Driving Mechanism for Multi-Level Governance of Domestic Waste Sorting Based on Social Network Analysis and Interpretative Structural Modeling

Tiening Cui[1] and Zhang Si[1]

Abstract

Domestic waste sorting is an important link of grassroots social governance. Drawing on the theory of multi-level governance, this paper identifies 14 factors affecting the multi-level governance of domestic waste sorting, and combines social network analysis (SNA) with interpretative structural modeling (ISM) to quantify the key influencing factors, and their correlation mechanism. The results show that: (1) To form the management system for multi-level governance, it is necessary to nurture and construct a framework with government governance as the basis, the social capital as the driver, and the system self-organization as the operating mechanism. (2) The factors affecting multi-level governance can be divided into four layers: three factors, including regulatory support, belong to the bottom layer, and play a key role in the formation of the driving mechanism for multi-level governance; nine factors, including incentive measure, belong to the middle layer, and play a transitional role in the operation of the driving mechanism; three factors, namely, publicity and education, mutual trust, and practice of social norms, belong to the surface layer, and directly affect the driving mechanism for the multi-level governance of domestic waste sorting. Although the three surface layer factors clearly depend on the factors on the other layers, they exert the most direct impact on the construction and operation of the driving mechanism. The analysis results shed new light on how to study the driving mechanism for the multi-level governance of domestic waste sorting.

---

[1] College of Economics & Management, Beijing University of Technology, Beijing 100124, China

1. Introduction

Over the years, waste sorting in China is led by the government. The market and social subjects only participate in the campaign passively. This institutional design downplays the importance of social forces to waste sorting, and dampens their desire to participate in waste sorting. In addition, the waste sorting measures detach from the reality, because the government always seeks quick success and instant benefit (Du and Huang, 2019).

In recent years, the concept of multi-level governance is increasingly popular. Many engaged in domestic waste sorting started to turn their attention to the multi-level governance model. The governance of domestic waste sorting involves many subjects, including the government, enterprises, residents, and social organizations. The government is responsible for maintaining the overall environment. Under the government's macro control, enterprises recycle, transfer, and process wastes, forming an industrial chain of waste sorting and processing, and make economic gains in this process. The importance of social organizations is manifested, when the government's top-low laws and regulations contradict the bottom-up needs and difficulties of the residents, and when the citizens' will is out of sync with their behavior. On the one hand, social organizations directly communicate with residents, and guide them to participate in waste sorting. On the other hand, social organizations act as an intermediary to dock the unified contents of laws and regulations with the specific local scenarios (Feng and Qin, 2019).

Therefore, the governance of waste sorting should not be implemented by the government or market alone. It is impossible to achieve the desired effect, if social forces are excluded from the governance process. After all, eco-environmental governance is not merely the duty of the environmental departments in the government. Rather, this important task should be collaboratively governed by multiple subjects, and carried out by all the people (Zhang, 2019).

Most of the existing studies either focus on the residents' waste sorting behavior (Wang et al., 2021; Liu et al., 2020; Wang et al., 2021; Xiao et al., 2020; Zhang et al., 2019), or emphasize the various means to improve waste recycling rate (Shi et al., 2021; Ahmad et al., 2020; Zheng and Gu, 2021; Gondal et al., 2021; Chu et al., 2018). The relevant tools of multi-level governance have been widely applied in the environmental field (Zhang et al., 2012; Yang and Li, 2021; Xu et al., 2020; Wang et al., 2021). However, only a few scholars have discussed the governance of urban domestic waste sorting from the angle of multi-level governance. Most of them qualitatively evaluated the responsibility of each participant, and the problems with the current model (Gu and Li, 2021; Jiang, 2020; Lu, 2020; Du and Huang, 2019; Diaz et al., 2017; Soltani et al., 2015). The few quantitative analyses examine the behavior strategies of each participant under a series of assumptions, with the aid of game methods (Wang et al., 2020; Long et al., 2019). Nonetheless, the game methods depend too much on the assumed preconditions, and only apply to the game of a limited number of players. They are not ideal for handling the complex task of waste sorting. To solve the problem, some researchers introduced the social

network analysis (SNA) to the investigation of multi-level governance (Xiao et al., 2021; Xu et al., 2016). The SNA is an important way to explore the relationship between influencing factors in the complex social network. The problem is the SNA cannot illustrate the details of the overall relationship between these factors.

