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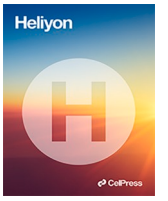

Research article

# Experiment in resilient city: An evaluation of China's demonstration city of safe development policies

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ABSTRACT

The drive of resilient city explores a new path for urban governance in the context of risk society, and China's demonstration city of safe development (DCSD) policies are the indigenous practice of resilient city idea. This paper used text mining technology and PMC-index model to establish an evaluation system for DCSD policies. Then eight representative sample DCSD policies were assessed. The results show that the average PMC-index scores 5.38 and reaches a great consistency grade. Nine model indicators indicate that the Chinese government has a clear policy focus on the efforts of DCSD, prefers to use compulsory type policy tools, and fully mobilizes the public to participate in safe city development jointly. Meanwhile, structural imbalance in policy instruments is a prominent disadvantage. The research establishes an evaluation system for DCSD policies, and provides a new perspective for the explorations of resilient cities worldwide. The extensive applicability of the policy evaluation model needs to be studied in depth in the future.

## 1. Introduction

Human beings have gone through a long history from the primeval forest to modern society, and in the process have created something new that is convenient for survival and development. "Organization" is the product of people's cooperation. "City", "urban community" or "metropolis", whatever one names such communities, urban systems always represent a higher level of organization. Here, social functions are highly developed. Wealth accumulation is its basic characteristic. The economy is well developed, attracting a large number of people to flock to the city. Peasants leave their places of origin in search of survival in this fertile soil. In each such community there were from the beginning certain common interests the safeguarding of which had to be handed over to individuals, true, under the control of the community as a whole: adjudication of disputes; repression of abuse of authority by individuals; control of water supplies, especially in hot countries; and finally when conditions were still absolutely primitive, religious functions [1]. In modern society, the country is the unified allocator of the interests of this huge social system, and undertakes various management functions of the city.

In its latest World Cities Report 2022, UN-Habitat pointed out that the rapid global urbanization process has only been temporarily delayed by coronavirus disease-2019 (COVID-19). The growth of the global urban population is back on track, with forecast growth of 2.2 billion people by 2050, when the proportion of inhabitants living in urban areas is expected to rise to 68 %, with most of the growth coming from developing countries [2]. However, when cities develop rapidly, there are negative effects such as population expansion,

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traffic congestion, resource shortages and pollution [3]. Since entering the 21st century, a series of public events affecting urban safety, such as the September 11, 2001, terrorist attacks, SARS, the Fukushima Daiichi nuclear accident and COVID-19 have continuously reminded people that the safety situation facing cities has become more severe [4].Especially in the context of the advent of the risk society [5], the theoretical circles and government departments are increasingly aware of the importance of urban safety. "Resilient city" is an academic neologism that has emerged against this background. Policy is an important tool for government public governance. As a result, policies related to resilient city have also promoted practical community to attracted extensive attention. Countries have made positive and beneficial explorations of resilient cities in accordance with the basic reality. A range of policy documents have been issued in particular. The localization practice of China's resilient cities is to build DCSD, which has blossomed nationwide since 2018. However, little attention has been paid to the actual outcomes of these policies. In order to make up for this fragmentation, we used text mining technology and PMC-index model to construct an evaluation framework for DCSD policies. Then substantial policy spillover of the eight sample policies was assessed, so as to provide theoretical and practical experience for improving resilient city development.

The rest of this paper is organized as follows. Section 2 reviews the relevant literature. Section 3 introduces policy samples and methodology. The empirical results are presented in Section 4. Section 5 shows the discussion. Section 6 summarizes the findings and limitations.

## 2. Literature review

### 2.1. Related literature on policies of resilient city

Resilient city has become a buzz word in urban governance domains. Some countries and regions have begun to explore the construction of resilient cities, the most representative of which is the promulgation of policies. For example, on June 11, 2013, New York City released "*A Stronger, More Resilient New York*" plan. Japan enacted *Basic Act for National Resilience Contributing to Preventing and Mitigating Disasters for Developing Resilience in the Lives of the Citizenry* in the same year. Between 2018 and 2023, China's demonstration city of safe development policies were promoted and spread throughout the country. In 2020, London rolled out *London City Resilience Strategy 2020*, updating the *Urban Climate Change Adaptation Strategy – Managing Risk and Building Resilience*, published in 2011. The explorations of resilient city practice in government departments have also triggered active discussions in the academic community. Research in this area consists of three dimensions. The first is the analysis of the policies related to resilient cities themselves, which includes climate resilience [6], natural disaster resilience [7–10], resilience related to the pandemic crisis [11] and water resilience [12]. The second part of the study is that scholars propose how to build resilient cities through policies from different perspectives. Academia expressed their viewpoints from enhancing urban hardware infrastructure [13–15] and reducing the size of urban space [16] to enhance urban resilience. Some researchers have also put forward proposals to create urban resilience systems based on the soft environment of cities, such as cultural environment [17], sectoral participation [18], governance methods [19–21] and policy resistance [22]. The last aspect of research is the impact of resilient city policies on society, covering energy [23], climate [24], migration governance [25] and social justice [8].

### 2.2. Policy evaluation research

Policy evaluation aims to improve the quality of policy decisions and ensure the achievement of policy objectives [26]. Qualitative and quantitative assessment are the two basic ways. In qualitative research, commonly used methods include theoretical analysis, comparative analysis, case study and expert interview [27]. Early scholars mainly used these approaches to evaluate public policies, and now quantitative estimates are increasingly valued by scholars [28]. However, the academic community is more likely to combine quantitative and qualitative analysis methods [29,30] in response to the shortcomings of low accuracy and high subjectivity. Combining PMC-index model and policy text mining can overcome the above shortcomings and has been widely used in policy quantification at home and abroad [31–34].

From the above literature review, it can be concluded that a lot of useful explorations have been made in the practical and theoretical circles for theresilient cities, which has laid a solid research foundation for our thematic study. In order to provide some suggestions for the reformulation and improvement of the policies, this paper uses the PMC-index model widely recognized by the academic community and the policy text content analysis method to establish a framework for evaluating the effectiveness of the DCSD policies. In the context of drives for resilient cities in full swing globally, we will propose the Chinese approaches to exploration of the resilient city.

## 3. Data sources and methods selection

### 3.1. Policy database establishment

Considering that the government of China first proposed to implement the demonstration cities of safe development project in 2010, this year is the beginning for establishing the policy sample database. The collection of policies mainly comes from the Peking University laws and regulations database (https://www.pkulaw.com/), and the full-text search is carried out with "safe development" and "demonstration city" as keywords. Second, it is supplemented by the State Council Policy Document Database (https://www.gov.cn/zhengce/) and commonly used search engines.

Through the above methods and manual reading, we have selected two policies most closely related to the construction of DCSD at the central level. In addition, in order to ensure the comprehensiveness of the content coverage of the policy sample, six representative local policies were taken to be evaluated. The basic information of the target policies is shown (sorted by time series) in Table 1.

### 3.2. Construction of the PMC-index model

As shown in Fig. 1, there are four main steps in the process of PMC-index model construction [35].

