

Weight Calibration of Marketization Evaluation Indicators for Government Financing Platforms in China Based on Reasoning and Optimization

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Abstract. This paper proposes a novel approach to calibrate weights for scoring items in determining the marketization indicator (MI) of government financing platforms in China, reducing the reliance on expert-estimated indicators. The credit is assigned to a financing platform using a soccer gaming rule, where platforms compete across all scoring items. By formulating an optimization problem grounded in fundamental reasonings of the relationship between credits and MIs, the method provides a more objective assessment of marketization degrees, offering valuable insights into platform performance and positioning. Results from applying the method to financing platforms in a province of western China reveal the significant impact of government capability on the comprehensive marketization indicator, while the policy environment is least weighted, and certain factors do not contribute to the MI estimation. The present method outperforms the conventional Equal Weight (EW) method, demonstrating higher consistency in aligning the ranking of MIs with credits. Although this work successfully reduces subjective judgments, some subjectivity remains in the calibration process.

Keywords: Government financing platforms, weight calibration, reasoning and optimization, performance evaluation.

1 Introduction

As extended from the definition by Xu et al. (2020) [1], with investment from local governments, financing functions, and a non-public enterprise legal person, a company can be considered a local financing platform if it has acts of substituting for local government financing and investment in the front-end use of financing funds or relying on cash flows from government departments or other financing platform companies for the back-end repayment of financing funds.

Government financing platforms are products in specific periods and under special policy conditions in China, and their development is closely related to the macroeconomic environment. Amidst the tax-sharing system reform implementation and the accelerated urbanization process, local government funding needs have been progressively increasing, leading to the emergence of financing platforms out of various explorations (Lu and Sun, 2013)

[2]. The financing platforms have to some extent, filled the gaps and deficiencies in the market, credit, and institutions, effectively addressing the issues of insufficient fiscal funds and restricted financing channels in various regions, greatly accelerating China's urbanization and industrialization process, and making a positive contribution in responding to financial crises, and promoting economic growth (Huang and Chan, 2018) [3].

For a long time, financing platforms relied mainly on debt rolling for debt repayment. However, the current economic downturn, recurring pandemics, and slow growth in local fiscal revenues, particularly with many provinces experiencing negative growth in land transfer revenues, have gradually increased the debt risks for government financing platforms (Pan et al., 2017) [4]. Simultaneously, regulatory policies for financing platforms have been progressively tightened, leading to a disconnection between them and financial institutions, effectively cutting off their funding sources (Sun et al., 2016) [5]. To address these challenges and mitigate risks, financing platforms must accelerate their transition to a market-oriented approach, enabling self-rescue, risk management, and fulfilling their missions.

Enriching theoretical research on the market-oriented transformation of financing platforms and promoting the practical implementation of this transformation has become crucial to ensuring China's economic security. Indeed, various research studies have put forward theoretical approaches and practical measures to promote the market-oriented transformation of financing platforms. For instance, Su et al. (2009) [6] believed that during the platform transformation process, it was essential to establish and improve mechanisms for local government debt repayment or jointly establish emergency funding pools by local governments and financing platforms. From the financing platforms' perspective, the core of their transformation lies in converting government credit into market credit, enabling independent operations, and gradually transitioning towards becoming urban comprehensive service operators and industrial investors (Zhao and Li, 2021) [7]. With the transformation direction determined, it is crucial to actively leverage existing assets to exploit economies of scale fully. Subsequently, the corporate governance structure must be optimized by transitioning from administrative to enterprise management to enhance mechanisms for personnel selection, decision-making, and supervision, as recommended by Zhou (2022) [8]. Concurrently, Wang (2021) [9] highlighted the importance to establish a sound risk management system and enhance risk control capabilities. Mao and Xu (2021) [10] suggested a "step-by-step, classified, and progressive collaborative" strategy for the market-oriented transformation of financing platforms, as it cannot be accomplished quickly. Ni and Yang (2022) [11] believed that when selecting their respective paths, financing platforms should fully consider the advantages of regional and financial resources and opt for a diversified development approach. All these previous research works, however, have rarely evaluated the development stages of financing platforms during their market-oriented transformation.

The development of financing platforms displayed evident differentiation among platforms in various regions and at different levels, with some facing operational difficulties and unresolved debts while others accumulated substantial debt risks, indicating the potential to spread financial and fiscal risks (Wen and Fan, 2016) [12]. The diverse features of financing platforms and their varied starting points lead to the need for distinct goals and strategies in their market-oriented transformation, where the degree of marketization significantly influences decision-making on their transformation pathways.

