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Demystifying the Barriers to Transport Infrastructure Project Development in Fast Developing Regions: The Case of China

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Abstract: Transport infrastructure (TI) has become one of the primary drivers for sustainable economic growth and social progress. However, a wider take-up is currently inhibited in fast developing regions (FDRs) by many barriers, which have not been explored explicitly in previous studies. In this study, a three-dimensional framework (i.e., macro environment, local environment, and the construction process) is proposed to structure the barriers in a reasonable way. Professionals' opinions on the importance of the barriers are collected through questionnaire survey. The survey results were analyzed by the ranking analysis technique. It is found that the top five barriers are "difficulty in survey and design during the construction process", "weak support from economy", "insufficient funding", "harsh regional climate", and "cost overrun". Further analysis, based on a factor analysis, indicates that these critical barriers could be grouped into three clusters: "administration on transport infrastructure", "construction technology and cost management", and "geographical and economic conditions". The research findings demonstrate the usefulness of the proposed framework, and the implication is that a barriers-based checklist favors stakeholders to improve the efficiency and sustainability of TI development in FDRs. Although the study is situated in China, it sheds light on the subject in other developing countries.

Keywords: transport infrastructure; barriers; fast developing regions; sustainable development; China

1. Introduction

Sustainability, mostly defined as the "development that meets the needs of current generations without compromising the ability of future generations to meet their own needs" [1], is a comprehensive concept that is used in different contexts. Since the emergence of the concept of sustainability, there has been an increasing awareness that the sustainability of cities and regions calls for the sustainability of infrastructure, and particularly of transport infrastructure (TI) [2,3]. Infrastructure deficit, which has often been claimed to be closely linked to equity and sustainability, is a common issue that many developing countries have confronted over the past decade [4–6]. A well-developed infrastructure, whether engineering facilities [7], municipal public works (e.g., roads, railways, airports, bridges), or public service facilities (e.g., sanitation, water supply, telecommunication, sewerage) is considered the foundation to maintain sustained and rapid development of economy [8–10]. Similarly, infrastructure development in the transportation sector functions as an economic driver [11,12] as well as an important instrument for alleviating unemployment and poverty [13,14]. A typical example goes to India where the fast growth of economy is fueled in part by its transport sector, and the sector contributes 6.4% of GDP [15,16].

In reality, urbanization and population growth yield enormous needs for transport infrastructure (TI) in developing countries [17,18]. To satisfy the needs, therefore, numerous TI projects were initiated in Russia, Malaysia and Philippines recently [19].

Previous studies demonstrated that coordinated transport infrastructure would offer balanced and stable regional development in terms of socio-economic development and environment [20–22]. However, compounded by technical complexity and involvement of stakeholders [23], the development of TI is subject to multidimensional obstacles [24]—economic, political, social, cultural, technological, and environmental [25–27]. The obstacles may give rise to some development problems such as time delay and cost overrun [28–30]. For instance, of 441 road projects owned by the National Highway Authority of India, 137 were delayed due to problems in land acquisition and environmental protection [31]. Researchers have pointed out that although these kinds of problems are widespread, they could be solved if rigorous risk assessment at the decision-making stage and efficient governance in the execution phase are conducted [32]. In addition, infrastructure in developing countries is vulnerable to low resilience and weak support of technical capability [33], and over-optimistic expectation and poor planning/management will aggregate the difficulty of the development process [34].

A fast developing region (FDR) refers to a smaller part of a developing country. While it has some features in common with the whole country, the embeddedness in culture, religion, economic foundation, and social structure makes it unique. Based on Vietnam, the work by Dang and Pheng revealed several key factors inhibiting the efficiency of public investment in TI [25]. Although the research findings shed light on the same issue in other developing countries, the situation in which relevant studies are fragmented has not been improved significantly. Furthermore, fewer efforts have been made to account for characteristics of fast developing regions (FDRs) in the examinations. To address this research gap, this study aims to propose a conceptual framework for structuring key obstacles to TI development in FDRs. The proposed framework is intended to elaborate the coherence of the obstacles and thereby lays a useful foundation for future studies. The results not only favor professionals to gain new insights into the barriers, but also imply some strategies for the implementation of TI projects.

The remainder of this paper starts with the theoretical framework on a proposed U-framework. Section 3 introduces the research materials and methods, including the case of China, methods and data analysis. Section 4 presents the findings and discussion. Finally, Section 5 concludes the paper.

2. Theoretical Framework: A Proposed U-Framework

Dang and Pheng found that the barriers to TI investment include capacity for estimation and monitoring, politicized decision-making, transparency and accountability, institutional weaknesses in planning, political commitment, and corruption in the construction sector [25]. Marques and Berg conducted a survey by using examples from water utilities and found that an appropriate allocation of risks in infrastructure contracts is a critical factor for successful contracts, thus it demonstrates that the risk management is essential in infrastructure projects [35]. Labadie examined low impact development of infrastructure, and complemented the barriers with lack of basic understanding of planning, insufficient economic incentive, inactive leadership, and insufficient technical information and assistance [29]. Likewise, Long et al. conducted a survey on large projects in Ho Chi Minh City Vietnam and classified 62 problems they identified into five categories, namely incompetent designers/contractors, poor estimation and change management, social and technological issues, site related issues, and improper techniques and tools [36]. Furthermore, some of these factors, for instance, delay in approval, unpredicted external events (e.g., currency fluctuation and trade recession), efficiency and productivity challenges, cost and time overrun, and inappropriate skills specifications were restressed in recent research [31,32,37,38].

