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INFRASTRUCTURE SERVICE QUALITY MODEL BASED ON SERVQUAL: FOCUSING ON SOUTH KOREA

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Abstract: To enhance the overall well-being of individuals, acquiring only a quantitative inventory of the individual infrastructure is insufficient and comprehending public perspectives on service levels and infrastructure needs is equally important. This study presents a model for infrastructure service quality that considers the various needs of residents. The study examined the significance and appropriateness of infrastructure service indices in determining the priorities and objectives of government investment in infrastructures. The primary objective was to construct and authenticate a multidimensional model of infrastructure service quality, building on the SERVQUAL framework established in 1988. A survey was distributed to individuals residing in Korea, and 12,500 completed questionnaires were collected. In this study, we conduct a path analysis to test our hypotheses using the AMOS software (version 29.0). The findings of the study indicate that residential satisfaction has a considerable impact on the quality of life. Additionally, this study indicates that the level of infrastructure performance in a residential area has a substantial impact on people's satisfaction with their housing. Furthermore, the findings indicate that it is crucial to address both the quantitative and qualitative dimensions of infrastructure simultaneously. Finally, the evaluation of the efficacy of infrastructure enhancement investments should consider the quality of the infrastructure services.

Key words: Infrastructure Service Quality, SERVQUAL, Residential Satisfaction, Quality of Life

1. INTRODUCTION

The United States and the United Kingdom define infrastructure as the 'backbone of the nation' and the 'backbone of the national economy,' acknowledging its role in facilitating urban economic activities. In contrast, South Korea lacks a clear definition of infrastructure. However, the constitution underscores the right to a healthy and pleasant living environment, which indirectly highlights the significance of infrastructure. The World Economic Forum's 2019 study [1] demonstrated that there was a strong correlation between the Global Competitiveness Index and infrastructure sector scores, suggesting a significant link between national competitiveness and infrastructure development. Consequently, developed countries such as the United States, United Kingdom, Canada, and Japan have adopted a comprehensive evaluation system to assess and manage infrastructure considering the massive demand.

However, until the 1980s, South Korea prioritized increasing its infrastructure supply to address critical shortages. However, with increased national income, citizens' expectations shifted towards sophisticated and high-performing infrastructures, and a notable gap emerged between quantitative and qualitative infrastructure demands. In recent years, there has been an increased need for decision-making based on a refined and logical demand analysis, although political bias has an increasing impact on such decisions.

A representative infrastructure evaluation system in South Korea is the safety rating system under the Special Act on Facility Safety Management, which assigns safety grades A to E to each managed facility, with a focus on structural safety and durability. While infrastructure surveys that target citizens, conducted intermittently by research institutions, primarily focus on the quantitative aspects of existing facilities, they fail to capture the qualitative changes in user demands. The American Society of Civil Engineers (ASCE) Report Card, another key infrastructure evaluation system, assesses infrastructure performance from various perspectives; however, the incorporation of an infrastructure perception index based on citizen surveys remains inadequate.

Therefore, this study developing an infrastructure service quality model for statistically validates the need to enhance infrastructure service levels to improve citizens' quality of life by shifting the government's traditional focus from economic development to international competitiveness. The survey is based on SERVQUAL [2], and it targets South Korean citizens. Further, the hypotheses were tested through path analysis using AMOS 29.0 software. By examining the specific relationship between infrastructure service levels and citizens' life satisfaction according to the SERVQUAL model, this study underscores the significance of improving the infrastructure service quality and its positive impact on citizens' quality of life. This approach aims to offer a new perspective on policy direction by statistically demonstrating the contribution of government infrastructure policy toward enhancing citizens' quality of life beyond mere economic growth and a competitive edge.

2. PRELIMINARY REVIEW

2.1 ASCE Report Card [3]

In the United States, 23 states issue infrastructure report cards every 2–3 years, with evaluation criteria expanding annually according to the current issues. These report cards go beyond evaluating specific indicators, such as capacity, condition, future need, operation and maintenance, public safety, resilience, and innovation. They provide a comprehensive assessment of the country's movements over the past four years, including funding and development. The evaluations were primarily based on the expert judgment of the evaluation committee and were qualitatively graded using a traditional Letter Grade Scale: A (90–100 %), B (80–89 %), C (70–79 %), D (51–69 %), and F (< 50 %).