This work suggests a set of scoring items that can be assigned weights to determine a comprehensive marketization indicator (MI) to indicate the marketization degree of a financing platform. Evaluation indicators find widespread application across diverse industrial fields, including rural development (Liu et al., 2021) [13], Driver's Traffic Literacy (Chen et al., 2022) [14], network distance education (Liu et al., 2023) [15], academic ecosystem (Wang, 2022) [16], sustainable development of smart city construction (Cappai et al., 2022) [17], ecological risk assessment (Zhang et al., 2021) [18]. These studies highlight the importance of selecting appropriate indicators and assigning their weights accurately for reliable evaluation outcomes. However, challenges arise in determining which method best suits such tasks and addressing the inherent subjectivity associated with expert judgments.

Unfortunately, calibrating the weights is distinct from calibrating parameters, as exemplified by Naeem et al. (2016) [19] in a UBCWM model where parameters can be determined to minimize the gap between simulated and observed results or in a functional mapping problem (Li and Wu, 2010) [20] with a sample of points available to measure fitting errors between inputs and outputs. Unfortunately, there is no available sample of marketization indicators (MIs) to be used for comparison with the weighted values across scoring items, making it challenging to assess the accuracy of the estimated weights.

In prior research endeavors, numerous methods have been employed to estimate the weights associated with an evaluation indicator. For example, Qiao et al. (2022) [21] utilized an improved CRITIC (Criteria Importance through Intercriteria Correlation) weighting method to evaluate wind farms power generation performance, while Li (2022) [22] employed machine learning for English teaching evaluation. Similarly, Yang et al. (2022) [23] used the Analytical Hierarchy Process combined with experts' priorities for weighting indicators in historic building value assessment. These methods displayed different features, but it is not easy to have criteria to decide which method is better than another. Moreover, the studies by Gagliardi et al. (2007) [24] and Gordon (1982) [25] highlighted that the application of these methods heavily relies on the subjective judgment of experts, introducing potential biases. Thus, while these methods offer valuable tools for decision-making and evaluation, their dependence on expert subjectivity necessitates careful consideration and validation in practical applications. Future research should focus on enhancing the objectivity and reliability of these approaches to ensure robust and accurate evaluation outcomes.

This study proposes a novel approach to calibrate weights for scoring items in determining the marketization indicator of a financing platform in China, reducing the need for expert-estimated indicators. A specially designed questionnaire grades financing platforms on each scoring item, and platforms compete against each other to gain credits. The weights are derived using basic reasonings by formulating an optimization problem grounded in fundamental relationships between platforms' credits and their marketization indicators. This innovative method offers an objective and data-driven approach to assess the marketization degree of financing platforms, providing valuable insights into their performance and positioning in the market.

Compared with the conventional Equal Weight Method (EWM), this study will apply the present approach to examine a sample of financing platforms in a province of western China, with two primary objectives: (1) identifying the least influential weights on the marketization indicator, and (2) assessing how this method enhances compliance with reasoning conditions.

By applying this innovative method, this work aims to gain deeper insights into the significance of different weightings on the marketization assessment and explore its potential in refining the evaluation process to align with logical reasoning standards. Through empirical analysis, this research aims to shed light on the effectiveness of the new approach in enhancing the accuracy and reliability of marketization indicator outcomes for financing platforms in the region.

2 Problems

The problem is to estimate the weights employed to define the marketization indicator (MI) of a financing platform, expressed as a weighted value over multiple performances:

$$MI(\mathbf{S}) = \sum_{i=1}^N \sum_{j=1}^{J(i)} [w_{ij} \cdot s_{ij}] \quad (1)$$

where, i and j = indices of scoring categories and items, respectively; N = number of categories; $J(i)$ = number of scoring items in category i ; w_{ij} = weight assigned to item j in category i ; s_{ij} = performance score of the j^{th} item in category i ; \mathbf{S} = matrix of s_{ij} .

Particularly, the MI for the k th firm is denoted as

$$MI(\mathbf{S}^{(k)}) = \sum_{i=1}^N \sum_{j=1}^{J(i)} [w_{ij} \cdot s_{ij}^{(k)}] \quad (2)$$

where, N = number of financing firms; $s_{ij}^{(k)}$ = performance score of platform k on the j^{th} item in category i ; $\mathbf{S}(k)$ = matrix of $s_{ij}^{(k)}$.