Basically, TI in developing countries is influenced by fragile ecological environment, high technical requirements caused by geography, shortage of financing, cultural heterogeneity, and backward facilities [36]. This gives the suggestion that potential barriers to TI development in FDRs span widely from one project to another, and structuring them in due ways is helpful to improve practitioners' perception. By examining the inherent relationships, those barriers with reference to developing countries are regrouped into three dimensions: macro environment, local environment, and the construction process. As shown in Figure 1, these dimensions are in the shape of umbrella in practice, which is named after a U-framework.

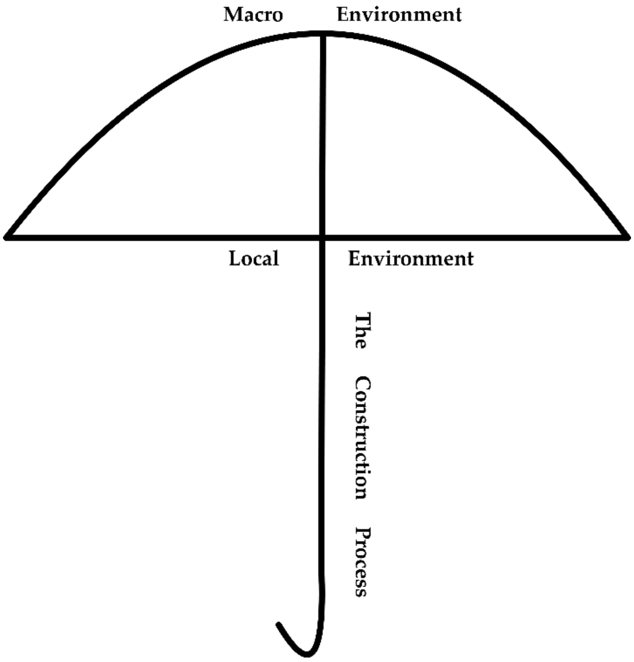

Figure 1. A proposed framework schemes.

The elements of the proposed framework are interdependent in addressing the barriers inhibiting the development of infrastructure. Specifically, the umbrella rib is composed of socio-economic factors (e.g., economic prosperity, inflation, and national planning) that generate all-pervading impacts on all types of TI projects. Factors in this dimension mainly highlight the non-differential and large-scale impacts at the national or regional level. Following this is the tube that represents a five-stage development process: inception, design, construction, operation, and demolition. This dimension relates to the barriers in terms of the planning and policymaking as well as the implementation and demolition that reflect the capacity of construction firm itself. The horizontal stretcher refers to extensive involvement of local sectors in the development process. Compared to the dimension of macro environment, factors under the last dimension put more emphasis on the local environmental influences around the projects, covering local cultures, geographical environment, locations of the projects, local regulations, etc. Arguably, factors such as incentives from local governments, capacity of manpower, market competition, and environmental protection can render much disturbance to the development of TI projects.

3. Materials and Methods

3.1. The Case of China

In recent years, the world economy has maintained a real GDP growth rate around 2.7%, along with heightened policy uncertainty, subdued investment and stagnant global trade. In this case, the emerging market and developing economies (EMDEs) are highly expected to lead the robust economic growth and serve as an important engine for global economic recovery. As illustrated in Table 1, the real GDP growth rate of EMDEs is almost twice that of the advanced economies or high-income countries, and it is estimated to increase to 4.7% in 2019 [19]. In effect, the EMDEs such as China, Brazil and India have played an increasingly vital role in the global economy.

Table 1. Global real GDP growth (%).

Year		World	EMDEs	Advanced Economies	Developing Countries	High-Income Countries
Actual growth	2014	2.7	4.3	1.9	4.4	1.9
	2015	2.7	3.5	2.1	3.6	2.2
Estimates	2016	2.3	3.4	1.6	3.5	1.6
Projections	2017	2.7	4.2	1.8	4.4	1.8
	2018	2.9	4.6	1.8	4.8	1.8
	2019	2.9	4.7	1.7	4.9	1.7

China, as a typical EMDE, has enjoyed rapid development since the reform in 1978. Benefiting from the opening-door policy, China maintained a growth rate approaching 10% in terms of gross domestic product (GDP) in the post-reform period (Figure 2) [39]. Despite the slight slowdown since 2012, such extraordinary growth performance has made China one of the world's fastest-growing developing countries. However, due to the geographic environment and biased policies, the widening development gap between the remote western region and the coastal region also appeared to be one of the most severe challenges, which inhibited the sustained and stable development of China's economy.