State and regional report cards are primarily managed by local chapters of the ASCE, which form local report card committees for experts in each infrastructure sector. These committees identify the necessary data sources and collect relevant information. Surveys will be conducted if data are unavailable or if additional research is needed. This process is the most time-consuming and labor-intensive part of creating a report card. Subsequently, the collected data were processed, and summaries for each evaluation area were prepared. Concerning these factors, initial scores were assigned to each facility, and an advisory panel of experts outside the local report card committee reviewed these evaluations. The compiled results were submitted to the ASCE headquarters for final score review and confirmation. The data used include reports, evaluations, plans, descriptions, and programs from federal, state, and local government agencies such as the US Army Corps of Engineers (USACE), the United States Environmental Protection Agency (EPA), and the Federal Aviation Administration (FAA).

The Social Overhead Capital (SOC) Report Card's effectiveness in communicating with the public stems from its explanatory style, which eschews professional or technical jargon in favor of a clear, concise, and easily understandable format akin to reporting cards and parent-teacher notices. This approach was designed to help the public grasp the significance and necessity of investing in SOC. The ASCE disseminates the evaluation process, detailed results, improvement recommendations, comprehensive reports, summaries, and infographics through various channels, including pamphlets, websites, and mobile platforms.

The evaluation results are regularly presented at Congress upon announcements. As mentioned previously, the American SOC Report Card, established in Congress in 1988, is an objective and impartial source of information. While there may be diverse opinions on improvement suggestions and implementation methods on the report cards, these factors serve as a basis for extensive discussions. The SOC Report Card has been a consistent reference in the media and congressional budget debates in the United States, and approximately 13 states have used it to justify increasing automotive fuel taxes to fund construction and maintenance.

2.2. Service Quality Model

The SERVQUAL service measurement model comprises five dimensions for assessing service quality: tangibles, reliability, responsiveness, assurance, and empathy [2]. Rooted in expectation–disconfirmation theory, the SERVQUAL defines service quality as the discrepancy between customer perceptions and expectations. This model is not limited to marketing, but is extensively used across various service sectors. This helps companies gauge the overall level of service perceived by customers, pinpoint key factors for quality management, and identify specific items within those factors for targeted management. Although the SERVQUAL is a general tool for service quality assessment, it requires customization and enhancement to fit each industry's unique determinants and factors identified during the assessment. Thus, for effective SERVQUAL applications, service quality dimensions must be reclassified according to industry type, and the wording of each measurement item should be tailored to a specific service context. The SERVQUAL serves as a foundation for developing service quality items; however, these must undergo validity and reliability checks before real-world applications [4]. The SERVQUAL-based service quality evaluation models have also been employed in urban service assessments, such as transportation services, which have a direct impact on citizens [5-9].

3. METHOD AND DATA COLLECTION

The survey for the infrastructure service quality model was evaluated on a seven-point scale. The questionnaire items such as satisfaction with actual infra expansion and investments to needs reflect residents' demands in infra investments and the effectiveness of assessing citizens' perceptions of enhancing residential environments. Data were collected through a nationwide survey of 12,500 individuals. The respondent characteristics are detailed in Table 1.

Table 1. Characteristics of respondents

	Division	Frequency	%
Gender	Male	6346	50.8 %
	Female	6154	49.2 %
Age	20s	2287	18.3 %
	30s	2335	18.7 %
	40s	2787	22.3 %
	50s	3797	30.4 %
	60s	1294	10.4 %
City Size	Metropolis	8713	11.1 %
	Small- and Medium-sized Regions	3787	30.3
	Total	12,500	100.0

This study proposes a model to analyze the direct and indirect effects of improving the level of infrastructure services on improving residents' life satisfaction. To develop an infrastructure service quality model, the authors adapted a path analysis methodology. Path analysis is a method of verifying a hypothesis by diagramming the path between independent and dependent variables and confirming the causal relationship between the variables. Path analysis can identify direct and indirect effects between multiple exogenous and endogenous variables by repeatedly applying regression analysis [10]. Based on the collected data, path analysis was conducted at the observed variable level for latent variables, such as satisfaction with infrastructure sectors (SIS), infra SERVQUAL (ISQ), and residential environment quality (REQ), to evaluate the relationships between these variables and extract in-depth implications.