#### 3.2.1. Classification of variables and identification of parameters

In order to improve the accuracy of the variable setting of the PMC-index model, we used Python and Gephi software to conduct policy text mining and content analysis on the selected eight policies. Specifically, it includes preprocessing such as text word segmentation, high-frequency keyword statistics and keyword co-occurrence network visualization. Table 2 lists the top 50 high-frequency keywords of DCSD policies in China, including "safety", "production", "emergency" and "city".

Based on the high-frequency keyword statistics and keyword co-occurrence matrix, Gephi0.10 was used to plot the co-word network, and the result is shown in Fig. 2. The node size reflects the keyword's strength of centrality, and the thickness of the line between the nodes represents the strength of the co-word relationship. The larger node and thicker connection between solid circles mean greater influence of the keyword [36]. As is illustrated in Fig. 2, the keywords "safety", "production", "emergency", "enterprise" and "management" have a high centrality. As the core theme of policy design, "safety" is located at the center of the network diagram, with the broadest radiation area and the most significant influence. In addition, some low-frequency and scattered terms in the network chart, such as "education", "training", "management", "project" and "culture", reflect that they are also essential implementation paths for DCSD progress.

Referring to the existing literature research, combined with high-frequency keyword statistics and co-word network diagrams, this paper eventually set 9 primary variables and 50 secondary variables (see Table 3). It should be pointed out that since policy tools are an essential path for public policy analysis [37], the research draws on the classification of policy instruments widely used by Howlett and Ramesh [38] and sets three basic policy tools of compulsory type, mixed type and voluntary type as first-level variables. After determining the PMC-index model variables, the parameters of the secondary variables are quantified by a binary algorithm, which means that the variable's value is set to 1 when policy conforms to the respective variable; if not, it would be scored 0. Appendix A shows the specific evaluation criteria of sub-variables.

#### 3.2.2. Constructing a multiple-input-output table

In light of the PMC-index model construction principles, combined with the variable settings of DCSD policies' PMC-index model, a multi-input-output table was built, as shown in Table 4.

#### 3.2.3. Calculation of the PMC-index

Measurement of the PMC-index usually follows four steps [35]. Firstly, put the primary and secondary variables into the multi-input-output table. Secondly, tabulating sub-variables assignments according to results of text mining and Equation (1) and (2). Thirdly, the measurement of the main-variables is based on Equation (3). Fourthly, using Equation (4), the sum yields the PMC-index.

$$X \sim N[0,1] \tag{1}$$

$$X = \{XR : [0 \sim 1]\} \tag{2}$$

$$X_i = \sum_{j=1}^{n} \frac{X_{ij}}{n} \; i = 1, 2, \ldots, 9 \tag{3}$$

$$PMC - index = \sum_{i=1}^{9} X_i \tag{4}$$

Where $i$ is the main-indicator, $j$ is sub-indicator, and $n$ is the number of sub-indicator.

The value of PMC-index represents the degree of policy consistency. In accordance with the scoring criteria of existing research [39,48,49], PMC-index scores of a policy are divided into four levels of consistency (see Table 5).

#### 3.2.4. Construction of the PMC-surface

Construction of the PMC-surface can use a visual three-dimensional image to show the quantitative evaluation results of the PMC-index, which intuitively analyze the advantages and disadvantages of DCSD policies. The prerequisite of the PMC-surface relies on the building of the PMC-matrix. Based on the nine primary indicators, it could create a $3 \times 3$ PMC-matrix for each policy. The PMC-matrix corresponding to PMC-surface was calculated from Equation (5).

$$PMC - surface = \begin{bmatrix} X_1 & X_2 & X_3 \\ X_4 & X_5 & X_6 \\ X_7 & X_8 & X_9 \end{bmatrix} \tag{5}$$

**Table 1**
Sample policies for PMC-Index model.

| Item | Policy name (Release agency) | Release time | Reason |
|---|---|---|---|
| P1 | Guiding opinions on the establishment of demonstration city of safe development (Office of the Work Safety Commission of the State Council) | January, 2013 | The first programmatic document for the construction of DCSD at the central level in China |
| P2 | Notice on the issuance of Quanzhou City's work plan for establishing demonstration city of safe development (Quanzhou Municipal People's Government) | July, 2013 | The first batch of pilot units for the creation of national DCSD |
| P3 | Notice on the issuance of Hangzhou's work Plan for the establishment of a national demonstration city of safe development (2014–2016) (General Office of Hangzhou Municipal People's Government) | September, 2014 | The first batch of pilot units for the creation of national DCSD |
| P4 | Notice on the issuance of Changchun City's plan for the establishment of a national demonstration city of safe development (2015–2020) (Changchun Municipal People's Government) | December, 2015 | The first batch of pilot units for the creation of national DCSD |
| P5 | Opinions on promoting urban safe development (General Office of the CPC Central Committee and General Office of the State Council) | January, 2018 | The national authoritative guidance document for the DCSD policy is in full bloom across the country |
| P6 | Notice on the issuance of the Shenzhen action plan for demonstration city zone of safe development of socialism with Chinese characteristics (2020–2025) (Shenzhen Safety Management Commission) | October, 2020 | The first action plan for the safe development of building a pilot demonstration zone of socialism with Chinese characteristics |
| P7 | Notice on the issuance of the implementation measures for the demonstration and establishment of Changsha safe development work (Office of Changsha Work Safety Commission) | April, 2023 | Implementation measures for the creation of representative DCSD at the prefecture and municipal levels |
| P8 | Regulations on urban safe development of Lanzhou City (Standing Committee of Lanzhou Municipal People's Congress) | April, 2023 | The first city-state local regulation in the country to legislate for the DCSD |

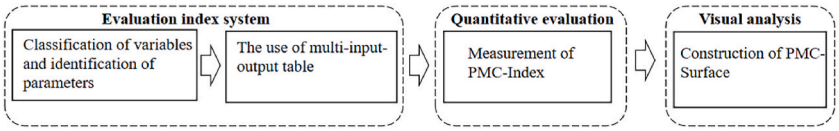


**Fig. 1.** The process of PMC-index model construction.

**Table 2**
Statistics of high-frequency words of DCSD policies.

| Sequence | High-frequency words | Frequency | Sequence | High-frequency words | Frequency |
|---|---|---|---|---|---|
| 1 | Safety | 1416 | 26 | Occupation | 62 |
| 2 | Production | 578 | 27 | Planning | 61 |
| 3 | Emergency | 280 | 28 | Hidden Trouble | 61 |
| 4 | City | 279 | 29 | Community | 60 |
| 5 | Development | 273 | 30 | Equipment | 59 |
| 6 | Enterprise | 245 | 31 | Street | 59 |
| 7 | Management | 184 | 32 | Preplanning | 58 |
| 8 | Department | 161 | 33 | Education | 57 |
| 8 | Supervision | 158 | 34 | Monitoring | 54 |
| 10 | Mechanism | 128 | 35 | Evaluation | 53 |
| 11 | System | 115 | 36 | Chemicals | 53 |
| 12 | Risk | 113 | 37 | Facility | 53 |
| 13 | Facility | 99 | 38 | Professional | 52 |
| 14 | Unit | 93 | 39 | Standard | 52 |
| 15 | Industry | 89 | 40 | Culture | 51 |
| 16 | Liability | 88 | 41 | By Law | 51 |
| 17 | Society | 82 | 42 | Surveillance | 51 |
| 18 | Rescue | 82 | 43 | Assessment | 49 |
| 19 | Demonstration | 77 | 44 | Standardization | 46 |
| 20 | Technology | 77 | 45 | Industrial Park | 45 |
| 21 | Accident | 73 | 46 | Duty | 44 |
| 22 | Township | 71 | 47 | Early Warning | 44 |
| 23 | Training | 69 | 48 | Emergency Management | 44 |
| 24 | Government | 68 | 49 | Project | 43 |
| 25 | Investigation | 66 | 50 | Colliery | 43 |

