Research on the Performance Grouping Path of Domestic Waste Classification in Xi'an City -A Hybrid Approach Based on NCA and fsQCA

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ABSTRACT

Objective: The purpose of this paper is to explore the improvement path of urban domestic waste classification performance under the resource-based theory, with a view to providing new ideas for the study of multi-factor interaction influencing urban environmental governance. Methodology: This study takes 14 major districts and counties in Xi'an City as the research object, and tries to explore the conditional grouping scheme for the improvement of the performance of domestic waste classification that is suitable for different cities or regions. This study adopts necessity analysis (NCA) to study the impact of individual conditions on the necessity and bottleneck level of domestic waste separation performance in Xi'an, and applies fuzzy set qualitative comparative analysis (fsQCA) from the grouping perspective to derive the grouping of conditions that produce high and non-high domestic waste separation performance in Xi'an, and analyses them in the context of actual cases. Results: It is found that: First, the three factors of organisational resources, technical resources and financial resources cannot individually constitute the necessary conditions for high and non-high domestic waste classification performance. Second, high domestic waste classification performance can be categorised into 3 paths: technology-economic driven, technology-organisation driven, and comprehensive driven. The non-high domestic waste classification performance can be summarised into 3 paths: lack of conditions, lack of technology, and financial-technological double constraints. Third, the grouping paths of high and non-high domestic waste classification performance are asymmetric. It is not possible to directly derive the non-high living rubbish classification performance path based on the high living rubbish classification performance path opposites, and infrastructure resources and platform resources have a more general impact on living rubbish classification performance. Conclusion: The government should play the synergistic role of organisational resources, technical resources and financial resources; maximise the role of technical resources in enhancing the performance of domestic waste classification; and strengthen the allocation of organisational and economic resources to play a supplementary role in enhancing the performance of domestic waste classification.

Keywords: *Domestic waste, Classification performance, NCA method, fsQCA method,*

1. INTRODUCTION

Urban living waste classification is an important symbol of good urban governance and an effective means to solve the problem of urban rubbish siege. The promulgation of the policy of "Implementation Plan of Living Waste Classification System" in March 2017 marked the beginning of the first widespread implementation of the system of living waste classification on a nationwide scale, and a number of subsequent policies have also been promulgated to promote the promotion of living waste classification in every aspect. In May 2021, the "14th Five-Year Plan" for the Development of Urban Living Waste Classification and Treatment Facilities further emphasised the importance of accelerating the construction of living waste classification and treatment facilities, and enhancing the level of living waste classification and treatment in the whole society. Therefore, exploring the path to improve the performance of urban domestic waste classification to enhance the

level of urban domestic waste classification is a realistic issue that needs to be studied urgently. Although the policy of domestic waste classification has been implemented in full swing in some large cities, the improvement of the performance of urban domestic waste classification faces many challenges, which are highlighted by the lack of resources for waste classification and low classification performance. From the perspective of organizational resources, the lack of detailed and targeted policies and the fragmentation of departments have become the key obstacles to the improvement of the performance of municipal waste classification [1,2]. From the viewpoint of financial resources, waste classification as a livelihood project requires regional economic level and government finance to ensure the provision of supporting facilities, technology and personnel. The heterogeneity of regional development makes it difficult to ensure the sustainability of financial resources in some regions, which exacerbates the difficulties in waste separation management [3]. From the perspective of technical resources, the construction of technical facilities such as urban household waste classification infrastructure and big data platform for waste classification is inadequate and unbalanced, which seriously inhibits the improvement of classification performance [4].

A scientific and effective resource base can achieve higher waste classification performance. Then how to solve the dilemma of resource base of rubbish classification and improve the performance of urban living rubbish classification. Scholars at home and abroad have explored the factors influencing the performance of urban living rubbish classification from multiple perspectives. One part of scholars analysed macro factors such as publicity and education, supervision and punishment, policy marketing, financial support and human capital [5-8], and the other part analysed micro factors such as public initiative, residents' classification habits and social capital [9-11]. These studies provide theoretical explanations for analysing the performance of urban domestic waste classification. Since the whole process of waste classification is affected by many factors, only a single level of analysis can not explain the performance of urban domestic waste classification in a better and complete way, and the synergistic effect of the interaction and combination of multiple factors on the performance of urban domestic waste classification should be considered. For example, Che Feng et al [12] used the QCA method to explore the effects of the conditional groupings of socio-economic security, social inclusion, social cohesion, and social empowerment on the governance capacity of urban multi-ethnic communities. Ming et al [13] took residents' participation in rubbish classification as an example, and used the fuzzy-set Qualitative Comparative Analysis (QCA) method to investigate the effects of the social economic security, social inclusion, social cohesion, and social empowerment on the governance capacity of urban multi-ethnic communities. Ming et al. [13] used Fuzzy-set Qualitative Comparative Analysis (FQCA) to analyse the effects of internal factors, external factors and socio-demographic factors on the participation rate of residents in waste sorting, and Baihui Jin et al. [14] used Necessary Condition Analysis (NCA) and Fuzzy-set Qualitative Comparative Analysis (fsQCA) to analyse the effects of external factors on the configuration of residents' participation, and pointed out that the two combinations of environment-driven and resource-driven paths can achieve a high participation rate of residents in waste sorting. can achieve a high participation rate of residents' waste classification. This provides inspiration and reference for this paper in choosing the method of multi-factors influencing the performance of urban household waste classification.