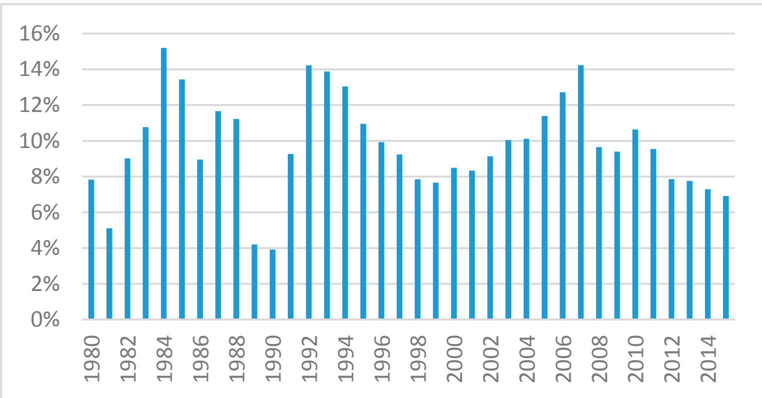

Figure 2. GDP growth rate at constant prices (%).

By the end of 2015, China's total population had reached about 1.37 billion, of which urban population accounted for 56.10% (Table 2) [39]. Furthermore, China's urban population is projected to be 827 million and the urbanization rate would be 57% by 2025 [40]. Such ambitious urbanization encourages enormous demands for infrastructure facilities, as pointed out by Hasan and Martin [41,42]. This trend is exemplified by highways, of which the network had doubled in size from 2004 to 2014, and high-speed rails boosting from 33% to 50% of the total length [19]. Notwithstanding the remarkable achievement, transport infrastructure in China is awaiting continuous development. As a response, many government initiatives such as the Belt and Road (B&R) place much emphasis on the development of transport projects. According to B&R strategies, an investment of US $157.10 billion is determined for the development of railways, roads and airports, with shares of 48%, 12% and 11% of the total, respectively, in the near future [19,43].

Table 2. China's population and its composition.

Year	Urban		Rural		Total Population
	Population	Proportion	Population	Proportion	
1980	191.40 [1]	19.39	795.65	80.61	987.05
1985	250.94	23.71	807.57	76.29	1058.51
1990	301.95	26.41	841.38	73.59	1143.33
1995	351.74	29.04	859.47	70.96	1211.21
2000	459.06	36.22	808.37	63.78	1267.43
2005	562.12	42.99	745.44	57.01	1307.56
2010	669.78	49.95	671.13	50.05	1340.91
2015	771.16	56.10	603.46	43.90	1374.62

[1] Unit: million person.

As one of the largest developing countries, China is made up of developing and developed regions. Massive development of TI projects has been increasing to match the pace of economy in developed regions, and it is now stretching over western China, which is a typical FDR for the time being. As illustrated in Table 3, transport infrastructure in western China has sustained rapid growth over the past decade; the density of railways in operation (DR) and density of highways (DH) amounted to 69.91 and 2690.37 km per 10,000 km^2, respectively, by 2015 [39]. In addition, the population density (DP) of the western region increased to 540.70 thousand per 10,000 km^2 at the end of 2015. In parallel with huge demand for new TIs in this FDR, a great deal of established infrastructure needs maintenance and improvement. Thus, western China is a hotspot where TI projects will prosper in the foreseeable future.

Table 3. Regional density of railways, highways and population since 1980s.

Year	Western Region			Middle Region			Eastern Region		
	DR	DH	DP	DR	DH	DP	DR	DH	DP
1982	26.89 [1]	524.25	421.89 [2]	105.51	2146.25	2790.18	100.29	2484.57	3748.03
1985	28.14	545.79	434.94	106.98	2164.71	2870.53	106.51	2590.48	3868.67
1990	28.53	596.05	472.80	111.76	2356.36	3171.21	112.11	2871.45	4251.09
1995	29.55	641.30	502.36	115.67	2541.80	3347.96	116.45	3621.77	4472.05
2000	32.20	806.57	518.93	128.43	3114.69	3422.67	123.36	4340.47	4858.30
2005	40.18	1136.36	523.04	169.82	4508.82	3424.32	185.57	5630.91	5101.31
2010	52.37	2283.93	525.25	202.08	10709.35	3472.37	222.17	10862.47	5531.11
2015	69.91	2690.37	540.75	264.23	11916.10	3549.51	313.79	12269.85	5733.52

[1] Unit: kilometers per 10,000 km^2; [2] Unit: thousand person per 10,000 km^2.

Compared with those developed provinces in the eastern region such as Beijing, Guangdong, and Shanghai (as depicted in Table 3), western China is sparsely populated and characterized by culture, ethnic minorities, religion, poor public services, and undeveloped economies [44]. In this sense, obstacles to TI development in this FDR must be covert and perplexing, and they appear in a different fashion. Some of them must be identical to those identified from the perspective of developing countries, and others may be obscure. Therefore, TI projects in western China are deemed to be a good case for examination in this study.

3.2. Methods

It is quite hard, if not impossible, to collect practical evidence to identify the spectrum of the barriers in FDRs. Questionnaire survey was thus considered a useful method. Bearing this in mind, a questionnaire was designed based on the literature and current practices in China to obtain information on the barriers known to practitioners and academicians. The main steps are presented as follows.

3.2.1. Formulation of Barriers

First, literature is reviewed extensively to extract those barriers recognized in previous studies. The publications reviewed contain textbooks, academic reports, journal articles and conference proceedings. For simplicity, a list of potential barriers resulted from the review is given in Table A1.