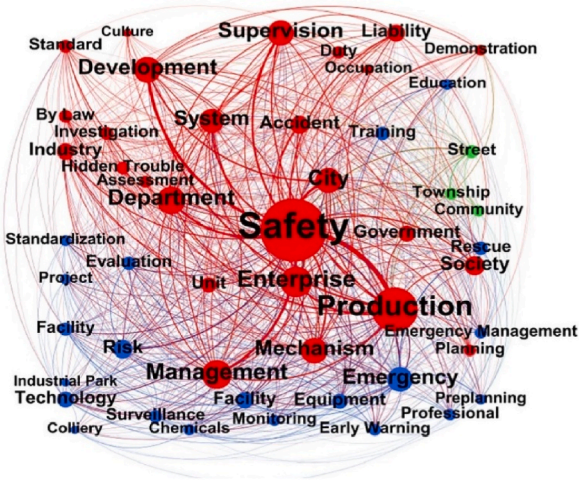


**Fig. 2.** High-frequency words network diagram of DCSD policies.

**Table 3**
Variable settings for quantitative evaluation of DCSD policies.

| Primary variables | Secondary variables | References |
|---|---|---|
| Policy Timeliness ($X_1$) | Long term ($X_{1\text{-}1}$); Medium term ($X_{1\text{-}2}$); Short term ($X_{1\text{-}3}$) | [39] |
| Policy Scope ($X_2$) | Nation ($X_{2\text{-}1}$); Regional ($X_{2\text{-}2}$); City ($X_{2\text{-}3}$); Town ($X_{2\text{-}4}$) | [40] |
| Policy Object ($X_3$) | Government ($X_{3\text{-}1}$); Enterprise ($X_{3\text{-}2}$); Expert ($X_{3\text{-}3}$); Intermediary ($X_{3\text{-}4}$); Non-governmental organization ($X_{3\text{-}5}$); Public ($X_{3\text{-}6}$) | [41,42] |
| Policy Field ($X_4$)[1] | Engineering resilience ($X_{4\text{-}1}$); Ecological resilience ($X_{4\text{-}2}$); Social resilience ($X_{4\text{-}3}$); Economic resilience ($X_{4\text{-}4}$); Technical resilience ($X_{4\text{-}5}$); Organizational resilience ($X_{4\text{-}6}$) | [43,44] |
| Policy Focus ($X_5$) | Safety production capacity ($X_{5\text{-}1}$); Supervision and guarantee capability ($X_{5\text{-}2}$); Emergency rescue construction ($X_{5\text{-}3}$); Risk prevention and control ($X_{5\text{-}4}$); Security guarantee capability ($X_{5\text{-}5}$) | High-frequency word statistics; Semantic network diagram |
| Policy Guarantee ($X_6$) | Leadership responsibility system ($X_{6\text{-}1}$); Division of department ($X_{6\text{-}2}$); Performance appraisal ($X_{6\text{-}3}$); Synergy ($X_{6\text{-}4}$) | High-frequency word statistics; Semantic network diagram |
| Compulsory Type Policy Tool ($X_7$)[2] | Organizational leadership ($X_{7\text{-}1}$); Regulation construction ($X_{7\text{-}2}$); Preparation of plans ($X_{7\text{-}3}$); Special action ($X_{7\text{-}4}$); Implementation ($X_{7\text{-}5}$); Administrative punishment ($X_{7\text{-}6}$); Access permit ($X_{7\text{-}7}$); Accountability and investigation ($X_{7\text{-}8}$) | [45–47] |
| Mixed Type Policy Tool ($X_8$) | Financial investment ($X_{8\text{-}1}$); Infrastructure construction ($X_{8\text{-}2}$); Information disclosure ($X_{8\text{-}3}$); Tax incentives ($X_{8\text{-}4}$); Financial support ($X_{8\text{-}5}$); Talent training ($X_{8\text{-}6}$); Information platform ($X_{8\text{-}7}$) | [45–47] |
| Voluntary Type Policy Tool ($X_9$) | Publicity and education ($X_{9\text{-}1}$); Commendation and awards ($X_{9\text{-}2}$); Policy guidance ($X_{9\text{-}3}$); Social participation ($X_{9\text{-}4}$); Exchange and cooperation ($X_{9\text{-}5}$); Industry self-discipline ($X_{9\text{-}6}$); Public opinion supervision ($X_{9\text{-}7}$) | [45–47] |

[1] Urban resilience is a hot topic in urban research, which generally includes: engineering resilience, ecological resilience, social resilience, economic resilience, technical resilience and organizational resilience. The above dimensions can comprehensively reflect the role areas of DCSD policies.

[2] Drawing on Howlett's classification of policy instruments, this study divides the policy tool of DCSD policies into compulsory type, mixed type and voluntary type policy tool.

**Table 4**
The multi-input-output table of quantitative evaluation of DCSD policies.

| Main-variables | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ |
|---|---|---|---|---|---|---|---|---|---|
| Sub-variables | $X_{1\text{-}1}$ | $X_{2\text{-}1}$ | $X_{3\text{-}1}$ | $X_{4\text{-}1}$ | $X_{5\text{-}1}$ | $X_{6\text{-}1}$ | $X_{7\text{-}1}$ | $X_{8\text{-}1}$ | $X_{9\text{-}1}$ |
| | $X_{1\text{-}2}$ | $X_{2\text{-}2}$ | $X_{3\text{-}2}$ | $X_{4\text{-}2}$ | $X_{5\text{-}2}$ | $X_{6\text{-}2}$ | $X_{7\text{-}2}$ | $X_{8\text{-}2}$ | $X_{9\text{-}2}$ |
| | $X_{1\text{-}3}$ | $X_{2\text{-}3}$ | $X_{3\text{-}3}$ | $X_{4\text{-}3}$ | $X_{5\text{-}3}$ | $X_{6\text{-}3}$ | $X_{7\text{-}3}$ | $X_{8\text{-}3}$ | $X_{9\text{-}3}$ |
| | | $X_{2\text{-}4}$ | $X_{3\text{-}4}$ | $X_{4\text{-}4}$ | $X_{5\text{-}4}$ | $X_{6\text{-}4}$ | $X_{7\text{-}4}$ | $X_{8\text{-}4}$ | $X_{9\text{-}4}$ |
| | | | $X_{3\text{-}5}$ | $X_{4\text{-}5}$ | $X_{5\text{-}5}$ | | $X_{7\text{-}5}$ | $X_{8\text{-}5}$ | $X_{9\text{-}5}$ |
| | | | $X_{3\text{-}6}$ | $X_{4\text{-}6}$ | | | $X_{7\text{-}6}$ | $X_{8\text{-}6}$ | $X_{9\text{-}6}$ |
| | | | | | | | $X_{7\text{-}7}$ | $X_{8\text{-}7}$ | $X_{9\text{-}7}$ |
| | | | | | | | $X_{7\text{-}8}$ | | |

