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The System Dynamics of Funding and Financing of Transport Infrastructure

Athena Roumboutsos[a,*], Aristeidis Pantelias[b]

[a] *University of the Aegean, Department of Shipping, Trade and Transport, 2A Korai str, Chios 82100, Greece*
[b]*University College London, Bartlett School of Construction and Project Management, 1-19 Torrington Place, London WC1E 7HB, UK*

Abstract

The delivery of transport infrastructure projects may be viewed as a system with many interrelating factors whose interactions define and influence the successful achievement of expected project outcomes. However, transport infrastructure delivery has seldom been addressed under such a systems view. The present research studies the transport infrastructure delivery system and its dynamics and identifies key tipping points in the project life-cycle that may determine success or failure with respect to the achievement of specific project outcome targets. Key safeguards are proposed to protect the success of infrastructure delivery over the life cycle of the infrastructure with respect to decisions made by the various stakeholders over time. The methodology proposed may be used as a tool for decision makers to predict the future outcome of their decisions.

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* Corresponding author. Tel.: +30- 6973396211; fax: +30-22710-35299
E-mail address: athena@aegean.gr

1. Introduction

Infrastructure projects are assessed under various contexts and for different purposes. Assessments can take place at the front end, aiming to determine whether projects should go forward with their implementation as well as how they should be structured. They can also be undertaken at the back end, usually aiming to evaluate whether initial expected outputs and outcomes have been met. In that sense, project assessments can be ex ante or ex post, depending on their timing with respect to the project's lifecycle. Furthermore, projects are usually monitored during their life cycle in an attempt to improve the prospect of achieving positive outcomes and avoiding/mitigating negative ones.

During implementation many elements may influence the performance of a project, especially with respect to transport infrastructure: the conditions pertaining to the implementation context (financial – economic and institutional); the business model structure based on which the project performs; the way its income and revenues are conditioned; its financing; and the effectiveness and flexibility of its governance. This creates a system of interdependent factors conditioning the likelihood of achieving initially defined and targeted outcomes.

Herewith, research undertaken within the context of the BENEFIT H2020 project is reported. The key working concept has been the view that transport infrastructure project implementation may be represented by a system of indicators describing its major components and that specific combinations of them would lead to the achievement of specific outcomes (Roumboutsos, 2015). The system and its indicators is presented in the next section (2). The model proposed is heuristic in nature, in the sense that it builds upon, continuously learns from and is further improved by the consideration of information originating from real project cases. The findings from a number of parallel streams of analysis undertaken are presented in Section 3 and lead to the formulation of a Transport Infrastructure Resilience Indicator (TIRI) which is estimated for various project outcomes and transport modes. The result of this estimation is the qualitative determination of the likelihood of attainment of specific outcome targets. In Section 4, the process of monitoring and identifying system "tipping" points is presented. The paper ends with key conclusions as identified through the process of developing the Transport Infrastructure Resilience Indicator.

A key assumption running through the entire process is that the model presented is stakeholder-neutral. It remains to the individual stakeholder, depending on his/her individual value system, to assign the respective weighting to the rating of the various outcomes or take action(s) in order to favour the achievement of outcomes that reflect his/her interests more strongly.

2. The System Model

A heuristic, dynamic system approach has been adopted in mapping the interrelations of the transport infrastructure implementation system model elements influencing its functionality. The key elements considered are: the implementation context; the business model; the funding scheme; the financing scheme; the contractual governance conditions of implementation; and, finally, the transport mode context. The focus of research is the interaction of these elements expressed through appropriately selected indicators.

The proposed model, as any system, receives inputs and generates outputs/outcomes. The system itself does not represent any stakeholder view. It is the importance of the outcomes that may be perceived differently by the various stakeholders based on their distinct interests. In this context, the presented research is stakeholder neutral.

In this section, system input and outcomes are defined and the elements of the system under study are presented (see Pantelias et al, 2015).

2.1. System Input

The procurement and delivery of transport infrastructure projects is the outcome of a decision making process that considers transport-related as well as wider policy goals. Based on such considerations projects are selected for

implementation with a view to attaining clearly set goals. The expected goals define project technical characteristics (e.g. type of infrastructure, scale, size, materials, etc.) which, in turn, determine the magnitude of the investment to be made. Last but not least, a decision is made about whether the project will be procured as a purely public project or will include private co-financing. The above decisions are considered as input to the system model and their detailed modelling lies outside the studied system. However, it is recognised that such decisions carry a significant weight in terms of the subsequent structuring of the project and could therefore be of critical importance to its overall success.

