Supporting the process of transport infrastructure decision-making:

an instrument to identify the combinations of conditions under which project objectives can be achieved

A dissertation submitted

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(...) Keep Ithaka always in your mind.
Arriving there is what you're destined for.
But don't hurry the journey at all.
Better if it lasts for years,
so you're old by the time you reach the island,
wealthy with all you've gained on the way,
not expecting Ithaka to make you rich.

Ithaka gave you the marvelous journey.
Without her you wouldn't have set out.
She has nothing left to give you now.

And if you find her poor, Ithaka won't have fooled you.
Wise as you will have become, so full of experience,
you'll have understood by then what these Ithakas mean.

Constantine Peter Cavafy

Doing a PhD is what I wanted to do. I knew it from my first months as an undergraduate student in Economics at the Aristotle University of Thessaloniki, my loved hometown in Greece. At this moment I did not even know well what a PhD exactly means and entails but this is one of the strange things that you cannot explain with words but you just know you are where you belong. This is what fulfills you and makes you happy.

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After finishing my undergraduate studies in Economics with a specialization in Business Administration and my master degree in Administration and Economy with a specialization in Economics and Regional Development, I started looking for a PhD opportunity. My search led to the University of Antwerp and the Department of Transport and Regional Economics. I thought this is the place for me to be, due to the very high relevance of the department with the field of my studies. Thus, I applied for a research/PhD vacancy that I found online and this is how all started. I still remember my first day at the University of Antwerp, 1st September 2014, when I arrived for passing my interview. All the professors in the interview were very friendly, which helped me feel less stressed.

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Abstract

Transport infrastructure (TI) is a vital economic and social asset, which absorbs high investments to be constructed and maintained. It is highly complex and involves high level of uncertainty, due to lack of knowledge of the past and the present and due to inability to predict future events. This is the reason why the decisions that decision makers are called to make for the TI projects throughout their lifecycle are critical.

The decisions that will be taken at the early planning and evaluation stage should be "correct'', meaning that the TI project that will be selected and approved to be constructed should meet its project objectives. The performance of TI projects needs to be monitored and controlled after its approval, during the construction and operation phase to ensure that the project objectives that have been initially set will be achieved. This is how project success is defined in project management literature and also in the present doctoral thesis. More specifically, in the present doctoral thesis, project success is defined as the achievement of four key project objectives, of the cost objective, the time objective, the traffic objective and the revenues objective, which have been found to be extensively presented in project management literature as the key project objectives for the (transport) infrastructure projects. Thus, a project is considered successful, if it is delivered on the cost and time that have been initially estimated (or with less cost and in less time) and with the traffic and revenues initially forecasted (or with higher traffic and revenues). These project objectives are an extended version of the traditional project management triangle or Iron Triangle or triple constraints, which included only the objectives of cost, time and scope.

Thus, it is of high importance to approve projects that are able to meet their key project objectives and to also keep monitoring and controlling the performance of the TI projects throughout their life to increase the likelihood that the project objectives will be met. However, it is common that the approved projects finally do not meet their project objectives. Cost-benefit analysis (CBA) is the core appraisal method that is used to support decision making for the approval or not of major infrastructure projects, including TI projects. Sometimes, if considered necessary, CBA is combined with other appraisal methods, such as the Multi-criteria analysis (MCA) or/and cost-effectiveness analysis (CEA). However, it is often the case that the cost and benefit estimates of the CBA are inaccurate and biased, thus leading finally to the approval of ''bad'' projects, which are projects that although appeared as positive in the CBA results, they finally did not meet their project objectives and have cost overruns and/or benefit shortfalls. The factors that lead to cost and time overruns and traffic and revenues underruns are many, as found in literature. Therefore, even a TI project with positive CBA results can finally end up to be a failure, in terms of not achieving its key project objectives of cost, time, traffic and revenues, due to the fact that key factors are not included in the CBA. The present doctoral thesis is useful to fill this gap.

The present doctoral thesis comes to support the TI projects' decision making process throughout the different phases of the TI projects' lifecycle, from the early stages of planning and evaluation till the construction and operation phase, by identifying the combinations of factors that affected the performance of past TI projects. This is the research objective of this thesis. It thus contributes to a more informed decision making process for TI projects throughout their lifecycle and to a decrease of the level of uncertainty involved in them.

The steps that have been followed in the thesis are the following: **step 1:** acquiring a knowledge background of TI project investments, **step 2:** identifying the key project objectives of TI projects to use them as dependent variables, **step 3:** identifying the research gap in the existing decision support tools that are currently used, **step 4:** identifying the factors that affect the performance of TI projects, amongst them selecting the most appropriate ones to use them as independent variables and also developing an indicator to be used as one of the independent variables, **step 5:** doing a literature review of the methods of analysis used currently in studies to find the cause and effect relationships between the key project objectives and the factors affecting

performance of TI projects, **step 6:** collecting data, cleaning them and calibrating them and running the fuzzy set qualitative comparative analysis (fsQCA), which is the method of analysis that has been selected, **step 7:** developing a new three-step decision support tool called **''Project objectives' achievement compass'' (POAC)**, based on the fsQCA findings, the indicators used and the fsQCA calibration method, **step 8:** demonstrating the application of the newly developed POAC and partially validating it, using cases used in the empirical analysis and **step 9:** wrapping up all the main thesis' outputs.

POAC is a compass that shows to the interested parties the direction and more specifically the ''path'' towards the achievement or not, of key project objectives. POAC is a new decision support tool that complements the CBA and the risk analyses done within CBA and supports rational decision making by taking into account factors that are not included in CBA. It can be applied during the construction and operation phase of the project, to monitor and control its performance in terms of achieving its projects objectives. Also, it can be applied at the planning and evaluation phase of the TI project (under scenarios and using estimations and assumptions), showing if the project is likely to achieve the project objectives or not and also showing due to which factor(s), one or more project objectives are likely not to be achieved, if the results show non-achievement of project objectives. Hence, in this way the POAC shows to its users also what to change in their project, so as to increase the likelihood of achieving the key four project objectives.

The POAC tool has the following advantages: it interprets the transport system from a holistic point of view, as the composition of key elements that interrelate and interact to produce performance outcomes and is characterized by simplicity, thanks to which rationality of decision making increases because it does not require someone to be an expert analyst to be able to apply it and interpret its results.

The readers of the thesis aside to get themselves familiar with the new decision support tool, they will be shown the exact steps they should follow so as to apply it. The demonstration of the tool's application is made for a TI project that is in its operation stage. However, as mentioned above POAC can be also applied at the planning and evaluation phase, assuming the values to be used in the indicators and creating different scenarios, considering that the indicators that POAC uses are available after contract award. The user in this case of applying the POAC at the early project stage of planning and evaluation could use sensitivity analysis of the various values used. Monte Carlo simulation could be also used to generate values for the factors included in the indicators.

The readers will be also introduced to an overall background knowledge relevant to the thesis' topic and will acquire knowledge for the overall sample of cases used in the analysis and for the reasons that caused cost and time overruns, traffic and revenue underruns in each of them. The data that are used are 51 European TI projects of all types of modes, both publicly financed and public private partnerships (PPPs) and of all investment sizes. These data are collected under the H2020 BENEFIT research project of the European Commission and the COST Action TU1001.