**Table 5**
PMC-index evaluation criteria of DCSD policies.

| PMC-index | 0.00–2.90 | 3.00–4.99 | 5.00–6.99 | 7.00–9.00 |
|---|---|---|---|---|
| Evaluation | Poor Consistency (PC) | Acceptable Consistency (AC) | Great Consistency (GC) | Perfect Consistency (PC) |

## 4. Results

### 4.1. The PMC-index of the eight DCSD policies

Based on the PMC-index model for DCSD policies constructed above, combined with the text contents of the eight representative policies, this paper used content analysis and text mining methods to establish a muti-input-output table for each secondary variable parameter. Then, we calculated the value of the PMC-index. The result is depicted in Table 6. The average PMC-index is 5.38 and reaches a great consistency grade. Therefore, the overall formulation of China's DCSD policies is reasonable and effective.

The eight representative policies have been classified into three grades, including three great levels (P5, P6, and P8), three acceptable levels (P2, P3, and P4), and two poor levels (P1 and P7). In order to show the overall values of the eight representative DCSD policies more directly, this section is presented by using a Radar chart (see Fig. 3). As shown in Fig. 3, the overall change in the eight target DCSD policies' scores is visualized, and the average values of each policy's main-indicator are compared. The detailed discussions are as follows:

As the proverb goes, to be focused everywhere is to have no focus. A clear policy stress is a prerequisite for effective government policies. In the results of the output scale, we find that the policy point ($X_5$) has a score of 0.75, the highest score among the nine primary variables, thus reflecting that DCSD policies text content has a more precise policy point. For a policy to work, it must mobilize multiple forces. This is reflected in the need for a diversity of policy objects. In modeling, policy object variable ($X_3$) ranked second, with a score of 0.71, indicating that the policy audience is extensive. A situation led by the government is basically established. Enterprises, professional forces, the public and other subjects participate in safty development collectively.

The use of policy tools is indispensable for the achievement of policy goals. From the combination of various policy instruments, it is possible to reflect on the rationality of the use of tools. Of the three essential policy instrument variables, the compulsory type policy tool ($X_7$) scored the highest and ranked second only to the policy focus variable ($X_5$) and policy object variable ($X_3$) among all host variables. The compulsory policy instrument type adopts rigid implementation methods and has the strongest degree of intervention,

**Table 6**
PMC-index and level of eight DCSD policies.

| Primary variables | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| $X_1$ | 0.67 | 0.67 | 0.33 | 0.67 | 0.67 | 1.00 | 0.33 | 0.33 |
| $X_2$ | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| $X_3$ | 0.50 | 0.67 | 0.83 | 0.83 | 0.67 | 1.00 | 0.33 | 0.83 |
| $X_4$ | 0.50 | 0.67 | 0.50 | 0.67 | 0.67 | 0.67 | 0.17 | 1.00 |
| $X_5$ | 0.60 | 0.80 | 0.80 | 0.60 | 1.00 | 0.60 | 0.60 | 1.00 |
| $X_6$ | 0.25 | 0.50 | 0.50 | 0.50 | 0.75 | 1.00 | 0.50 | 1.00 |
| $X_7$ | 0.38 | 0.63 | 1.00 | 0.75 | 0.75 | 0.63 | 0.75 | 0.75 |
| $X_8$ | 0.14 | 0.43 | 1.00 | 0.57 | 0.57 | 0.29 | 0.29 | 0.57 |
| $X_9$ | 0.14 | 0.14 | 0.43 | 0.43 | 0.43 | 0.86 | 0.29 | 0.71 |
| PMC-index | 3.68 | 5.00 | 5.90 | 5.52 | 6.00 | 6.53 | 3.75 | 6.70 |
| Rank | 8 | 6 | 4 | 5 | 3 | 2 | 7 | 1 |
| Level | PC | AC | AC | AC | GC | GC | PC | GC |

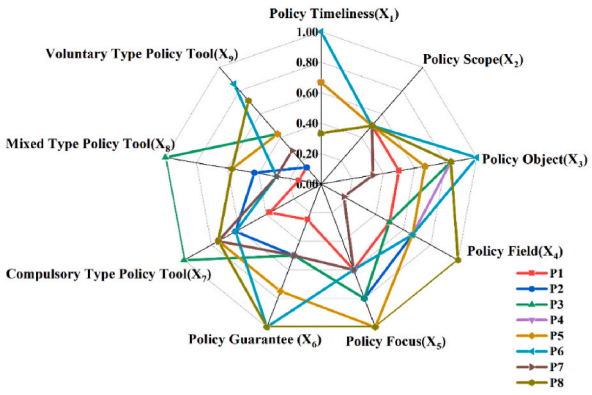


**Fig. 3.** Radar chart of the eight representative policies.

which highlights the initiative and strength of the government in public safety governance. The scores of mixed type policy tool ($X_8$) and voluntary type policy tool ($X_9$) were 0.48 and 0.43, respectively, ranking in the bottom two places and fluctuating wildly. It suggested that the internal structure of the use of policy tools in China's DCSD policies is uncoordinated, showing characteristics of "emphasis on compulsory type policy tools, disdain on mixed type policy tools, and lack of voluntary type policy tools".

The purpose of this study is to measure the systematization and synergy of policies from the regional aspect, that is, from the perspective of national, regional and urban-rural areas. Although the variable of policy scope ($X_2$) did not fluctuate, the score was lower than the average. Therefore, it indicates that the radiation area of the policy is not extensive enough. The coordination between regions and urban-rural linkages has not been fully mobilized.

This study will be used "policy field" as a one-dimensional model construction, which actually corresponds to the academic hot word of urban resilience. The connotation of this term is very abundant, and we are only carrying out an exploratory experiment. The empirical findings show that the main variable with large fluctuations is policy field ($X_4$). The fluctuation of the $X_4$ indicator may reflect two reasons. Firstly, the government has undergone diachronic changes in different aspects of urban resilience. That is, it has experienced the importance of soft power from the initial hardware infrastructure construction to organizational development and cultural progress. Secondly, this combination of soft and hard urban resilience efforts is actually a response to the background of the times. For example, the advent of the fourth industrial revolution, represented by artificial intelligence and big data, has created an opportunity for urban safety governance. The efforts of scientific and technological resilience in the policy are the government's initiative to use technological means to strengthen the resilience of cities.