Table 1. Scoring items and their classification

ID	Scoring item	Class
I.1	Decision-making mechanism	Governance capability
I.2	Status of the operating entity	
I.3	Management and checks-and-balances mechanism	
I.4	Internal management system	
I.5	Financial condition - Debt-to-equity ratio	
I.6	Financial condition - Return on equity	
II.1	Macroeconomic supportive policies	Policy environment
II.2	Ability to grasp policies	
II.3	Special policies granted by local governments	
III.1	Integratable resource conditions	Resource endowment
III.2	Sustainability of resources	
III.3	Adequacy of pledged collateral	
III.4	Scale of operating assets	
IV.1	Willingness to cooperate in resolving existing debt	Political momentum
IV.2	Coordinating ability to promote resource integration	
IV.3	Guiding government financing platforms to establish core competitiveness	
V.1	Willingness to cooperate in resolving existing debt	Financial potential
V.2	Providing financial products required for transformation	

V.3	Debt servicing adequacy ratio	
V.4	Overall debt-servicing capacity	
VI.1	Degree of regional industrial agglomeration	Market endowment
VI.2	Opportunities and capabilities to participate in industrial development	
VI.3	Possibility of attracting strategic partners.	

Table 1 gives all twenty-three scoring items that are classified into six categories to indicate a financing platform's:

Governance capability, which is a comprehensive institutional arrangement that balances the interests and demands of various stakeholders, including the government, finance, financial institutions, partners, and regulatory authorities, with its governance capacity reflected in effective communication and coordination externally, and well-established regulations and performance management internally;

Policy environment, which mainly refers to the economic, financial, fiscal, and regulatory policies a financing platform faces, constituting the dynamic, complex, diverse, and varied external conditions crucial for their survival and development;

Resource endowment from the local government in which the financing platform operates, including natural, operational infrastructure and industrial resources, which form the fundamental conditions for the platform's growth and strengthening;

Political momentum, which can be understood as the proactive conditions provided or created by the local government during the transformation and development of government financing platforms, including but not limited to government-purchased services for debt repayment, budget arrangements, resource allocation, tax refunds, financial subsidies, fiscal incentives, and government coordination;

Financial potential that can be interpreted as the advantage that government financing platforms have during the process of transforming their resource endowment (including asset growth and risk control) into financial credit, supported by government credit and resource allocation;

Market endowment that can be assessed by the regional market endowment reflecting the regional financial growth potential and expectations, mainly including locational advantages, transportation convenience, non-government-dependent industrial foundation, and the potential of attracting future industries, and by the enterprise market endowment reflecting the spatial potential, attractiveness, and profitability of the enterprise's market-oriented business.

3 Solution strategy

The solution procedure starts with the first reasoning based on credit assignment following a popular rule in soccer games, followed by the second reasoning when clustering financing platforms into groups, and then an optimization formulation to calibrate weights assigned to scoring items.

3.1 Credits for individual firms

It is natural to design the scoring items that are positively correlated with the MI:

$$MI(\mathbf{S}^{(k)}) \geq MI(\mathbf{S}^{(l)}) \quad \text{if } s_{ij}^{(k)} \geq s_{ij}^{(l)} \quad \text{for } \forall(i, j) \quad (3)$$

Competing with all the other firms across all the scoring items, a financing platform acquires its credit:

$$C^{(k)} = \sum_{i=0}^N \sum_{j=0}^{J(i)} \sum_{l \in \{l: l \neq k\}} \mu_{ij}^{(k,l)} \quad (4)$$

with a popular rule in soccer games:

$$\mu_{ij}^{(k,l)} = \begin{cases} 3 & \text{if } MI(s_{ij}^{(k)}) > MI(s_{ij}^{(l)}) \\ 1 & \text{if } MI(s_{ij}^{(k)}) = MI(s_{ij}^{(l)}) \\ 0 & \text{if } MI(s_{ij}^{(k)}) < MI(s_{ij}^{(l)}) \end{cases} \quad (5)$$

where, $C^{(k)}$ = total credit gained by the k th platform; $\mu_{ij}^{(k,l)}$ = credit acquired by platform k when competing with platform l on the scoring item j in category i .

The financing platforms' credits can be sorted from the smallest to the largest,

$$C^{(\bar{k}(1))} \leq C^{(\bar{k}(2))} \leq \dots \leq C^{(\bar{k}(K))} \quad (6)$$

where, $\bar{k}(m)$ is the index of the firm with the smallest credit.

Ideally, the MIs of platforms are expected to follow this increasing order of their credits with,

Reasoning 1#:

$$MI(S^{(\bar{k}(m))}) \leq MI(S^{(\bar{k}(m+1))}) \quad \text{for } 1 \leq \forall m < K \quad (7)$$

Classification with clustering techniques

The performance of a financing platform in one category of the scoring items is determined as the average over the items in this category, expressed as:

$$s_i^{(k)} = \frac{1}{J(i)} \sum_{j=1}^{J(i)} s_{ij}^{(k)} \quad (8)$$

in which, $s_i^{(k)}$ = average score over the scoring items in the i^{th} category.