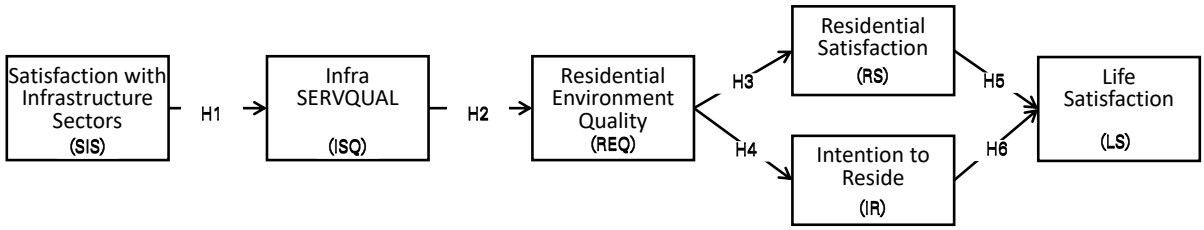
4. MODEL DEVELOPMENT AND ANALYSIS

4.1. Infrastructure Service Quality Model and Research Hypotheses

Infrastructure services are defined as provided by essential facilities to citizens that are crucial to a country's economic and social development. As infrastructure is closely intertwined with the lives of citizens, the quality of services that it provides is directly linked to the citizens' quality of life. When delivered smoothly and efficiently, infrastructure services not only contribute to economic growth but

also ensure the safety and convenience of citizens. This study proposes a model to evaluate the quality of infrastructure services as perceived by citizens, and it aims to statistically evaluate the impact of the quality of these services on life satisfaction. The research model consists of six hypotheses (H1–H6), as shown in Figure 1. By considering SIS as an exogenous variable and REQ, residential satisfaction (RS), and intention to reside (IR) as mediating variables, this study seeks to thoroughly investigate how improvements in infrastructure affect residents' quality of life.

Figure 1. Infrastructure Service Quality Model



Satisfaction with Infrastructure Sectors (SIS): In this study, the infrastructure service quality model is considered as an exogenous variable to investigate whether the service quality elements related to different infrastructure sectors vary, given that each sector provides distinct functionalities. Based on an analysis of infrastructure evaluation models in the USA [3] and the UK [11], infrastructure sectors are categorized as transportation infrastructure (TR), water infrastructure (WT), energy infrastructure (EN), telecommunications infrastructure (TC), waste and environment infrastructure (WE), and living infrastructure (LV).

Infra SERVQUAL (ISQ): The pivotal factor of this study, ISQ has been redefined to align with the SERVQUAL factors. The ISQ redefined factors are five items: Usability (UB), Accessibility (AC), Safety (SF), Convenience (CV), and Recoverability (RV), Table 2 provides the definitions of each factor.

Table 2. Infra SERVQUAL Define

SERVQUAL	Infra SERVQUAL
Reliability: Degree to which a service is provided accurately and reliably as promised.	Usability (UB): Degree to which the expected function of each infrastructure is adequately received (e.g., schools → educational services, hospitals → medical services, etc.).
Tangibles: Physical aspect of service provision.	Accessibility (AC): Degree to which infrastructure can be used when needed.
Assurance: Confidence given to customers through the knowledge and competence of the service provider.	Safety (SF): Degree to which infrastructure maintenance is well-managed and not hazardous.
Empathy: Service provider's understanding of individual customer needs and showing personalized attention.	Convenience (CV): Convenience during the use of infrastructure, satisfaction with costs, satisfaction with service provision, etc.
Responsibility: How quickly and appropriately the service provider responds to the needs and problems of customers.	Recoverability (RV): Satisfaction with infrastructure damage in the event of disasters or calamities, satisfaction with service provision, etc.

Residential Environment Quality (REQ): The infrastructure services quality is anticipated to have a positive impact on the residential satisfaction and intention to reside by affecting the quality of the residential environment. In this study, REQ encompasses a sense of safety, comfort, and pleasantness. Each element is defined as follows:

- A sense of safety (SS) pertains to a feeling of physical and mental ease, free from danger or threats in the event of disasters or calamities.
- Comfort (CF) denotes the feeling of ease and accessibility when using public facilities such as transportation, medicine, welfare, administrative offices, and educational, cultural, and sports facilities.
- Pleasantness (PL) signifies a feeling of satisfaction against the environmental conditions (e.g., odor, water pollution, and garbage collection) that are conducive to physical and mental well-being.