Drawing on the concept of multi-level governance, this paper establishes a system of the factors affecting the multi-level governance of domestic waste sorting, and innovatively combines the interpretative structural modeling (ISM) with SNA to find the effective paths for the multi-level governance of waste sorting. On this basis, several suggestions were proposed and improved, from the perspective of the construction of multi-level governance mechanism.

The remainder of this paper is organized as follows: Section 2 introduces the construction of the influencing factor system, and details the research method; Section 3 analyzes the effective paths for the multi-level governance of domestic waste sorting based on SNA-ISM; Section 4 provides the conclusions and suggestions.

2. Methodology

2.1 Index system of influencing factors

Multi-level governance originates from the theory of government. Governance, as the starting point of the theory, differs from the traditional top-down management. Drawing on the theory of multi-level governance, this paper formulates a theoretical management system for the multi-level governance of domestic waste, with government governance as the basis, the social capital as the driver, and the system self-organization as the operating mechanism. The factors influencing the multi-level governance of domestic waste sorting were compiled into a system (Table 1) through four steps: index design, opinion solicitation, index screening, and index confirmation.

Table 1: Factors affecting multi-level governance of domestic waste sorting

Primary indices	Secondary indices	Tertiary indices
Government governance	Supervision and management Incentive measure Publicity and education	R1 Regulatory support R2 Intensity and coverage of grassroots supervision R3 Incentive measure R4 Punitive measure R5 Publicity and education
Social capital	Social trust	R6 Mutual trust R7 Management trust
	Social network	R8 Diversity of social organizations R9 Orderliness of social organizations
	Social norms	R10 Consensus of social norms R11 Practice of social norms
Self-organization mechanism	Cooperation mechanism Competition mechanism Feedback mechanism	R12 Collaboration of participants R13 Check-and-balance of participants R14 Feedback of information exchange

2.2   SNA

In the 1930s, the British anthropologist Brown first proposed the concept of social network. The most important research method of social network structure is the SNA, also known as structural analysis. The SNA mainly analyzes the relationship structure and its attributes of the social network. During the analysis, the individuals and complex relationships in real complex networks are abstracted into nodes, lines, and directions, and the correlations between the key factors and actors of each network are examined through visual graphs and quantitative indices.

The multi-level governance of domestic waste is a complex system affected by multiple subjects and factors. These influencing factors affect each other directly or indirectly. From the angle of the SNA, each factor can be viewed as an actor, and the relationship between influencing factors as the interactive relationship between actors. On this basis, it is possible to form a complex social network of the influencing factors.

Based on the SNA and the relevant metrics, this paper analyzes the overall spatial network features, and individual network features of the factors affecting the multi-level governance of waste sorting. The following influencing factors were identified: the factors that have the greatest effect on the other factors; the factors that are the least controlled by the other factors; the intermediary factors that connect the most influencing factors.

2.3 ISM

The ISM is a scientific mathematical approach proposed by American professor J.N. Warfield in 1976(Warfield, 1978). The main function of the ISM is to explore the complicated socio-economic system. Through the ISM, the complex relational structural system can be decomposed into a plurality of small subsystems, the complex problem can be simplified with the help of people's knowledge and experience, as well as modern technology, and a final multi-level hierarchical model can be obtained to explain the internal relationship of the system. In the final model, the hierarchical relationship of the influencing factors is clearly displayed, making it easy to recognize the most crucial factors.

The basic idea of the ISM is to analyze the various elements and their relationships using tools like matrices, directed graphs, and computers, solve the multi-level hierarchical structure between system elements, and finally explain the hierarchical relationship between elements, thereby enhancing the understanding the problem. The main steps of the ISM include definition of the system, screening of system elements, hierarchical analysis of system elements, and explanation of system integrity.