Such decisions are assumed to be made in a rational way leading to projects that have a clear and rational "raison d'être". Notably, non-rational or sub-optimal decisions will feature as system imbalances.

2.2. System outcomes

Every transport infrastructure project produces outcomes that fall under five possible categories:

- Level of achievement of transport goals: pertaining to the degree by which the project has achieved its transport-related "raison d'être" (e.g. relieving congestion, increasing mobility, etc.);
- Level of achievement of forecast traffic: pertaining to the degree by which the project has met its initial usage expectations;
- Level of achievement of Project Management targets: pertaining to the degree by which the project has been delivered within time, budget and specifications (i.e. "iron triangle" considerations);
- Level of achievement of Other Benefits (economic, environmental, societal, institutional): pertaining to the degree by which the project has managed to deliver originally anticipated benefits that cannot be "harvested" by the Business Case [1], such as economic returns to society, environmental benefits, institutional changes, etc. (as and where applicable).

The model is "operationalised" to address four specific outcomes. Two pertain to the Project Management outcomes: cost and time to (construction) completion. The other two correspond to infrastructure operational goals, which are also considered in order to justify the investment: Actual vs forecast traffic and revenues.

2.3. System Indicators

The elements of the system are described by respective composite indicators, which have been developed, validated and revised (see Vanelslander et al, 2015; Voordijk et al, 2015; Mitusch et al, 2015; Pantelias et al, 2015; Roumboutsos et al, 2016a; Mladenović et al, 2016) during the course of research. Their brief presentation follows.

The implementation context is described by two indicators: the Financial-Economic (FEI) and the Institutional (InI) indicators. These indicators encompass more than their title may suggest and are built based on international indices published by prominent international institutions. More specifically, the Institutional indicator shows the extent to which the political, legal and regulatory, and administrative context in a country is stable and of a high quality. The Financial-Economic indicator measures more broadly the business environment and can be seen as a proxy of the level of productivity of a country as it focuses on the capacity of the national economy to achieve sustained economic growth over the medium term, controlling for the current level of economic development.

The Business Model element is described by two composite indicators representing the two major parts of the business model, i.e. costs and revenues. The corresponding indicators also aim to capture conditions improving efficiency and effectiveness which essentially lead to Cost Saving and Revenue Support.

In this context the composite Cost Saving Indicator (CSI) includes the ability to construct (level of civil works/ technical difficulty; capability to construct based on the market position of the contractor with respect to

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[1] The Business Case is defined as the value of the project that is anticipated to be "captured" and its corresponding costs (investment). The Business Case forms the basis for all the corresponding contractual arrangements.

construction or respective project delivery capability (example for rolling stock); construction risk allocation as per contractual agreement; assessment of optimal construction risk allocation based solely on the capability to construct); ability to monitor /control/plan and provide political support of the respective public or contracting authority; adoption of innovation and its successful application; life cycle planning and operation (life cycle planning verification; capability to operate based on the market position of the operator; operation risk allocation as per contractual agreement; assessment of optimal operational risk allocation based solely on the capability to operate). It is evident, based on the above description, that the CSI, in all practical terms, illustrates a measure of a project's efficiency during construction and operation.

The Revenue Support Indicator (RSI) is also a composite indicator that includes the level of coopetition of the new (greenfield) and existing (brownfield) parts of the project expressing the level of business development scope designed to attract demand (e.g. airports etc.); the level of project exclusivity with respect to its position in the transport network (e.g. metros, bridge and tunnel projects, ports airports under certain conditions); and the level to which a transport network supports the project's exclusivity. The RSI also includes revenue sources attached to the project (traffic from new and brownfield operation as well as traffic from other transport infrastructure bundled in the project as well as revenues related to non-transport services all in relation to the capability to manage demand; demand risk allocation; assessment of demand risk allocation based on the capability to manage demand; quality of service). Notably, the RSI may be considered a measure of the project's ability to generate revenues, and also a measure of the project's efficiency in exploiting the potential sources of revenue.

The Governance element is described by the composite Governance Indicator (GI), which refers to factors setting the governance scene within a project. In this respect, it is defined by the contractual conditions and the process leading to them. In principle, the GI is a measure of the contractual governance efficiency and flexibility.

The Funding Scheme element is described by two indicators: The Remuneration Attractiveness Indicator (RAI) and the Revenue Robustness Indicator (RRI). The indicators consider the project income and revenue streams weighted against the associated risks and are also cumulatively expressed as per the percentage of cost coverage they represent.