Since the scoring items are classified into six categories, the platforms will be clustered into six groups to allow the strength of each platform, particularly in one of the categories, to be reflected in one of the groups. The six groups will be identified by

$$\min_{\bar{s}, u, x} \sum_{k=1}^K \sum_{i=1}^N \left[\sum_{g=1}^6 x_{g,i}^{(k)} - s_i^{(k)} \right]^2 \quad (9)$$

subject to the uniqueness of one firm belonging to only one category,

$$\sum_{g=1}^6 u_g^{(k)} = 1 \quad (10)$$

and only one group being active,

$$\begin{cases} x_{g,i}^{(k)} = \hat{s}_{g,i} & \text{if } u_g^{(k)} = 1 \\ x_{g,i}^{(k)} = 0 & \text{otherwise} \end{cases} \quad (11)$$

which is equivalent to:

$$\begin{cases} 100(u_g^{(k)} - 1) \leq x_{g,i}^{(k)} - \hat{s}_{g,i} \leq 100(1 - u_g^{(k)}) \\ x_{g,i}^{(k)} \leq 100u_g^{(k)} \end{cases} \quad (12)$$

where, g = group index; $x_{g,i}^{(k)}$ = an auxiliary variable that can be interpreted as the representative score on category i assigned from group g to platform k ; $u_g^{(k)}$ = a binary to indicate whether platform k belongs to group g ; $\hat{s}_{g,i}$ = the value on category i of clustering group g ; and the maximum score is 100.

The problem with objective (9) subject to (10) and (12) is a mixed quadratic programming (MQP), which can be solved to give the optimums: $u_g^{*(k)}$ and $\hat{s}_{g,i}^*$.

Thus, the k^{th} platform will belong to the group that is numbered as:

$$\hat{g}(k) = \sum_{g=1}^6 g \cdot u_g^{*(k)} \quad (13)$$

where, the average credit of a group of firms can be determined as

$$C^{[g]} = \frac{1}{N_g} \sum_{k \in \{k: \hat{g}(k)=g\}} C^{(k)} \quad (14)$$

with N_g being the number of firms that belong to the g^{th} group.

The credits of groups can also be sorted from the smallest to the largest,

$$C^{[\hat{g}(1)]} \leq C^{[\hat{g}(2)]}, \dots, \leq C^{[\hat{g}(6)]} \quad (15)$$

with each group having the lower (MI_g^{\min}) and upper (MI_g^{\max}) bounds,

$$MI_g^{\min} \leq MI(S^{(k)}) \leq MI_g^{\max} \quad \text{for } \forall k \in \{k : \hat{g}(k) = g\} \quad (16)$$

Ideally, as illustrated in Figure 1, groups are expected to have a clear boundary between them with,

Reasoning 2#:

$$MI_{\hat{g}(m)}^{\max} \leq MI_{\hat{g}(m+1)}^{\min} \quad \text{for } m = 1, 2, \dots, 5 \quad (17)$$

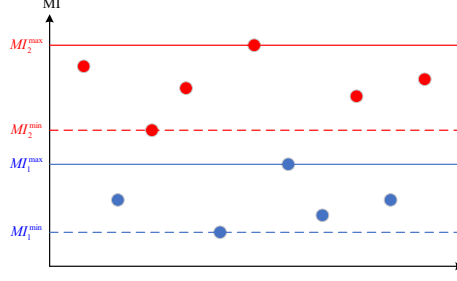


Figure 1. The boundary between groups

3.2 Optimization to calibrate weights

The weights assigned to scoring items are calibrated to minimize the violation over what is expected in Reasonings 1# and 2#, with the 2nd reasoning prioritized over the first. With the definition of MI substituted into the mathematical expressions, the optimization can be formulated as linear programming (LP) to

$$\min_{w,x,y,MI} P \cdot \sum_{m=1}^5 x^{(\bar{g}(m))} + \sum_{m=1}^{K-1} y^{(\bar{k}(m))} \quad (18)$$

subject to:

- (1) the group bounds:

$$MI_g^{\min} \leq \sum_{i=1}^N \sum_{j=1}^{J(i)} [w_{ij} \cdot s_{ij}^{(k)}] \leq MI_g^{\max} \quad \text{for } \forall k \in \{k : \hat{g}(k) = g\} \quad (19)$$