Based on this, this paper, on the basis of the analytical framework of resource-based theory, combined with the official data of Xi'an districts and counties, analyses the impact of the interaction of three factors, namely organizational resources, financial resources and technological resources, on the performance of domestic waste classification in Xi'an by applying the Necessary Conditional Analysis (NCA) and Fuzzy Set Qualitative Comparative Analysis (fsQCA), and identifies the conditional grouping paths for improving the performance of domestic waste classification in Xi'an The paper helps to deepen the understanding of urban domestic waste classification performance in Xi'an. This paper helps to deepen the rational understanding of the path to improve the performance of urban domestic waste classification, and also provides new ideas for the research on the interaction of multiple factors on urban environmental governance.

2. ANALYTICAL FRAMEWORK

Resource-Based Theory (RBT) was firstly put forward by economist Penrose in 1959 in the book

"Theory of Enterprise Growth"[15] , and then it was widely used in many research fields such as operation management, performance management and so on. With the in-depth research of scholars at home and abroad, resource-based theory has been introduced into the field of public management, becoming one of the more important theories for analyzing the governance of public things. It is found that different scholars have different opinions on the division of RBT, Penrose divides resources into material resources and human resources, and Wernerfelt divides resources into tangible assets and intangible assets. Domestic scholars generally divide resources into organizational resources, financial resources and technical resources. Among them, scholars such as Tang Zhiwei[17] and Lee[18] use organizational resources, financial resources and technological resources to construct a resource-based theoretical analysis framework and conduct in-depth discussions on public sector performance management. This provides inspiration and reference for the research on the influencing factors of urban waste classification performance. As an important people's livelihood project, the resources involved in waste classification are complex and extensive, requiring not only a large number of supporting facilities, but also the synergistic efforts of a number of resources such as technology and personnel. Therefore, based on the resource-based theory, this paper analyses the three dimensions of organizational, financial and technological resources to provide a theoretical framework for a better understanding of the performance of urban waste classification in China.

2.1 Impact of Organizational Resources on MSW Sorting Performance

The classification of municipal waste cannot be separated from the policy regulation in this paper, and the policy support is the foundation for the smooth implementation of governmental work [19], and the lack of specific and detailed policy guidelines will make the work of waste classification difficult [20]. In addition, the phenomenon of government departments being divided and fragmented has become an important factor affecting the effectiveness of rubbish classification, and it is necessary to carry out multi-departmental co-operation in order to effectively promote the smooth implementation of rubbish classification [21].

2.2 Impact of Financial Resources on the Performance of Urban Domestic Waste Classification

The government provides good financial support for the implementation of domestic waste classification policy, which can better enhance the performance of urban domestic waste classification [3]. In addition to the government's internal financial resources, the influence of external economic resources on the performance of domestic waste classification should not be ignored. On the one hand, economic development can affect the government's financial resources, which in turn affects the government's performance [22]; on the other hand, areas with a better level of economic development are equipped with better waste separation facilities, which provide infrastructure protection for the effective implementation of waste separation [23].

2.3 Impact of Technological Resources on the Performance of MSW Sorting

The infrastructure for urban domestic waste classification is a prerequisite and basic guarantee for the realization of the reduction, resourcefulness and harmless treatment of urban domestic waste, and a strong support for the promotion of the construction of ecological civilization [24,25]. In addition, the establishment of technology platforms such as intelligent management of urban living waste classification greatly improves the precision and accuracy of urban living waste classification, promotes the detailed management of waste, and thus improves the performance of urban living waste classification[26] .

On the basis of the above analysis, organizational resources are further subdivided into two levels: organizational readiness resources and organizational synergy resources; financial resources are subdivided into two levels: financial resources and economic resources; and technical resources are subdivided into two levels: infrastructure resources and platform resources. MSW classification is a complex and multifaceted system, in order to more comprehensively analyse the mechanism of improving MSW classification performance, it is necessary to systematically explore the synergistic influence of multiple factors on MSW classification performance. For example, the strong financial resources of the region promote the provision of regional technical infrastructure and the investment of financial funds, which