Residential Satisfaction (RS) and Intention to Residential (IR): While RS refers to an individual's subjective emotional state, IR indicates the desire to continue residing in the current residence, suggesting that this emotional state may translate into actual behavioral outcomes.

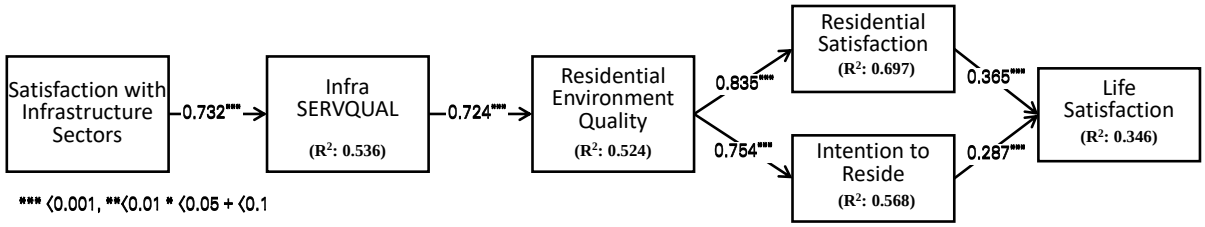
Life Satisfaction (LS): An individual's overall life satisfaction

4.2. Validation

The model's fit was assessed using various statistical measures: the ratio of X^2 to degrees of freedom, root mean square residual (RMR), parsimonious goodness of fit index (PGFI), the Tucker-Lewis index (TLI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) [12]. The acceptance levels for these indices were derived according to the criteria from previous studies. The comparison of the proposed model's fit and acceptance levels indicated that CMIN/DF ($\leqslant$3.0) was 59.949, RMR ($\leqslant$0.1) was 0.053, PGFI ($\geqslant$0.5) was 0.697, TLI ($\geqslant$0.9) was 0.927, CFI ($\geqslant$0.9) was 0.938, and RMSEA ($\leqslant$0.1) was 0.0697, sufficing a majority of the criteria. Thus, the proposed model all hypotheses were found to be statistically significant (see Figure 2).

Upon examining the results of hypothesis testing, the analysis included standardized path coefficients, indicating the strength of the relationship between the independent and dependent variables, and the squared multiple correlations (R^2) for an endogenous construct, which represents the amount of variance explained by the independent variables. The hypothesis-testing results showed that all the hypotheses in this study were significant. This means that SIS has a positive impact on the ISQ, which, in turn, enhances the REQ, leading to increased RS and IR in a particular area, ultimately having a positive impact on life satisfaction.

Figure 2. Results of hypotheses testing



The implications for each hypothesis derived from the path analysis results at the observed variable level for latent variables, such as the relationships between latent variables, ISI, ISQ, and REQ, are as follows (Table 3):

1) H1: SIS → ISQ

The satisfaction with different infrastructure sectors explained approximately 53.6 % of the variance in ISQ, which was statistically significant. Notably, the infrastructure sectors that had the most impact on service quality were transportation and living infrastructure. This suggests that transportation and living infrastructure are the most closely related to the citizens' daily lives. Additionally, there were slight variations in the service quality aspects that were most affected by each infrastructure sector. Accessibility and convenience are crucial for transportation infrastructure, water infrastructure, safety, and recoverability, energy infrastructure, usability, accessibility, and safety, telecommunications infrastructure, safety, convenience, and recoverability, environmental infrastructure, safety, and recoverability, and living infrastructure, usability, accessibility, and convenience. This indicates that the measured service quality elements vary across infrastructure sectors.

2) H2: ISQ → REQ

The infrastructure service quality accounted for 52.4 % of the variance in REQ, which was statistically significant. This suggests that both the quality of infrastructure services, and various factors considered in choosing a residence have a direct impact on the REQ. However, because it explained more than half of the variance, it confirmed its significance as a factor. The analysis of the impact of specific sectors showed varied in terms of the impact of ISQ on different aspects of REQ. For a sense of safety in the residential environment, the infrastructure's reliability and safety were crucial; for comfort, its accessibility, convenience, and reliability; and for pleasantness, its safety, and recoverability. This indicates that enhancing the quality of residential environments requires satisfying various aspects of infrastructure service quality.