- (2) violations over Reasoning 1#:

$$\sum_{i=1}^N \sum_{j=1}^{J(i)} [w_{ij} \cdot s_{ij}^{(\bar{k}(m))}] - y^{(\bar{k}(m))} \leq \sum_{i=1}^N \sum_{j=1}^{J(i)} [w_{ij} \cdot s_{ij}^{(\bar{k}(m+1))}] \quad \text{for } 1 \leq \forall m < K \quad (20)$$

- (3) violations over Reasoning 2#:

$$MI_{\bar{g}(m)}^{\max} - x^{(\bar{g}(m))} \leq MI_{\bar{g}(m+1)}^{\min} \quad \text{for } m = 1, 2, \dots, 5 \quad (21)$$

- (4) Sum of weight equal to 1.0:

$$\sum_{i=1}^N \sum_{j=1}^{J(i)} w_{ij} = 1 \quad (22)$$

where, the order mapping $\bar{k}(m)$ and $\bar{g}(m)$ must be determined by (6) and (13), respectively.

4 Case studies

4.1 Industrial background

Government financing platforms, which emerged in China in the early 21st century and rapidly grew, have significantly contributed to the nation's economic advancement by resolving the issue of mismatched construction funds and fiscal revenue while also serving as

effective counter-cyclical measures to mitigate economic fluctuations and foster banking industry development.

This study is based on a province of western China, where the existing stock of financing platforms mainly consists of medium and long-term bonds with relatively balanced issuance sizes and whose financing platforms generally exhibit weak profitability in operational activities, strong dependence on the government, and high debt levels. As of the end of 2017, there were 159 outstanding financing platform bonds in the province, issued by 39 issuers, with a total scale of 151.15 billion yuan. Most of the issuers had a credit rating of AA, accounting for 62.16% of the total. By the end of 2021, the number of issuers increased to 61, and the issuance of financing platform bonds shifted from being concentrated at the provincial level to the municipal (prefecture) level. Additionally, there were significant differences in the bond scale among different municipalities (prefectures), which, apart from its capital city, had bonds on relatively small scales.

In recent years, the province has intensified efforts to transform financing platforms to prevent local debt risks and promote local investment and financing system reform. However, against the backdrop of imbalanced economic development in this western province, municipal (prefectural) and county-level financing platforms with relatively weaker fiscal strength and higher pressure on infrastructure investment face greater difficulties and resistance in their transformation, resulting in generally lagging progress. Additionally, the high debt level, pressures of bond rolling issuance and refinancing, rising financing costs, and increasing challenges from strict financial regulation have compounded the difficulties. In this transitional phase, where explicit government credit support is detached and market-oriented profitability is yet to be established, the risks associated with the existing stock of financing platform debt, especially the hidden debt, may be exposed at an accelerated pace.

The market-oriented transformation of financing platforms in this western province is imminent. Due to significant differences among these financing platforms, there is an urgent need for a scientific assessment of their level of marketization, providing a sound basis for decision-making on their transformation direction, pathways, and functional positioning.

4.2 Questionnaire

Table 2. Questionnaire sample

ID	Question	Options
0.1	The name of your company is: _____	
0.2	Your role in your company is: _____	
0.3	The number of years you have worked at the platform company is: _____	
I.1	What do you think about the current level of your company's autonomous decision-making based on market principles?	[0, 50, 75, 100]
I.2	What do you think about the current level of your company's autonomy in management?	[0, 50, 75, 100]
I.3	Do you think the responsibilities of your company's board of directors, supervisory board, and management team are clear and effectively implemented, and has the incentive and restraint mechanism for the management team been established and effectively utilized?	[0, 50, 75, 100]
I.4	What do you think about the current internal management situation of	[0, 50, 75,

	your company?	100]
I.5	How about the debt-to-equity ratio of your company?	[0, 50, 75, 100]
I.6	The return on equity (ROE) situation of your company?	[0, 50, 75, 100]
II.1	How do you view the current macroeconomic policies?	[0, 50, 75, 100]
II.2	Do you think your company currently can grasp policies?	[0, 50, 75, 100]
II.3	What do you think about the local government granting your company special policies?	[0, 50, 75, 100]
III.1	What do you think about the current situation of your company's ability to integrate available resources?	[0, 50, 75, 100]
III.2	What do you think about the sustainability of your company's resources?	[0, 50, 75, 100]
III.3	What is the sufficiency of the pledged collateral for your company?	[0, 50, 75, 100]
III.4	What is the scale of operating assets for your company?	[0, 50, 75, 100]
IV.1	What do you think about the local government's resource integration mechanism?	[0, 50, 75, 100]
IV.2	How about the local government's ability to coordinate and promote resource integration?	[0, 50, 75, 100]
IV.3	How about the local government's approach in guiding your company to establish core competitiveness?	[0, 50, 75, 100]
V.1	What is the current willingness of financial institutions to cooperate with your company in resolving existing debt?	[0, 50, 75, 100]
V.2	How diverse are the funding sources of your company at present?	[0, 50, 75, 100]
V.3	What is the current debt repayment situation of your company?	[0, 50, 75, 100]
V.4	What is the current overall debt-servicing capacity of your company?	[0, 50, 75, 100]
VI.1	Industrial agglomeration in the region where your company is located.	[0, 50, 75, 100]
VI.2	The opportunities and capabilities of your company in participating in industrial development.	[0, 50, 75, 100]
VI.3	The possibility of your company attracting strategic partners.	[0, 50, 75, 100]