Second, a pilot was tested among five professionals, as described in Table 4, through in-depth interview. Two of the professionals were from TI construction enterprises, one from governmental authority in charge of infrastructure development, and two were scholars from universities. All of the participants had over ten years of related experience in this area.

Table 4. Profiles of the interviewees.

Interviewee	Position	Enterprise Name	Type	Work Experience
A	Associate professor	XX Jiaotong University [1]	Academic	26 [2]
B	Full professor	XX Tiedao University	Academic	25
C	Project manager	China Railway Construction Group Co.,Ltd.	Industry	15
D	Project manager	China Communications construction company Ltd.	Industry	16
E	Official director	XX Transport Commission	Government	11

[1] The names of the interviewees are hidden for privacy; [2] Unit: year.

The interview was directed to judge the rigorousness and comprehensiveness of the factors by considering TI development in western China. Comments of the professionals were used to improve the tentative factors.

Third, case study was adopted to complement the tentative factors. Consequently, a list of 37 barriers was derived as shown in Table A2 [6,23,25–31,36,40,45–48].

Lastly, questionnaire survey was conducted to collect professionals' opinion on the established barriers. The questionnaire comprises three sections. The first section gives an introduction to the questionnaire and instructions for respondents. The necessity and importance of this research work, confidentiality of the survey, and contacts for respondents to use are also included. The second section aims to collect respondents' profiles with respect to educational background, years of work, organizational types, and transport project types. In the last part, respondents are requested to mark an importance level per factor using the 5-point Likert scale, where 5 stands for important, 1 for unimportant, and 3 for neutral [49].

For convenience, the questionnaire was distributed using email and an online platform. The targeted respondents are line managers and senior managers from top ten Chinese TI construction firms, experts, governmental officers, and consulting companies. A snowball sampling technique was adopted to increase the response rate. Respondents were requested to invite more qualified professionals through their social networks to participate in this survey.

3.2.2. Respondents' Profiles

A total of 458 questionnaires were sent out and 88 returned, giving a response rate of 19.21%. However, two questionnaires were found invalid due to incomplete answers. As shown in Figure 3, a vast majority of the respondents were line managers, senior managers, and academics. Of all participants, 40% held a PhD degree and 57% had more than six years of TI-related experience. They had participated in at least one type of TI project, of which road projects share was 81%. Since the distribution of respondents is extensive, the composition of respondents was considered useful to provide unbiased evaluation to the investigation.

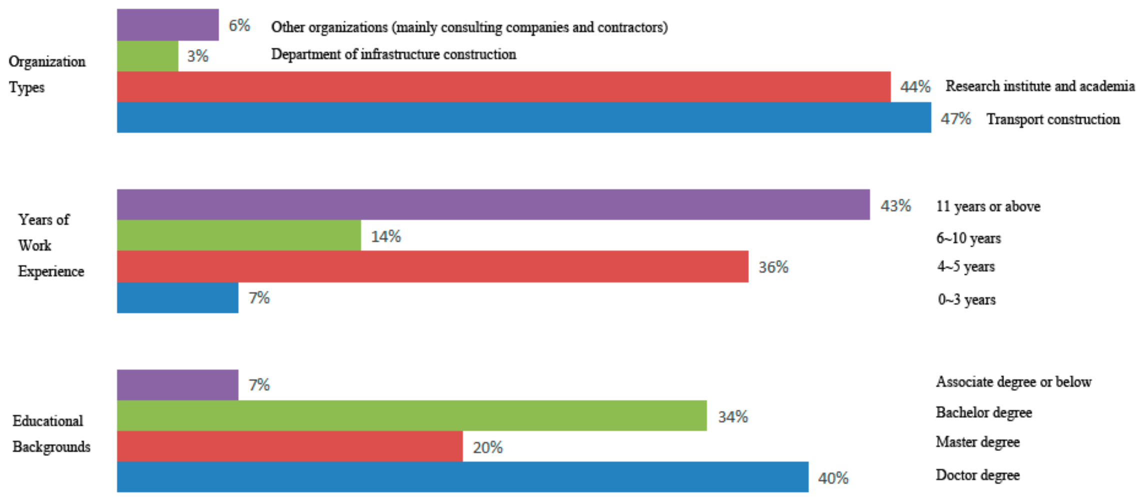

Figure 3. Respondents' profiles.

3.3. Data Analysis

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS). Preliminary examination was conducted to test whether the collected data are appropriate for detailed analysis, namely the reliability analysis. The reliability represents the consistency or stability of the results obtained from the questionnaire survey, and the commonly used methods of reliability test are Cronbach's coefficient alpha, Split-half reliability and Kuder–Richardson reliability. According to Crocker and Algina, alpha coefficient is the lower bound for reliability estimation, thus the alpha coefficient is better than Split-half [50]. Additionally, the Kuder–Richardson reliability only applies to true–false item, i.e., test data of binary score. As a result, Cronbach's coefficient alpha has the advantage of measuring internal consistency among factors and reliability of the five-point Likert scale used in opinion questionnaire [51]. Cronbach's coefficient ranges between 0 (no consistency) and 1 (complete consistency). In this study, Cronbach's coefficient is 0.970, indicating strong internal consistency and the reliability of the scale used. Thus, the sample is treated as a whole for conducting ranking analysis and factor analysis.

