Extended Abstract
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Paper Title	Geographic networks matter for pro-environmental waste disposal behaviors in Rural China: Bayesian estimation of a spatial probit model

Abstract prepared for presentation at the 97th Annual Conference of the Agricultural Economics Society, The University of Warwick, United Kingdom

27th – 29th March 2023

Abstract	***200 words max***
Recent years have witnessed an increased social, political and academic interest in the influencing mechanism of pro-environmental waste disposal behaviors. Researchers generally acknowledged that social networks can influence the behavior of others via sharing information. However, given the theory of behavioral contagion, it is believed that geographic networks provide channels to directly observe the behavior of others and to further adapt self-behavior even in the absence of social networks. Despite this fact, a systematic analysis of how geographic networks contribute to waste disposal behavior is still lacking. Therefore, this study distinguishes geographic networks from social networks and investigates the impact of geographic networks on four waste disposal behavior indicators (i.e., domestic waste sorting, agricultural waste disposal, sewage collection, toilet retrofitting) by Bayesian estimation of a spatial autoregressive probit model. The empirical results confirm that geographic networks affect four waste disposal behaviors in a significantly positive way, while the positive impact of social networks is only detected in the case of sewage collection and toilet retrofitting. Besides, the effect of geographic networks does not decrease as the distance among samples increases. Furthermore, taking spatial heterogeneity into account, different waste disposal behavior indicators respond differently to household background characteristics and local socio-economic conditions.	

Keywords	Rural waste treatment; Influencing mechanism; Geographic networks; Spatial autoregressive probit model
JEL Code	C11; C31; C83; D9; Q53

Introduction *100 – 250 words*

Rural development is often hampered by severe rural waste management issues, which further deteriorate environmental pollution, threaten public health, and hinder rural economic growth. Being the world's largest waste generator since 2004 (World Bank, 2005), China produced more than roughly 175 million tons of rural solid waste in 2017, of which at least 40% was dumped openly and burnt illegally (World Bank Group, 2019). Moreover, the generation rates of rural solid waste ranged between 0.25 and 2.1 kg*(capita*d)$^{-1}$ across rural regions and have shown an accelerating trend. To overcome these issues in rural areas of China, the "Three-year Action Plan for Rural Living Environment Improvement" was implemented in 2018, aiming at the construction of integrated sustainable waste disposal systems. Referring to the multiple targets of this plan, our study integrates four different waste disposal indicators (i.e., domestic waste sorting, agricultural waste disposal, sewage collection, and toilet retrofitting) and reveals the current situation and challenges of rural waste treatment. Besides, this study defines geographic networks by distances among households and highlights the interdependence of waste disposal behaviors among neighbors. Given these, one main objective of this paper is to verify whether the pro-environmental waste disposal behavior of one household influences others nearby. The influence of geographic networks on waste disposal behaviors is formally proposed and examined using spatial analysis, which provides a sound reference for the establishment of waste management communities and the enhancement of cooperation across rural areas.

Methodology *100 – 250 words*

To data, several techniques have been developed to model binary choice outcomes in a spatial structure. Particularly, Bayesian Estimation with Markov Chain Monte Carlo (MCMC) has experienced rapid development in spatial limited dependent variable models because of the relative flexibility, computational efficiency (e.g., no numerical integration required by traditional Bayesian approach (LeSage and Pace (2009)), and unbiased estimation of the standard errors (LeSage, 2000; LeSage and

Pace, 2009). Regarding the improvement of Bayesian estimation of spatial limited dependent variable models in various research fields, see for example LeSage (2011) on business, Arima (2016) and Krisztin et al. (2020) on land use change, Zeng et al. (2019) on freeway crash severity, Abdul Mumin et al. (2022) on the diffusion of agricultural technology, and so forth. Nevertheless, only a few empirical studies have examined the spatial dependence on waste disposal behaviors by placing an emphasis on Spatial Econometrics, which will be investigated in this study by estimating a spatial probit model with Bayesian techniques. In addition, due to the nature of non-linearity and spatial dependence in the spatial autoregressive probit model, the magnitude of estimated parameters cannot reflect the change in the probability of waste disposal choices when an explanatory variable changes by one unit. Following the definition of marginal effects by LeSage and Pace (2009), relevant marginal effects are estimated further to interpret the results. Additionally, the dataset used in this research is from the Survey on Ecological conservation and high-quality rural development in the Yellow River Basin in 2020.

Results

100 – 250 words

Our analyses suggest that more than one-third of households do not separate domestic waste or collect sewage, or dispose of agricultural waste properly. At the same time, more than half of the households do not replace dry toilets with flush toilets. These results highlight the challenges of implementing the "Three-year Action Plan for Rural Living Environment Improvement". Besides, the empirical results suggest that spatial interdependence should be considered when studying household waste disposal behaviors. Importantly, the strength of spatial interdependence varies under different distances for different waste disposal behavior indicators. Apart from these, different waste disposal behaviors are influenced to varying degrees by explanatory variables. Firstly, family size and education level only significantly affect the probability of domestic waste sorting in a positive way. Secondly, higher annual income drives an increased probability of performing well in agricultural waste disposal, sewage collection, and toilet retrofitting, but not in waste sorting. Meanwhile, incentive measures could significantly increase the probability of public participation in sewage collection and toilet retrofitting, meaning that environmental governance can potentially motivate people to engage in sustainable waste management. Surprisingly, high governance appreciation leads to a significant decrease in the probability of waste sorting. Furthermore, stronger social networks increase the probability of sewage collection and toilet retrofitting, while this is not the case for domestic waste sorting and agricultural waste disposal. Additionally, a negative influence of high settlement density on sewage collection and toilet retrofitting was found.

Discussion and Conclusion

100 – 250 words

Using a framework based on the theory of behavioral contagion, this paper emphasizes the need to distinguish between geographic networks and social networks and reveals the positive impact of geographic networks on waste disposal behaviors. The results provide important insights as regards policy making. Firstly, given the importance of geographic networks, policymakers need to recognize the power of behavioral contagion, which can further encourage them to use this as a tool and improve household waste management by giving examples of good waste treatment behavior in buildings and areas and strengthening the cooperation across regions. Secondly, considering the mismatch between the general willingness and actual waste disposal behaviors, it is critical to enhance self-regulation and citizen engagement in waste management through providing relevant information and knowledge, investing in education, and publicizing the importance of individual responsibility in environmental protection. Furthermore, promoting the awareness of public participation in waste management is crucial to avoid motivation crowding-out effects when authorities design and implement incentive measures. Meanwhile, the relatively low settlement density in rural areas requires local authorities to adopt decentralized waste management systems rather than centralized waste ones. Apart from these, both sewage collection and toilet retrofitting are capital-intensive waste disposal systems, which gives rise to similarities between influencing mechanisms. This finding can inspire policymakers to establish linkages and create synergies between waste management systems, thus improving waste management efficiently.