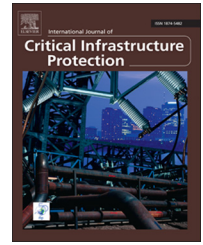


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An analytical model for benchmarking the development of national infrastructure items against those in similar countries

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ABSTRACT

Analysis of the critical infrastructure development experiences of similar countries can help identify the critical infrastructure items that are lacking in a country of interest, mitigate the risks pertaining to policy implementation failures and provide useful planning information to policymakers. To support such examinations, a double-L fuzzy similarity model that uses the infrastructure indicators included in the World Competitiveness Yearbook of 2011 is employed. A new analytic model is then developed that leverages the fuzzy model evaluations to analyze infrastructure data and understand the leading/lagging performance of infrastructure indicators in various countries. To illustrate the application of the analytic model, 10 countries that display the most similar infrastructure development conditions to those of Taiwan (country of interest) are selected. Comparing the infrastructure indicators of the 10 similar countries can enable Taiwanese policymakers to determine the significantly leading (relatively strong), significantly lagging (relatively weak) and non-significant indicators for the Taiwan environment and help identify infrastructure items that require further investment, select benchmarks for infrastructure development and set development goals.

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1. Introduction

The public infrastructure greatly affects the economic growth of a country and is a major factor that contributes to overall economic development [9,10]. The basic operations of modern society rely on the public infrastructure, without which essential services such as global supply chains, just-in-time production and consumption, global communications and high-quality health care could not exist [36].

Important government functions are to provide an infrastructure that meets the needs of the economy and society, and to ensure the ongoing and satisfactory performance of

the critical infrastructure [30]. However, governments encounter complex problems when they plan public infrastructures. For example, policymaking involves great uncertainties, planning does not yield immediate results, planning is a continuous process and no objective scale currently exists for measuring the performance of infrastructure investments [32].

Clifton et al. [7] have noted that the public interest is not the only goal in infrastructure planning because of privatization, liberalization and deregulation. Sclar [26] has shown that privatization policies change the relationship between government and investors, as the government ceases to be a

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manager, investors cease to be passive and project profitability drives public infrastructure policies. Allocations to different areas of the national infrastructure may be uneven and may be associated with the fragmentation of a country and its society [7,24,26]. Therefore, the development of a national infrastructure cannot be seen from a purely commercial perspective [7]. By establishing a public infrastructure that meets the requirements for national development, a government can reduce the negative effects of privatization, liberalization and deregulation policies.

The experiences of other countries with regard to infrastructure development are useful in formulating national development goals and plans, and especially in mitigating risks associated with failures of policy implementation and identifying infrastructures that are lacking. Many annual international survey reports (e.g., Travel and Tourism Competitiveness Report and the World Competitiveness Yearbook of 2011 [15] from the International Institute for Management Development and the Competitiveness of Cities Report from the World Economic Forum) provide invaluable and constantly updated benchmark information about developments in economies, travel and tourism, and urban areas for policymakers. Consistent with analytical targets in the areas of economy, travel and tourism, and urban development, the international survey reports define key indicators of critical infrastructure performance. Each indicator refers to one type of critical infrastructure, such as roads, railroads and air transportation. Policymakers can use the evaluation indicators to pursue several objectives: (i) rank a country among other countries; (ii) evaluate changes in a country over time; and (iii) assess the progress of a country with regard to international commitments [29]. By analyzing international survey reports, policymakers not only understand the advantages and disadvantages of their own public infrastructures, but also become aware of possible learning opportunities from other countries. Drawing on the success stories of leading countries, a government can improve the public infrastructure and increase its own operational efficiency as well as that of industries and companies, promoting inward investment in the form of funding, people and equipment, and contributing to the realization of new business models and increased domestic demand [11,34].

The crucial task in external cross-country analysis based on international survey reports is to identify the infrastructure components that should be improved (i.e., those with weak indicators). Previous studies drawing on international survey reports to perform external cross-country analysis have adopted important factors analysis and indicator performance analysis. Important factors analysis leverages data mining, multivariate statistics and optimization models to identify the indicators with the highest values in highly performing countries. These results provide a reference for low-performing countries that seek to improve [18,25,37]. Indicator performance analysis leverages cluster analysis, multivariate statistics and fuzzy evaluations to identify crucial development projects for a country based on the performance of a single indicator [11,34]. When developing a national infrastructure, important factors analysis does not enable policymakers to determine the indicators whose values differ significantly between their own country and

highly performing countries. Therefore, policymakers should consider indicator performance analysis when attempting to identify the weak elements of their country's infrastructure.

Traditional indicator performance analysis is based on the actual values (or standard deviations) of various infrastructure indicators or the rankings of nations based on these indicators. However, evaluating the performance of national infrastructures in this way has been shown to be ineffective [11,34]. An extension of indicator performance analysis to the double-L fuzzy model developed by Wang [34] is a more effective analytical tool for making international comparisons. The fuzzy model uses cluster analysis and fuzzy set theory to transform the standard deviation of each indicator to a fuzzy value. This is a more effective evaluation scale than standard deviations or national rankings for measuring leading and lagging degrees. The leading (lagging) degree specifies the difference between the value of one indicator between a country and lagging (leading) countries. A higher leading degree corresponds to a larger difference between the country of interest and lagging countries, indicating a larger advantage. A higher lagging degree corresponds to a larger difference between the country of interest and leading countries, implying a larger disadvantage. Policymakers can use the fuzzy model to evaluate each indicator more precisely than the other methods mentioned above.

When identifying lacking critical infrastructure items, the fuzzy model adopts a single perspective from which the overall fuzzy degree of infrastructure indicators of a country is evaluated. If the lagging degree of one infrastructure item is large and the leading degree is small, then the infrastructure item is considered to be significantly lagging. Since the fuzzy model does not yield information related to the lacking critical infrastructure items for the country of interest, countries with better standard deviations or economic rankings are chosen as possible learning candidates. However, whether all countries with better standard deviations or national rankings are suitable learning candidates is a question that should be considered. Many empirical studies have shown that land area [3,21] and population size [15] significantly affect the primary economic environment and the industrial composition of a country. In other words, the infrastructure requirements of countries vary from country to country. As a result, before identifying the weak critical infrastructure items and learning candidates, policymakers should evaluate the similarities between the environment in the country of interest and the environments in other countries. However, only a few models are available for performing this task.

This paper presents a new analytic approach for identifying weak critical infrastructure items. The approach involves the comparison of pairs of countries with similar infrastructure compositions (similar economic environments) with respect to the performance of each infrastructure item. If the performance of one infrastructure item of a country of interest significantly lags that of a similar country, then the infrastructure item is designated as lacking. Such a comparison not only enables policymakers to identify infrastructure items that require further investments, but also to effectively identify learning candidates and benchmarks, enabling measurable goals to be set for the development of infrastructure items.

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