provide technical support and financial guarantee for the effective promotion of the work of domestic waste classification, and the provision of these conditions further promotes the implementation of organizational readiness resources and organizational synergy resources. Under the combined effect of all resources, residents and other living rubbish classification work subjects continuously improve their own rubbish classification behaviour, and then improve the performance of living rubbish classification. However, due to the differences in the three dimensions of organizational resources, financial resources and technical resources in different regions, the impact of multifactorial linkage on the performance of urban living waste classification is an open problem, and its combination path is not fixed, and there are problems of equivalence and asymmetry. The QCA method under the group perspective is very suitable for exploring the problems of equivalence and asymmetry between multi-factors and urban domestic waste classification performance. Therefore, this paper introduces the QCA method and constructs an analytical framework of the effects of six factors, namely, organizational readiness resources, organizational synergy resources, financial resources, economic resources, infrastructure resources, and platform resources, on the performance of MSW classification (“Figure 1”), in order to explore the multifactorial hybrid path to improve MSW classification performance.

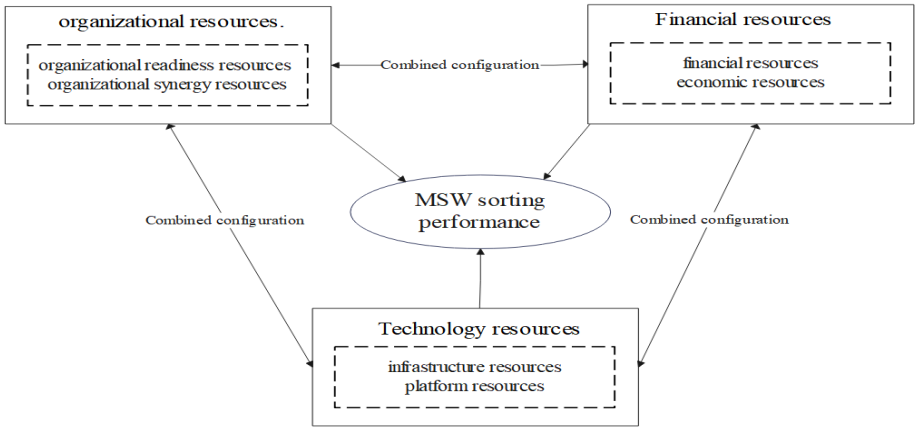

Figure 1 Synergistic impact of resource base on MSW sorting performance.

3. RESEARCH METHODOLOGY

This section consists of three main parts: an introduction to the methodology of mixing NCA and QCA, data sources, and variable measurement and calibration. This research method combines traditional qualitative and quantitative methods, which is very suitable for explaining the problem of multiple causes of one effect. The outcome variable of "Xi'an municipal waste classification performance", which is the subject of this paper, has complex causes, and its results are related to multiple factors, which can never be contributed by a single factor, so the qualitative comparative research method is very suitable for this case study.

3.1 NCA and QCA Methods

The NCA method is an important research method for accurately and sensitively identifying necessary conditions. Not only is it possible to accurately investigate whether a condition is necessary for a particular result to be achieved, but it is also possible to carry out bottleneck level analyses detailing the conditional thresholds/bottleneck levels required for a particular level of result [27]. In this paper, the NCA approach is used as a complement to the fsQCA approach, where the fsQCA approach can help to discover the conditional variables that play a role in the emergence of a particular outcome, while the NCA approach can help to explore the necessity-determining conditions that prevent the emergence of a particular outcome. Necessity condition analysis has good applicability to the problem of investigating what level of resource base elements are required to produce outcomes of high waste sorting performance.

QCA methods differ from traditional quantitative research in their emphasis on explaining multiple concurrent causal relationships by identifying those different context-specific causal pathways that lead to the same outcome [28-

30]. Among other things, fsQCA can deal with degree of variability and partial affiliation, and is suitable for analyzing which resource base groupings can produce high domestic waste segregation performance.

3.2 Data Sources

The data for this study come from two main sources. First, the antecedent conditions include six indicators: organizational readiness resources, organizational synergy resources, financial resources, economic resources, infrastructure resources, and platform resources. The required data come from the government portal of each district and county, the official website of Xi'an Urban Management and Comprehensive Law Enforcement Bureau, and Xi'an Statistical Yearbook-2021. Second, the outcome variable in this paper is urban household waste categorization performance, with data from the Xi'an Municipal Urban Management and Comprehensive Law Enforcement Bureau. In order to actively respond to the central waste classification policy, the Xi'an Urban Management and Comprehensive Law Enforcement Bureau regularly assesses and scores the waste classification performance of each district and county. In order to reduce data volatility and maintain data consistency, this paper adopts the comprehensive scores of living rubbish classification of Xi'an districts and counties from the report "2021 Xi'an City Districts and Counties Living Garbage Classification Work Evaluation and Ranking" as the basis for measuring the performance of living rubbish classification of districts and counties. Finally, the two databases mentioned above were matched, and after removing the residual data, the 2021 domestic waste classification performance of the 14 districts and counties in Xi'an City, Shaanxi Province, with complete data, was used as the study case. In addition, this study further analyses the groupings derived from fsQCA by further combining mainstream media reports and official government websites in Xi'an.

