Managing transport system investment risk: Maximising Prioritisation of Infrastructure Investment Proposals in the Face of Uncertainty

Executive Summary

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Background

In the last decade, interest in future mobility and transport (FMT) has seen consistent growth across the world. FMT is sought to address many transport problems, such as poor accessibility and growing congestion. However, FMT brings significant uncertainties, along with anticipated benefits. Also, many forms of FMT are expected to cause disruptions within the transport sector and potentially beyond. Therefore, infrastructure investment planning should consider the impacts of FMT. Investment decisions are usually made on the basis of general assumptions which presume that the existing infrastructure will continue to be used in the same way as they now. Also, much of the work that attempts to predict uptake and behaviours of FMT is still in development. Some literature suggests potential impacts of FMT, however, current models' ability to predict potential impacts in measurable and quantifiable terms is limited. A typical TIIA framework adopts a multi-criteria assessment (MCA) approach with a set of criteria. Infrastructure resilience against uncertainties is incorporated in some TIIA framework. However, the criteria typically used to assess infrastructure resilience are too broad and unspecific, which can leave room for subjectivity that would lead to inconsistent and unfair assessments, particularly when used across a variety of transport projects. This study explores ways to improve the capability of existing TIIA frameworks to account for the uncertainties of FMT. The improved TIIA framework would ensure that transport infrastructure planning is better prepared for the introduction of FMT and that the proposals with more future FMT potentials will be better placed within investment prioritisation.

Approach

This study explores literature to first determine a TIIA framework that is used typically in practice, and second to identify the impacts and uncertainties of FMT. It then proposes a methodology that can improve the TIIA framework. The proposed methodology is then applied to a real-life context using recent major transport projects. Through this, its limitations are identified and the conclusion is developed.

The literature review aims to provide sufficient knowledge of TIIA frameworks, particularly those that are used in practice, and the impacts and uncertainties of FMT. The scope of the review includes the literature that describes the TIIA frameworks that are used in Australian practice and the impacts and uncertainties of FMT. The implications for infrastructure investment assessment and prioritisation processes are explored by examining how the potential impacts can change the assessment outcomes.

Through reviewing existing TIIA frameworks, this study will explore appropriate ways to improve the framework to account for the uncertainties of FMT. The proposed additional tasks should not disrupt the existing process and/or require substantial additional resources. Therefore, this study needs to identify the TIIA tools currently used, the data required in the assessment and the tasks involved in the activities. Also, the appropriateness will be determined, while considering the impacts and uncertainties of FMT to ensure that the proposed methodology effectively assess them.

Once the proposed methodology is defined, it is applied in a real-life context by assessing existing transport investment proposals to test its applicability and practicality. This process can improve the methodology and identifies its limitations. Three recent major transport investment proposals from Australia are used. These are Brisbane Metro (QLD), METRONET: Yanchep Rail Extension (WA) and North East Link (VIC), which are all identified as high priority by Infrastructure Australia (Infrastructure Australia, 2020).

Literature Review

Transport Infrastructure Investment Assessment (TIIA) Frameworks

The TIIA frameworks used in Australia adopt a MCA approach. The MCA provides a systematic process to consider an investment proposal from various perspectives and the outcomes of various assessment tools. For instance, the Infrastructure Australia framework (Infrastructure Australia, 2018a) considers the "strategic fit" that assesses alignments between the project's objectives and the government's objectives; "deliverability" that assesses the project's "readiness" such as maturity of planning and assessments; and the "economic, social and environmental value" that assesses the project's value to society. A TIIA framework typically considers the following impacts using the set of criteria:

- Travel time and congestion;
- Vehicle operating costs including fuel costs;
- Environmental impacts such as air pollution;
- Health impacts; and
- Other social impacts.

Resilience against future uncertainties can be assessed within a TIIA by incorporating infrastructure resilience consideration. However, the TIIA frameworks that are currently used inadequately assess resilience against future uncertainties, including those associated with FMT. As a result, the infrastructure investment proposals that are resilient are not always prioritised.

Impacts and Implications on Infrastructure, Planning and Policy

The impact on transport demand and congestion will vary significantly depending on technology type. Also, there are claims that are potentially conflicting. This suggests that it is difficult to estimate the impacts and uncertainties of FMT in a quantified manner from the technical point of view at the moment. This means that numerical assessment tools, such as CBA, become pointless without reliable assumptions.

FMT can impact transport infrastructure, planning and maintenance in many ways through impacts on existing infrastructure and network, planning, and government's strategic-level objectives. This suggests that improving the current infrastructure investment assessment framework is crucial to ensure that the framework accommodates these changes and as a result, the decisions maximise the benefits to society.

Exploring ways to Improve the TIIA Framework

We reviewed how resilience is generally assessed to identify a suitable method to assess the resilience against the uncertainties of FMT. First, various methods that are commonly used to assess resilience, in general, are identified, then, disruption due to FMT is closely examined.

Infrastructure Resilience

Infrastructure resilience is often associated with the resilience of critical infrastructure against disruption due to natural disasters. However, the concept of "resilience" is wider than natural disasters and covers the capacity to withstand disruption, absorb disturbance, and adapt to changing conditions (Hughes & Healy, 2014).

Infrastructure resilience can be measured using various methods. However, stochastic analysis based on probability distributions requires historic forecasting models that can predict the likelihood of disruptions and determine appropriate forms of distributions for modelling. Also, conducting simulations is extremely difficult to ensure that they produce reliable outcomes when simulating mixed vehicle environment with a lot of uncertainties with demand and supply. When adopting MCA, the quality of analysis relies on the set of criteria used, thus, the criteria need to be specific and relevant in the context of FMT.

