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Analyzing Influencing Factors of Financing Decision for Urban Rail Transit Projects Using DEMATEL Approach

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Abstract: Financing behavior, based on the financing decision made by the owner of urban rail transit projects, will directly affect the capital cost of its operation and the construction schedule of the project. This paper intended to combine financing demand and financing options with the project construction schedule, quality and investment management, and based on DEMATEL methodology, to identify and sort the factors that constraining the financing behavior and financing structure in rail transit financing and then systematically analyze them. On this basis, the paper kept "Fund Timely Raised and Cost Lowest" as the objective and proposed an optimum framework in response to the financing structure under multi factors.

Keywords: Factors analysis, financing decision-making, the DEMATEL method, urban rail transit.

1. INTRODUCTION

Urban Rail Transportation, as a modern public transportation infrastructure facility, is deeply affecting the progress of the whole social development. It has the advantages of safe, fast, high transportation volume, low pollution and high efficiency. Urban transit construction helps the development of public transportation facilities and will play an irreplaceable role in the comprehensive development of the whole society. In China, the urban rail transportation reached its high speed development period in the eleventh 'Five Year Economic Development Plan' ('Five Year Plan'). And in the twelfth 'Five Year Plan' period, it is getting more as the focus of infrastructural investment. With further speeding of urbanization in China, rail transit will take about 50~60% of daily resident trips in modern city transportation system. The development of urban rail transportation will become a key point in solving urban transportation congestion problems. But the urban rail construction is demanding huge fund. Since 2004, the investment for urban rail construction in Guangzhou has been increasing year by year. And up to end of 2014, total sum for this investment has reached RMB 182.112 billion (USD1 = RMB6.3 @ exchange rate of April 2015) as shown in Table **1**. Of this, Guangzhou municipal (district) government investment is RMB 74.922 billion, about 41.14% of the total sum; the bank loan is RMB 65.081 billion, about 35.74% of the total sum. The two takes the highest percentage in the total investment as shown in Fig. (**1**). For the rest, the fund comes from (super) short term securities loans, medium term notes, corporate bonds, financing leases, bank loans, corporate loans, etc.

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Now, although the government has increased its fund and policy support to urban rail transportation project, the money gap for this investment is still quite big in term of normally negative operation of urban rail transportation project. Exploring the factors that affecting urban rail project financing decision and how based on the restraining factors to optimize the financing structure are the key issues to be put under consideration in pushing the healthy development of urban rail construction. But opinions can be differed. More lecturers from the western world think that local financial ecological environment has key influence in financing model selection. For example, unnecessary legal requirements, complicated and non-transparent administrative procedure, etc. are often increasing the cost to the investors [1]. World Bank Analysis Report showed that the industrialized countries' economy development cycle and the developing countries' credit rating are the important factors in infrastructure financing model selection[2]. Some scholars from China suggested that government investment in the early stage of the project, social framework participation and degree of its involvement, impact of the project to the public, etc. are the key factors in urban transit financing decision[3]. Some scholars also suggested to put government environment and market environment under consideration and propose to introduce the PPP (Public-Private Partnership) model into urban rail financing [4-7]. Above mentioned studies did not systematically put all affecting factors in urban rail financing under full consideration. Therefore, this paper intends to systematically analyze the internal and external factors in urban rail financing and the inter-relationship between the factors, and by way of DEMATEL methodology to quantitatively disclose the comprehensive influence of these factors and then find the key factor. The result of this study provides a scientific decision-making guideline for urban rail transportation financing.

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Table 1. Paid-in investment of guangzhou metro construction from 2004 to 2014. Unit: 100,000,000 Yuan.