3.3.1. Ranking Analysis

The approach of ranking analysis based on mean scores was employed to develop a descending order list of importance level. As revealed in previous studies, this analytical approach is helpful to detect any barrier that was considered critical by respondents [52,53]. Given two items with same mean values, the item with a higher standard deviation (SD) deserves a lower ranking [54].

As shown in Table 5, there are 20 items with mean values larger than average (2.94); "harsh regional climate" (F14) and "cost overrun" (F04) have same mean values (3.02) in importance and different values in standard deviation (SD).

The proposed U-framework will be considered valid if all of the identified factors match the three dimensions strictly, i.e., macro environment, local environment, and the construction process. Therefore, the links between factors and the three dimensions entered into further examination and the results are listed in Table 6.

Table 5. Ranking of the critical barriers in western China.

Code	Mean	Standard Deviation	Rank	Code	Mean	Standard Deviation	Rank
F27	3.10	1.1105	1	F32	2.94	1.3061	20
F09	3.07	1.5157	2	F26	2.93	1.1185	21
F13	3.03	1.4820	3	F06	2.92	1.2409	22
F37	3.02	1.1204	4	F31	2.92	1.2503	23
F14	3.02	1.2757	5	F20	2.91	0.9957	24
F04	3.01	1.2152	6	F28	2.91	1.0524	25
F24	3.00	1.1310	7	F33	2.91	1.2354	26
F30	3.00	1.2759	8	F19	2.90	1.1815	27
F02	3.00	1.2940	9	F35	2.90	1.2762	28
F08	3.00	1.2940	10	F01	2.88	1.6804	29
F11	3.00	1.2940	11	F03	2.87	1.2831	30
F05	2.99	1.3767	12	F18	2.86	1.1326	31
F10	2.99	1.4587	13	F16	2.85	1.0622	32
F12	2.98	1.1511	14	F34	2.85	1.1260	33
F25	2.97	1.0052	15	F36	2.85	1.2249	34
F23	2.97	1.0167	16	F17	2.84	1.1700	35
F15	2.97	1.1149	17	F21	2.80	1.1495	36
F29	2.95	1.0773	18	F22	2.73	1.0391	37
F07	2.94	1.1847	19				

Table 6. A framework for restructuring the barriers.

Category	Code	Barriers
Macro environment	F02	Excessive transport planning changes
	F04	Fragmentation of administrative system
	F05	Lack of sustainable and effective policies
	F08	Macroeconomic downturn
	F10	Poor financial environment
	F13	Insufficient funding
Local environment	F09	Weak support from economy
	F11	High pressure of debt repayment
	F12	Heavy tax burden of construction firms
	F30	Lack of local R&D institutes and services
	F32	Complex topography and landform
	F37	Harsh regional climate
The construction process	F07	Improper monitoring and control
	F14	Cost overrun
	F15	Ineffective cost management
	F23	Obsolete technical standards
	F24	Multiple technical problems
	F25	Insufficient sharing and communication of technical experience
	F27	Difficulty in survey and design
	F29	Lack of innovative application

3.3.2. Factor Analysis

Factor analysis (FA) has been broadly used to detect any multivariate relationships between factors [55,56]. The main steps include analyzing the internal structure, detecting common underlying dimensions, and reducing variables into a more readable framework [56]. Preliminary examinations, including Kaiser–Meyer–Olkin (KMO) and Bartlett's sphericity test, are essential to look at whether the sample is suitable for further factor analysis [57].

The value of KMO ranges from 0 to 1, where 1 means "complete correlation", indicating that the variables are strongly linked and relatively compact [56]. In reverse, if the KMO value equals 0, it means no correlations between variables and inappropriateness for factor extraction. The Bartlett's test of sphericity is built on the correlation matrix of variables as the starting point is to test whether it is an identity matrix or not. If the Bartlett's sphericity statistic is relatively large and the corresponding probability value is less than the associated significance level, it means a correlation among the original variables, and the suitability of the correlation matrix for factor extraction [58,59].

As calculated, the value of Bartlett's test of sphericity is 1462.77 with the significance at a 0.000 level, indicating an acceptable correlation level among the original variables. KMO statistic is 0.903, larger than the 0.5 threshold, implying that the sample meets the application requirements for FA. The results of KMO and Bartlett's sphericity test suggest that the same underlying dimensions and specific structure exist among highly ranked factors [57].

Four steps were then taken in the study: principal component analysis, selecting factors with eigenvalues greater than 1, matrix rotation, and determining the number of factor. Twenty variables were involved in the principal component analysis. Three underlying grouped factors were extracted and retained with eigenvalues greater than 1 (Table 7), explaining 70.42% of variance in the survey data. In view of the correlation between variables, direct oblimin rotation of principal component analysis was adopted to interpret the variables. In line with this rotation method, oblique rotation can better reflect the real psychological phenomenon and provide more useful information than orthogonal rotation [60,61].

Table 7. Total variance explained for critical factors.