Following the SNA, this paper employs the ISM decomposition method for the hierarchical analysis on the structural relationship and interaction mechanism of the factors affecting the multi-level governance of waste sorting, and then correctly recognize the paths for the multi-level governance.

3. Effective Path Analysis

3.1 SNA

The 14 factors affecting the multi-level governance of waste sorting were treated as nodes in the social network, and numbered as R1-R14. The direct effects between the factors were determined by qualitative approaches like the Delphi method. Then, multiple rounds of communication and discussion were held with the experts in the relevant fields, and the workers of waste sorting, trying to recognize the relationship between the influencing factors. If a factor in a row directly affects a factor in a column, then the intersecting grid of the two factors will be assigned the value of 1; otherwise, the grid will be assigned the value of 0. In this way, an adjacency matrix can be obtained as Table 2.

Table 2: Adjacency matrix of factors affecting the multi-level governance of domestic waste sorting

Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
R1	0	1	1	1	1	0	1	0	1	0	1	0	1	0
R2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
R3	0	0	0	0	0	0	0	0	0	0	1	0	0	0
R4	0	0	0	0	0	0	0	0	1	0	1	0	0	0
R5	0	0	0	0	0	0	0	0	0	0	1	0	0	0
R6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R7	0	0	0	0	1	0	0	0	0	0	0	0	0	0
R8	0	1	0	0	1	0	0	0	0	0	1	1	1	1
R9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
R10	0	0	0	0	1	1	1	0	0	0	1	1	0	0
R11	0	0	0	0	1	0	0	0	0	0	0	0	0	0
R12	0	0	0	0	1	0	0	0	1	0	1	0	0	0
R13	0	1	0	0	0	0	0	0	1	0	1	0	0	0
R14	0	0	0	0	0	1	1	1	1	0	1	1	1	0

3.1.1 Overall network features

The overall network structure can be measured by network density, network distance, and network level. In this paper, the overall network represents the closeness between influencing factors. Network distance refers to the length of the shortest path between two nodes in the network. The shorter the distance, the faster the information sharing, and the more frequent the interactive feedbacks between the two nodes. Network level refers to the degree of transfer mechanism of each influencing factor. The higher the level, the more hierarchical the network. These parameters are analyzed in details below:

The network of factors affecting the multi-level governance of domestic waste sorting had a density of 0.2198, suggesting that the factors of the network are weakly correlated. The mean distance between network nodes was 1.333, indicating that each factor can propagate to another factor in the network, passing through an average of 1.333 elements. Hence, the network structure is highly accessible. The network level was calculated as 0.9636, a sign of the good transfer mechanism of the network. According to the measured results of network density, distance, and level, the overall network boasts strong, and close connections between nodes, which provides a good network basis for establishing the dynamic paths of multi-level governance.

3.1.2 Network centrality analysis

The individual centrality mainly reflects the degree of centrality of each influencing factor in the network. Here, degree centrality, betweenness centrality, and closeness centrality are adopted to measure the degree of influence, conductivity, and independence of the factors (nodes), respectively. The results of individual centrality analysis on the network are recorded in Table 3.

Table 3: Results of individual centrality analysis on the network

	Out-degree	In-degree	Betweenness centrality	In-degree closeness	Out-degree closeness
R1 Regulatory support	8	0	0.000	7.143	16.667
R2 Intensity and coverage of grassroots supervision	1	3	3.000	9.924	9.701
R3 Incentive measure	1	1	0.000	7.692	8.280
R4 Punitive measure	2	2	3.000	10.744	9.028
R5 Publicity and education	1	7	2.000	40.625	7.692
R6 Mutual trust	0	2	0.000	9.028	7.143
R7 Management trust	1	3	0.200	9.924	8.280
R8 Diversity of social organizations	6	1	1.200	7.692	23.214
R9 Orderliness of social organizations	1	5	1.700	16.049	8.280
R10 Consensus of social norms	5	0	0.000	7.143	12.381
R11 Practice of social norms	1	9	2.700	44.828	7.692
R12 Collaboration of participants	3	3	1.533	9.091	9.091
R13 Check-and-balance of participants	3	3	1.333	9.091	10.924
R14 Feedback of information exchange	7	1	2.333	7.692	23.214