### 4.2. The PMC-surface of the eight DCSD policies

Using formula (5), the eight representative DCSD policies were arranged according to the PMC-index results to generate eight $3 \times 3$ PMC matrices, shown in Table 7. The PMC surfaces for eight DCSD policies were drawn based on the PMC matrices (outline in Figs. 4–11). The horizontal line of the PMC matrix corresponds to the abscissa in the graph (represented by the numbers 1, 2, and 3); The vertical columns in the matrix correspond to the ordinates in the graph (represented by series 1, series 2, and series 3). On the strength of the PMC-surface chart and policy score results, we evaluated the advantages and disadvantages of each policy according to the scoring level and give corresponding improvement strategies. The specific analysis results are as follows.

#### 4.2.1. Great consistency policies

There are three policies with a policy assessment level of "GC". At the beginning of 2018, after the central government issued the policy of promoting DCSD, provincial and municipal governments successively updated the guidance documents such as DCSD construction work plans, rating management measures, evaluation rules and scoring standards. Compared with 2013, the level of policy formulation has been highly improved. The policy issuing institution has been upgraded from the Office of the State Council Security Committee to the General Office of the CPC Central Committee and General Office of the State Council (*Liang Ban*). From the side, it reflects that the construction of the first batch of pilot units has achieved positive outcome, and the Chinese government has strengthened its efforts to implement the policies of DCSD.

It is worth noting that the regulation issued by the Standing Committee of the Lanzhou Municipal People's Congress. This is the first local regulation on DCSD in China. It highlights ground-breaking innovation and clearly writes down the promotion of the development of resilient city and smart city. Among all the evaluation indicators, only one item of policy timeliness was below the average. This is determined by the authority and soundness of the policy, and long-term regulations can give the public stable expectations for action. The regulation underlines the forward-looking, positioning the direction and goal of legislation from a macro perspective. It also takes notice of the details about urban safety drive, setting a primary benchmark in the nationwide.

The PMC-index of P6 is 6.53, ranking second. Since China's reform and opening up in 1978, Shenzhen has become a *trendsetter* for local cutting-edge innovation. The same is true for safe urban development. Shenzhen is committed to building a pilot demonstration zone of socialism with Chinese characteristics, and it is also an important central city in the Guangdong-Hong Kong-Macao Greater Bay Area. P6 is the latest action plan the Shenzhen Municipal Safety Management Commission issued to build DCSD, which pays special

**Table 7**
The PMC matrices of eight DCSD policies.

| Policy | P1 | P2 | P3 |
|---|---|---|---|
| PMC-matrix | $\begin{bmatrix} 0.67 & 0.50 & 0.50 \\ 0.50 & 0.60 & 0.25 \\ 0.38 & 0.14 & 0.14 \end{bmatrix}$ | $\begin{bmatrix} 0.67 & 0.50 & 0.67 \\ 0.67 & 0.80 & 0.50 \\ 0.63 & 0.43 & 0.14 \end{bmatrix}$ | $\begin{bmatrix} 0.33 & 0.50 & 0.83 \\ 0.50 & 0.80 & 0.50 \\ 1.00 & 1.00 & 0.43 \end{bmatrix}$ |
| Policy | P4 | P5 | P6 |
| PMC-matrix | $\begin{bmatrix} 0.67 & 0.50 & 0.83 \\ 0.67 & 0.60 & 0.50 \\ 0.75 & 0.57 & 0.43 \end{bmatrix}$ | $\begin{bmatrix} 0.67 & 0.50 & 0.67 \\ 0.67 & 1.00 & 0.75 \\ 0.75 & 0.57 & 0.43 \end{bmatrix}$ | $\begin{bmatrix} 1.00 & 0.50 & 1.00 \\ 0.67 & 0.60 & 1.00 \\ 0.63 & 0.29 & 0.86 \end{bmatrix}$ |
| Policy | P7 | P8 | |
| PMC-matrix | $\begin{bmatrix} 0.33 & 0.50 & 0.33 \\ 0.17 & 0.60 & 0.50 \\ 0.75 & 0.29 & 0.29 \end{bmatrix}$ | $\begin{bmatrix} 0.33 & 0.50 & 0.83 \\ 1.00 & 1.00 & 1.00 \\ 0.75 & 0.57 & 0.71 \end{bmatrix}$ | |

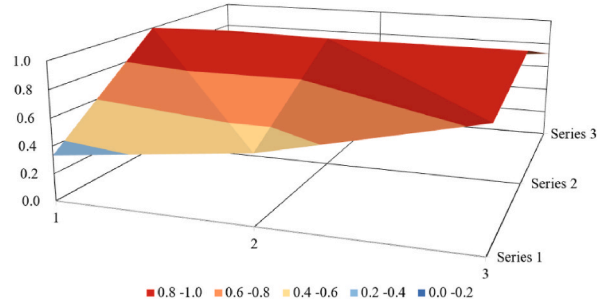


**Fig. 4.** PMC-surface of P8.

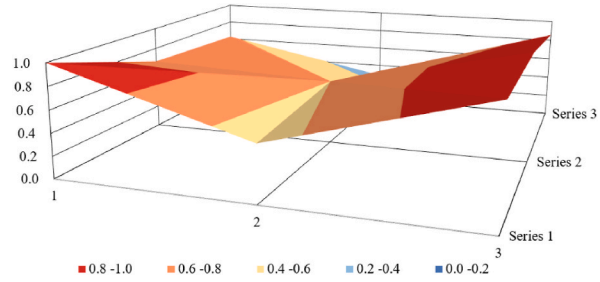


**Fig. 5.** PMC-surface of P6.

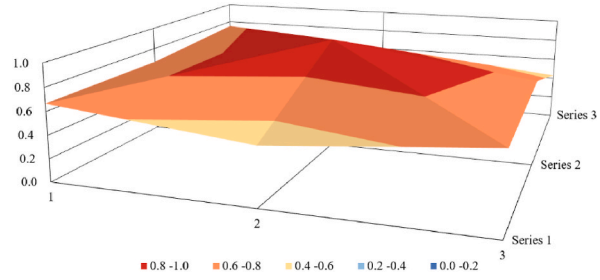


**Fig. 6.** PMC-surface of P5.

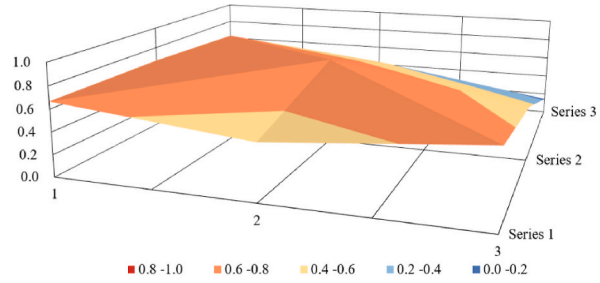


**Fig. 7.** PMC-surface of P2.

attention to regional cooperation and emergency linkage. This policy is also the only policy in the sample that combines long-term, medium-term and short-term policy objectives. Considering that the policy of P6 does not include construction points, such as capacity building for safety production capacity and regulatory safeguards, the uses of compulsory type and mixed type policy tools are relatively single, $X_8$-$X_5$-$X_7$ can be used as its optimization path.