Cluster	Initial Eigenvalues [1]		
	Total	Percent of Variance	Cumulative %
1	11.030	55.148	55.148
2	1.698	8.488	63.636
3	1.357	6.786	70.422

[1] Extraction method was principal component analysis.

The three clusters obtained from the principal component analysis were further computed to derive their factor loadings to mirror the association between factors and variables. According to Hair et al., either the communality or factor loading below 0.5 is not acceptable [62]. Given the sample size of this study, any factor loading with the value below 0.55 should be excluded from analysis [57]. Thus, the variable "high pressure of debt repayment" (F11) and "lack of local R&D institutes and services" (F30) were removed eventually.

The derived cluster matrix for the remaining 18 barriers is shown in Table 8. As displayed in this table, Cluster 1 is composed of variables F04, F05, F02, F09, F07, F24, F12, F10, F25, and F13; Cluster 2 includes variables F23, F15, and F29; and Cluster 3 contains variables F32, F14, F08, F27, and F37. The variables under these three clusters spell out governmental administration of transport infrastructure and project management, construction technology and cost overrun, and geographical and economic conditions. Based on initial interpretation and inherent relationships, the three clusters are labeled as follows: administration on transport infrastructure (Cluster 1), construction technology and cost management (Cluster 2), and geographical and economic conditions (Cluster 3).

Table 8. Cluster matrix after direct oblimin rotation.

Code	Factors	Cluster 1 [1]	Cluster 2	Cluster 3
F04	Fragmentation of administrative system	0.911	-	-
F05	Lack of sustainable and effective policies	0.812	-	-
F02	Excessive transport planning changes	0.790	-	-
F09	Weak support from economy	0.717	-	-
F07	Improper monitoring and control	0.685	-	-
F24	Multiple technical problems	0.684	-	-
F12	Heavy tax burden of construction firms	0.674	-	-
F10	Poor financial environment	0.659	-	-
F25	Insufficient sharing and communication of technical experience	0.637	-	-
F13	Insufficient funding	0.628	-	-
F23	Obsolete technical standards	-	0.822	-
F15	Ineffective cost management	-	0.775	-
F29	Lack of innovative application	-	0.688	-
F32	Complex topography and landform	-	-	0.926
F14	Cost overrun	-	-	0.738
F08	Macroeconomic downturn	-	-	0.650
F27	Difficulty in survey and design	-	-	0.635
F37	Harsh regional climate	-	-	0.563

[1] Rotation method is Oblimin with Kaiser Normalization.

4. Findings and Discussion

4.1. Cluster 1: Administration on Transport Infrastructure

This cluster accounts for 55.148% of the total variance (Table 7), and it consists of "fragmentation of administrative system" (F04), "lack of sustainable and effective policies" (F05), and "excessive transport planning changes" (F02). While the factors included concur with previous studies on the close ties of government to TI development [34,63], the barrier "excessive transport planning changes" (F02), referring to frequent adjustment of planning in the policymaking process, is a new one that can be easily found in western China. In essence, government plays dual roles, namely the client and regulator, in this domain. These two roles are complementary and competing on many occasions. As a result, inconsistent decision-making from different governmental departments can surface, suggesting that they might not be able to serve as focal points for inter-ministerial and interagency coordination. Furthermore, the dual roles of client and regulator played by government in infrastructure projects, typically, are not positive. The reasons are two-fold: (1) as a regulator, the decentralized decision-making structure causing multiple management system leads to ineffective management and buck-passing among different departments; and (2) as a client, the administrative monopoly in the infrastructure industry results in the lack of competition, which may undermine the positivity of this role.

The lack of administrative system is embodied with ineffective political commitment, frequent changes of transport planning, and massive short-lived policies [25]. Moreover, other problems with governmental administration such as bureaucracy, institutional incompletion, lack of penal systems and non-transparency to the public in the planning and policy-making phase have exacerbated the influence of administration on TI development in the region. The remainder of factors under this cluster are concerned with governmental ability to manage a TI project. In developing countries, regulations are often formulated to impede the entrance of foreign construction business. Thereby, the interests of domestic firms can be secured [64]. Less participation of foreign competitors in the sector is unbeneficial to the advancement of innovation and professionalism. This in turn weakens the development potential of infrastructure in less developed countries [65]. The absence of opportunities to learn from foreign partners suggests that domestic firms would find it harder to improve project management, finance, labor, and construction technology by themselves [66].

4.2. Cluster 2: Construction Technology and Cost Management

This cluster shares 8.488% of the total variance (Table 7) with the focus on construction issues in the execution phase. Technology is one of the most indispensable production factors for TI projects, especially in an intricate socioeconomic context [36]. In comparison with monotonous plain topography in the coastal region, TI in western China requires more advanced technologies to mitigate geological and environmental restriction. However, due to limited access to new technologies and up-to-date information, construction firms in this region are accustomed to obsolete technologies. In addition, higher cost of innovation weakens the willingness of relevant firms to apply or to purchase technologies from overseas. Furthermore, even though some latest technologies are supplied via not-for-profit agencies and public sector clients, problems with technological application may still be encountered [67,68].