Year	Municipal Financial Authority	District Financial Authority	Short-term Securities Loan	Mid-term Note	Corporate Bond	Super-Short term Securities Loan	Financing Lease	Bank Loan	Bank and Corporate Loan	Total
2004	45.00	-	-	-	-	-	-	17.52	-	62.52
2005	43.00	-	-	-	-	-	-	58.01	-	101.01
2006	54.00	-	-	-	-	-	-	77.84	-	131.84
2007	40.00	-	-	-	-	-	-	62.68	-	102.68
2008	48.00	-	-	-	-	-	-	77.39	-	125.39
2009	51.00	-	-	-	-	-	-	95.68	-	146.68
2010	71.00	-	-	-	-	-	-	64.27	-	135.27
2011	85.00	7.44	-	30.00	-	-	-	37.15	6.87	166.46
2012	60.00	5.79	-	70.00	-	-	2.39	59.54	0.19	197.91
2013	95.00	15.57	25.00	-	-	-	72.93	70.79	4.56	283.86
2014	110.00	18.42	50.00	-	80.00	35.00	39.00	29.94	5.14	367.51
Total	702.00	47.22	75.00	100.00	80.00	35.00	114.32	650.81	16.77	1,821.12
Percentage	38.55%	2.59%	4.12%	5.49%	4.39%	1.92%	6.28%	35.74%	0.92%	100.00%

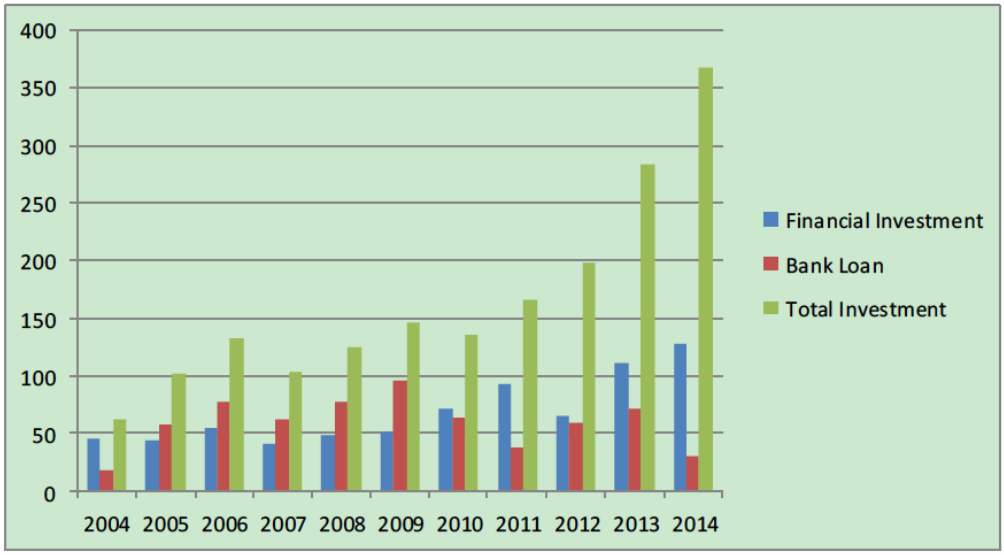

Fig. (1). Investment of guangzhou metro construction from 2004 to 2014.

2. RESEARCH DESIGN

2.1. Main Research Ideas

This paper synthetically uses literature review, questionnaire method and DEMATEL method. The research is divided into three steps as shown in Fig. (**2**).

2.2. Creation of Factor System in Financing Decision

Based on the operation condition of urban rail transportation project in China and abroad, its investment can be divided into three models: "Investment and Operation both by Government", "Investment by Government and Operation by Market" and "Investment by Multi-parties and Operation by Market". The financing action performed by urban rail project construction parties will directly affect both the capital cost of business operation and the project execution schedule as well. For years, the scholars all over the world tried to find the most optimized financing model. But due to the constraints by some objective factors, the actual financing decision always differs with the optimized financing decision in theory. Early theory review showed that, in urban rail project financing in China, the factors are linked to the urban rail