The P5 PMC-index is 6.00, ranking third. P5 is jointly issued by the Chinese *Liangban*, which is a guiding document for the central government to advocate and promote the construction of DCSD nationwide. It points out the direction for provinces and cities to formulate specific policies. The policy is both instructive, suggestive and standardized, which provides a template for the municipal

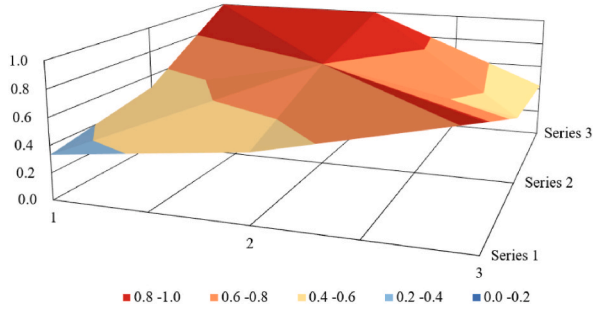


**Fig. 8.** PMC-surface of P3.

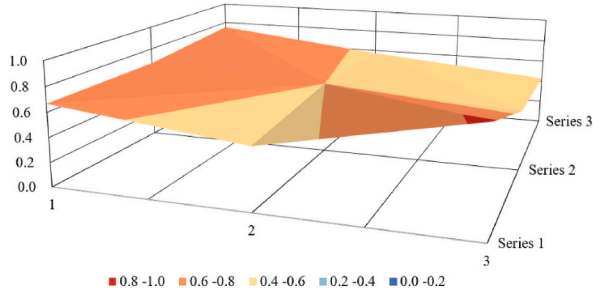


**Fig. 9.** PMC-surface of P4.

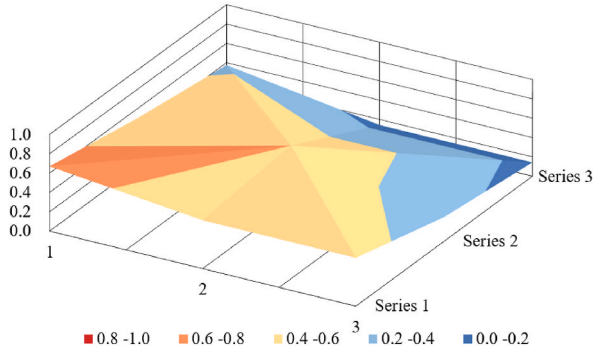


**Fig. 10.** PMC-surface of P1.

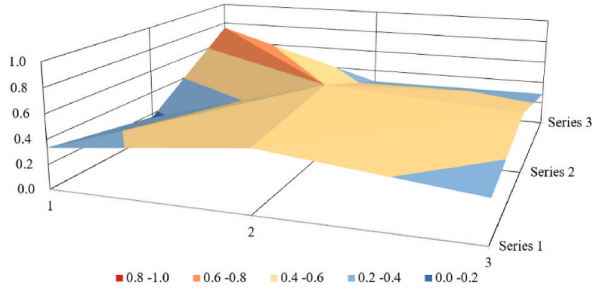


**Fig. 11.** PMC-surface of P7.

and county-level governments to acting according to local conditions. It is only slightly below average in terms of policy audience. The co-governance of multiple subjects has become a sign of the transformation of the government from a city manager to governor of good urban governance. Therefore, the central government should overcome the management inertia of a strong government and fully

mobilize the community of social interests to participate in urban public safety governance.

#### 4.2.2. Acceptable consistency policies

The three acceptable levels of policies came from the local level, namely P2, P3, and P4.

P2 has a PMC-index of 5.00, ranking sixth. P2 is issued by Quanzhou Municipal People's Government, which clarifies the three-year work plan for building DCSD. However, it merely copy-like implements the central government's policy. The policy is less innovative, relatively homogeneous, and rarely uses voluntary policy tools, which is the main reason for the sizable concave surface of the PMC of P2. In addition, the scores of $X_3$, $X_6$, $X_7$, and $X_8$ in the secondary indicators are all slightly lower than the average value, hence the suggested path for indicator optimization is $X_9$-$X_6$-$X_7$-$X_8$-$X_3$.

P3 has a PMC-index of 5.90, ranking fourth. Among the eight policies, the policy tools are the most comprehensive and sufficient. However, the policy timeliness is relatively single, and it is also necessary to strengthen engineering, ecology, organizational resilience and enlarge the scope of policy guarantees. Therefore, the proposed indicator optimization path is $X_1$-$X_6$-$X_4$.

The PMC-index of P4 is 5.52, ranking fifth. Changchun is one of the first pilot units for the construction of a national DCSD. The municipal government has formulated a five-year plan, which has performed well in terms of policy timeliness, policy scope, policy object, policy field, and the use of three essential types of policy tools. Only the policy focus and policy guarantee are lower than average. Therefore, the suggested indicator optimization path is $X_5$-$X_6$.

#### 4.2.3. Poor consistency policies

In general, policies enacted at the central level tend to be of higher quality, but surprisingly, the PMC-index of P1 is 3.68, which assessed poor consistency, and it has the lowest score. P1 is the earliest document issued by the central government to guide the establishment of the first batch of pilot units of national DCSD. Except for indicators $X_1$ and $X_2$, all other indicators are below the average value. P1 only emphasizes the government's organizational leadership in the construction of DCSD, lacks specific policy safeguard measures, and has a single policy tool, resulting in a larger concave surface of its PMC-surface. In summary, it is suggested that the indicator optimization path is $X_6$-$X_8$-$X_7$-$X_9$-$X_3$-$X_5$-$X_4$.

Another policy with assessment level of poor consistency is P7, the latest implementation measure issued by the Office of Changsha Municipal Work Safety Commission in April 2023 to guide the creation of DCSD. Among the secondary variables of P7, only one indicator $X_7$, is above the average. Therefore, $X_1$ (policy timeliness), $X_3$ (policy object), $X_4$ (policy field), $X_5$ (policy point), $X_6$ (policy guarantee), $X_8$ (mixed type tools) and $X_9$ (voluntary type tools) should be further improved. From the perspective of prioritizing the improvement of inferiority values, the suggested optimization path is $X_4$-$X_3$-$X_1$-$X_8$-$X_5$-$X_9$-$X_6$.

## 5. Discussion

In the context of the development of resilient cities in full swing on an international scale, we analyze the policy effectiveness of China's localized practice policy of resilient cities, DCSD policies, in order to inspire some critical thinking in the practical and theoretical circles. Subject to the overall results of policy effectiveness evaluation, it is imperative for local governments to formulate urban resilient policies according to local conditions. From this point of view, the central government plays more of a role as the *helmsman* in city safety governance, and local governments should actively explore and practice. The proper contribution of this paper is expressed in three aspects. Firstly, the research uses text mining technology and the PMC-index model to dig deeper into China's DCSD policies, which establishes an evaluation framework for these policies. Secondly, we selects 8 DCSD policies as representative samples and analyzes the strengths and weaknesses of each policy based on empirical evaluation. Last but not least, through the investigation of the localization practice of China's resilient city exploration, some useful insights for the efforts of resilient cities on a globe scale are given.