The Financing Scheme element is expressed through one indicator, the Financing Scheme Indicator (FSI), which reflects an expanded version of the weighted average cost of capital of the project that is able to consider financing contributions from both public and private sources.

Finally, the transport mode context is described with one indicator within the system: the Reliability Availability Indicator (IRA). Notably, other characteristics relevant to this element constitute input to the system and cannot be changed during implementation (e.g. infrastructure type, size of investment, etc.).

3. Transport Infrastructure Resilience Indicator (TIRI)

Resilience is defined in the context of this research as "the ability of a Transport Infrastructure project to withstand changes within its structural elements with respect to its ability to deliver specific outcomes (such as cost and time to completion, expected traffic and expected revenue targets)".

In the present section, the characteristics of the Transport Infrastructure Resilience Indicator (TIRI) are described followed by a brief reference to the analyses and respective findings that form the foundations of and provide the guidelines for the application of its underlying rating methodology.

3.1. Characteristics of the Transport Infrastructure Resilience Indicator

When addressing the resilience of a system, a number of the methodological considerations need to be addressed. These concern:

System Boundaries: The first consideration is the need to clearly identify the boundaries of the system of interest (Henry and Ramirez-Marquez, 2012). The present methodology, as in Filippini and Silva (2014), considers the

systemic nature of the model (see Pantelias et al, 2015) which communicates with the wider universe of infrastructure delivery through its inputs, i.e. all decisions concerning the project made prior to project award. These also include the project budget, construction duration, forecast traffic and revenues.

Amongst the system indicators the Financial Economic Indicator (FEI) and the Institutional Indicator (InI) are considered exogenous to the project as they affect the project but cannot be influenced by its stakeholders. All other indicators are considered endogenous as, while they also affect project performance, actions may be taken in order to influence the sign of their impact. Moreover, they may also be used to address negative effects from the exogenous indicators.

Figure-of-Merit: A system's resilience is measured against its ability to reach specific goals (Henry and Ramirez-Marquez, 2012). The model considers four goals with respect to system performance Cost-to-Completion; Time-to-Completion; Actual vs Forecast Traffic; and Actual vs Forecast Revenue. Hence, the TIRI addresses four different Figures-of-Merit. As expected, the system may exhibit simultaneous resilience for one or more figures-of-merit but not necessarily for all.

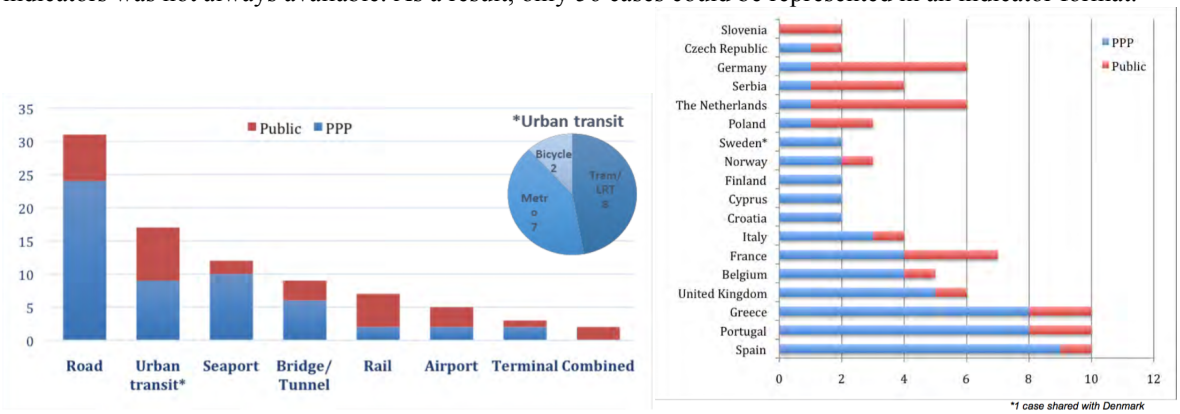
Actionable Variables and Background Conditions: The Transport Infrastructure Resilience Indicator (TIRI) rating is structured by clearly differentiating between the endogenous and the exogenous indicators. In the developed rating system, it becomes immediately obvious which indicators need to be addressed in order to improve resilience (Rose and Krausmann, 2013).

System Stability: It is acknowledged that the system will change over time, especially as a response to involuntary changes in the exogenous indicators. In this context, it is not enough to provide a TIRI rating reflecting current conditions (Static Transport Infrastructure Resilience Indicator, S-TIRI). This indicator needs to be accompanied by an indication of potential resilience to change. To this end, the methodology also includes a Dynamic Transport Infrastructure Resilience Indicator (D-TIRI).