3.3 Variable Measurement and Calibration

Variable measurement and calibration consists of three main components: antecedent condition measurement, outcome measurement, and variable calibration.

3.3.1 Measurement of Antecedent Conditions

Organizational resources: Organisational resources are divided into two resources: organisational readiness and organisational synergy. Referring to the approach of Xu Lu and other scholars [31], this paper measures the government's readiness by the number of policy documents related to domestic waste classification issued by the governments of 14 districts and counties. In addition, referring to the approach of Gao Denghui et al. [21], the authors measure the government's organizational synergy resources by whether or not each district and county has a domestic waste separation service centre for unified coordination. A value of 1 is assigned to the presence of a domestic waste classification service centre, while a value of 0 is assigned to the absence of such a service centre.

Financial resources: Financial resources are subdivided into financial and economic resources. Financial resources are measured using the measurement method of Chen Shixiang and Ding Yixia and other scholars [32, 33] to measure financial resources and economic resources by the per capita general public budget expenditure of Xi'an City in 2021 and per capita gross regional product in 2021, respectively.

Technology resources: Technology resources are divided into infrastructure and platform resources. Referring to the scholars Guerrero [34] and according to the actual situation of living rubbish classification in Xi'an, this paper chooses the coverage rate of urban living rubbish classification collection points in 14 districts and counties in Xi'an to measure the infrastructure resources. In addition, drawing on the practice of Ma Yu and other scholars [23], the platform resources are measured by whether the districts and counties have built a smart management platform for urban living rubbish classification, and the value of having a smart management platform is assigned as 1, and that of not having one is assigned as 0.

3.3.2 Outcome Measurements

Urban domestic waste classification performance was measured using the comprehensive score of domestic waste classification in each district and county in Xi'an for the year 2021. The Urban Management and Comprehensive Law Enforcement Bureau of Xi'an

scored each district and county's waste classification performance assessment in FY2021, with larger values indicating higher urban living waste classification performance in that district.

3.3.3 Variable Calibration

In fuzzy set qualitative comparative analysis (fsQCA), the data variables are first calibrated before the grouping analysis is carried out by converting the previously collected raw data into an affiliation degree with values between 0 and 1 suitable for fsQCA analysis. In this paper, the direct method of calibration was adopted with reference to previous studies[35,36] , and with the characteristics of the data distribution in this study. Under the premise of excluding singularities, the maximum value of the data is set as "fully affiliated" corresponding to 0.95 affiliation, the minimum value is set as "not affiliated at all" corresponding to 0.05 affiliation, and the intermediate value is set as "crossover" corresponding to 0.05 affiliation. intersection" corresponds to 0.5 degree of affiliation. In this paper, according to the characteristics of data distribution, the economic resources, financial resources, organizational readiness resources, infrastructural resources, and the outcome variable of household waste classification performance collected in the study are set as fuzzy variables corresponding to the above degree of affiliation for data calibration. Due to the data characteristics, this paper for organizational synergy resources and platform resources are used clear set assignment method, selected dichotomous variables, respectively, assigned to 0 and 1, representing the existence or non-existence of the variable. The calibration of the conditional and outcome variables for the detailed content is shown in “Table 1”.

Table 1. Calibration of outcome and condition variables

variant	variable name	Variable assignment and calibration
outcome variable	Domestic Waste Separation Performance	For continuous variables, the qualitative anchors were set to 84.701, 79.86 & 71.803 corresponding to 0.95, 0.5 & 0.05
conditional variable	organizational readiness resources	For continuous variables, the qualitative anchors were set to 13.35, 5 & 2.68 corresponding to 0.95, 0.5 & 0.05
	organizational synergy resources	Dichotomous variable, 1 for having a domestic waste separation service centre, 0 for not having one
	Economic resources	For continuous variables, the qualitative anchors were set to 132323, 78012 and 27591.75 corresponding to 0.95, 0.5 and 0.05
	Financial resources	For continuous variables, the qualitative anchors were set to 9460.9, 6031.5 & 2148.7 corresponding to 0.95, 0.5 & 0.05
	Infrastructure resources	Continuous variables, setting qualitative anchors at 100, 99.35 & 83 corresponding to 0.95, 0.5 & 0.05
	Platform resources	Dichotomous variable, Waste Separation Intelligent Management Platform (WSMP) has been established as 1, not set to 0

4. ANALYSING RESULTS

This section consists of three main parts: necessary condition analysis, group state analysis, and robustness test. In the necessary condition analysis, NCA is used to conduct the necessary condition analysis and fsQCA necessity analysis is applied to verify it. In the group state analysis, fsQCA is used to analyse the group state paths of high MSW classification performance and non-high MSW classification performance. Finally, the robustness test was conducted by censoring the number of cases.