(1) Degree centrality

In the social network of multi-level governance, R1 had the highest out-degree, i.e., this factor exerts the strongest direct effect on the other factors. On the contrary, R6, with an out-degree of zero, virtually does not affect the other factors. The factors differed more significantly in out-degree. According to the out-degrees, R11 suffers from the greatest effect from the other factors, while R1 and R10 are the least affected by the other factors.

(2) Betweenness centrality

The betweenness centrality varied greatly between influencing factors. Specifically, R2, R4, and R1 had relatively high betweenness centralities. These factors act as the hub of internodal communication, and bear on the resource flow of the network. The absence of these factors would delay or block the information channels. In contrast, R1, R3, R6 and R10 do not significantly affect the information transfer in the network, due to their weak betweenness centralities.

(3) Closeness centrality

Judging by in-degree closeness, R5 and R11 are not very independent in the network structure, and largely dependent on the other factors, in terms of information input. Meanwhile, R1 and R10 are relatively independent, and not controlled by the other factors, in that respect. The out-degree closeness shows that R1, R8, and R14 are not very independent, and their influence over the multi-level governance mechanism needs to be transferred by the other factors. By contrast, R5, R6, and R11 are highly independent, and directly affects the mechanism in terms of information output.

In addition to the SNA, this paper sets up an ISM to divide the factors affecting the multi-level governance into multiple levels, in a bid to further clarify the driving mechanism for the multi-level governance of domestic waste sorting.

3.2   ISM

3.2.1   Construction of reachability matrix

Based on the adjacency matrix of the SNA, a reachability matrix was obtained through logic calculation. The matrix reflects the mutual reachability between the points in the directed graph via certain channels.

On Matlab 2020b, the following reachability matrix M can be obtained:

$$M = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

It can also be solved that: when k=3, $(A+I)2 \neq (A+I)3 = (A+I)4$, i.e., the reachability matrix M=(A+I)3.

3.2.2 Matrix decomposition and level division

After obtaining the reachability matrix, the elements on each level of the ISM can be obtained through cyclic solving the intersection between the reachable set and the antecedent set. In this way, the hierarchical structure of the system can be solved. For element S_i, the reachable set $R(S_i)$ is the set of column elements making a node in row S_i of the reachability matrix equal to one:

$$R(S_i) = \{S_j \epsilon M | w_{ij} = 1\} \tag{1}$$

where, M is the set of elements; w_{ij} is the value from element S_i to element S_j; w_{ij}=1 indicates that S_i is associated with S_j.

For element S_i, the antecedent set $Q(S_i)$ is the set of row elements making a node in column S_i of the reachability matrix equal to one:

$$Q(S_i) = \{S_j \epsilon M | w_{ji} = 1\} \tag{2}$$

The common set $Z(S_i)$ is the intersection between the reachable set and the antecedent set:

$$Z(S_i) = R(S_i) \cap Q(S_i) \tag{3}$$

If $R(S_i) = R(S_i) \cap Q(S_i)$, i.e., $Z(S_i) = R(S_i)$, then $R(S_i)$ is the first layer, and its elements are the outermost factors affecting the goal, i.e., the set of the highest elements. After removing the column and row of the set of the highest elements, a new matrix can be formed. The above steps need to be repeated to produce a multi-level ISM. Table 4 shows the influencing factors on each layer.