Table 3. Path model analysis results

Path			Estimate		S.E.	C.R.
			B	β		
SIS ⇒ ISQ (H1)	TR	UB	0.312	0.316	0.009	36.517***
	TR	AC	0.372	0.355	0.009	41.005***
	TR	SF	0.245	0.253	0.009	28.552***
	TR	CV	0.337	0.324	0.009	37.288***
	TR	RV	0.239	0.246	0.009	27.403***
	WT	UB	0.096	0.087	0.01	9.558***
	WT	AC	0.071	0.061	0.011	6.624***
	WT	SF	0.122	0.113	0.01	12.057***
	WT	CV	0.075	0.065	0.011	7.034***
	WT	RV	0.117	0.108	0.01	11.394***
	EN	UB	0.103	0.098	0.01	10.578***
	EN	AC	0.107	0.096	0.01	10.343***
	EN	SF	0.124	0.121	0.01	12.699***
	EN	CV	0.101	0.092	0.01	9.834***
	EN	RV	0.087	0.084	0.01	8.783***
	TC	UB	0.043	0.042	0.009	4.567***
	TC	AC	0.039	0.036	0.01	3.905***
	TC	SF	0.062	0.062	0.009	6.636***
	TC	CV	0.06	0.056	0.01	6.091***
	TC	RV	0.061	0.061	0.01	6.411***
	WE	UB	0.032	0.032	0.01	3.399***
	WE	AC	0.017	0.016	0.01	1.682+
	WE	SF	0.064	0.064	0.01	6.614***
	WE	CV	0.036	0.034	0.01	3.572***
	WE	RV	0.078	0.079	0.01	8.022***
	LV	UB	0.182	0.193	0.009	20.717***
	LV	AC	0.186	0.186	0.009	19.963***
	LV	SF	0.127	0.137	0.009	14.332***
	LV	CV	0.185	0.186	0.009	19.857***
	LV	RV	0.14	0.15	0.009	15.53***
ISQ ⇒ REQ (H2)	UB	SS	0.28	0.282	0.009	31.107***
	UB	CF	0.152	0.141	0.009	16.467***
	UB	PL	0.129	0.12	0.01	13.056***
	AC	SS	0.016	0.017	0.008	1.878+
	AC	CF	0.325	0.321	0.009	37.586***
	AC	PL	0.044	0.044	0.009	4.761***
	SF	SS	0.181	0.179	0.009	20.058***
	SF	CF	0.098	0.089	0.009	10.553***
	SF	PL	0.248	0.227	0.01	25.077***
	CV	SS	0.013	0.013	0.009	1.485
	CV	CF	0.162	0.159	0.009	18.584***
	CV	PL	0.074	0.073	0.009	7.972***
	RV	SS	0.113	0.112	0.009	12.634***
	RV	CF	0.031	0.029	0.009	3.438***
	RV	PL	0.147	0.135	0.01	15.013***
REQ ⇒ RS, IR (H3, H4)	SS	RS	0.251	0.27	0.007	37.718***
	SS	IR	0.217	0.197	0.009	25.514***
	CF	RS	0.248	0.288	0.006	40.178***
	CF	IR	0.267	0.261	0.008	33.882***
	PL	RS	0.317	0.367	0.006	51.271***
	PL	IR	0.35	0.342	0.008	44.402***
RS, IR ⇒ LS (H5, H6)	RS	LS	0.405	0.346	0.01	42.437***
	IR	LS	0.276	0.28	0.008	34.268***

Note: S.E. = standard error, C.R. = critical ratio, *** <0.001, **<0.01, * <0.05, + <0.1

3) H3: REQ → RS, H4: REQ → IR

The verification of the relationship between the REQ, RS, and IR that REQ explained 69.7 % of the variance in residential satisfaction and 56.8 % of the variance in intention to side, confirming its statistical significance. The analysis of the impact of specific aspects of REQ showed that all aspects had a significant impact on these outcomes, with pleasantness having the highest impact.