The objective of this study is to calibrate the weights assigned to scoring items for determining the marketization indicator using a sample of financing platforms. Subsequently, other platforms can employ these calibrated weights to evaluate their marketization degree based on their respective grades on the scoring items. Table 2 illustrates a questionnaire sample to gather scoring information from various financing platforms in this province of western China. The initial three questions in section "0" are intended to assess the informativeness of the responses, as some interviewees may be unable to provide helpful information. The remaining 23 questions correspond to the 23 scoring items in Table 1, offering only four options (0, 25, 75, and 100) to ensure ease, definitiveness, and clarity in answering. The survey targeted primarily executives or financial personnel of financing platform companies in this western province, and 49 valid questionnaires were collected as feedback.

Platf orm	I	II	III	IV	V	VI	Clust er	Platfor m	I	II	III	IV	V	VI	Clust er
12#	75.0	75.0	81.3	58.3	87.5	58.3	E	37#	75.0	75.0	68.8	75.0	31.3	41.7	C
13#	87.5	83.3	31.3	75.0	68.8	66.7	D	38#	62.5	41.7	56.3	50.0	50.0	50.0	B
14#	83.3	58.3	62.5	75.0	81.3	75.0	D	39#	54.2	58.3	75.0	75.0	43.8	75.0	C
15#	100.0	100.0	100.0	91.7	81.3	100.0	F	40#	66.7	50.0	50.0	25.0	31.3	33.3	B
16#	75.0	66.7	56.3	66.7	68.8	58.3	D	41#	100.0	100.0	100.0	100.0	100.0	100.0	F
17#	54.2	58.3	56.3	66.7	37.5	58.3	C	42#	66.7	58.3	81.3	66.7	50.0	66.7	C
18#	37.5	58.3	25.0	66.7	31.3	58.3	B	43#	41.7	75.0	62.5	66.7	56.3	50.0	C
19#	75.0	83.3	50.0	75.0	62.5	66.7	D	44#	83.3	91.7	68.8	75.0	81.3	75.0	E
20#	70.8	100.0	87.5	75.0	87.5	83.3	E	45#	41.7	66.7	43.8	66.7	43.8	58.3	B
21#	87.5	83.3	75.0	66.7	87.5	83.3	E	46#	83.3	58.3	62.5	66.7	56.3	50.0	D
22#	12.5	25.0	0.0	16.7	56.3	33.3	A	47#	83.3	58.3	62.5	66.7	62.5	58.3	D
23#	62.5	66.7	43.8	58.3	37.5	50.0	B	48#	87.5	58.3	75.0	66.7	62.5	58.3	D
24#	62.5	58.3	31.3	50.0	37.5	50.0	B	49#	87.5	75.0	87.5	100.0	87.5	91.7	F
25#	75.0	50.0	37.5	66.7	56.3	16.7	B	AVG	74.9	72.8	65.8	70.6	65.8	66.5	--

The specific scores representing each cluster in six categories are provided in Table 4. As depicted in Figure 2 and Table 4, the F cluster/group exhibits the most outstanding performances across all six categories, while the E cluster demonstrates notable strength in scoring items of the II and V categories. The D and C clusters display weaknesses in Category III and V, respectively, with the B cluster performing more poorly in both categories and the A cluster showing the poorest performance across all six categories among all groups.