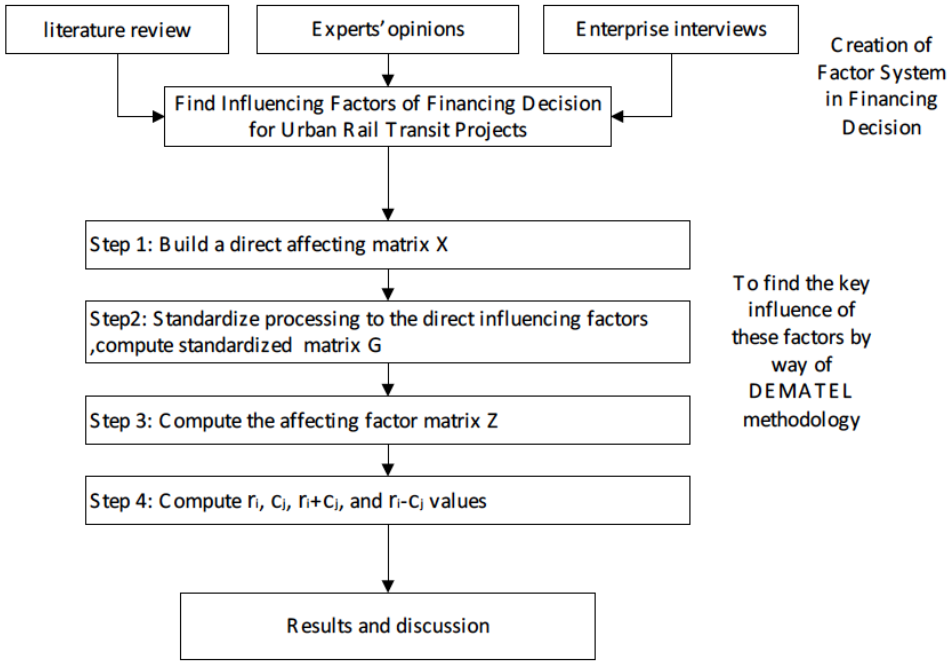

Fig. (2). Research ideas.

project itself, the construction parties, the government and the government policy. This paper will analyze the internal and external main factors in urban rail project financing decision and split the factors into 5 categories (Project Characteristic, Project Management, Government Support, Government Policy and Economic) and 15 Sub-categories. Then, based on scientific and full-coverage basis, we find that the key factors in urban rail project financing decision-making as shown in Table **2**.

2.3. Creation of DEMATEL Model and Calculation

DEMATEL (Decision Making Trial and Evaluation Laboratory) method, literally translated as the decision-making trial and evaluation laboratory, is the methodology proposed by the American Institute named Bottelle in 1971. And the main idea is based on the Questionnaire responses of a number of experts in the field about interaction between the various factors by determinant calculus, and to analyze the logical and direct influencing relationship between the factors, to build a direct affecting matrix and calculate the degree of the mutual influence, determining whether the inter-relationship exist or its strength. Rounding influence of small targets, it ultimately aims to simplify the system structure. Basic steps of building a model to find the key factors by way of DEMATEL methodology are as follows [8-10]:

(1) To simplify the analysis, the influencing factors are denoted as F1, F2…, F15.To quantify the effects of various factors, a calculation matrix, $X = (x_{ij})_{15\times 15}$, is built. $x_{ij}(i = 1,2,\cdots 15; j = 1,2,\cdots 15; i \neq j)$ is the effect of Fi on Fj. x_{ij} is assigned the value of zero when there is no effect, 1 when there is but only moderate effect, 2 when there is effect, and 3 when there is considerable effect. Based on the reply to the Q&A form and find the factors and its impact to other factors. Then build a direct affecting matrix X among each factors detailed as shown in Table **3**.

(2) After standardize processing to the direct influencing factors,

$$G = \frac{1}{\max\limits_{1\le i\le 15}\sum\limits_{j=1}^{15} X_{ij}} X,$$

building a standardized matrix G ,then using the MATLAB software to calculate the affecting factor matrix $Z=G(I-G)^{-1}$ detailed as shown in Table **4**.