Disruption due to FMT

We explored the disruption due to FMT alongside with typically characterised disruption to determine a suitable method to assess the uncertainties of FMT. Here, we consider three types of disruptions:

- The disruption that causes negative impacts;
- The disruption that causes positive impacts; and
- The avoided disruption due to improvements in TIIA framework.

As shown, disruption due to FMT can increase or decrease utilisation. This suggests that the disruption due to FMT is more complex than the disruption due to natural disasters, which then suggests that a typical method/methodology to assess infrastructure resilience cannot fully assess the disruption due to FMT. To account for the complexity of FMT, we propose the “FMT uncertainty” criterion to be added within the existing TIIA framework, while noting that the suitable method still needs to be explored for a full assessment of the FMT uncertainty. The additional criterion would widen the scope, wider than “infrastructure resilience”, considering both increase and decrease of utilisation.

Exploring a Suitable Assessment Tool for the New Criterion

We explored various methods that can be used as the assessment tool for the “FMT uncertainty” criterion. This is necessary because examining the disruption due to FMT highlighted that a typical assessment tool for infrastructure resilience cannot fully assess the uncertainties of FMT.

Scenario testing is particularly useful when the future is uncertain and is often used in the context of FMT. It is also often used for prioritisation of transport investment proposals. Additionally, MCA is the most commonly used tool for TIIA as previously discussed, while CBA would be technically difficult as has been highlighted. Thus, we recommend the scenario testing using a MCA approach as the most suited tool for assessing the uncertainties of FMT due to technicality, practicality and applicability advantages.

Testing the Applicability and Practicality

For testing the applicability and practicality, the FMT uncertainty assessment is incorporated within the Infrastructure Australia framework (Infrastructure Australia, 2018a). Figure 12 and Table 2 (see Section 5.1) illustrates the assessment of FMT uncertainty.

Scenarios

For testing, this study incorporates the scenarios that are considered in the Transport Portfolio SAP 2019-20 document:

a) Chasing Goliath: Provide integrated transport services that deliver efficient and safe solutions for a growing State;
b) Uberlicious: Provide technology-enabled integrated transport solutions and services to support economic development and optimise the use of transport services;

c) Safe and Sound: Redirect investment into maintenance projects and optimise resources in existing transport services to continue to deliver sustainable, safe and reliable journeys; and
d) Tortoise and the Hare: Develop policy and create conditions to facilitate and enable the adoption of positive transformational transport options focused on network optimisation and influencing individual's behaviour and travel choices.

Overall, the following scenario assumptions are found as the key factors that can influence the assessment outcome across the scenarios:

- Changes in demand for PT;
- Electric vehicle and AV uptake;
- Assumption relating to congestion and pollution;
- Strategic objectives/directions; and
- Assumptions relating to economic growth.

Assessment of the FMT Uncertainty

The FMT uncertainty assessment outcomes of the three projects showed that North East Link is likely to result positively, while Brisbane Metro and METRONET: Yanchep Rail Extension are likely to be exposed to considerable uncertainty. This suggests that investment decisions for the two projects need to be carefully considered, while North East Link should stay on the high priority list.

The testing found that the assessment outcome is considerably influenced by certain features of the project scope. These are:

- The nature of the work, whether the project is a road, PT or active travel project;
- Integration of technology features, such as better journey planning tools and more efficient operation management systems; and
- Being integrated within wider transport optimisation and service integrations, such as being part of the MaaS scheme.

The testing revealed that the uncertainties associated with social value were not fully captured. This can be due to the lack of comprehensiveness of the scenarios, leading to a shortage of assumptions relating to social value in the scenarios used in this study. This limits the assessment's ability to assess the uncertainties associated with social value. Similarly, across all scenarios, the changes in deliverability criterion also suffered from lacking related assumptions. Additionally, the assessment suffers from a key limitation of MCA, which is the risk of subjectivity.

Discussion

Through the testing, first, considerable demand uncertainties were evident, which can lead to uncertainty in all benefits and disbenefits. This emphasises that all resulting impacts due to changes in demand need to be exclusively assessed under the "changes in utilisation" criterion. It also suggests that the disruption of FMT needs to be fully understood when undertaking the assessment. Second, it found that the projects that are often inflexible in the way they can be used, are exposed to more uncertainties than others. Third, the comprehensiveness of the assessment depends on the comprehensiveness of the scenarios. Fourth, identifying "triggers' would be useful as it can flag potential loss of utilisations without any detailed analyses, which can be identified through the assessment of FMT uncertainty.

This study considered both an increase and decrease of utilisation. This is particularly important, given that the increase can offset the decrease, because overall network-wide impacts need to be considered in infrastructure planning, even when assessing at project-level.

Concluding Remarks

This study explored ways to improve the capability of existing TIIA frameworks to account for the uncertainties of FMT. The literature review determined a framework that is used typically for TIIA in practice and identified the impacts and uncertainties of FMT. This study then explored incorporating infrastructure resilience within the TIIA framework. However, an examination of the disruption of FMT revealed that a commonly used infrastructure resilience assessment tool cannot fully assess the uncertainties of FMT, without any improvements. This study, therefore, considered adopting scenarios and MCA and identified a set of criteria that can fully assess the FMT uncertainties. The applicability and practicality of the proposed assessment tool are tested using real-life transport projects, which also identified its key limitations.

To best deal with the uncertainties of FMT, regularly conducting detailed analyses of status quo and emerging trends based on recent historical data is crucial. Additionally, further work on analysing transport demand trends and forecasting that can feed into developing more comprehensive scenarios would improve the capability and comprehensiveness of the proposed methodology.