Table 4: Levels of influencing factors

Level	Factor	Meaning
L1	R5, R6, and R11	Direct factor
L2	R3, R7, and R9	Shallow factor
L3	R4, and R12	Intermediate factor
L4	R2, and R10	Intermediate factor
L5	R13	Intermediate factor
L6	R1, R8, and R14	Root factor

According to the results in Table 4, each element was represented as a box, and the elements on the same level were placed on the same row. For the clarity of level analysis and modeling, the six levels of elements were combined into four levels, forming the final ISM for the factors affecting the multi-level governance of domestic waste sorting (Figure 1).
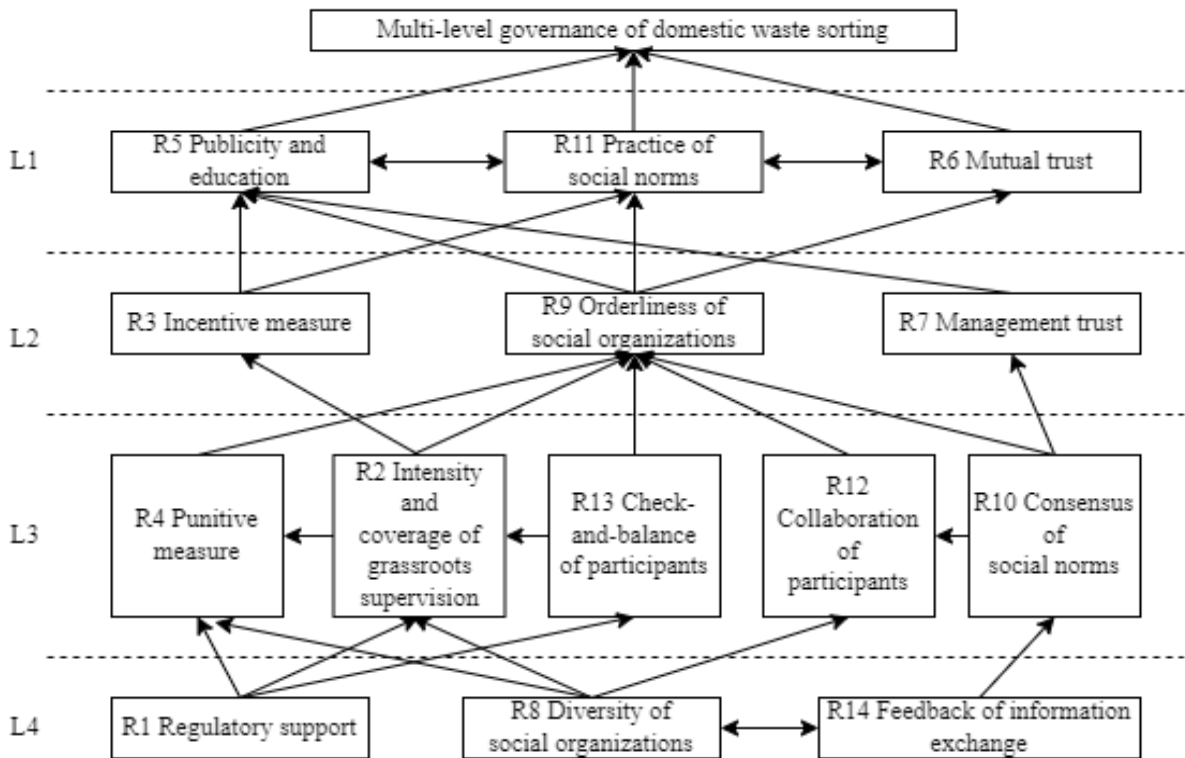
Figure 1: ISM of influencing factors

On the first level, R5, R6, and R11 are the three surface elements that directly affect the driving mechanism for the multi-level governance of domestic waste sorting. All of them are directly or indirectly affected by the 11 remaining factors. Among them, publicity and education is the most widely used measure to encourage residents to participate in waste sorting and multi-level governance. Human is by nature a social animal. One of the direct ways to drive the multi-level governance mechanism is to improve the trust between residents, and the mutual influence between their behaviors. The participation / non-participation in the multi-level governance mechanism is clearly reflected by whether the residents carry out waste sorting, and how often they sort wastes in daily life. These two issues manifest the effects of the other influencing factors, mirror the operating effect of the multi-level governance mechanism, and directly bear on that mechanism.