4.1 Analysis of Necessary Conditions

NCA analysis can determine whether a condition is necessary for the outcome, and can further analyse the effect size (d) of the necessity of the condition, also known as the 'bottleneck level', which takes a value between 0 and 1, with larger values representing a larger effect of the condition.[37] The NCA necessity condition must satisfy two conditions at the same time: firstly, the effect size (d) must be no less than 0.1, and the Monte Carlo simulation permutation test shows that the effect size is significant ($p < 0.05$) [27,38].

NCA provides both CR and CE estimation methods to derive the effect size (d). “Table 2” shows the results of necessity-related indicators obtained using the CR and CE methods. The results show that the conditional variables organizational readiness resources, economic resources, financial resources, and infrastructure resources do not satisfy the necessity criterion, and therefore, they are not necessary to produce the outcome variable.

Table 2. Results of the analysis of the necessary conditions for the NCA method

prerequisite	methodologies	precision	ceiling area (ceiling zone)	realm	Effect size (d)	P-value
organizational readiness resources	CR	78.6 per cent	0.117	0.87	0.134	0.241
	CE	100%	0.079	0.87	0.090	0.305
economic resources	CR	78.6 per cent	0.058	0.86	0.067	0.324
	CE	100%	0.093	0.86	0.108	0.065
Financial resources	CR	78.6 per cent	0.048	0.88	0.054	0.374
	CE	100%	0.015	0.88	0.017	0.641
Infrastructure resources	CR	92.9 per cent	0.163	0.88	0.184	0.197
	CE	100%	0.196	0.88	0.222	0.059

a Note: 1. Calibrated fuzzy set affiliation. 2. $0.0 \leq d < 0.1$ means "low level"; $0.1 \leq d < 0.3$ means "medium level". p-value stands for Permutation test in NCA analysis, the closer the p-value is to "0", the more significant the effect.

“Table 3” further reports the results of the bottleneck level analysis. The bottleneck level (%) refers to the level (%) at which the antecedent conditions need to be met to reach the maximum observed range of the outcome, as shown in “Table 3” 13.2 per cent of organizational readiness resources, 7.9 per cent of economic resources, and 5.5 per cent of infrastructural resources would be required to attempt to achieve 60 per cent of the performance of the separation of household waste, while all other elements would be unnecessary.

Table 3. Results of NCA method bottleneck level (%) analysis

Domestic Waste Separation Performance	organizational readiness resources	economic resources	Financial resources	Infrastructure resources
0	NN	NN	NN	NN
10	NN	2.1	NN	NN
20	NN	3.2	NN	NN
30	NN	4.4	NN	NN
40	NN	5.5	NN	NN
50	4.2	6.7	NN	NN
60	13.2	7.9	NN	5.5
70	22.1	9.0	NN	25.7
80	31.1	10.2	NN	45.8
90	40.1	19.3	23.2	65.9
100	49.0	21.4	97.3	86.1

a Note: The CR methodology was chosen for the analysis of this table, NN=unnecessary

This paper further employs the necessary conditions analysis in fsQCA, as shown in "Table 4", which indicates that none of the individual conditions (all with consistency less than 0.9) are necessary for either high or non-high MSW sorting performance, which is consistent with the results of NCA.

Table 4. Necessity test of fsQCA for individual conditions

prerequisite	in the end	
	High domestic waste segregation performance	Non-high domestic waste segregation performance
High organizational readiness resources	0.535	0.690
Low organizational readiness resources	0.676	0.536
High organizational synergy resources	0.683	0.600
Low organizational synergy resources	0.317	0.400
High financial resources	0.393	0.739
Low financial resources	0.802	0.471
High economic resources	0.636	0.438
low economic resources	0.574	0.786
High infrastructure resources	0.857	0.459
Low infrastructure resources	0.290	0.697
High platform resources	0.840	0.225
Low platform resources	0.106	0.774

4.2 Configuration Analysis

In this paper, fsQCA3.0 software is used to analyse the conditional groupings that lead to high and non-high MSW sorting performance respectively, and these different groupings indicate different waste sorting effects to achieve the same outcome (high MSW sorting performance and non-high MSW sorting performance). The resulting conditional groupings are further named according to the grouping theorisation process [43].