Accuracy and Transparency: The TIRI needs to be based on information that is accurate and transparent (Fisher et al, 2010). The rating methodology proposed is systematic, consistent and does not require a qualitative assessment or objective interpretations. Therefore, the resulting TIRI ratings (Static and Dynamic) are both reproducible and easy to verify.

3.2. Transport Infrastructure Project Performance

The BENEFIT project case study database constituted the basis of analysis. The dataset assembled for the purpose of the analysis of the case studies includes 86 cases, of which 55 are PPPs and 31 public projects. Figure 1 presents their distribution with respect to (a) transport mode and (b) country of implementation. Both delivery models are clearly differentiated through colour coding. However, data to construct the various aforementioned indicators was not always available. As a result, only 56 cases could be represented in an indicator format.



(a) (b)

Figure 1: Distribution of BENEFIT Case studies per mode (a) and country (b)

A multi-analyses approach was followed to identify the factors influencing a project's likelihood to reach pre-specified outcome targets (see Roumboutsos et al, 2016a and Mladenović et al, 2016). The indicator sets were analysed quantitatively using Fuzzy set Qualitative Comparative Analysis (cfr. Ragin, 2008), Importance Analysis (or Sensitivity Analysis, cfr. Saltelli et al, 2008) and Econometrics. The actual cases were also analysed qualitatively per mode. Emphasis was placed on the assessment of project performance with respect to the financial-economic crisis and its impact. These four streams of analyses were compared and considered in a complementary fashion in order to provide guidelines with respect to the combination(s) of indicators and their respective values required to achieve specific outcome targets per mode (see Roumboutsos et al, 2016b). Findings are presented per mode and outcome in Tables A.1 to A.4 of the Annex.

A key finding from the synthesis of these analyses has been the fact that each transport infrastructure mode is influenced differently by the implementation context and that different indicators contribute in each case to the achievement of project outcome targets. This finding guides the assessment of resilience towards an infrastructure mode-specific process, which also includes a different specification of the threshold that defines "high" and "low" values for the indicators of each mode under consideration. It is also noticeable that some indicators are more prominent than others while neither single indicators nor specific combinations of them are able to secure the successful attainment of single outcomes targets, let alone of all four outcomes targets simultaneously. More specifically:

Indicators Exogenous to the project

- The Financial-Economic indicator (FEI) is an important indicator, but does not have the same impact on all modes. Road projects are particularly sensitive to the FEI as it was found to influence all outcomes apart from revenues. For urban transit projects the FEI could have a varying affect which may be offset by other indicators. In bridge and tunnel projects the negative impact of a low and/or decreasing FEI may also be offset by high values of other indicators (GI, CSI and RSI). For airports the FEI influenced cost and time targets but traffic and revenues should consider an extended version of it.
- The Institutional indicator (InI) has been identified as potentially the most important external indicator across all modes and for all outcomes. In many cases it was identified to be able to offset the impact of a low or decreasing FEI.

Indicators Endogenous to the project

- The Governance indicator reflects in many ways the level of institutional maturity in the country of project procurement. In this effect, it may compensate and/or enhance the Institutional Indicator.
- The Cost Saving indicator describes the project's technical difficulty and also the capabilities of key project actors: the constructor's to construct, the operator's to operate, and the monitoring authority's to monitor the project in consideration. This indicator was found to contribute to all outcomes and, in most cases, works in combination with GI. More specifically, it was found in many cases that a low value of the CSI could be offset by a higher value of GI and vice versa.
- The Revenue Support indicator could only have a positive role. However, it is not always possible to have a high value and/or in many cases the projects are not designed for a high value of the RSI.
- The Remuneration Attractiveness Indicator can act as a policy tool. Demand-based remuneration schemes (low value of RAI) work well under positive exogenous conditions. In an adverse context a low value of RAI needs to be supported by other indicators.
- The Revenue Robustness Indicator expresses the riskiness of the project revenue streams as well as the estimated level of cost coverage.

What is noticeable is the importance of the overall Business Model and Governance indicators across all modes and outcomes with the exception of revenues for roads, where the influence of the implementation context is far more prominent. The same indicators are also important for ports, although positive outcomes may be achieved under poor conditions for these specific projects. It should also be noted that while the Governance indicator is

based on the contractual setup and reflects the tendering procedure, both Business Model indicators (CSI and RSI) are composite and for each mode particular aspects of them may be of greater importance.