In addition, they will be able to gain knowledge about a new indicator that has been developed in this thesis, so as to be used as one of the independent variables in the analysis and also about the fsQCA analysis of different sub-samples of the overall sample of the 51 transport infrastructure European projects. Thus, not only the readers will see how fsQCA method works and how its results are interpreted but they will also take overall conclusions out of the fsQCA results, showing the combinations of conditions under which project objectives can be achieved, which reply to the two research questions of the thesis. The output of the present thesis can be useful for analysts, decision makers, financiers and in general for all the stakeholders that are involved in TI planning and evaluation, construction and operation and academic scholars working with similar scientific topics. The main limitation of this study is that the POAC tool has not been externally validated yet.

Nederlandstalig abstract

Transportinfrastructuur (TI) is een vitale economische en sociale troef, die hoge investeringen absorbeert die moeten worden aangelegd en onderhouden. Het is zeer complex en brengt een hoge mate van onzekerheid met zich mee, vanwege een gebrek aan kennis van het verleden en het heden en vanwege het onvermogen om toekomstige gebeurtenissen te voorspellen. Dit is de reden waarom de beslissingen die besluitvormers moeten nemen voor de TI-projecten gedurende hun levenscyclus van cruciaal belang zijn. De beslissingen die in de vroege plannings- en evaluatiefase worden genomen, moeten 'juist' zijn, wat betekent dat het TI-project dat wordt geselecteerd en goedgekeurd om te worden gebouwd, aan de projectdoelstellingen moet voldoen. De prestaties van TI-projecten moeten worden gecontroleerd en gecontroleerd na goedkeuring, tijdens de constructie- en exploitatiefase om ervoor te zorgen dat de aanvankelijk gestelde projectdoelstellingen worden bereikt. Dit is hoe projectsucces wordt gedefinieerd in de projectmanagementliteratuur en ook in dit proefschrift. Meer specifiek, in dit proefschrift wordt projectsucces gedefinieerd als het bereiken van vier belangrijke projectdoelstellingen, van de kostendoelstelling, de tijddoelstelling, de verkeersdoelstelling en de inkomstendoelstelling, waarvan is vastgesteld dat ze uitgebreid worden gepresenteerd in projectbeheer literatuur als de belangrijkste projectdoelstellingen voor de (transport)infrastructuurprojecten. Een project wordt dus als succesvol beschouwd als het wordt opgeleverd met de aanvankelijk geraamde kosten en tijd (of met minder kosten en in minder tijd) en met het verkeer en de inkomsten die aanvankelijk waren voorspeld (of met meer verkeer en inkomsten). Deze projectdoelstellingen zijn een uitgebreide versie van de traditionele projectbeheerdriehoek of de ijzeren driehoek of drievoudige beperkingen, die alleen de doelstellingen van kosten, tijd en reikwijdte omvatten.

Het is dus van groot belang om projecten goed te keuren die in staat zijn om hun belangrijkste projectdoelstellingen te bereiken en om ook de prestaties van de TI-projecten gedurende hun hele leven te blijven monitoren en controleren om de kans te vergroten dat de projectdoelstellingen zullen worden gehaald. Het komt echter vaak voor dat de goedgekeurde projecten uiteindelijk niet aan hun projectdoelstellingen voldoen. Kosten-batenanalyse (KBA) is de belangrijkste beoordelingsmethode die wordt gebruikt ter ondersteuning van de besluitvorming over het al dan niet goedkeuren van grote infrastructuurprojecten, waaronder TI-projecten. Soms wordt MKBA, indien nodig geacht, gecombineerd met andere beoordelingsmethoden, zoals de Multicriteria-analyse (MCA) of/en kosteneffectiviteitsanalyse (KEA). Het is echter vaak zo dat de kosten- en batenramingen van de KBA onnauwkeurig en vertekend zijn, wat uiteindelijk leidt tot de goedkeuring van 'slechte' projecten, dit zijn projecten die, hoewel positief in de KBA-resultaten, uiteindelijk hun projectdoelstellingen niet hebben gehaald en kostenoverschrijdingen en/of tegenvallende baten hebben. De factoren die leiden tot kosten- en tijdoverschrijdingen en verkeers- en inkomstenonderschrijdingen zijn talrijk, zoals blijkt uit de literatuur. Daarom kan zelfs een TI-project met positieve KBA-resultaten uiteindelijk mislukken in de zin van het niet behalen van de belangrijkste

projectdoelstellingen van kosten, tijd, verkeer en inkomsten, vanwege het feit dat sleutelfactoren niet zijn opgenomen in de KBA . De huidige doctoraatsthesis is nuttig om deze leemte op te vullen.

Dit proefschrift ondersteunt het besluitvormingsproces van de TI-projecten gedurende de verschillende fasen van de levenscyclus van de TI-projecten, van de vroege stadia van planning en evaluatie tot de constructie- en exploitatiefase, door de combinaties van factoren te identificeren die de prestaties beïnvloedden. van eerdere TI-projecten. Dit is het onderzoeksdoel van dit proefschrift. Het draagt dus bij aan een beter geïnformeerd besluitvormingsproces voor TI-projecten gedurende hun hele levenscyclus en aan een vermindering van de onzekerheid die ermee gepaard gaat. De stappen die in het proefschrift zijn gevolgd zijn de volgende: stap 1: het verwerven van een kennisachtergrond van TI-projectinvesteringen, stap 2: het identificeren van de belangrijkste projectdoelstellingen van TI-projecten om ze als afhankelijke variabelen te gebruiken, stap 3: het identificeren van de onderzoekskloof in de bestaande beslissingsondersteunende instrumenten die momenteel worden gebruikt, stap 4: identificeren van de factoren die van invloed zijn op de prestaties van TI-projecten, waaronder het selecteren van de meest geschikte om ze als onafhankelijke variabelen te gebruiken en ook het ontwikkelen van een indicator die moet worden gebruikt als een van de onafhankelijke variabelen, stap 5: literatuuronderzoek doen naar de analysemethoden die momenteel in onderzoeken worden gebruikt om de oorzaak en gevolg-relaties te vinden tussen de belangrijkste projectdoelstellingen en de factoren die de prestaties van TI-projecten beïnvloeden, stap 6: gegevens verzamelen, opschonen en kalibreren en het uitvoeren van de fuzzy set kwalitatieve vergelijkende analyse (fsQCA), de gekozen analysemethode, stap 7: het ontwikkelen van een nieuwe driestaps beslissingsondersteunende tool genaamd ''Project goals' achievement compass'' (POAC), gebaseerd op de fsQCA bevindingen, de gebruikte indicatoren en de fsQCA kalibratiemethode, stap 8: demonstreren van de toepassing van de nieuw ontwikkelde POAC en gedeeltelijk valideren het, met behulp van cases die zijn gebruikt in de empirische analyse en stap 9: het afronden van alle hoofdresultaten van de scriptie.