4.2.1 Group Path Analysis of High Domestic Waste Separation Performance

In this paper, the fsQCA method is used to analyse the grouping paths that produce high versus non-high household waste sorting performance, respectively. Drawing on Du Yunzhou and other scholars, the case frequency threshold is set to 1, the original consistency threshold is set to 0.8, and the PRI consistency is set to 0.75 [28, 29]. By comparing the nesting relationship between intermediate and parsimonious solutions, the core and edge conditions of each grouping state are identified [33]. The calculation results are shown in "Table 5", there are 10 grouping paths for high and non-high domestic waste classification performance, and both the consistency of individual solutions and the overall solution consistency are higher than 0.75, which is in accordance with the regulations. In terms of the five grouping paths of high domestic waste classification performance, the overall solution consistency is 0.925, which indicates that about 92.5% of the urban areas with domestic waste classification performance are showing a high level of performance. The overall solution coverage is 0.633, which indicates that the five conditional groupings can explain 63.3% of the cases with high domestic waste separation performance. Group state H1 suggests that technical resources represented by high infrastructure resources and high platform resources play a central role, complementing the auxiliary conditions of high economic resources, non-high organizational readiness resources, and non-high financial resources, which can promote high domestic waste sorting performance. This path explains 10.2% of the cases of high domestic waste classification performance; Group state H2 shows that technical resources represented by high infrastructure resources and high platform resources play a central role, complementing high organizational synergy

resources, non-high organizational readiness resources, and auxiliary conditions of financial resources, and can effectively enhance domestic waste classification performance. This path explains 6.8% of the high domestic waste classification performance cases; Group state H3 indicates that high platform resources play a central role, complement high organizational resources, non-high financial resources and non-high infrastructure resources in auxiliary conditions, and can enhance domestic waste classification performance. This path explains 2.6% of the high domestic waste classification performance cases; group state H4 indicates that technical resources represented by high infrastructure resources and high platform resources play a central role, complement high organizational readiness resources, high financial resources, non-high organizational synergy resources, and the auxiliary conditions of non-high financial resources, and can improve domestic waste classification performance. This path explains 7.9% of the high domestic waste classification performance cases; Group state H5 shows that technical resources represented by infrastructure resources and platform resources play a central role, complement high economic resources, high organizational synergy resources, and non-high financial resources auxiliary conditions, and can enhance domestic waste classification performance. This path explains 3.6 per cent of the high domestic waste classification performance cases.

Table 5. Configuration paths for high and non-high household waste classification performance

conditional variable	High domestic waste segregation performance					Non-high domestic waste segregation performance				
	H1	M2			H5	NM1			NH4	NH5
		H2	H3	H4		NH1	NH2	NH3		
organizational readiness resources	×	×	-	-		×		-	-	-
organizational synergy resources		-	-	×	-	-	×	×	×	-
economic resources	-		×	×	-	×	×	-	-	×
Financial resources	×	×	×	-	×	-	-	×	-	×
Infrastructure resources	●	●	×	●	●	⊗	⊗	⊗	⊗	
Platform resources	●	●	●	●	●	⊗	⊗		⊗	⊗
Raw coverage	0.410	0.383	0.093	0.086	0.337	0.214	0.327	0.193	0.173	0.173
Unique coverage	0.102	0.068	0.026	0.079	0.036	0.087	0.069	0.093	0.067	0.067
Consistency	0.949	1	1	1	0.920	1	1	1	1	1
Solution consistency	0.925					1				
Solution coverage	0.633					0.669				

a Note: ● = core condition present ⊗ = core condition missing × = auxiliary condition missing - = auxiliary condition present Blank indicates that the condition is not important to the outcome

In order to better distinguish and compare the differences in HLW classification performance under different conditions, this paper summarises three grouping paths of HLW classification performance based on the results in Table 5, namely, technology-economy-driven paths (H1), technology-organisation-driven paths (M2), and integrated-driven paths (H5).

4.2.1.1 Technology-Economy Driven Path (H1)

Under the conditions of continuously increasing the number of rubbish classification facilities such as classified rubbish bins, classified removal vehicles and classified rubbish treatment plants, and perfecting the application of information technology platforms such as the Internet of Things, mobile Internet and artificial intelligence analysis, the rubbish classification needs of residents have been increasingly satisfied, and their daily rubbish

classification behaviours have been managed and serviced in an all-round way. In addition, the region has a high economic resource base, which provides a good soil for the smooth implementation of the waste classification policy, and thus promotes the improvement of the performance of waste classification. For example, Yanta District has complete infrastructure resources and strong platform construction strength, which has led to the formation of high technical resources, in addition, as the largest core area of Xi'an's central urban area, its strong economic strength also provides strong financial support for rubbish classification work. The synergistic effect of technical resources and economic resources jointly ensures the basic conditions for domestic waste classification, promotes the development of residents' waste classification behaviour, and thus enhances the performance of domestic waste classification.

4.2.1.2 Technology-Organisation Driven Pathway (M2)

In areas with relatively weak economic and financial resources, those with sound technical and organizational resources for domestic waste classification can also have higher performance in domestic waste classification. The effective equipping of technical resources for each link and the whole process of rubbish sorting and collection is a necessary guarantee for the promotion of rubbish sorting, while the effective supplementation of organizational resources provides policy support and organizational guarantee for the implementation of rubbish sorting. For example, the Baqiao District government has issued a number of normative policy documents, such as the Three-Year Action Plan for Classification of Urban Living Waste in Baqiao District, which lays a good organizational foundation and upper-level design for the implementation of waste classification in the district. In addition, the government has set up cloud platforms such as the Urban Management Intelligence Centre to intelligently manage waste classification, which has effectively improved the performance of the district's domestic waste classification.