On the second level, the main factors are R3 and R7. Incentive measure is a positive tool that encourages the residents to sort waste by various means. The orderliness of social organizations is affected by multiple factors, and affects the three surface factors. It is a key indicator of the operation of the multi-level governance mechanism. The orderly operation of social organizations sets up standard rules for the multi-level governance mechanism. Management trust affects the formulation of the multi-level governance mechanism indirectly via publicity and education. The residents' trust in waste sorting workers determines whether the sorting effect is recognized, and thus affect the residents' participation in the multi-level governance mechanism.

On the third level, the main factors are R4, R2, R13, R12, and R10. Specifically, punitive measure, and intensity and coverage of grassroots supervision reflect how the government governance is implemented. As a negative tool, punitive measure affects factors like the orderliness of social organizations, which in turn acts on the multi-level governance mechanism. Intensity and coverage of grassroots supervision mainly serves as a constraint, which thoroughly supervises the residents' waste sorting behavior from multiple angles. Collaboration of participants, and check-and-balance of participants are specific indices on the self-organization level. The cooperation and check-and-balance between multi-level governance participants jointly create a good atmosphere for the formation of the multi-level governance mechanism, by affecting the orderliness of social organizations. Consensus of social norms is an important indicator on the level of social capital. It horizontally affects the degree of collaboration between participants, and vertically impacts the orderliness of social organizations, and management trust. To advance the multi-level governance mechanism, the only way is to enhance the participants' recognition of the multi-level governance philosophy, and thus boost the residents' trust in waste sorting workers. Then, the participants will actively join the multi-level governance.

The bottom factors are on the fourth level. According to the principle of ISM level division, the factors on deeper levels have a greater driving effect on the system, and can directly or indirectly affect the other factors. These bottom factors play the leading role in the formation of the driving mechanism for the multi-level

governance of domestic waste. The factors on the fourth level are R1, R8, and R14. Among them, regulatory support lays the institutional basis for the formation and orderly development of the multi-level governance mechanism for domestic waste, and provides the precondition for the operation of the multi-level governance mechanism. Whether the mechanism can operate normally also depends on the diversity of social organizations. The various participants underpin the development of the multi-level governance mechanism. Finally, multi-level governance not only emphasizes the participation of multiple subjects, but also the information exchange and feedbacks between them. The information exchange provides a long-lasting driver for the multi-level governance mechanism.

4. Conclusions

Drawing on the theories of multi-level governance, this paper sets up a system of the factors affecting the multi-level governance of domestic waste sorting, from such three dimensions as government governance, social capital, and self-organization mechanism. Besides, the SNA and ISM were adopted to construct the internal correlations between the influencing factors. The main conclusions are as follows:

The SNA results show that the network has a moderate density. The influencing factors are mutually reachable and well connected for effective information transfer. Regulatory support, and feedback of information exchange exert the greatest impact on the other factors in the network, while practice of social norms is under the greatest impact from the other factors. Intensity and coverage of grassroots supervision, and punitive measure are important intermediaries in the network. In terms of information input, practice of social norms largely depends on the other influencing factors. Regulatory support, and diversity of social organizations affect the multi-level governance mechanism indirectly via the other factors. On the contrary, publicity and education, mutual trust, and practice of social norms directly influence the multi-level governance mechanism.

The ISM results reveal clear hierarchical relationship between the influencing factors for the multi-level governance of domestic waste sorting. Specifically, the three surface factors of publicity and education, mutual trust, and practice of social norms have the most direct influence over the driving mechanism for the multi-level governance of domestic waste. The intermediate factors include incentive measure, orderliness of social organizations, management trust, punitive measure, intensity and coverage of grassroots supervision, check-and-balance of participants, collaboration of participants, and consensus of social norms. The intermediate factors are affected by deep-seated factors, while affecting surface factors. In addition, the bottom factors of regulatory support, diversity of social organizations, and feedback of information exchange are the fundamental drivers of the multi-level governance mechanism, providing the strongest impetus to system operation.