POAC is een kompas dat de geïnteresseerde partijen de richting en meer specifiek het ‘pad’ naar het al dan niet bereiken van belangrijke projectdoelstellingen laat zien. POAC is een nieuwe beslissingsondersteunende tool die een aanvulling vormt op de MKBA en de risicoanalyses die binnen de MKBA worden uitgevoerd en die rationele besluitvorming ondersteunt door rekening te houden met factoren die niet in de MKBA zijn opgenomen. Het kan worden toegepast tijdens de constructie- en exploitatiefase van het project, om de prestaties te monitoren en te controleren in termen van het bereiken van de projectdoelstellingen. Het kan ook worden toegepast in de plannings- en evaluatiefase van het TI-project (onder scenario's en gebruikmakend van schattingen en veronderstellingen), waarbij wordt aangetoond of het project de projectdoelstellingen waarschijnlijk zal bereiken of niet en ook laat zien door welke factor(en), een of meer projectdoelstellingen zullen waarschijnlijk niet worden bereikt als uit de resultaten blijkt dat de projectdoelstellingen niet worden gehaald. Op deze manier laat de POAC zijn gebruikers dus ook zien wat er in hun project moet veranderen, om de kans op het behalen van de vier belangrijkste projectdoelstellingen te vergroten. De POAC-tool heeft de volgende voordelen: het interpreteert het transportsysteem vanuit een holistisch oogpunt, als de samenstelling van belangrijke elementen die met elkaar in verband staan en interageren om prestatieresultaten te produceren, en wordt gekenmerkt door eenvoud, waardoor de rationaliteit van de besluitvorming toeneemt omdat het vereist niet dat iemand een deskundige analist is om het toe te passen en de resultaten ervan te interpreteren.

Afgezien van de lezers van het proefschrift om vertrouwd te raken met de nieuwe tool voor beslissingsondersteuning, zullen ze de exacte stappen worden getoond die ze moeten volgen om het toe te passen. De demonstratie van de toepassing van de tool is gemaakt voor een TI-project dat zich in de operationele fase bevindt. Zoals hierboven vermeld, kan POAC echter ook worden toegepast in de plannings- en evaluatiefase, waarbij wordt uitgegaan van de waarden die in de indicatoren moeten worden gebruikt en verschillende scenario's worden gecreëerd, aangezien de indicatoren die POAC gebruikt beschikbaar zijn na de gunning van het contract. De gebruiker zou in dit geval van toepassing van de POAC in de vroege projectfase van planning en evaluatie gebruik kunnen maken van een gevoeligheidsanalyse van de verschillende gebruikte waarden. Monte Carlo-simulatie zou ook kunnen worden gebruikt om waarden te genereren voor de factoren die in de indicatoren zijn opgenomen. De lezers zullen ook kennis maken met een algemene achtergrondkennis die relevant is voor het onderwerp van het proefschrift en zullen kennis verwerven voor de algemene steekproef van gevallen die in de analyse zijn gebruikt en voor de redenen die in elk van hen kosten- en tijdoverschrijdingen, verkeer en inkomsten hebben veroorzaakt. De gegevens die worden gebruikt, zijn 51 Europese TI-projecten van alle soorten modi, zowel publiek gefinancierde als publiek-private partnerschappen (PPS) en van alle investeringsgroottes. Deze gegevens worden verzameld in het kader van het H2020 BENEFIT onderzoeksproject van de Europese Commissie en de COST Action TU1001.

Bovendien zullen ze kennis kunnen opdoen over een nieuwe indicator die in dit proefschrift is ontwikkeld, om te worden gebruikt als een van de onafhankelijke variabelen in de analyse en ook over de fsQCA-analyse van verschillende submonsters van de totale voorbeeld van de 51 Europese transportinfrastructuurprojecten. Zo zullen niet alleen de lezers zien hoe de fsQCA-methode werkt en hoe de resultaten worden geïnterpreteerd, maar ze zullen ook algemene conclusies trekken uit de fsQCA-resultaten, waarbij ze de combinaties van voorwaarden laten zien waaronder projectdoelstellingen kunnen worden bereikt, die een antwoord zijn op de twee onderzoeken vragen van het proefschrift. De output van dit proefschrift kan nuttig zijn voor analisten, besluitvormers, financiers en in het algemeen voor alle belanghebbenden die betrokken zijn bij TI-planning en -evaluatie, constructie en exploitatie en academische wetenschappers die met soortgelijke wetenschappelijke onderwerpen werken. De belangrijkste beperking van deze studie is dat de POAC-tool nog niet extern is gevalideerd.

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Abbreviations

AWV	Agency for road and traffic of the ministry of the Flemish community (Vlaamse Overheid, Agentschap Wegen En Verkeer)
BENEFIT	Business models to enhance and enable financing of infrastructure in transport
BM	Business model
BOT	Build-operate-transfer
CAPEX	Capital expenditures
CBA	Cost benefit analysis
CEA	Cost-effectiveness analysis
Cons.	Consistency
Cov.	Coverage
CSI	Cost saving indicator
csQCA	Crisp set QCA
DBFM	Design, build, finance and maintain
EIB	European investment bank
ENPV	Economic net present value
EU	European/European Union
EUR	Euros
FEI	Financial economic indicator
FSI	Financing scheme indicator
fsQCA	Fuzzy set qualitative comparative analysis method
GDP	Gross domestic product
GI	Governance indicator
H2020	Horizon 2020
HSR	High speed rail
IA	Indicator of availability
ICT	Information and communication technology
Idem	The same as previously mentioned
INI	Institutional indicator
IR	Indicator of reliability
IRA	Reliability/availability indicator
IS/IT	Information systems/information technology
Km	Kilometers
LIB index	Market liberalisation index
M EUR	Million euro
MAMCA	Multi-actor, multi-criteria approach
max	Maximum
MCA	Multicriteria analysis
mins	Minutes
mvQCA	Multi-value QCA
N.a.	Non-applicable
NPV	Net present value
OECD	Organization for economic co-operation and development
OLS	Ordinary least square
OPEX	Operating expenses
PFI	Private finance initiative
PPPs	Public private partnerships

PSC	Public sector comparator
QCA	Qualitative comparative analysis
RAI	Remuneration attractiveness indicator
RQ	Research questions
RRI	Revenue robustness indicator
RSI	Revenue support indicator
RWS	Rijkswaterstaat (agency of the Dutch ministry of infrastructure and the environment responsible for water management)
SP	Stated preference
SPV	Special purpose vehicle
TEN-T	Trans-European core network
TIs	Transport infrastructures
ToD	Time of formal decision to build
vs	Versus
WGIs	World Bank governance indicators
WSJ	Watermael-Schuman-Josaphat
WWII	World War II

1. Introduction

Transportation systems are complex and they are composed by three elements, being the infrastructure, the means of transfer, and the load (Blauwens, De Baere, & Van De Voorde, 2002) (Cascetta, Cartenì, Pagliara, & Montanino, 2015). Transport infrastructure (TI) is a vital economic and social asset, which absorbs high investments to be constructed and maintained and is highly centralized, i.e. one single entity controls everything (Short & Kopp, 2005) (Markolf, Hoehne, Fraser, Chester, & Underwood, 2019). TI is mainly financed by the government, which allows the operation of the means of transport. Its realisation requires sometimes tens of millions (projects), hundreds of millions (major projects) and billions of dollars (megaprojects) (Flyvbjerg, 2014). In 2017, European countries[1] invested approximately 33 billion euro in rail, almost 47 billion euro in road, almost 1.4 billion euro in inland waterways, 1.9 billion euro in maritime port infrastructures and 3.5 billion euro in airport infrastructures (International Transport Forum, 2019). The high costs of the TI investments increase the level of commitment of the decision makers into continuing the TI project. The amount of money that has been already invested into the project are sunk costs, which are costs that have been incurred but cannot be recovered (OECD, 1993). As a result of the sunk costs, the lock-in effect is created (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010). Lock-in effect is defined as *"the over-commitment of parties to an inefficient project before the formal decision to build and to the inefficient specifications of the project after the formal decision to build has been made"* (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010, p5). Thus, the stakeholders involved are ''trapped'', ''locked in'' finishing the project that they have started (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010).