Table 4. Six groups identified with clustering method

Cluster	I	II	III	IV	V	VI
A	27.1	20.8	12.5	16.7	40.6	25
B	64.2	55	43.1	55	41.9	45.8
C	59.9	68.8	65.6	67.7	40.6	59.4
D	81.1	66.7	61.9	68.2	69.9	68.9
E	83.3	92.7	78.1	75	85.2	69.8
F	93.8	95	93.8	98.3	95	95.8

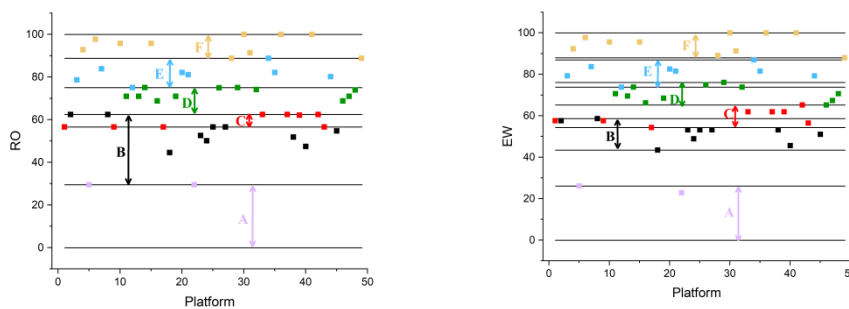
4.4 Results and analysis

Table 5. Weights calibrated for each scoring item by optimization

Item	Weight	Item	Weight	Item	Weight	Item	Weight
I.1	1.1%	II.1	5.2%	III.4	4.1%	V.3	4.0%
I.2	5.6%	II.2	0.0%	IV.1	6.0%	V.4	2.0%
I.3	2.9%	II.3	0.0%	IV.2	1.2%	VI.1	5.0%
I.4	9.0%	III.1	2.6%	IV.3	4.5%	VI.2	5.7%
I.5	9.3%	III.2	2.7%	V.1	11.4%	VI.3	7.0%
I.6	3.8%	III.3	1.6%	V.2	5.3%		

The final weights calibrated with optimization for all the scoring items are presented in Table 5, revealing that the subtotals of weights in Category I to VI are 31.7%, 5.2%, 11%, 11.7%, 22.7%, and 17.7%, respectively. This indicates that the government capability (Category I) has the most significant impact on the comprehensive marketization indicator compared to other categories, while the policy environment (Category II) is the least weighted. According to the weights assigned to individual scoring items, the "Willingness to cooperate in resolving existing debt (V.1 in Table 1)" holds the highest weight in estimating the Marketization Indicator (MI). Surprisingly, the "ability to grasp policies (II.2)" and "special policies granted by local governments (II.3)" do not contribute to the MI estimation. The conclusion could be contingent on this study's sample size of financing platforms.

Figure 3 illustrates the overlaps of boundaries between the six groups, comparing the present Reasoning and Optimization (RO) method with the conventional Equal Weights (EW) method. The results highlight the superiority of the RO method over the EW method, as the latter has two groups, B and D overlapping with C and E, respectively, resulting in a total of 6.5% violation over the second reasoning condition. In contrast, the RO method only has the B group overlapping with C, with a lower violation rate of 5.8%. This indicates that the RO method exhibits stronger performance and improved accuracy in determining the group boundaries, making it a more practical approach for evaluating marketization degrees of financing platforms.



(a) Reasoning and optimization (RO)

(b) Equal weights (EW)

Figure 3. Boundary overlaps between groups

Table 6 presents comprehensive results for all 49 financing platforms, including their credits determined by the soccer gaming rule and the Marketization Indicators (MIs) calculated using weights estimated by the Reasoning and Optimization (RO) and Equal Weights (EW) methods, along with their rankings from the smallest to the largest. Notably, three financing platforms achieve full marks in the credit and MI evaluations.

Table 6. Values and orders of credits and MIs

Platform	Value			Order			Platform	Value			Order		
	Credit	RO	EW	Credit	RO	EW		Credit	RO	EW	Credit	RO	EW
1#	1062	56.6	57.6	14	14	14	26#	1492	75.0	75.0	29	29	31
2#	1073	62.5	57.6	16	16	15	27#	894	56.6	53.3	10	10	9
3#	1678	78.6	79.3	33	33	33	28#	2227	88.9	89.1	41	41	41
4#	2383	92.9	92.4	43	43	43	29#	1544	75.1	76.1	31	31	32
5#	374	29.5	26.1	2	2	2	30#	2646	100.0	100.0	47	47	47
6#	2549	97.8	97.8	46	46	46	31#	2282	91.4	91.3	42	42	42
7#	1923	83.9	83.7	38	38	38	32#	1490	74.2	73.9	28	28	28
8#	1162	62.5	58.7	20	20	16	33#	1116	62.5	62.0	17	17	18
9#	960	56.6	57.6	11	11	13	34#	2166	88.9	87.0	40	40	39
10#	2411	95.9	95.7	44	44	44	35#	1888	82.1	81.5	37	37	36
11#	1407	71.0	70.7	25	25	26	36#	2646	100.0	100.0	48	48	48
12#	1516	75.1	73.9	30	30	29	37#	1150	62.5	62.0	19	19	19
13#	1461	71.0	69.6	26	26	25	38#	786	51.9	53.3	6	6	7
14#	1565	75.1	73.9	32	32	30	39#	1069	62.2	62.0	15	15	17
15#	2456	95.9	95.7	45	45	45	40#	735	47.5	45.7	4	4	4
16#	1215	68.9	66.3	21	21	22	41#	2646	100.0	100.0	49	49	49
17#	868	56.6	54.3	9	9	11	42#	1137	62.5	65.2	18	18	20
18#	628	44.6	43.5	3	3	3	43#	972	56.6	56.5	12	12	12
19#	1363	71.0	68.5	23	23	24	44#	1743	80.2	79.3	34	34	34
20#	1867	82.1	82.6	36	36	37	45#	854	54.8	51.1	8	8	6
21#	1858	81.2	81.5	35	35	35	46#	1257	68.9	65.2	22	22	21
22#	357	29.5	22.8	1	1	1	47#	1377	71.0	67.4	24	24	23