4.2.1.3 Integrated Driven Pathways (H5)

The joint matching of technical, financial and organizational resources also generates high performance in domestic waste classification. As rubbish classification is a public good, it requires a large amount of financial support in terms of rubbish classification facilities and personnel, etc. Strong collaborative support from government organisations further improves the efficiency of rubbish classification, effectively mobilises multiple participants to promote the governance of rubbish classification, and thus improves the performance of domestic rubbish classification effectively. In Xincheng District, for example, the government has promulgated a series of relevant policy documents, stipulating in detail the specific tasks of domestic waste classification, and further improving the promotion mechanism of waste classification. In addition, the government has set up a complete domestic waste separation service centre and a digital city management platform to achieve online and offline simultaneous management and services, which has increased the participation rate and correctness rate of residents in waste separation and improved the performance of domestic waste separation.

4.2.1.4 Analysis of Substitution Relationships Between Highly Categorised Performance Conditions

Comparison of configurations H1, H2 and H5 reveals that when there are complete basic setup resources and sufficient platform resources, better economic resources and organizational synergy resources have an alternative role in the enhancement of high domestic waste classification performance. Classification facilities are a favourable grip for the advancement of waste classification practice, and the arrangement of scientific, reasonable and convenient domestic waste classification facilities affects the final effect of residents' waste classification. In addition, government departments have set up fully functional domestic waste separation and treatment service centres as well as digital city management platforms, which have achieved simultaneous online + offline management and services, increased the participation and correctness rate of residents in waste separation, and facilitated the improvement of the performance of domestic waste separation.

4.2.2 Group Path Analysis of Performance of Non-high Domestic Waste Classification

Based on “Table 5”, three types of grouping pathways for non-high MSW sorting performance were summarised, namely the conditionally deprived pathway (NM1), the technologically

deficient pathway (NH4), and the financial-technical dual constraints pathway (NH5).

Conditional scarcity type: Path NM1 shows that the lack of technological resources and incomplete in terms of organizational and financial resources are not conducive to the performance of household waste separation. The possible explanation is that when there is a lack of technical resources, residents do not consider waste separation as a necessity, and even if they have the will to separate waste, they are unable to put the separation behaviour into practice. At the same time, the lack of relevant policy guidance and regional economic support, rubbish classification work is blind, fragmented, etc., even if there are better organizational synergies and financial resources to ensure that rubbish classification work is difficult to implement, and thus inhibit the improvement of the performance of domestic waste classification.

Technically deficient: Path NH4 shows that having scarce technical resources and organizational synergy resources, even with better organizational readiness resources and financial resources, is still not conducive to improving the performance of domestic waste classification. Technical resources are the basic guarantee of waste classification affecting the final effect of waste classification. Unreasonable allocation of financial resources makes regional access to resources uneven, even if there are strict institutional norms, rubbish classification can not be truly implemented.

Financial-technological dual constraints type: Path NH5 shows that despite having better organizational resources, backward financial and technological resources still lead to poorer performance in domestic waste classification. The lack of financial resources limits the scope and extent of government funding and hinders the synergistic effect of the government; while the backward technological platform construction not only inhibits the improvement of the level of government services, but also reduces the efficiency of the government's work, which is not conducive to the improvement of the performance of domestic waste classification.

Comparative analysis reveals that the group paths of high and non-high domestic waste classification performance are characterised by asymmetry, and it is not possible to directly derive one from the other. In addition, further comparison of the high and non-high domestic waste classification performance group paths reveals that technical resources such as infrastructure resources and platform resources play a relatively important and general influence on domestic waste classification performance.

4.3 Robustness Tests

In order to improve the reliability of the study, this paper refers to Du Yunzhou's study and conducts a robustness test by deleting the number of cases [29]. Two cases were randomly selected, namely "Baqiao District" and "Lantian County". The results are shown in “Table 6” and “Table 7”, and there is no significant change in the consistency and other values, so the results of the analyses in this paper are considered to be robust from a general point of view.