This is the reason why the decisions that decision makers are called to make before and after the approval of a TI project are critical. The decision that will be taken at the planning and evaluation phase of the project should be "correct'', meaning that the TI project that will be selected and approved should provide the economic and/or social benefits that it ''promised'' to provide and have the costs as they were initially estimated (Welde, 2018). In other words, the project that will be selected should meet its project objectives. This is how project success is defined in project management literature, as the achievement of the project objectives and/or the satisfaction of the project sponsors/customers (Schwalbe, 2006). This is how project success is also defined in the present doctoral thesis, as the achievement of four key project objectives, of the cost objective , the time objective, the traffic objective and the revenues objective. These are the four project objectives that have been found to be extensively presented in project management literature, as the key project objectives for project success, as shown in section 1.1 below in detail. Thus, if a project achieves all or some of these objectives, it is considered successful or partially successful in terms of project management. These project objectives are an extended version of the traditional project management triangle or Iron Triangle or triple constraints, which included only the objectives of cost, time and scope. Thus, based on these constraints, the project is considered successful, if it is delivered on the cost and time that have been initially estimated (or with less cost and in less time) and the scope that has been initially expected (Schwalbe, 2006). In the present doctoral thesis, an updated version of traditional Iron Triangle is used, with main key project objectives, the cost, time, traffic and revenues, based on the findings of literature review (see below section

[1] The European countries that are taken into consideration are the countries that are included in the sample, except Cyprus, for which no data were available. The 13 countries that are taken into consideration are Belgium, Czech Republic, Finland, France, Germany, Greece, Norway, Poland, Portugal, Serbia, Slovenia, Spain and United Kingdom. These figures are composed by calculating the sum of the investments in euro per TI: rail, roads, inland waterways, maritime ports and airports for 2016. The year 2016 is selected because more data were available compared to 2017, the last year with available data. For rail, data were available for all the 13 countries; for road, data were not available for Portugal; for inland waterways, data were not available for Greece, Norway, Poland, Portugal, Slovenia, Spain and United Kingdom, mainly because in these countries no navigable inland waterways are present; for maritime port infrastructures, data were not available for Czech Republic, Norway, Poland, Portugal, Serbia and United Kingdom and for airport infrastructures data were not available for United Kingdom.

1.1). However, the success of a project depends on the stakeholder's perspective from whom it is examined. For example, a project might be delivered with cost overruns and with a delay and be a failure from a project management perspective but it might have achieved its project objective of e.g. reducing emissions and thus being considered a success for the society stakeholder. Therefore, success can be defined based on the achievement of various project objectives but the four ones selected represent the core ones that need to be achieved. Let's imagine making a pizza. In order to make the pizza, we primarily need the bread dough crust and additionally to that the extra toppings. This metaphor is used to show that the importance of the key four objectives selected to define success in this doctoral thesis but to also show that success can be also defined more broadly, i.e. as the achievement of additional project objectives.

Thus, it is of great importance to approve projects that are able to meet their key project objectives. However, it is common that the approved projects finally do not meet their project objectives (Flyvbjerg, 2009). Often the ''unfittest'' TI projects survive (Flyvbjerg, 2009), these are ''bad'' TI projects that look positive and good in paper, in their cost benefit analysis (CBA) results and thus approved but when they actually implemented they do not meet their project objectives and have cost overruns and/or benefit shortfalls. Flyvbjerg (2009, 2008b) supports that the reason is strategic misrepresentation of the CBA results, which means deliberately making an error in e.g. the cost estimation in order to get the project approved or the reason is optimism bias, which means a non-deliberate error due to the over-optimistic nature of humans to overestimate benefits and underestimate costs subconsciously. There are so many more factors, additionally to these two, that lead to cost and time overruns and traffic and revenues underruns, as it has been also found and presented in chapter 2.

What makes things more difficult in terms of project objectives' achievement is the uncertainty involved in projects and especially in the TI projects, which have the highest level of uncertainty and zero-to-low levels of reversibility the minute the decision is implemented (Cascetta, Cartenì, Pagliara, & Montanino, 2015). *''Uncertainty can be defined as the entire set of beliefs or doubts that stems from our limited knowledge of the past and the present (especially uncertainty due to lack of knowledge) and our inability to predict future events, outcomes and consequences (especially uncertainty due to variability)''* (van Asselt, 2000).

The **uncertainty** surrounding the TI projects' environment causes **risks**. Uncertainty and risks are often used interchangeably, which is not correct. What causes the confusion between these two concepts is the fine lines separating them. Although there is not one universal definition of uncertainty and risk, uncertainty could be defined as an aspect of knowledge (Salling & Leleur, 2011), i.e. lack of knowledge. The two sources of uncertainty are: a) the inherent variability within the system (ontological uncertainty), which refers to socio-economic & technological developments, for which additional research may not lead to an improvement in the quality of the output and b) lack of knowledge due to model incompleteness (epistemic uncertainty), for which additional research can improve the quality of the output (Salling & Leleur, 2011). To reduce the level of uncertainty, risk analysis is conducted (Salling & Leleur, 2011). Risks can be quantified aiming to reduce their harmful impacts, while uncertainty is unforeseen and cannot be predetermined and quantified. It is beyond prediction and human control (Hasani, 2018).

There are numerous definitions of risk in literature and there is not a universal one (van Asselt, 2000) (Olsson, 2006). Sartori et al. (2015) define risk as probability or likelihood of risk occurrence multiplied by its severity of its impacts. The main project management professional institutions, the US Project Management Institute (PMI) and the UK Association for Project Management (APM) define risks in a very similar way. PMI defines project risk as *''an uncertain event or condition that, if it occurs, has an effect on at least one project objective''* (Project Management Institute, 2008). APM defines project risk as ''an uncertain event or set of circumstances that, should it occur, will have an effect on the achievement of the project's objectives (Simon, Hillson and Newland 1997, p 16).

Considering the risks and uncertainty involved in projects, including TI projects, activities are unlikely to go exactly as planned in every project (Lake, 1997). The project manager should inform the team managers about any risks to the achievement of project objectives that are identified and ensure that appropriate recovery plans are in place (The British Standard for Project Management BS6079, 1996). This is the role of risk management, as being one of the nine knowledge areas of project management and for which various tools are used, qualitative and quantitative (Raz & Michael, 2001) (Project Management Institute, 2017) (Lavanya & Malarvizhi, 2008) (Burek, 2007) (Raz & Michael, 2001) (Burek, 2007) (Kremljak, 2011) (Sartori et al., 2015) (Kania, n.d.) (Schwalbe, 2006) (Flyvbjerg, 2006).