## 6. Conclusions

In this study, a combination of qualitative and quantitative research was used to incorporate 9 first-level variables and 50 second-level variables, such as policy timeliness and policy tools, and a quantitative evaluation model of PMC-index of DCSD policies was established. To enrich research conclusions, we evaluated the effectiveness of eight representative DCSD policies in China. After a quantitative evaluation, the following conclusions are drawn.

Firstly, the average PMC-index score of 5.38 for all policies indicates a high quality of formulation. Secondly, the eight representative policies have been classified into three levels, including three great levels (P5, P6, and P8), three acceptable levels (P2, P3, and P4), and two poor levels (P1 and P7). Last but not least, on the one hand, three indicators scored relatively high, including policy focus ($X_5$), policy object ($X_3$), and compulsory type policy tool ($X_7$), but on the other hand, three indicators scored relatively low, including voluntary type policy tool ($X_9$), mixed policy type tool ($X_8$) and policy scope ($X_2$).

Based on the research results, this paper makes the following recommendations for the development of future DCSD policies. Firstly, enrich the policy toolbox and rationally match the types of policy tools. At present, the use of policy tools shows the characteristics of "emphasis on compulsory type policy tools, disdain on mixed type policy tools, and lack of voluntary type policy tools" and "internal structural imbalance". It is recommended that these authorities pay sufficient attention to future policy formulation. For example, in addition to ensuring direct financial investment, it can also provide a suitable policy environment for the drive for DCSD through various forms such as tax incentives and financial support. Secondly, expand the scope of policies and attach importance to regional, urban-rural coordinated development. From the results of the research, the low score of the indicator of policy scope is mainly

due to the fact that some policies need to put a high premium on regional synergy and urban-rural coordinated development. In the face of a risk society characterized by "uncertainty", and the trend of urban agglomerations is becoming more obvious, strengthening the synergy between regions and urban-rural areas can better respond to emergencies. Thirdly, in the policy field, we should greatly value ecological and organizational resilience. Of the eight representative policy documents evaluated, neither of the central policies focused on building ecological and organizational resilience, and only some local authorities mentioned it. During decades of rapid development, China has consumed a large amount of ecological resources, and the ecosystem is facing enormous pressure [50]. Cities cannot grow at the expense of ecological security and must get rid of the old traditional "polluting first and cleaning up later" mode. In the next round of policy revisions, policymakers could consider integrating key variables such as climate resilience into policy areas. On the other hand, rubust organizational resilience can enable the government to respond to sudden crises, while ensuring strong organizational leadership, two-way break down administrative barriers and working together. In this regard, the self-organization ability of the public can be enhanced by cultivating social capital forces, and various forms of construction, such as community party organization systems, should be actively explored. Finally, it is essential for governments at all levels to incorporate useful experience gained in practice into policy content promptly. From the first policy of guiding the pilot project of DCSD issued by the central government in 2011 to the current introduction of implementation rules in various places, the quality of policies has made a qualitative leap at this stage. It also shows that the government can summarize the experience of pilot project practice in a timely manner, apply it to policy formulation, and correct the shortcomings of previous policies. We should continue to highly concerned the actual effectiveness of policies in practice in the hereafter.

Meanwhile, this article also has some limitations. In the future research, the policy sample database will be expanded. With the help of big data, machine learning or other technologies, in-depth mining can be conducted. In addition, the paper assigns the same weight to all indicators, ignoring the objective relationship between indicators. In the next step of the study, variable assignment differentiation will be considered.

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## Data availability statement

All the data involved in the paper.

## CRediT authorship contribution statement

**Juan Liu:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis. **Chengli Wang:** Writing – review & editing, Methodology. **Rui Zhang:** Visualization, Formal analysis, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. The variables and criteria of sub-variables

| Main-variables | Sub-variables | Evaluation criteria |
|---|---|---|
| $X_1$ | Long term$X_{1\text{-}1}$ | Whether the policy involves long-term aim (longer than five years); if yes, it scores 1; if no, it scores 0. |
| | Medium term$X_{1\text{-}2}$ | Whether the policy involves medium-term aim (between 1 and 5 years); if yes, it scores 1; if no, it scores 0. |
| | Short term$X_{1\text{-}3}$ | Whether the policy involves short-term aim (less than or equal to one year); if yes, it scores 1; if no, it scores 0. |
| $X_2$ | Nation$X_{2\text{-}1}$ | Whether the policy scope involves nation; if yes, it scores 1; if no, it scores 0. |
| | Region$X_{2\text{-}2}$ | Whether the policy scope involves region; if yes, it scores 1; if no, it scores 0. |
| | City$X_{2\text{-}3}$ | Whether the policy scope involves city; if yes, it scores 1; if no, it scores 0. |
| | Town$X_{2\text{-}4}$ | Whether the policy scope involves town; if yes, it scores 1; if no, it scores 0. |
| $X_3$ | Government$X_{3\text{-}1}$ | Whether the policy object involves government departments; if yes, it scores 1; if no, it scores 0. |
| | Enterprise$X_{3\text{-}2}$ | Whether the policy object involves enterprise; if yes, it scores 1; if no, it scores 0. |
| | Expert$X_{3\text{-}3}$ | Whether the policy object involves expert; if yes, it scores 1; if no, it scores 0. |

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(*continued*)

