National digital economy and waste treatment trends in China.

Studying the impact of digital economic development on waste management is of great significance for achieving the goals of sustainability and environmental protection. Firstly, the application of digital technology can significantly enhance the efficiency and effectiveness of waste management systems (European Environment Agency [5]). Tools such as smart sensors, real-time data analytics, and optimization algorithms enable cities to collect, transport, and process waste more efficiently, thereby reducing the cost of waste disposal and improving resource utilization efficiency (Mukherjee et al. [6]). Secondly, digitalization can improve waste-sorting and recycling processes by tracking and monitoring the flow of different types of waste, optimizing recycling plans and resource recovery rates, reducing reliance on landfilling and incineration, and contributing to environmental protection by reducing resource waste and pollution (Kurniawan et al. [7]; Maiurova et al. [8]). Furthermore, digital waste management generates a wealth of data that supports data-driven decision-making, helping urban decision-makers better understand waste generation and processing patterns, and formulate more effective policies and strategies to meet the growing demand for waste management (Korherr et al. [9]). The development of the digital economy also fosters innovation in the waste management sector, providing opportunities for businesses and entrepreneurs to develop intelligent, sustainable, and environmentally friendly waste management solutions, creating job opportunities and economic growth (Cheah et al. [10]). Most importantly, the development of the digital economy and improvements in waste management contribute to urban sustainability by reducing waste generation, increasing waste processing efficiency, and reducing environmental impacts (Jiang et al. [11]). This ensures that cities can continue to develop and create better living conditions for future generations. Therefore, the objective of this research is to strive for a new balance in development, one that promotes economic progress while preserving the urban environment and facilitating sustainable development.

2. Digital Economy

Assessment and analysis of the digital economy are of paramount importance. Worldwide, an amount of research effort also goes into the digital economy. For example, Herrador and Hernandez [12] delve into the impact of digital information and communications technology on accounting education, while Fidan [13] employs the Gini method to analyze intersectoral digital economic development in Turkey and Lithuania. Coyle and Nguyen [14] bring attention to the complexities that digitalization introduces to conventional economic measurement. Additionally, Otioma et al. [15] provide insights into the development of the digital economy in Kigali through a macro-spatial lens, and Stavytskyy et al. [16] explore how the DESI (Digital Economy and Society Index) influences consumption index growth in Europe.

Particularly, recent studies have highlighted the critical role of the digital economy in driving sustainable economic growth in China. Liu et al. [17] find that digital finance, especially through technological innovation, has a significant and spatially spreading influence on sustainable growth. Jiao and Sun [18] examine how digital economic development positively impacts urban economic growth, noting the heterogeneous effects and the pivotal role of urban employment. Kong and Li [19] reveal that the development of the digital economy enhances green economic efficiency, especially in digitally advanced regions, highlighting the synergy between digital industrialization and environmental sustainability. Liu et al. [20] discover that digital financial inclusion plays a significant role in bolstering economic growth by fostering entrepreneurship and consumer spending. Sun and Tang [21] observe that digital inclusive finance promotes sustainable economic growth by improving financial accessibility and boosting consumer spending among residents. Ma and Lin [22] find that digital infrastructure construction can enable green economic performance in Chinese cities. Dong et al. [23] highlight the digital economy's effectiveness in reducing energy vulnerability, particularly in higher-income regions.

3. Waste Treatment

The management of waste, with a particular emphasis on incineration, stands as a vital component in contemporary waste management strategies across the globe, including in China. The shift from landfill to incineration in waste disposal in China, primarily due to concerns over land usage, is comprehensively discussed by Li et al. [24]. Their research delves into the intricacies of the waste incineration industry, including its upstream and downstream development, and scrutinizes pertinent governmental policies. Kang et al. [25] contribute to this field by assessing the biomass fraction in Korean waste incineration facilities to better estimate greenhouse gas (GHG) emissions. They highlight the variance in biomass fractions across different waste types and stress the necessity of tailored GHG estimations for each incineration facility. Adding to this discourse, Khan et al. [26] provide a thorough review of the advancements in waste-to-energy incineration technologies, particularly in the context of climate change, exploring both the technological evolution and environmental implications.

Additionally, Lu et al. [27] engage in an inventory analysis and social life cycle assessment (SLCA) of GHG emissions emanating from waste-to-energy incineration, underlining the effects of new laws and regulations on GHG management. Yamamoto et al. [28] investigate the potential trade-off between incineration and recycling, using Japan as a case study.

Their findings suggest that excess incineration capacity may indeed reduce recycling rates, hinting at a possible conflict between these two waste management strategies. Thomas et al. [29] estimate the socially optimal recycling rate in Japan, finding that the cost-minimizing approach may result in recycling rates lower than currently observed and mandated levels. This research implies that some developed countries, including Japan, may be setting inefficiently high recycling goals. Gradus et al. [30] compare the cost-effectiveness of recycling versus incineration of plastic waste in the Netherlands. Their analysis reveals that the implicit CO2 abatement price for plastic recycling is substantially higher than current carbon prices, suggesting that recycling, in this case, may not be the most economically viable option compared to incineration.

4. Urban Development and Urban Waste

Urban development and its intrinsic link with urban waste generation constitute a critical area of focus in modern environmental studies. Liu and Wu [31] embarked on a comprehensive statistical analysis in China, unraveling the myriad factors that influence municipal solid waste generation. Their study sheds light on crucial elements like economic growth, energy consumption, and the scale of urban areas. In a similar vein, Wildeboer and Savini [32] delve into the critical role of state policies in waste valorization within the circular economy paradigm, with a specific lens on construction and demolition waste in Hong Kong and Rotterdam, and its consequential effects on urban development.

Wang and Gong [33] turn their attention to the disparate development and economic strains of urban versus rural wastewater treatment in China, examining this issue through the lens of discharge limit legislation. They underscore the necessity of establishing appropriate discharge limits to equitably distribute the financial burden. Li et al. [34] explore the influence of environmental regulation on the green total factor productivity (GTFP) of Chinese cities, revealing how varying levels of urban economic development impact GTFP. Akbulut-Yuksel and Boulatoff [35] study the effectiveness of a green nudge, specifically the Clear Bag Policy in Canada, in promoting recycling and reducing municipal solid waste. Ihlanfeldt and Taylor [36] analyze the externality effects of small-scale hazardous waste sites on urban commercial property markets, finding significant negative impacts on property values. Kyriakopoulou and Picard [37] investigate the impact of local traffic pollution on the formation of residential and business districts in cities, shedding light on the trade-offs between production externalities, pollution, and commuting costs.

Furthermore, Zhu et al. [38] conducted a comprehensive study on urban-rural coordination in Sichuan Province, China, employing a Principal Component Analysis (PCA)—Grey Entropy measurement model to assess the synchronization of urban and rural development. Peng and Deng [39] innovatively use eco-civilization principles to formulate an indicator system for evaluating urban resource and environmental carrying capacity (URECC) in Guiyang, China. Xu et al. [40] combine nighttime light data with other metrics to assess URECC in Chinese cities, highlighting the impact of economic growth on URECC and its regional disparities.

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