Till now, analysis of risks was used to reduce the likelihood of non-achievement of project objectives but in the present doctoral thesis a more holistic analysis is developed to do that, which contributes towards the achievement of project objectives without focusing on project risks but on key elements that affect the performance of TI projects.

The present doctoral thesis comes to support the decision making process in TI projects by identifying the combinations of conditions (i.e. combinations of factors) that affected the performance of past TI projects. It thus contributes to a more informed decision making process for TI projects throughout their lifecycle and to a decrease of the level of uncertainty involved in them. Decision makers expect from science to play the role of the provider of knowledge or in other words of the one that will reduce uncertainty, via the usage of empirical methods (van Asselt, 2000).

A key outcome of the thesis is a new decision support tool to be used complementarily with the existing decision support tools throughout the lifecycle of the TI projects, i.e. during the later stages of the projects, the construction and operation phases, monitoring and controlling the performance of the projects for delivering a TI project on budget and on time and also for achieving the traffic and revenues that have been initially forecast. Also, it can be applied during the early stages of the development phase supporting the TI appraisal (under scenarios and using estimations and assumptions).

The core decision support tool that is used in the TI appraisal is the Cost-Benefit Analysis (CBA). The newly developed decision support tool in the present thesis comes to be used complementarily to the CBA and the other conventional appraisal methods to support decision making for the approval or not of a TI project and it brings the following advantages. It is simple to be used and understood and it provides information about what group of factors combined contributed to the success and failure of past TI projects, thanks to the empirical analysis used. The factors that are used in the empirical analysis are the state of the art of the factors that have been found to affect the performance of TI projects when they interact. In order to solve a problem, tracing back its causes is needed. Thus, for solving the problem of having cost overruns, we need to know what caused cost overruns in the past projects and take lessons in that way for improving the future TI projects.

The new decision support tool does not only inform its users about the likelihood that a project will be delivered over budget, delayed and with traffic and revenues less than they have been initially forecast but it also shows the reasons behind this failure. By informing the users about the groups of factors that when they interact they cause failure, this allows them to ‘’change the game’’ by trying to improve the factors that have been found to be the reason of failure. In other words, it gives to the users a warning signal of what they should change to be successful, such as the funding scheme for example. Thus, using maybe another funding scheme that is less risky could be considered, other than e.g. tolls, which depend on traffic demand. Thus, the users can create and test different scenarios till they finally see that the new tool shows that the TI project is likely to be successful. Hence, the project manager, analyst, decision maker and financier can do their ‘’best’’ in order to finally achieve project success. Knowing the uncertainty surrounding TI projects, the new tool will also show, if the exogenous environment such as the institutional (e.g. regulations imposed) or/and financial-economic environment (e.g. inflation) might affect the non-achievement of project success. Although these changes are out of the control of the manager, it allows them to make a more informed decision knowing that these factors might affect project success. Therefore, uncertainty is reduced when applying the new tool and rationality in the decision making increases.

The readers of the thesis, aside to getting themselves familiar with the new decision support tool developed in the thesis, will be shown the exact steps they should follow so as to apply it. The demonstration of the tool's application is made for a TI project that is in its operation stage. This thesis does not apply the POAC at the feasibility stage of TI projects. However, POAC can be also applied at the feasibility stage already, assuming the values to be used in the indicators and creating different scenarios, considering that the indicators that POAC uses are available after contract award. For example, one indicator used by the POAC is the governance indicator that refers to all the contractual arrangements in the project. Thus, so as to know the specific arrangements used in the contract, the contract should be awarded first. However, it is also likely that the governance indicator can be also calculated before the contract award, using assumptions. For example, even if the contract has not been awarded yet for a TI project, it could be assumed or expected that there will be encouragement of competition between more than one bidders in the procurement process and that there will be clauses in the contract indicating guarantees of performance. Another example would be the cost saving indicator of the business model. Even if the contract has not been awarded yet for a TI project, it could be assumed or expected that the capabilities of the constructors (operators) are high and that land and other expropriations will complete at project award. Since the actual values are not available for the indicators to be calculated at the early stages of the projects, during their development phase, the user could use sensitivity analysis of the various values used. Monte Carlo simulation could be also used to generate values for the factors included in the indicators.

The readers will be also introduced to an overall background knowledge relevant to the thesis' topic. They will also acquire knowledge for the overall sample of cases used in the analysis and for the reasons that caused cost and time overruns, traffic and revenue underruns in each of them.

In addition, they will be able to gain knowledge about a new indicator that has been developed in this thesis, so as to be used as one of the independent variables in the analysis and also about the fsQCA analysis of different sub-samples of the overall sample of the 51 TI European projects. Thus, not only the readers will see how fsQCA method works and how its results are interpreted but they will also take overall conclusions out of the fsQCA results showing the combinations of conditions under which project objectives can be achieved, which reply to the two research questions of the thesis. The output of the present thesis can be useful for analysts, decision makers, financiers and in general for all the stakeholders that are involved in TI planning, construction and operation and academic scholars working with similar scientific topics (Emberger, Pfaffenbichler, Jaensirisak, & Timms, 2008) (The British Standard for Project Management BS6079, 1996).

1.1 Research context and identification of the key project objectives of transport infrastructure projects

The aim of this section 1.1 is dual: firstly to define and clarify terms mentioned in the Introduction of section 1, such as ''what is project and project management'', and also introduce and clarify new ones, thus providing a complete and clear research context and background that will lay the foundations for a better understanding of the research objective of the present thesis. Secondly, the aim of this section is to identify the key project objectives of TI projects through literature.

The present doctoral thesis focuses on TI projects, project management and the factors affecting their performance. Understanding these terms is important. *"A* ***project*** *is a temporary endeavour involving a connected sequence of activities and a range of resources, which is designed to achieve a specific and unique outcome, and which operates within time, cost and quality constraints and which is often used to introduce* *change''* (Lake, 1997). While **project management** is *"the application of a collection of tools and techniques to direct the use of diverse resources toward the accomplishment of a unique, complex, one time task within time, cost and quality constraints" (Olsen, 1971*). APM Body of Knowledge (2012) adds to this definition by saying that project management is not only applying a set of processes and methods but also applying the knowledge, skills and experience to achieve the project objectives. Therefore, the ultimate goal of project management is the achievement of project objectives or in other words **project success**. Project management is composed of nine **knowledge areas** that describe the main competencies developed by project managers, i.e. management of 1) project scope, 2) project time, 3) project cost, 4) project quality, 5) human resource, 6) communications, 7) risk, 8) project procurement and 9) project integration (Schwalbe, 2006). The first four knowledge areas are considered core functions of project management because they lead to project objectives, while the next four areas are facilitating areas because their goal is to support and facilitate the core functions and thus the achievement of project objectives. The ninth knowledge area of project integration integrates all the knowledge areas. For each of these knowledge areas, there are specific project management tools that are used (Schwalbe, 2006).