Based on the above conclusions, four suggestions were presented to promote the multi-level governance of urban domestic waste sorting:

(1) Strengthen the institutional construction for the multi-level governance of domestic waste sorting, and provide the fundamental guarantee for the operation of the mechanism.

(2) Give full play to social organizations in multi-level governance, and actively explore and implement the cooperation model with these organizations.

(3) Rationalize and refine the whole process of waste sorting, provide an effective platform for implementing the macro policies, and encourage the residents to sort wastes.

(4) Design an effective reward mechanism for waste sorting behavior, improve the overall sorting rate based on the mutual trust of residents, truly implement the sorting of urban domestic waste, and formulate a powerful driving mechanism for the multi-level governance.

References

[1]   Du Chunlin, Huang Taozhen (2019). From Government Leading to Multiple Co-governance: the governance dilemma and innovation path of urban solid waste classification [J]. Administrative Tribune, 26(04), 116-121.

[2]   Feng Linyu, Qin Peng (2019). Practical dilemmas and obligatory approaches to household waste classification [J]. China Population, Resources and Environment, 29(05), 118-126.

[3]   Zhang zhizhong (2019), Exploring the Way of ecological Good Governance for the modernization of national Governance -- A review of National Governance and Ecological Ethics [J]. Journal of Central South University of Forestry & Technology (Social Sciences), 13(06), 109-110.

[4]   Wang, HJ; Gui, HR; Ren, C; Liu, GJ (2021). Factors Influencing Urban Residents' Intention of Garbage Sorting in China: An Extended TPB by Integrating Expectancy Theory and Norm Activation Model[J]. Sustainability, 13(23).

[5]   Liu, AJ; Osewe, M; Wang, HX; Xiong, H (2020). Rural Residents' Awareness of Environmental Protection and Waste Classification Behavior in Jiangsu, China: An Empirical Analysis[J]. International Journal of Environmental Research and Public Health, 17(13).

[6]   Wang, H.L; Li, J.X; Mangmeechai, A; Su, J.F (2021). Linking Perceived Policy Effectiveness and Proenvironmental Behavior: The Influence of Attitude, Implementation Intention, and Knowledge[J]. International Journal of Environmental Research and Public Health, 18(6).

[7]   Xiao, SJ; Dong, H.J; Geng, Y.; Tian, X.; Liu, C.; Li, H.F. (2020). Policy impacts on Municipal Solid Waste management in Shanghai: A system dynamics model analysis[J]. Journal of Cleaner Production, 262,121366.

[8]   Zhang, B.; Lai, K.H.; Wang, B.; Wang, Z.H. (2019). From intention to action: How do personal attitudes, facilities accessibility, and government stimulus matter for household waste sorting?[J]. Journal of Environmental Management, 233, 447-458.

[9]   Shi, C.P.; Tan, C.; Wang, T.; Wang, L.G. (2021). A Waste Classification Method Based on a Multilayer Hybrid Convolution Neural Network[J]. Applied Sciences-Basel, 11(18), 8572.

[10] Ahmad, K.; Khan, K.; Al-Fuqaha, A. (2020). Intelligent Fusion of Deep Features for Improved Waste Classification[J]. IEEE Access,8, 96495-96504.

[11] Zheng, H.; Gu, Y. (2021) EnCNN-UPMWS: Waste Classification by a CNN Ensemble Using the UPM Weighting Strategy[J]. Electronics, 2021.10(4), 427.

[12] Gondal, A.U.; Sadiq, M.I.; Ali, T.; Irfan, M.; Shaf, A.; Aamir, M.; Shoaib, M.; Glowacz, A.; Tadeusiewicz, R.; Kantoch, E. (2021). Real Time Multipurpose Smart Waste Classification Model for Efficient Recycling in Smart Cities Using Multilayer Convolutional Neural Network and Perceptron[J]. Sensors, 2021.21(14), 4916.

[13] Chu, Y.H.; Huang, C.; Xie, X.D.; Tan, B.H.; Kamal., S.; Xiong., X.G. (2018). Multilayer Hybrid Deep-Learning Method for Waste Classification and Recycling[J]. Computational Intelligence and Neuroscience, 5060857, 9 pages.