23#	848	52.6	53.3	7	7	8	48#	1472	73.9	70.7	27	27	27
24#	744	50.2	48.9	5	5	5	49#	2056	88.9	88.0	39	39	40
25#	980	56.6	53.3	13	13	10							

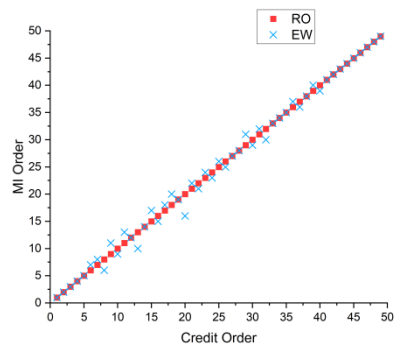


Figure 4. Ordering mismatch between MI and credits

Following the first reasoning, the ranking of MIs determined by the weights is expected to align with the ranking of credits determined by the soccer gaming rule, indicating a higher level of consistency. Figure 4 illustrates the ranking relationship between credits and MIs, comparing the RO with the EW method. The points representing the ranking relationship between credits and MIs determined by the RO method are all positioned on the 45-degree line, indicating perfect consistency between the rankings. However, in contrast, about half of the financing platforms (26 points) show discrepancies between the positions of credits and MIs with the EW method. The results imply that the RO method can produce more desirable weights than the EW method, better aligning with the first reasoning and matching the ranking of credits.

5 Discussions

This study aims to reduce, though not eliminate, subjective judgments during the process of calibrating weights assigned to scoring items for estimating the marketization indicator (MI) of a government financing platform. Subjective judgment is minimized by estimating all weights collectively through an optimization model based on fundamental reasoning conditions rather than determining weights individually for each scoring item. However, some subjective judgments remain in the procedure, such as selecting the rule to determine the credit gained by a financing platform, deciding the number of clusters used to group platforms, and the responses provided by interviewees in the questionnaire to assign marks for each scoring item.

It's important to highlight that the sample size of local government financing platforms influences the assignment of weights to various scoring items, which may also change across stages due to shifts in policy opportunities and regulatory environments affecting these platforms.

6 Conclusion

This study proposes a novel approach to calibrate weights assigned to scoring items in determining the marketization indicator (MI) of government financing platforms in China, reducing the need for expert-estimated indicators. The credit is assigned to a financing platform using a popular rule in soccer games, where platforms compete with others in a sample across all scoring items. By utilizing a specially designed questionnaire and formulating an optimization problem grounded in fundamental reasonings of the relationship between the credits and MIs, the method assesses marketization degrees more objectively, providing valuable insights into platform performance and positioning.

Results of applying the method to the financing platforms in a province of western China suggest:

- (1) The government capability exerts the most substantial influence on the comprehensive marketization indicator among all categories, while the policy environment is the least weighted; intriguingly, the factors "ability to grasp policies" and "special policies granted by local governments" do not contribute to the MI estimation.
- (2) The superiority of the present Reasoning and optimization (RO) method over the conventional Equal Weight (EW) method, with the EW method showing two more groups overlapping with each other, resulting in a total of 6.5% violation over the clustering reasoning, while the RO method only has the B group overlapping with C, with a lower violation rate of 5.8%.
- (3) The RO method achieves a higher level of consistency, as the ranking of MIs aligns with credits determined by the soccer gaming rule, while the Equal Weights (EW) method shows discrepancies for about half of the financing platforms.

It is worth highlighting that this study successfully reduces subjective judgments during calibrating weights, but some subjective judgments persist in the procedure.

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