As found in previous studies, cost is a major barrier of infrastructure construction in developing countries [29,30]. Evidence suggests that nine out of ten megaprojects have suffered over budget [69]. This is real in western China. In effect, high requirements for technology, long distance of material transportation, and widening deficit for labor have raised the cost of TI development in the territory. Apart from frontline workers that are available from local sectors, most of construction professionals are recruited from the coastal region [70]. Due to insufficient public budget, governments in developing countries have to face an increasing monetary burden of TI projects [71]. In addition, inadequate capacity of cost management in terms of estimation, planning and control will result in frequent occurrence of cost overrun [28].

4.3. Cluster 3: Geographical and Economic Conditions

Cluster 3 account for 6.786% of the total variance (Table 7) in explaining the critical barriers. This cluster spells out geographical and economic interfaces between TI construction and FDR attributes. Geographical obstacles distribute widely in western China, especially in those remote regions with inclement geographical terrain. In effect, the so-called geography concerning topography, landform and climate have an impact on TI development. For instance, irregular geographical surroundings would not only impose the difficulty in conducting field survey and schematic design in the pre-phase of construction process, but also pose considerable challenges onto construction. In the meantime, organization of onsite construction activities ought to stay flexible in interpreting regional climatic characteristics to avoid cost overrun and time delay [72]. Hence, it is implied that a thorough evaluation of local situations should be conducted prior to the development of FDR's TI project.

Due to the long development period of time, assumptions given to a TI project at an early stage might not happen as anticipated at the end. This is attributable to considerable changes on raw materials, labor, construction equipment, building materials and energy, and economic prosperity that can be encountered in a local socioeconomic context [73,74]. In addition, investment growth in China has slowed down sharply from 21% (2012) to 10% (2015), rebalancing towards more sustainable style, and the slowdown in investment growth mirrors deteriorating construction business confidence and weakening return prospects [19].

4.4. Implications of the Proposed U-Framework

The barriers discussed above fall into three groups, which coincide with the dimensions of the proposed U-framework. Specifically, the barriers in Cluster 1 refer to the macro-environment dimension; Cluster 2 is concerned with the construction process; and Cluster 3 is about local environment. Consequently, the proposed framework can be echoed using the case of western China. The result demonstrates the reliability of the U-framework, suggesting that it can be used as an approach to provide the process and framework for TI development in other developing countries.

The U-framework is of usefulness to the management of TI development in FDRs. As shown in Figure 4, "difficulty in survey and design" (F27) is ranked first with the highest mean score. This can be verified by an infrastructure case in western China, namely the Sichuan-Tibet railway (Chengdu to Ya'an section started in December 2014). The railway line starts from an altitude of 500 m in the Chengdu Plain, and it spreads out all the way up to an altitude of over 4000 m of the Qinghai-Tibet Plateau. Unstable topography and geographic conditions have led it to be the most difficult project in survey and design [75]. Following this item are "weak support from economy" (F09) and "insufficient funding" (F13), ranked second and third, respectively. In recent years, the shortage of budgets has increasingly become a key factor impeding the development of transport infrastructure in western China [76]. In this context, the Chinese government has to enforce some national policies to favor social capitals to invest in TI projects. Although the research result is based on the Chinese empirical evidence, it shed light on the implementation of TI projects in other FDRs.

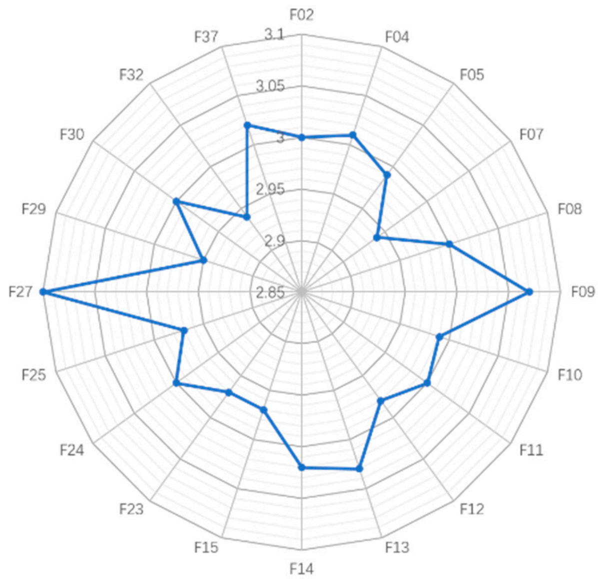

Figure 4. Score distribution of the critical barriers.

In previous studies, approaches to classifying the determinants of infrastructure development vary significantly from one study to another. Shen et al. divided the indicators of infrastructure project sustainability into three categories: economic, social, and environmental [77]. The work by Long et al. attributed the problems of large construction projects to be organizational, project attributes-related, coordination-related and environmental problems [36]. To improve the perception of infrastructure development, Park and Kwon decomposed infrastructure practices in Korea into five phases: planning and engineering, project budget, bid and contract, construction, and post-construction [53]. There appears to be no apparent agreements among researchers on theoretical construct for exploring the barriers, and this will definitely undermine the reasonableness of the results. Therefore, the proposed U-framework can not only elaborate the coherence of the obstacles from a different angle, but also contribute a new approach of structuring the barriers to the body of knowledge.