| Main-variables | Sub-variables | Evaluation criteria |
|---|---|---|
| | Intermediary $X_{3\text{-}4}$ | Whether the policy object involves intermediary; if yes, it scores 1; if no, it scores 0. |
| | Non-governmental organization$X_{3\text{-}5}$ | Whether the policy object involves non-governmental organization; if yes, it scores 1; if no, it scores 0. |
| | Public$X_{3\text{-}6}$ | Whether the policy object involves public; if yes, it scores 1; if no, it scores 0. |
| $X_4$ | Engineering resilience$X_{4\text{-}1}$ | Whether the policy involves engineering resilience; if yes, it scores 1; if no, it scores 0. |
| | Ecological resilience$X_{4\text{-}2}$ | Whether the policy involves ecological resilience; if yes, it scores 1; if no, it scores 0. |
| | Social resilience$X_{4\text{-}3}$ | Whether the policy involves social resilience; if yes, it scores 1; if no, it scores 0. |
| | Economic resilience$X_{4\text{-}4}$ | Whether the policy involves economic resilience; if yes, it scores 1; if no, it scores 0. |
| | Technical resilience$X_{4\text{-}5}$ | Whether the policy involves technical resilience; if yes, it scores 1; if no, it scores 0. |
| | Organizational resilience$X_{4\text{-}6}$ | Whether the policy involves organizational resilience; if yes, it scores 1; if no, it scores 0. |
| $X_5$ | Safety production capacity$X_{5\text{-}1}$ | Whether the policy focus involves safety production capacity; if yes, it scores 1; if no, it scores 0. |
| | Supervision and guarantee capability$X_{5\text{-}2}$ | Whether the policy focus involves supervision and guarantee capability; if yes, it scores 1; if no, it scores 0. |
| | Emergency rescue construction$X_{5\text{-}3}$ | Whether the policy focus involves emergency rescue construction; if yes, it scores 1; if no, it scores 0. |
| | Risk prevention and control $X_{5\text{-}4}$ | Whether the policy focus involves risk prevention and control; if yes, it scores 1; if no, it scores 0. |
| | Security guarantee capability $X_{5\text{-}5}$ | Whether the policy focus involves security guarantee capability; if yes, it scores 1; if no, it scores 0. |
| $X_6$ | Leadership responsibility system$X_{6\text{-}1}$ | Whether the policy guarantee measure involves leadership responsibility system; if yes, it scores 1; if no, it scores 0. |
| | Division of labor$X_{6\text{-}2}$ | Whether the policy guarantee measure involves division of labor; if yes, it scores 1; if no, it scores 0. |
| | Performance appraisal$X_{6\text{-}3}$ | Whether the policy guarantee measure involves performance appraisal; if yes, it scores 1; if no, it scores 0. |
| | Synergy$X_{6\text{-}4}$ | Whether the policy guarantee measure involves synergy; if yes, it scores 1; if no, it scores 0. |
| $X_7$ | Organizational leadership$X_{7\text{-}1}$ | Whether the policy applies organizational leadership policy tool; if yes, it scores 1; if no, it scores 0. |
| | Regulation construction$X_{7\text{-}2}$ | Whether the policy applies regulation construction policy tool; if yes, it scores 1; if no, it scores 0. |
| | Preparation of plans$X_{7\text{-}3}$ | Whether the policy applies preparation of plans policy tool; if yes, it scores 1; if no, it scores 0. |
| | Special action$X_{7\text{-}4}$ | Whether the policy applies special action policy tool; if yes, it scores 1; if no, it scores 0. |
| | Implementation$X_{7\text{-}5}$ | Whether the policy applies implementation policy tool; if yes, it scores 1; if no, it scores 0. |
| | Administrative punishment$X_{7\text{-}6}$ | Whether the policy applies administrative punishment policy tool; if yes, it scores 1; if no, it scores 0. |
| | Access permit$X_{7\text{-}7}$ | Whether the policy applies access permit policy tool; if yes, it scores 1; if no, it scores 0. |
| | Accountability and investigation$X_{7\text{-}8}$ | Whether the policy applies accountability and investigation policy tool; if yes, it scores 1; if no, it scores 0. |
| $X_8$ | Financial investment$X_{8\text{-}1}$ | Whether the policy applies financial investment policy tool; if yes, it scores 1; if no, it scores 0. |
| | Infrastructure construction$X_{8\text{-}2}$ | Whether the policy applies infrastructure construction policy tool; if yes, it scores 1; if no, it scores 0. |
| | Information disclosure$X_{8\text{-}3}$ | Whether the policy applies information disclosure policy tool; if yes, it scores 1; if no, it scores 0. |
| | Tax incentives$X_{8\text{-}4}$ | Whether the policy applies tax incentives policy tool; if yes, it scores 1; if no, it scores 0. |
| | Financial support$X_{8\text{-}5}$ | Whether the policy applies financial support policy tool; if yes, it scores 1; if no, it scores 0. |
| | Talent training$X_{8\text{-}6}$ | Whether the policy applies talent training policy tool; if yes, it scores 1; if no, it scores 0. |
| | Information platform$X_{8\text{-}7}$ | Whether the policy applies information platform policy tool; if yes, it scores 1; if no, it scores 0. |
| $X_9$ | Publicity and education$X_{9\text{-}1}$ | Whether the policy applies publicity and education policy tool; if yes, it scores 1; if no, it scores 0. |
| | Commendation and awards$X_{9\text{-}2}$ | Whether the policy applies commendation and awards policy tool; if yes, it scores 1; if no, it scores 0. |
| | Policy guidance$X_{9\text{-}3}$ | Whether the policy applies policy guidance policy tool; if yes, it scores 1; if no, it scores 0. |
| | Social participation$X_{9\text{-}4}$ | Whether the policy applies social participation policy tool; if yes, it scores 1; if no, it scores 0. |
| | Exchange and cooperation$X_{9\text{-}5}$ | Whether the policy applies exchange and cooperation policy tool; if yes, it scores 1; if no, it scores 0. |
| | Industry self-discipline$X_{9\text{-}6}$ | Whether the policy applies industry self-discipline policy tool; if yes, it scores 1; if no, it scores 0. |
| | Public opinion supervision$X_{9\text{-}7}$ | Whether the policy applies public opinion supervision policy tool; if yes, it scores 1; if no, it scores 0. |

## Appendix B. Multi-input-output table for eight DCSD policies

| Primary varibales | Secondary variables | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|---|
| $X_1$ | $X_{1\text{-}1}$ | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | $X_{1\text{-}2}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| | $X_{1\text{-}3}$ | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| $X_2$ | $X_{2\text{-}1}$ | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | $X_{2\text{-}2}$ | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | $X_{2\text{-}3}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{2\text{-}4}$ | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| $X_3$ | $X_{3\text{-}1}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{3\text{-}2}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{3\text{-}3}$ | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| | $X_{3\text{-}4}$ | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| | $X_{3\text{-}5}$ | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| | $X_{3\text{-}6}$ | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| $X_4$ | $X_{4\text{-}1}$ | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| | $X_{4\text{-}2}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | $X_{4\text{-}3}$ | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | $X_{4\text{-}4}$ | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |

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(*continued*)

| Primary varibales | Secondary variables | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|---|
| | $X_{4\text{-}5}$ | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | $X_{4\text{-}6}$ | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| $X_5$ | $X_{5\text{-}1}$ | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| | $X_{5\text{-}2}$ | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| | $X_{5\text{-}3}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{5\text{-}4}$ | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| | $X_{5\text{-}5}$ | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| $X_6$ | $X_{6\text{-}1}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{6\text{-}2}$ | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | $X_{6\text{-}3}$ | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{6\text{-}4}$ | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| $X_7$ | $X_{7\text{-}1}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{7\text{-}2}$ | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| | $X_{7\text{-}3}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{7\text{-}4}$ | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| | $X_{7\text{-}5}$ | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{7\text{-}6}$ | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| | $X_{7\text{-}7}$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| | $X_{7\text{-}8}$ | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| $X_8$ | $X_{8\text{-}1}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{8\text{-}2}$ | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{8\text{-}3}$ | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| | $X_{8\text{-}4}$ | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | $X_{8\text{-}5}$ | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | $X_{8\text{-}6}$ | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | $X_{8\text{-}7}$ | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| $X_9$ | $X_{9\text{-}1}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $X_{9\text{-}2}$ | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | $X_{9\text{-}3}$ | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | $X_{9\text{-}4}$ | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| | $X_{9\text{-}5}$ | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | $X_{9\text{-}6}$ | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | $X_{9\text{-}7}$ | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |

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