(3) Based on the composite affecting matrix, computing $r_i = \sum_{j=1}^{15} z_{ij}(i = 1,2\ldots 15),$, $c_j = \sum_{i=1}^{15} z_{ij}(j = 1,2\ldots 15)$, $r_i + c_j$ and $r_i - c_j$, using DEMATEL to find the Center and Reference of each factor as shown in Table **5**.

3. RESULTS AND ANALYSIS

3.1. DEMATEL Calculation Result Analysis

Analysis results, in terms of DEMATEL processing results that are processed by the above stated method and by the analysis model for the influence factors of financing decision for urban rail transit project, are as follows in accordance with the model stated above:

(1) Reason factors are 7 and results factors are 8 according to the occurrence reason index for factors. The reason factors, influencing the financing decision for urban rail transit project, shall be in accordance with the following sequence by the importance degree: F12 Laws and regulations , F1 Industrial characteristics , F11 Government policy support , F10 Government finance input ,F9 Investment management , F6 Schedule management , F2 Project scale. These factors, directly influencing the financing decision, served as the active factors that significantly influence other factors,

Table 2. Key affecting factor system.

Internal/External Categories	Affecting Factor	Factor Analysis	References
Project Characteristic	F1 Urban Rail Industry Characteristic	Rail industry characteristic: high investment, complicated technology, long construction period, etc. will affect financing scale and financing ratio.	Enterprise interviews
	F2 Project volume	Project construction scale, financing for single or multiple line, will affect financing scale.	[2]
	F3 Project Construction cycle	Longer construction cycle, will need more funds. Difficult to get return in short-term and difficult to get market capital involvement.	Enterprise interviews
	F4 Project Construction period	More funds needed in peak period. Fund timely needed will decide its financing option.	Enterprise interviews
	F5 Project Risk	Complexities of the project, project easy or difficult will directly affect the investment money and indirectly affect the financing scale.	[11]
Project Management Factor	F6 Progress Management	Project ahead of behind schedule will affect the project execution schedule and hence affect the payment term and financing requirement. Project period will affect its development cost. Early project completion and quality assured will reduce the cost expenses and avoid the cost increase due to inflation.	[12-13]
	F7 Safety Management	Proposal and design change, due to geology reason, geology risk, ambient environment, and project construction safety consideration reasons. It will increase extra work beyond the contract and will affect financing volume. Meanwhile will also need funds for safety and accident precaution.	Enterprise interviews
	F8 Quality Assurance	Quality will have direct or in-direct links with project cost and schedule. Will also affect financing scale and its timing.	Enterprise interviews
Government Support	F9 Investment Management	Construction period Investment management (includes design budget, tender budget, tender price management, signing of contract, contract management, change of contract, budget management, etc.) will affect project construction money amount change. Contract payment variation and final account settlement will also affect financial timing and amount.	[14]
	F10 Government Financial Support	Government has enough fund or not will affect business financing options.	[15-17]
	F11 Government policy Support	Government preferential policy will affect the introduction of market capital and will affect financing options.	[18]
Government Policy	F12 Government Laws and Regulations	Government law and regulation will protect the interest of the investment from market investor. It will benefit the introduction of market capital and will create a legal basis for realization of multi financing option.	[19]
	F13 Government Income Tax Policy	Preferential financial system and tax income system by the government, for example Guarantor by Government, financial subsidy, tax rebate, municipal bond, etc., will benefit for the expending of the project financing.	Enterprise interviews
Economic Factor	F14 Financial Mechanism	Good financing environment can help to increase financing market scale, expend financing channel and improve financing efficiency.	[20-22]
	F15 Interest Rate	When interest rate increasing is expected, project will prefer long-term financing option. When interest decreasing, project will prefer short-term financing option.	Enterprise interviews

shall be strengthened; the results factors shall be in accordance with the following sequence by the importance degree: F5 Construction risk, F3 Project construction cycle, F14 Financial mechanism, F4 Project construction phase, F13 Tax policy, F7 Safety management, F15 Interest rate level, F8 Quality management . These factors affected by other factors, further influence financing decision, which is the most important factor affected by other factors.