Table 6. Robustness test of some cases removed 1

prerequisite	in the end	
	High domestic waste segregation performance	Non-high domestic waste segregation performance
High organizational readiness resources	0.522	0.639
Low organizational readiness resources	0.703	0.601
High organizational synergy resources	0.629	0.534
Low organizational synergy resources	0.370	0.465
High financial resources	0.414	0.727
Low financial resources	0.777	0.477
High economic resources	0.698	0.481
low economic resources	0.519	0.751
High infrastructure resources	0.892	0.371
Low infrastructure resources	0.219	0.787
High-platform resources	0.868	0.246
Low platform resources	0.101	0.753

Table 7. Robustness test of some cases removed 2

conditional variable	High domestic waste segregation performance					Non-high domestic waste segregation performance				
	H1	H2	H3	H4	H5	NH1	NH2	NH3	NH4	NH5
organizational readiness resources	×	×	-	-		×		-	-	-
organizational synergy resources		-	-	×	-	-	×	×	×	-
economic resources	-		×	×	-	×		-	-	×
Financial resources	×	×	×	-	×	-	-	×	-	×
Infrastructure resources	●	●	×	●	●	⊗	⊗	⊗	⊗	
Platform resources	●	●	●	●	●	⊗	⊗		⊗	⊗
Raw coverage	0.446	0.398	0.13	0.1	0.361	0.25	0.374	0.193	0.108	0.108
Unique coverage	0.119	0.079	0.031	0.091	0.042	0.102	0.110	0.077	0.996	0.996
Consistency	0.945	1	1	1	0.914	1	1	1	1	1
Solution consistency	0.917					1				
Solution coverage	0.659					0.662				

5. SUMMARY OF THE STUDY

Based on the analytical framework of resource-based theory, this study takes 14 major districts and counties in Xi'an as the research object, and based on the basic investigation and analysis of various types of resource conditions affecting the performance of domestic waste classification in Xi'an, firstly, it adopts the NCA method to study the necessity of individual resource conditions in the formation of the performance of domestic waste classification, and then it further applies the fsQCA method from the grouping perspective to conduct a grouping path study of the condition factors affecting the performance of domestic waste classification in Xi'an. The group state path study was conducted on the conditional factors affecting domestic waste classification performance in Xi'an. The condition paths that generate high and non-high domestic waste classification performance are classified into groups, and the logical law of their generation is summarised to determine the core conditions and key groups that generate high and non-high domestic waste classification performance in Xi'an. The main conclusions of the study are as follows:

- The independent existence of the three factors of organisational resources, technical resources and financial resources will not result in high or non-high levels of domestic waste classification performance, and cannot alone constitute the necessary conditions for high or non-high domestic waste classification performance. The process of domestic waste classification is a complex social-ecological system formed by the interaction of multiple factors, and the influence of different combinations of elements on the performance of domestic waste classification must be paid attention to.
- High domestic waste classification performance can be categorised into 3 paths: technology-economy driven, technology-organisation driven, and integrated driven. Non-high domestic waste classification performance has three paths: conditionally scarce, technology-deficient, and financial-technology dual-constraint.
- The group paths of high and non-high domestic waste classification performance show asymmetry. It is not possible to directly deduce the other side through one side, and it is not possible to simply use the reasons for high living rubbish classification performance to simply take its opposite to explain the non-high-performance living rubbish classification performance, and both group paths need to be paid attention to; comparing the common factors affecting the high and non-high living rubbish classification performance, it can be found that the infrastructure resources, platform resources and other technological resources have a more general impact on the performance of the classification of living rubbish.

6. CONCLUSION

The above findings provide insights for improving the performance of MSW segregation. Firstly, the performance of waste separation is affected by the combination of various resource elements, and the optimisation of waste separation performance can no longer be achieved by only strengthening the input of a single resource element. Therefore, local governments should take a holistic view and allocate organizational, economic and technological resources in a synergistic manner to promote the performance of domestic waste classification in the region. Secondly, local governments should take technological resources as the key to optimising the performance of domestic waste classification, and through the continuous construction and improvement of the intelligent service platform for domestic waste classification and the infrastructure for domestic waste classification in the region, improve the satisfaction of residents with the classification of domestic waste so as to further increase the accuracy and efficiency of their classification, and thus enhance the performance of domestic waste classification. Thirdly, in addition to the core resources affecting the performance of domestic waste classification, the government should pay attention to the auxiliary role of organizational and economic resources in improving the performance of domestic waste classification. On the one hand, the government should improve the whole process of domestic waste classification, including the supporting rules and regulations and supervision and management mechanism, so as to escort the improvement of domestic waste classification performance; strengthen the coordination effect of the domestic waste classification service centre in the whole process of domestic waste classification, so as to enable the responsible parties to better play the role of linkage and synergy. On the other hand, government departments should set up special funds and financial subsidies and other regional financial support funds to provide economic protection for the work of domestic rubbish classification; adjust the investment direction of financial funds in accordance with local conditions to achieve accurate investment in many aspects of domestic rubbish classification, such as collection, transportation, disposal, etc., so that the financial funds can effectively cover the whole process of rubbish classification; the government should do a good job in the management of rubbish classification project funds plan, improve the financial funds supervision system, and put the funds in a better position to improve the performance of domestic garbage classification. The government should do a good job of waste classification project fund plan management, improve the financial fund supervision system, and the use of funds to the public in a timely manner to improve the credibility of the government's work and public support, so as to enhance the performance of domestic waste classification.

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