The **project management processes** are the following: *initiating, planning, executing, monitoring and controlling and closing* (Schwalbe, 2006). A **process** is a series of actions for the achievement of a result. **The planning and monitoring & controlling processes are the busiest ones.**

If we link the project management processes with the project management knowledge areas, then the **planning process of a TI project** includes the following project management activities: 1) **integration management** in which project management plan and project selection methods are developed, 2) **scope management** in which the scope is planned and defined and work breakdown statements are created, 3) **time management** in which the activities, their sequence and duration are defined and a schedule is developed; Gantt charts, critical path analysis and schedule performance measurements are some of the techniques used, 4) **cost management** in which cost is estimated and planned, using techniques such as net present value, return on investment and payback analysis, 5) **quality management** in which plans for quality assurance are developed, 6) **human resource management** in which a human resource plan is developed, 7) **communication management** in which communication plans are developed, 8) **project risk management** in which a risk management plan is developed, risks are identified, qualitative and/or quantitative risk analysis is performed and risk response is planned, using tools like probability/impact matrices and risk rankings and lastly 9) **procurement management** in which purchases and acquisitions and contracting are planned, using tools such as make-or-buy analysis, contracts and supplier evaluation matrices. In the **monitoring & controlling processes**, all the above project management activities are also performed but this time not in order to develop plans and estimations but in order to measure progress towards the achievement of project objectives, monitor any deviations from the plans and take actions to correct these deviations. More specifically, project works are controlled, scope is controlled, cost, schedule, quality, project team and risks are controlled, contracts are administered and with respect to communication management, reports of performance are prepared and stakeholders are managed (Schwalbe, 2006).

The **core functions of cost, time and scope** of project management represent the triple constraint or Iron Triangle or project management triangle, as mentioned also in the introduction (Schwalbe, 2006) (The British Standard for Project Management BS6079, 1996) (Atkinson, 1999). The Iron Triangle project objectives are the most commonly used by project managers to measure **project success** and has been found to be vital for project success (Pollack, Helm, & Adler, 2018). **Project objectives are the most appropriate success criteria** (de Wit, 1988). Iron Triangle is a short term set of criteria compared to benefits that are long term (Pinto and Pinto, 1991). While there was a consensus with respect to two out of the three constraints/project objectives, i.e. the time and cost, the third constraint of the Iron Triangle was contested, if it should be quality or alternatively scope, performance, or requirements, because it is considered subjective compared to cost and time that are objective (Pollack, Helm, & Adler, 2018). The reason why is because quality is difficult to be quantified and even if it is quantified, it may still remain subjective, depending on its interpretation by project managers.

Although, the Iron Triangle is considered a key concept for **project management success**, it is supported that is insufficient (Atkinson, 1999). Atkinson (1999) states that the Iron Triangle is composed by insufficient project management criteria to measure project management success and he suggests the Square Route as a way to measure project management success, which is composed of four main project management criteria groups: the Iron Triangle, the technical strength of the resultant system[2] and the benefits of the organization and of the stakeholders. A main benefit for the organization and stakeholders is the profit , i.e. contractors' profit. As de Wit (1988) mentions, cost, time and quality are lower-level objectives for the project execution phase, which are subordinate to the objective at higher level, such as profitability. Thus, it is shown that profit, which is part of the revenues, is also used as a success criterion. This is also supported by Rothengatter (2019), who states that cost and time are not sufficient project management criteria of megaprojects, but other criteria such as revenues are also important to fully consider the objectives behind a project. Also, when examining the literature that is relevant to TI projects, which are investigated in the present thesis, another key project objective that is used is traffic demand (see Table 1.1).

Therefore, the project management criteria that are found to be broadly used in the literature of TI projects are the cost, time, traffic demand and revenues project objectives (Table 1.1). There is also a link among these objectives with respect to their achievement, i.e. the one can affect the other, e.g. delays can cause both cost overruns and benefit shortfalls (Flyvbjerg, 2014) (Pollack, Helm, & Adler, 2018).

[2] This paper is examining project management criteria for the project management of Information Systems/Information Technology (IS/IT) projects.

Table 1. 1: Key project objectives of (transport) infrastructure projects

Title of paper/book	**Key project objectives of (transport) infrastructure projects**				
	Cost	Time	Traffic	Revenues/ benefits	Quality
Ahmadabadi & Heravi (2019)	x	x	x		x
Atkinson (1999)	x	x		x	x
Attard & Enoch (2011)			x	x	
Babatunde & Perera (2017)			x	x	
Beria, Grimaldi, Albalate & Bel (2018)	x		x		
Bonnafous (2015)				x	
The British Standard for project management BS6079 (1996)	x	x			x
Bruzelius, Flyvbjerg, & Rothengatter (2002)	x		x	x	
Cantarelli et al. (2012)	x				
Carpintero & Gomez-Ibañez (2011)	x		x	x	
Cascetta, Cartenì, Pagliara, & Montanino (2015)			x		
Chung, Song, & Park, (2012)			x	x	
de Jong, Vignetti, & Pancotti (2018)	x	x	x	x	
de Wit (1988)	x	x			x
Flyvbjerg, Skamris Holm, & Buhl (2004)	x				
Garrido, Gomez, Baeza, & Vassallo (2017)				x	
Goenka, Vasudevan, & Garvin (2016)	x	x			
Hoffman, Berardino, & Hunter (2013)			x		
King, Manville, & Shoup (2007)			x		
Kumar, Jindal & Velaga (2018)			x	x	
Lake (1997)	x	x			x
Lay & Daley (2002)			x		
Macário, Ribeiro, & Costa (2015)	x		x	x	
Nicolaisen & Næss (2015)			x		
Odeck (2004)	x				
Parthasarathi & Levinson (2010)			x		
Ramos, Cantillo, Arellana & Sarmiento (2017)			x	x	
Richardson & Haywood (1996)			x	x	
Rouhani, Oliver Gao, & Richard Geddes (2015)			x	x	
Salling & Leleur (2015)	x		x		
Sanko, Morikawa and Nagamatsu (2013)			x		
Sartori, Catalano, Genco, Pancotti, Sirtori, Vignetti, & Del Bo (2015)	x	x	x	x	
Short & Kopp (2005)			x		
Sismanidou and Tarradellas (2017)			x		
Welde (2011)			x		

Source: Own composition based on literature review

1.2 Research gap and objective

CBA is the core appraisal method that is used to support decision making for the approval or not of major infrastructure projects, including TI projects (Sartori et al., 2015) (Flyvbjerg, 2009). Sometimes, if considered necessary, CBA is combined with other appraisal methods, such as the Multi-criteria analysis (MCA) or/and cost-effectiveness analysis (CEA) (EIB, 2013) (Saitua, 2007) (Macharis, 2007). However, it is often the case that the cost and benefit estimates of the CBA are inaccurate and biased, thus leading finally to the approval of the so-called unfittest (i.e. bad) projects, which are projects that although appeared as positive in the CBA, they finally did not meet their cost and benefits objectives (Flyvbjerg,2009).

For example, this was the case for the **Channel tunnel project**, the longest underwater rail tunnel in Europe that connects France and the UK. While the project was expected to be highly beneficial both financially and economically, it finally had 80% cost overruns and 50% revenues underruns compared to the forecasts. Thus the project has been proven to be non-viable (Flyvbjerg, 2009). This was also the case for the **high speed rail infrastructure Paris-Brussels-Amsterdam**, which is part of the bigger project Paris-Brussels-Amsterdam-Cologne-London and includes the aforementioned Channel Tunnel (Moschouli & Vanelslander, 2018). More specifically, in the French part of the high speed rail infrastructure, although the CBA showed a positive economic net present value (ENPV), things still went wrong, meaning that the project objectives of cost and revenues (traffic based revenues) were not achieved. There were 54% cost overruns from the project's evolutions and 22% cost overruns due to the increase in civil engineering market prices caused by the high level of public works and the additional cost of the agreements.