Another point of interest is the Financing Scheme indicator and its role in developing strategic trade-offs between cost and time outcomes. It was observed that projects with high contributions of public sector support (high value of FSI) seek to achieve "on-budget" targets, while in cases where private financing is dominant (low FSI) there is an effort to predominantly achieve "on-time" targets. In addition, supporting project revenues lead to higher values of the FSI.

In summary, while the outcomes of transport infrastructure projects are influenced by factors outside the managerial ability of the parties involved, there are many other internal project factors that may be addressed to improve their potential of achieving expected outcome targets. This is an important input for the development of the resilience assessment methodology as it suggests that project resilience could be improved by managing internal project parameters since external factors are not within the influence of project stakeholders. Further to this remark, it also interesting to note that between the endogenous indicators there are three, namely the Remuneration Attractiveness, Revenue Robustness and Financing Scheme Indicators, that may be considered "**policy indicators**" as they drive project outcomes differently according to their values. This is a sharp contrast with respect to the other internal indicators for which, when important, low values are associated with low likelihood of achieving outcome targets.

3.3. The Transport Infrastructure Resilience Indicator Rating System

The Transport Infrastructure Resilience Indicator comprises three basic rating categories, namely A, B and C. These are specified as follows:

A: Describing very high likelihood of reaching the figure-of-merit target values (achievement of outcome). Projects assigned an A rating exhibit high values for both exogenous (Financial-Economic (FEI) and Institutional (InI)) and endogenous (all other) indicators. The threshold values that determine the required "high" indicator values for each infrastructure mode are specified separately based on the synthesis of findings.

B: Describing average likelihood of reaching the figure-of-merit target values (achievement of outcome). A project assigned a B rating exhibits potential vulnerability that may be due to either exogenous (Financial Economic Indicator (FEI) and Institutional Indicator (InI)) or endogenous (all other indicators) conditions. Because of these two different sources of vulnerability, this rating category is further divided into B_{EX} and B_{EN}, corresponding to:

- **B_{EX}**: A rating describing a fairly robust internal project structure but subject to exogenous vulnerability;
- **B_{EN}**: A rating describing a project implemented under largely positive exogenous conditions but with internal structure vulnerabilities.

C: Describing low likelihood of reaching the figure-of-merit target values (achievement of outcome). Projects assigned a C rating are vulnerable to both exogenous and endogenous conditions.

Furthermore, due to the many indicators involved in determining each rating for each figure-of-merit and mode, slightly better or worse conditions may exist. These are presented with additional rating notches, (+) or (-) shown next to the basic rating, A, B or C. Table 1 summarises the range of potential values of the proposed rating system.

Following this rating system and in combination with indicator combinations leading to the likelihood of achievement of outcomes per mode, a detailed methodology addressing each mode and outcome was developed (see Roumboutsos et al, 2016a).

Table 1: Transport Infrastructure Resilience Indicator Rating System

Exogenous Vulnerability	Rating Category	Endogenous Vulnerability
None	A	None
None	A-	Some
Some	B_{EX}	Limited
Endogenous structure reduces vulnerability	B_{EX}+	Limited
Endogenous structure increases vulnerability	B_{EX}-	Limited
Limited	B_{EN}	Some
Limited	B_{EN}+	The combination of endogenous and exogenous conditions reduces vulnerability
Limited	B_{EN}-	The combination of endogenous and exogenous conditions increases vulnerability
Existing The combination of endogenous and exogenous conditions reduces vulnerability	C+	Existing The combination of endogenous and exogenous conditions reduces vulnerability
Existing	C	Existing

4. System Monitoring and "Tipping Points"

Monitoring the infrastructure delivery system is carried out by monitoring the project's rating. For each outcome, indicator combinations and their respective values formulate "tipping" points. More specifically, for each outcome (or the outcomes of interest to a particular stakeholder) the indicator values should be such so that, ideally, the rating is equal or higher to B_{EX+} or just B_{EX}. This rating category secures that the endogenous project indicators are such that the project has a significant likelihood of withstanding the impact of a relatively adverse implementation environment. Additionally, both exogenous and endogenous indicators may change over the life time of a project. While there may be little influence both decision makers and managers can exert over exogenous indicators, endogenous indicators are clearly within their sphere of influence. However, it is commonly known (cfr. Polydoropoulou and Roumboutsos, 2009) that the ability to influence endogenous indicators is reduced as the project development progresses. This places increased emphasis on the quality of decision-making at the front end of projects.

To this end and in order to describe a process that can lead to higher project implementation resilience, the planning phase is taken as the starting point presenting a stage during which a series of iterative investigations need to be undertaken to test for various scenarios of project structuring and implementation. Figure 2 illustrates the suggested process as described in this section which is also applicable to subsequent project phases, i.e. procurement, financial close, implementation as well as renegotiations (if applicable).