5. Conclusions

Transport infrastructure is known for its gigantic contributions to human well-being and sustainable development in terms of social welfare, economy and environment in the international arena. Nonetheless, the development of transport infrastructure projects in fast developing regions (FDRs) is subject to considerable barriers, and approaches to identifying the obstacles have not received adequate attention. This study was situated in the context of western China, and the key barriers identified are three-faceted, namely administration on transport infrastructure, construction technology and cost management, and geographical and economic conditions. These three dimensions spell out a U-framework for structuring the barriers in an effective way.

The top five barriers refer to difficulty in survey and design, weak support from economy, insufficient funding, harsh regional climate, and cost overrun. Whilst part of these factors were revealed in previous studies, it is implied that adequate capacity of local government, technology innovation, cost management efficiency, and ability to cope with geographical environment deserve much attention in FDRs. Moreover, the barriers-based checklist presented in this paper can not only help decision makers to prepare and implement TI projects in China as well as other developing countries, but also to revise and establish corresponding policies or guidelines on the planning, financing, construction, and management of infrastructure. The identification of strategic barriers therefore enables stakeholders to improve the efficiency and sustainability of infrastructure development.

This study probably offers the latest research on transport infrastructure development in a smaller part of a developing country. However, due to space limitations, this paper will not elaborate further on how the barriers are encountered in reality and how they are to be handled. While the proposed framework may be applied in developing countries and elsewhere, it is recommended to collect empirical evidence to attain more insights.

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Appendix A

Table A1. Barriers impeding the development of infrastructure.

Factors	References [1]	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Financial condition	Economic return			√	√	√										√
	Capital funding			√			√	√					√			√
	Perceived costs			√	√	√									√	
	Changing markets				√											√
Governmental administration	Related policies	√	√	√										√		
	Politicized decision		√		√											√
	Government approval														√	
	Regulation and institution		√		√							√				√
	Corruption		√													√
	Project management			√												
TI planning	Project planning				√											
	Rapid urbanization		√													
Social and culture	Public support			√												
	Social equity										√					
	Land acquisition		√		√											
	Demographic pattern													√		
Construction technology	Information technology			√	√											√
	Innovation and research		√						√							√
	Design rework									√						
	The choice of technology				√											
Natural environment	Climate variations			√												√
	Physiographic characteristics			√												
	Environmental clearances														√	
	Pollution															√

[1] a, [45]; b, [25]; c, [29]; d, [30]; e, [28]; f, [6]; g, [40]; h, [46]; i, [23]; j, [47]; k, [27]; l, [26]; m, [48]; n, [31]; o, [36].

Table A2. Barriers impeding the development of transport in western China.

Code	Obstacle Factors	Sources		
		Literature	Interview	Case Study
F01	Lack of integrity, strategic and forward-looking transport planning		B; C	Chongqing Jiangbei Airport
F02	Excessive transport planning changes	[25,30]	B	
F03	Conflicts and coordination between regions		E	Dazhou-Chongqing High Speed Railway
F04	Fragmentation of administrative system	[25,36]	D	
F05	Lack of sustainable and effective policies	[44,48]	D	Metro Line 1 of Guiyang
F06	Slow government permit and approval	[31]	C	
F07	Improper monitoring and control	[27,29]		
F08	Macroeconomic downturn	[30,36]	A	
F09	Weak support from economy		E	Delingha Airport
F10	Poor financial environment	[6,26]		Guilin-Liuzhou Expressway
F11	High pressure of debt repayment		C	
F12	Heavy tax burden of construction firms		A	
F13	Insufficient funding	[36,40]		
F14	Cost overrun	[28,29]	A; B	Guiyang-Guangzhou High-speed Railway
F15	Ineffective cost management		D	
F16	Cultural difference and conflicts		C	Delingha Airport
F17	Complex local social environment	[47]		Southern Xinjiang railway
F18	Ideas behind		B; E	
F19	Thinly populated area			Lanzhou-Xinjiang High-speed Railway
F20	Difficulty in dealing with existing infrastructure		E	
F21	Weak infrastructure supporting		A	Chengdu Shuangliu International Airport
F22	Problems of land acquisition and resettlement	[25]		Nanning-Kunming Railway
F23	Obsolete technical standards	[36,46]	B	
F24	Multiple technical problems			Lanzhou-Xinjiang High-speed Railway
F25	Insufficient sharing and communication of technical experience	[29,30]		
F26	Lack of IT development and application	[30,36]	B	
F27	Difficulty in survey and design		C;D	The Qinghai-Tibet Railway
F28	Inadequate capacity of project management		E	
F29	Lack of innovative application	[36,46]	B	
F30	Lack of local R&D institutes and services	[46]		
F31	Lack of related composite talents		D; E	
F32	Complex topography and landform	[29]	A; B	Qinghai-Tibet Railway
F33	Happening of natural disaster		C	Sichuan-Tibet Highway
F34	Land resource shortage	[30]		
F35	Fragile ecological environment	[29]		Nanning-Kunming Railway
F36	Complex geological structure			Shenfu Expressway
F37	Harsh regional climate	[29,36]	A	Lajishan Tunnel

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