(2) Centrality refers to the importance degree of the factor in the system, the factors shall be in accordance with the following sequence by the centrality index of the factor: F10 Government finance input, F11 Government policy support, F9 Investment management, F1 Industrial characteristics, F6 Schedule management, F3 Project construction cycle, F2 Project scale, etc. From the point of view of centrality sequence of comprehensive influence factors and occurrence

Table 3. Direct affecting matrix among factors in urban rail financing decision-making.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	0	3	3	3	3	2	3	3	3	3	3	2	2	2	2
F2	3	0	3	2	2	3	2	2	2	3	3	2	2	2	2
F3	3	3	0	3	3	3	3	3	3	3	3	2	2	2	2
F4	2	2	2	0	3	2	3	3	2	3	2	2	2	2	2
F5	3	2	3	2	0	3	3	3	3	2	2	2	1	1	1
F6	2	2	3	3	3	0	3	3	3	3	2	2	2	2	2
F7	2	2	3	3	3	2	0	3	2	2	2	2	1	1	1
F8	2	2	3	3	3	2	3	0	2	2	2	2	1	1	1
F9	2	3	3	3	2	3	3	3	0	3	2	2	2	3	3
F10	3	3	3	3	3	3	2	3	3	0	3	2	3	3	3
F11	3	3	3	3	2	3	2	2	3	3	0	3	3	3	3
F12	2	2	2	2	2	2	2	2	3	2	3	0	3	3	3
F13	2	2	2	2	2	1	1	1	2	3	3	2	0	3	3
F14	2	2	2	2	2	2	1	1	2	3	3	2	3	0	3
F15	2	2	2	2	2	2	1	1	2	2	3	2	2	3	0

Table 4. Composite affecting matrix among factors in urban rail financing decision-making.

`	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	0.271	0.333	0.344	0.344	0.327	0.320	0.326	0.335	0.354	0.370	0.359	0.254	0.284	0.299	0.299
F2	0.309	0.232	0.312	0.290	0.274	0.310	0.273	0.281	0.299	0.336	0.326	0.207	0.257	0.271	0.271
F3	0.309	0.281	0.243	0.291	0.274	0.311	0.274	0.282	0.322	0.336	0.326	0.208	0.258	0.272	0.272
F4	0.275	0.268	0.278	0.231	0.286	0.276	0.285	0.293	0.286	0.322	0.291	0.198	0.245	0.258	0.258
F5	0.294	0.266	0.298	0.276	0.215	0.296	0.285	0.292	0.306	0.296	0.286	0.195	0.219	0.231	0.231
F6	0.303	0.296	0.328	0.329	0.313	0.257	0.313	0.321	0.339	0.353	0.321	0.242	0.270	0.285	0.285
F7	0.255	0.249	0.258	0.281	0.269	0.257	0.199	0.275	0.266	0.278	0.269	0.205	0.205	0.217	0.217
F8	0.255	0.249	0.258	0.281	0.269	0.257	0.269	0.206	0.266	0.278	0.269	0.205	0.205	0.217	0.217
F9	0.315	0.330	0.340	0.341	0.301	0.339	0.322	0.331	0.281	0.368	0.335	0.252	0.283	0.320	0.320
F10	0.359	0.352	0.363	0.362	0.343	0.361	0.321	0.352	0.374	0.323	0.381	0.269	0.325	0.341	0.341
F11	0.353	0.346	0.356	0.355	0.314	0.354	0.314	0.323	0.368	0.386	0.306	0.287	0.321	0.337	0.337
F12	0.274	0.269	0.254	0.253	0.259	0.275	0.259	0.266	0.308	0.300	0.314	0.176	0.271	0.285	0.285
F13	0.243	0.238	0.222	0.221	0.206	0.221	0.205	0.212	0.253	0.287	0.282	0.199	0.175	0.257	0.257
F14	0.263	0.258	0.265	0.264	0.226	0.263	0.225	0.233	0.275	0.311	0.303	0.214	0.263	0.206	0.276
F15	0.249	0.244	0.251	0.250	0.214	0.250	0.213	0.220	0.260	0.273	0.288	0.203	0.228	0.262	0.192

Table 5. Centre and Reference of Factors in urban rail project financing decision-making.