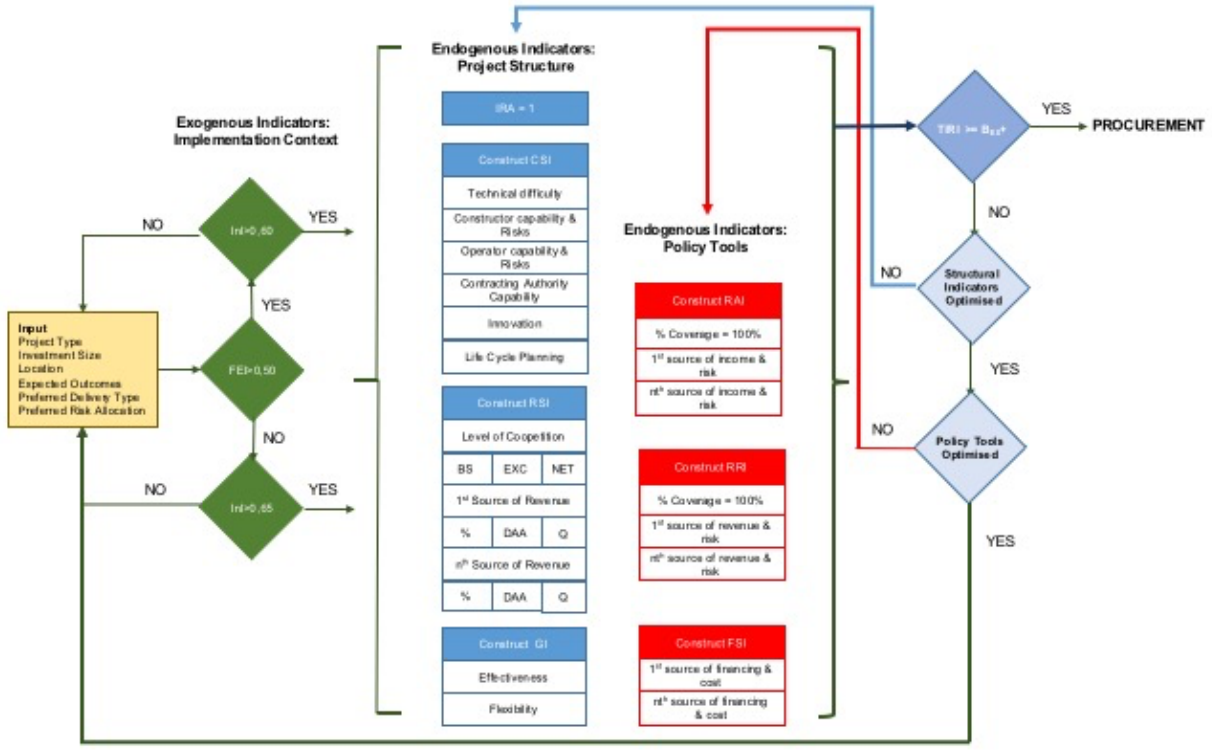


Figure 2: Schematic representation of iterative investigation process at the planning stage

The presentation which follows is generic and endogenous indicator combinations should be considered per outcome and transport infrastructure mode.

4.1. Planning Phase

Exogenous Indicators: Implementation Context (FEI and InI)

The analysis identified that projects delivered in a implementation context characterised by a Financial-Economic indicator of FEI<0.50 should be treated with extreme caution, since their likelihood of reaching specified outcome targets is severely diminished. However, if the Institutional Indicator has a high value (InI>> 0.65) then, a relative improvement of the odds is expected, especially if an increasing trend in the FEI is observed. The conditions for FEI are not compulsory for urban transit projects, while a high InI is important in this case.

Endogenous Indicators: Project Structure (IRA, CSI, RSI, GI)

The design of the structure of the project together with input from all previous studies leads to the initial estimation of the corresponding indicators. Within this section, the Reliability/Availability (IRA), the Cost Saving (CSI), the Revenue Support (RSI) and the Governance (GI) indicators are considered.

IRA is considered to be IRA=1 reflecting the reliability and availability of service. If, within the life cycle of the project, partial operation or staged inauguration is planned, IRA will take respective values over time.

CSI at the planning phase should reflect the actual conditions for its known parameters and assist in the investigation of plausible scenarios for those not known following the indicator estimation process. More specifically, the CSI considers in principle the following parameters: Technical difficulty, Constructor Capability, Operator Capability, Contracting Authority's Capability, Innovation, and Life cycle planning.