[14] Zhang, N.; Wang, Z.C.; Ru, H.K.; Li, H.Y. (2012). Study on the Spatio-Temporal Evolution of China's Smart Water Co-Governance in G-E-P Mode[J]. International Journal of Environmental Research and Public Health, 18(23), 12648.

[15] Yang, Z.F.; Li, Q.L. (2021). Research on the construction of social co-governance system of ecological environment protection[A]. 2020 ASIA Conference on Geological Research and Environmental Technology, 632(2021), 052060.

[16] Xu, L.Y.; Zhou, Z.Y.; Du, J.G. (2020). An Evolutionary Game Model for the Multi-Agent Co-Governance of Agricultural Non-Point Source Pollution Control under Intensive Management Pattern in China[J]. International Journal of Environmental Research and Public Health, 17(7), 2472.

[17] Wang, J.; Huang, J.C.; Huang, S.L.; Tzeng, G.H.; Zhu, T. (2021). Improvement Path for Resource-Constrained Cities Identified Using an Environmental Co-Governance Assessment Framework Based on BWM-mV Model[J]. International Journal of Environmental Research and Public Health,18(9), 4969.

[18] Gu Limei, Li Huanhuan. (2021). Administrative mobilization and Multiple Participation: The realization of participatory governance of household waste Classification -- Based on the practice of Shanghai[J]. Journal of Public Management, 18(02), 83-94+170.

[19] Jiang Yunfei (2020). Multiple co-governance of urban solid waste classification and its mechanism construction[J]. Journal of Central South University of Forestry & Technology (Social Sciences), 14(03), 14-20.

[20] Lu Kebing (2020). Multiple co-governance model of household waste classification and management in Hangzhou: Current situation, problems and countermeasures[J]. Environmental Protection and Circular Economy, 40(03), 16-20.

[21] Du Chunlin, Huang Taozhen (2019). From Government Leading to Multiple Co-governance: the governance dilemma and innovation path of urban solid waste classification[J]. Administrative Tribune, 26(04), 116-121.

[22] Diaz-Barriga-Fernandez, A.D.; Santibanez-Aguilar, J.E.; Radwan, N.; Napoles-Rivera, F.; El-Halwagi, M.M.; Ponce-Ortega, J.M. (2017). Strategic Planning for Managing Municipal Solid Wastes with Consideration of Multiple Stakeholders[J], ACS Sustainable Chemistry & Engineering,5(11), 10744-10762.

[23] Soltani, A.; Hewage, K.; Reza, B.; Sadiq, R. (2015). Multiple stakeholders in multi-criteria decision-making in the context of Municipal Solid Waste Management: A review[J], Waste Management, 35, 318-328.

[24] Wang, Z.; Wang, Q.X.; Chen, B.X.; Wang, Y. (2020). Evolutionary game analysis on behavioral strategies of multiple stakeholders in E-waste recycling industry[J], Resources Conservation and Recycling, 155, 104618.

[25] Long, R.Y.; Yang, J.H.; Chen, H.; Li, Q.W.; Fang, W.Q.; Wang, L. (2019). Co-evolutionary simulation study of multiple stakeholders in the take-out waste recycling industry chain[J], Journal of Environmental Management, 231, 701-713

[26] Xiao, L.S.; Huang, S.; Ye, Z.L.; Zhang, O.W.; Lin, T. (2021). Identifying multiple stakeholders' roles and network in urban waste separation management-a case study in Xiamen, China[J], Journal of Cleaner Production, 123569.

[27] Xu, W.Y.; Zhou, C.B.; Cao, A.X.; Luo, M. (2016). Understanding the mechanism of food waste management by using stakeholder analysis and social network model: An industrial ecology perspective[J], Ecological Modelling, 337, 63-72.

[28] Warfield J.N. (1978). SOCIETAL SYSTEMS Planning, Policy and Complexity[J]. Proceedings of the IEEE, 66(3), 362-363.