Affecting Factor	Affecting Degree	Affected Degree	Centre	Reference
F1 Industrial Characteristics	4.8208	4.3257	9.1465	0.4951
F2 Project Volume	4.2464	4.2119	8.4583	0.0345
F3 Construction Period	4.2586	4.3674	8.626	-0.1088
F4 Construction Phases	4.0487	4.3669	8.4156	-0.3182
F5 Construction Risk	3.9854	4.0901	8.0755	-0.1047
F6 Progress management	4.5519	4.3436	8.8955	0.2083
F7 Safety Management	3.699	4.0841	7.7831	-0.3851
F8 Quality Management	3.6991	4.2191	7.9182	-0.52
F9 Investment Management	4.7775	4.5584	9.3359	0.2191
F10 Government Financial Investment	5.1645	4.8152	9.9797	0.3493
F11 Government Policy Support	5.0566	4.6547	9.7113	0.4019
F12 Laws and Regulations	4.0474	3.3135	7.3609	0.7339
F13 Income Tax Policy	3.4754	3.8094	7.2848	-0.334
F14 Financial Mechanism	3.8442	4.0561	7.9003	-0.2119
F15 Interest Rate	3.5967	4.0561	7.6528	-0.4594

reason categories study, key influence factors in financing system of urban rail transit project are F10 Government finance input, F11 Government policy support, F9 Investment management, F1 Industrial characteristics and F6 Schedule management.

3.2. Project Financing Structure Analysis

(1) On above mentioned analysis to the factors, it showed that the government will plays a key role in constraining and proposing urban rail transportation financing. For rail transportation construction, local government should not only guarantee the investment but also set up supporting policy to urban rail transportation companies. For example, to allow these companies to make use of the profit made from the land development along the metro line, for the metro construction fund; And to allow these companies make use of government credit as budget cash flow for the basis of rail transportation project financing.

(2) The investment volume of urban rail transportation project is high. The technology for its implementation is complicated. The construction period is long and the liquidity of the project is low. Compared with other commercial projects, it financing option is limited. So it should maximize favorable factors and minimize unfavorable factors and make full use of all kinds of new financing options to expand its financing channel. For example, the companies can use financing lease and loan for latest metro construction equipment and facility. Using this way, it will reach both the target financing objective and avoid construction risk as well.

(3) In project management, the rail transportation construction units should actively coordinate with other construction parties to overcome the difficulties during project execution period and meet the target schedule. If any dispute, in removal of land, pipe and tube redeployment, geologic condition change, etc., shall not make it a delay to the project schedule. Shall promptly adjust the project execution plan and change the fund requirement if needed. The project owners shall enhance its investment management, follow strictly the earlier budget plan and make it a target objective. Shall perform investment plan management, enhance tender and contract management, tighten the control to engineering change management system, improve the contract change and performance rating system, set up the contract and information account management system, timely control the investment, the cost change and financing requirement change. Based on above mentioned, to set up a dynamic financing system fully meet urban rail transportation requirements.

CONCLUSION

Using DEMATEL approach, the paper analyze influencing factors of financing decision for Urban Rail Transit Projects in-depth, obtaining results that key influence factors in financing system of urban rail transit project are Government finance input, Government policy support, Investment management, Industrial characteristics and Schedule management. As Government finance input, Government policy have the greatest impact, Rail transportation financing decision-making shall mainly be controlled by government authorities to search for multi financing channels and financing combination. Secondly, financing decisions for urban rail transit project are mainly affected by the factors including Investment management, Industrial characteristics and

Schedule management. And meanwhile urban rail financing is always in a dynamic changing state. Suggest the investors to setup a dynamic financing structure according to these factors, to reach the balancing multi targets among financing cost and financially security, flexibility, enterprise controllability, etc.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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