RSI is assessed based on the project's configuration in the transport network and the revenue sources initially planned. The indicator considers the following parameters: Level of Coopetition, Sources of revenues, and Quality of service/ user satisfaction per source of revenue.

GI is composed of two sets of parameters (or sub-indicators) concerning governance effectiveness/efficiency and flexibility. It takes into account:

- The project's "needs" in capabilities as they are estimated in the construction of the CSI and RSI,
- The preferred risk allocation
- The procurement laws and regulations applied in the contracting authority's respective level of government. At the planning stage the minimum values of the parameters are set.

Endogenous Indicators: Policy Tools (RAI, RRI, FSI)

This set of indicators reflect the contracting authority's (public sector) policy.

RAI reflects the decision with respect to the potential streams of project income or the remuneration scheme associated with the risks each source of income may present and the coverage ratio potentially achieved. Normally, 100% cost coverage should be estimated at this stage although respective scenarios of lower coverage may also be developed.

RRI reflects the various sources of project generated revenues (connected to RSI) associated with their respective risk and the expected cost coverage that may be assumed. Again, 100% coverage should be estimated at this stage, but also respective scenarios of lower coverage may be developed.

FSI reflects the model of project delivery (Public or with Private Financing) as well as the potential structure of the financing in terms of cost of capital. Notably, at this stage, key scenarios may be tested: 100% public financing (FSI=1); strictly or the majority of the financing coming from the private sector (usually FSI<0,300); private financing with significant public support through guarantees, public contribution of financing etc. (usually FSI>0,600). The effect on FSI of innovative financing instruments can also be tested at this point.

4.2. Procurement

The analysis at the planning stage will define the procurement process, tendering documents and other minimum requirements so that the Governance indicator can achieve a value greater or equal to the one identified in the planning process. As corroborated by experience, all initial estimates generated during the planning stage will, more often than not, not materialise in practice. All endogenous indicators should then be re-calculated based on the contractual agreement terms and the capabilities of the actual actors involved (constructor, operator etc.) and the project rated once again. If the rating is less than favourable, corrective actions need to be investigated. Notably, from this stage onwards, the flexibility of the structural indicators is reduced.

4.3. Financial Close

Reaching financial close will finally define the Financing Scheme Indicator. At this point it is worth estimating the project rating in order to identify the optimum synthesis of financing sources that would lead to an improved and stable rating. Notably, the value of the FSI has a different influence on the various outcomes and decision-makers would need to make an overall assessment based on their own interests and priorities.

4.4. Implementation Phase

During the implementation phase, both exogenous and endogenous indicators may vary over time. More specifically:

- The implementation context (FEI and InI) may become more or less favourable;

- Contractual terms, especially with respect to risk allocation may be honoured to a greater or lesser extent (GI, CSI, RSI);
- Coverage and risks related to the income and revenues may vary (RAI, RRI);
- Financing sources and respective cost of capital may vary (FSI)
- etc.

The Transport Infrastructure Resilience Indicator Rating will provide a measure of the project's stability and likelihood of reaching outcomes allowing for corrective actions or mitigation measures to be introduced. As noted previously, following project award and financial close the project system becomes less flexible.

4.5. Renegotiations

The model may be applied to assess improvements that can be brought about during potential renegotiations. Notably, renegotiations should result in an improved project rating for individual outcomes of interest or all of them simultaneously. However, the anticipated challenge under a renegotiation setting is whether interests and priorities are aligned, as if this does not hold true each party would be seeking the optimal settlement of its own individual interests which may not necessarily coincide with an overall optimal restructuring of the project. The use of the Transport Infrastructure Resilience Indicator rating could help identify such imbalances or misalignments of interests and help craft renegotiation solutions that are as close to the overall optimum as reasonably possible.

5. Conclusions

Transport infrastructure delivery has been modelled as a system described by the interrelations of indicators representing the exogenous conditions of the implementation context; the endogenous conditions referring to its structure and organization; and its endogenous condition referring to the policy intervention (tools) indicators. The performance of these indicators was reflected in the underlying rating categories of the Transport Infrastructure Resilience Indicator. Each rating category corresponds to different combination(s) of indicator values per outcome and transport mode having a particular likelihood of reaching pre-defined project outcome targets. The rating category that reflects the "tipping point" of the Transport Infrastructure Resilience Indicator should be considered at $B_{EX}+$ or just at B_{EX}, as below this rating the likelihood of not achieving a pre-defined outcome target is increased.