4) H5: RS → LS, H6: IR → LS

Finally, RS and IR accounted for 34.6 % of the variance in life satisfaction, which was statistically significant. Although the explanatory power was not considerably high because various factors affected LS, it still represented over one-third of the impact. This suggests that satisfaction with REQ, affected by infrastructure, significantly affects LS.

5. DISCUSSION

In this study, the close relationship between infrastructure satisfaction and improvement in citizens' quality of life was statistically verified by analyzing the relationships between life satisfaction, residential satisfaction, and infrastructure satisfaction. These findings indicate the need to maintain the infrastructure at a level that meets citizens' expectations and enhances their quality of life. It was revealed that both the quantity or expansion of individual infrastructures and an understanding of the service level of infrastructure, as perceived by users and their demands, are crucial.

The national satisfaction score for actual infrastructure expansion and improvement investments was 59 points, with smaller cities scoring 56 points, which was lower than that of larger cities, exhibiting a score of 61 points. This indicates that citizens are generally dissatisfied with infrastructure investments, which are often affected by political judgments, leading to frequent undervaluations or overvaluations owing to opaque processes and ideological biases. Establishing a system that reflects local residents' needs in infrastructure investments for regional balance is expected increase residents' satisfaction with such investments and further enhance the perceived level of infrastructure services. Furthermore, it could mitigate controversies over sensitive issues such as the impact of political decisions on regional infrastructure investment priorities.

In response to whether residents' demands should be reflected in investments for infrastructure improvement and expansion, 95.1 % indicated that it should be reflected (④ Should be somewhat reflected + ⑤ Should be reflected + ⑥ Must be definitely reflected), while 4.9 % felt that it was not necessary (① Not necessary at all + ② Not necessary + ③ Somewhat not necessary). Additionally, regarding the usefulness of evaluating citizens' perceptions based on the infrastructure service quality model for improving residential environments, 92 % found it useful (④ Somewhat useful + ⑤ Useful + ⑥ Very useful), and 8 % found it not useful (① Not at all useful + ② Not useful + ③ Somewhat not useful).

Therefore, future research should propose an infrastructure report card evaluation system for Korea that considers both the quantitative and qualitative aspects of infrastructure, as suggested by the theoretical model in this study. The use of evaluation elements of the ASCE Report Card is suggested to assess the performance and quantitative aspects of infrastructure and to consider the evaluation elements of the infrastructure perception index for qualitative aspects. If infrastructure perception is evaluated among citizens, for instance, in the case of transportation infrastructure, it would be assessed not by the length of roads or the number of subway stations/bus stops but also by commute times and access times to regional transportation networks such as highways or airports. For the living infrastructure, the evaluation may depend on the time taken to reach public administration offices, medical institutions, and libraries. Such accessibility assessments can meet the required levels by expanding specific facilities. However, in cases where facility expansion is impractical, such as in airports, infrastructure service levels may be enhanced through various strategies, such as improving the connected transportation system. Another representative example is that residents might perceive water infrastructure not in terms of the capacity of freshwater and drinking water facilities but based on whether they can receive clean tap water when needed without concern for the cost. Based on the evaluation results, plans for improving or constructing freshwater and drinking water facilities to meet user demands can be formulated. In essence, the infrastructure service level, as perceived by users, becomes the target in the evaluation model, and various means to achieve this goal, such as securing quantitative stock, improving the aging infrastructure, and adjusting fees, can be suggested.

Furthermore, as indicated by the aforementioned results, there were differences in the service quality aspects that were most affected by each infrastructure sector. This implies that the measurement elements can be defined differently, as citizens perceive infrastructure differently by sector. For instance, the transportation and living infrastructure are closely associated with the quality element of 'accessibility,' and thus, 'accessibility' can be used as the perceived element of the capacity evaluation element in the ASCE Report Card. Factors such as water, environmental, and telecommunication infrastructures are closely related to the quality element of 'recoverability,' and thus, 'speed of recovery' can correspond to the resilience evaluation element in the ASCE Report Card. If an infrastructure master plan is developed based on the results of the Korean-style report card, more systematic, objective, and efficient decision making for infrastructure improvement or expansion investments can be expected, which ensures the efficiency, effectiveness, and reliability of infrastructure investment policies. In addition, it is anticipated that it can be utilized as a post-evaluation system for infrastructure investment policies.

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