Hence, even a TI project with positive CBA results can finally end up to be a failure, in terms of not achieving its key project objectives of cost, time, traffic and revenues due to the fact that key factors are not included in the CBA. **POAC** is useful to fill this gap.

POAC, meaning **''Project Objective Achievement Compass''**, is a compass, because it shows to the interested parties the direction and more specifically the ''path'' towards the achievement or not of key project objectives. The phases of the construction project life cycle are typically the following: conception, feasibility (including definition and development/planning, evaluation & design) (till here pre-investment phase), implementation/construction, operation & maintenance and termination (van den Ende & van Marrewijk, 2014) (Demirkesen & Ozorhon, 2017) (Halawa et al., 2013) (Zou et al., 2007) (Sammer, Klementschitz, & Roider, 2003). POAC will be an additional step to the analyses done in the evaluation phase of the TI project and in their construction and operation phase.

The factors that are used in POAC are the following six key elements: government arrangements, business model, funding scheme, financing scheme, implementation context and transport mode typology. These key elements are interrelated and interact to produce the performance outcomes. They are closely linked with the **critical success factors** in project management. Each key element that is used in this new tool could be considered as a grouped critical success factor. The added value of these key elements is that their interrelation and interaction produces performance outcomes. Critical success factors refer to conditions and events that contribute to project results, while project success criteria refer to a group of standards used to judge project success (Uluocak, 2013).

A TI project is visualized and interpreted as a complex system, that is composed by these key elements, which have some risk characteristics that need to be considered and understood. This conceptual framework that understands the complexity of TI projects and interprets it as a system of interrelated elements that finally lead to the achievement or not of project objectives is called the **BENEFIT framework** and is developed in Roumboutsos, Voordijk, & Pantelias (2018) by Soecipto, Willems and Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018). For each of these elements, quantified indicators have been constructed that capture the characteristics of these elements. The aim for creating these indicators was to identify the combinations of these indicators that lead to the achievement and to the non-achievement of the key project objectives. These indicators are only available after contract award, thus in order to apply the POAC before the contract award, in the feasibility stage, estimations and assumptions can be made and scenarios can be used. This brings us to the research objective and research questions of the present doctoral thesis.

The **research objective** of the present doctoral thesis is to identify the combinations of conditions under which a TI project can achieve (or not) its project objectives, of cost, time, traffic and revenues.

The research objective is investigated via the following **research questions**:

- RQ1: Which are the combinations of conditions that lead to the achievement of the project objectives of TI projects?
- RQ2: Which are the combinations of conditions that lead to the non-achievement of the project objectives of TI projects?

POAC is a decision support tool that comes to provide more informed knowledge to the decision makers and reduce the likelihood of failure and increase the likelihood of success of the TI projects throughout their lifecycle. *''Decision support is a structured and participatory search process that aims to provide robust insights that facilitate decision makers to act consciously in a complex and thus uncertain and risk world''* (van Asselt, 2000).

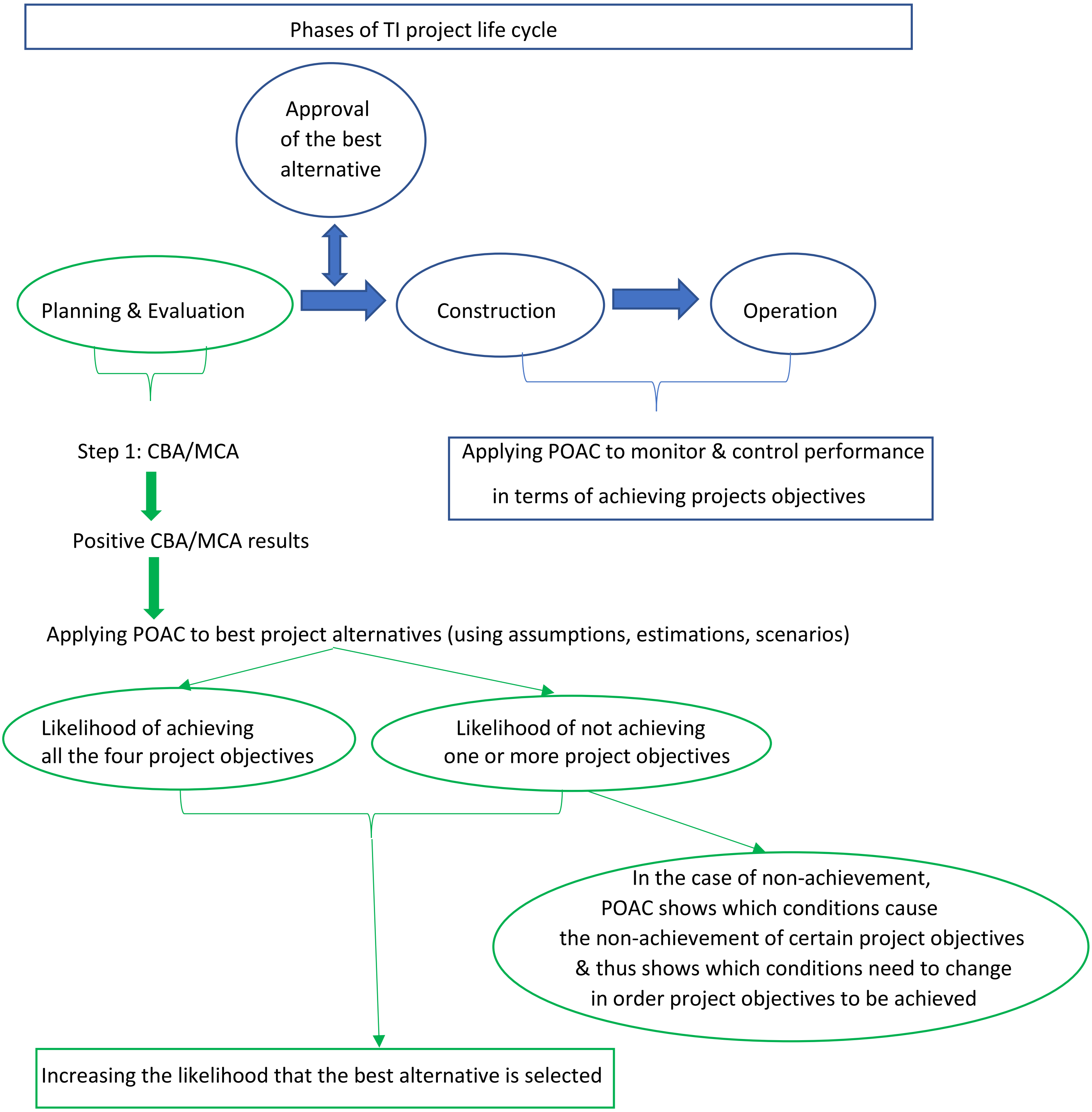
More specifically, POAC is applied in order to enhance rational decision making by showing if it is likely that the project will achieve its project objectives or not. If POAC shows that there is likelihood that all four key project objectives will be achieved, no further action is required. If POAC shows that there is likelihood that one or more key project objectives will not be achieved, at the same time it shows which conditions are the ones that cause the non-achievement of the project objectives. Thus, it shows which conditions need to change (if possible) in order project objectives to be achieved, which increases the likelihood that the project will achieve its project objectives (Figure 1).