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Annex

Table A.1: Summary of indicators influencing outcomes in Road Infrastructure projects

Outcomes / Indicators	Cost to Completion	Time to Completion	Actual vs Forecast Traffic	Actual vs Forecast Revenue
Financial – Economic Indicator (FEI)	Strong positive or negative influence depending on high or low value	Positive or negative influence depending on high or low value (May be off-set by GI and InI)	Very strong Positive or negative influence depending on high or low value	
Institutional Indicator (InI)	Pre-requisite	Pre-requisite (Acts in combination with GI)	High value may limit effect of FEI	
Governance Indicator (GI)	Needed (compensates for low CSI)	Pre-requisite (Acts in combination with InI)	High value may limit effect of FEI	Support: High Value
Cost Saving Indicator (CSI)	Needed (compensates for low GI)	Needed	High value may limit effect of FEI	Support: High Value
Revenue Support Indicator (RSI)	Support			Expected for High Value
Remuneration Attractiveness Indicator (RAI)		Driver: Low values	High value may limit effect of FEI	Support: High Value
Revenue Robustness Indicator (RRI)		Driver: Low values		Key Indicator
Financing Scheme Indicator (FSI)	Driver: High values			Expected for High Value
Reliability /Availability (IRA)			Needed	Needed

Table A.2: Summary of indicators influencing outcomes in Bridge & Tunnel Infrastructure projects

Outcomes / Indicators	Cost to completion	Time to completion	Actual vs Forecast Traffic	Actual vs Forecast Revenues
Financial – Economic Indicator (FEI)	High Value important. Low Values may be off-set by high values of the other indicators			
Institutional Indicator (InI)	High Value	High Value	High Value (prerequisite for Low RAI)	High Value (prerequisite for Low RAI)
Governance Indicator (GI)	High Value	High Value	High Value (prerequisite for Low RAI)	High Value (prerequisite for Low RAI)
Cost Saving Indicator (CSI)	High Value	High Value	High Value (prerequisite for Low RAI)	High Value (prerequisite for Low RAI)
Revenue Support Indicator (RSI)	High Value (High LoC Important)	High Value (High LoC Important)	High Value (High LoC Important)	High Value (High LoC Important)
Remuneration Attractiveness Indicator (RAI)		Low Value (May compensate for RRI)		
Revenue Robustness Indicator (RRI)		Low Value (May compensate for RAI)		High Value
Financing Scheme Indicator (FSI)	High Value	High Value	High Value	High Value
Reliability /Availability (IRA)			Needed	Needed

Table A.3: Summary of indicators influencing outcomes in Urban Transit projects

Outcomes / Indicators	Cost to completion	Time to completion	Actual vs Forecast Traffic	Actual vs Forecast Revenues
Financial – Economic Indicator (FEI)				Only with respect to advertisements
Institutional Indicator (InI)	High Value	High Value	High Value	High Value
Governance Indicator (GI)	High Value	High Value (May be combined with CSI)	High Value (May be combined with CSI)	High Value
Cost Saving Indicator (CSI)	High Value	High Value (May be Combined with GI)	High Value (May be Combined with GI)	High Value
Revenue Support Indicator (RSI)	High Value	High Value	High Value (With emphasis on LoC)	High Value
Remuneration Attractiveness Indicator (RAI)			Support	High Value
Revenue Robustness Indicator (RRI)				High Value
Financing Scheme Indicator (FSI)				
Reliability /Availability (IRA)			Prerequisite	Prerequisite
Comment	All indicator above should have high values			At least two of the above indicators should bear a high value.

Table A.4: Summary of indicators influencing outcomes in Airport Infrastructure projects

Outcomes / Indicators	Cost to completion	Time to completion	Actual vs Forecast Traffic	Actual vs Forecast Revenues
Financial – Economic Indicator (FEI)	High Value important	High Value important	High Value - Connected to international Financial – Economic conditions	High Value - Connected to international Financial – Economic conditions
Institutional Indicator (InI)	High Value	High Value	High Value	High Value
Governance Indicator (GI)	High Value	High Value	High Value	High Value
Cost Saving Indicator (CSI)	High Value	High Value	High Value	High Value
Revenue Support Indicator (RSI)	High Value (High LoC Important)	High Value (High LoC Important)	High Value (High LoC Important)	High Value (also alternative revenues)
Remuneration Attractiveness Indicator (RAI)		Low Value (May compensate for RRI)		
Revenue Robustness Indicator (RRI)		Low Value (May compensate for RAI)	High Value	High Value
Financing Scheme Indicator (FSI)	High Value	High Value		
Reliability /Availability (IRA)			Needed	Needed