Rational decision making refers to the process in which individuals come to a decision by using facts and information, analysis, and a step-by-step procedure and it is the opposite of intuitive decision making (Uzonwanne, 2016). The reasons why rational planning fails are the technical (i.e. 1) limited organizational resources, financial and human resources, due to which employing expert planners or providing the managers the capacity to do the planning is not possible and 2) lack of analytical skills to interpret the information managers have and political problems of rational planning (i.e. reflecting the impact that the rational processes have on the balance of power in organizations (Boyne et al., 2004). Therefore, decision making cannot be fully rational due to certain limits that humans face (i.e. bounded rationality) but this does not mean that decision making is irrational but rather bounded rational, meaning they try to make a decision as rational as possible given the limits and conditions they face, such as limited data and limited cognitive ability (Sent, 2018).

A great value of the tool is acquired when used during the construction and operation phases of TI project. However, it can be used also ex ante and be of high usefulness during the planning and evaluation stage of TI projects, after the main appraisal methods, i.e. CBA, or/and MCA or/and CEA. Therefore, POAC can be also used before and after the evaluation phase and the approval of the project, i.e. during the construction phase for monitoring and controlling the performance of the project in terms of achieving its cost and time objectives and during the operational phase for monitoring and controlling the performance of the project in terms of achieving its traffic and revenues objectives (Figure 1).

POAC comes to overpass the impediments that make rational decision making fail, since applying POAC does not require someone to be an expert with high analytical skills to interpret the information. Hence it is also easy for the politicians to understand its results because there are no complex data or special terminology in it. This is a main advantage of the POAC. Thus, the POAC tool can be used by analysts/scientists, decision makers, providing information based on empirical evidence, financiers, and in general by all the stakeholders that are involved in TI planning, construction and operation and by academic scholars, working with similar scientific topics.

Figure 1: POAC as a supporting instrument for TI projects' decision making process



Source: Own composition

The POAC tool has the following advantages: it interprets the transport system from a holistic point of view as the composition of key elements that interrelated and interact to produce performance outcomes. Another key advantage of POAC is its simplicity, thanks to which rationality of decision making increases because it does not require someone to be an expert analyst to be able to apply it and interpret its results. Another advantage of the POAC is that it takes into account the uncertainty due to variability (i.e. ontological uncertainty), i.e. due to changes in the institutional and financial-economic context, while many of the traditional risk methods focus on the epistemic uncertainty (i.e. due to model incompleteness). Scenario analysis also takes into account uncertainty due to variability and the real options analysis as well. It needs to be clarified that further research on the ontological uncertainty cannot improve the quality of the scientific output, as it is the case with the further research on the epistemic uncertainty, because the ontological uncertainty is out of the control of the managers. However, it is important to be taken into consideration because although managers cannot control it, they can know what the impact of these exogenous factors can be on the achievement of the project objectives.

Thus, if analysts/planners, decision makers or financiers in a TI project want to know if their TI project has a likelihood to achieve its project objectives and be delivered on budget, without delays and with the traffic and revenues as forecast, then POAC is a useful tool. On top of knowing if the project is likely to achieve the project objectives or not, the interested project stakeholders will know also due to which condition(s) one or more project objectives are not achieved, if the results show non-achievement of project objectives. Thus, in this way the POAC shows also to its users what to change in their project so as to increase the likelihood of achieving project objectives. The POAC can be used during the construction and operation phase of the project, since projects are dynamic and continuously changing, thus regularly examining their conditions throughout their lifecycle is important, so as to see if there are any changed conditions that finally lead to the non-achievement of the traffic and revenues objectives and it can be also applied at the planning and evaluation phase of the project, using assumptions and estimations to calculate the indicators' values. Figure 1 above shows schematically how the POAC tool that is developed in this doctoral thesis can support the TI projects' decision making process throughout their life cycle.

1.3 Structure of the thesis

This doctoral thesis is further structured in eight chapters as shown below and in Figure 2.

Chapter 2: Factors affecting the performance of TI projects in literature: This chapter presents the factors that affect performance (success and failure) of TI projects. From this literature review, the indicators that are used as ''independent variables'' of this thesis are identified.

Chapter 3: Methodology: This chapter shows the methodological approach used, i.e. the steps followed in the research, the type of data used, the methods of data collection and the method of analysis used together with a justification. The method that has been selected is the fuzzy set Qualitative Comparative Analysis (fsQCA).

Chapter 4: Case selection: This chapter presents the cases and their main characteristics that are included in the chapters 5, 6 and 7 of the present doctoral thesis. Having a good understanding of the cases that are used in the sample is important for the interpretation of the empirical analysis' results. The total number of cases are 51 and their data were collected under the BENEFIT HORIZON 2020 research project of the European Commission and from the COST Action TU1001 and are publicly available in the BENEFIT project website[3]. The TI projects are from: 15 European countries, all modes of transport (airport, road, rail, metro/rail, tram/light

[3] BENEFIT website: http://www.benefit4transport.eu/. For detailed information for each of the 51 cases, see the e-book and wiki section in the BENEFIT website.

rail, seaport, bridge/tunnel, public transport depot and bicycle sharing network), different investment sizes, different types of project delivery, i.e. publicly financed and privately co-financed (i.e. public private partnerships (PPPs)), and various project outcomes, either delivered according to the estimated cost, time, traffic and revenues or not delivered according to the estimates, i.e. both ''successful'' and ''non-successful'' projects.

Chapter 5: The importance of transport mode to produce performance outcomes: In this doctoral thesis, a TI project is visualized as a system composed by interrelated elements that interact to produce the performance outcomes, based on the BENEFIT conceptual framework. One of these elements is the transport mode. The rest of the elements are the contractual arrangements, the business model, the implementation context, the financing scheme and the funding scheme. For each of these elements a quantifiable indicator has been created that captures its characteristics. This chapter shows the process through which the indicator for the transport mode element has been developed. Firstly, a typology was created based on a literature review and then the method fsQCA was used for identifying the most significant conditions, from all the listed ones in the typology, affecting the performance of TI projects in order to create the indicator.

Chapter 6: Success and failure of transport infrastructure projects: which combinations of conditions explain it? An ex post evaluation of transport infrastructure projects: Ex post analysis is conducted using the existing cases of 51 European TI projects. This analysis is conducted to identify the combinations of conditions that affect the performance, i.e. the success and failure, of the TI projects. These results play the role of a ''benchmark'' of worst and best combinations of conditions that affect the TI performance, which are used as the third step of the 3-step tool developed in the present thesis, the POAC tool.

Chapter 7: Demonstration of the application of the ''Project objectives' achievement compass'' (POAC): In this chapter, it is demonstrated how to apply the developed POAC tool via an example, a tram project in Belgium. Also an exercise of validation of the model's results is made for seven TI project cases of the dataset, including the tram project in Belgium.

Chapter 8: Conclusions: The last chapter presents a summary of the main findings of the doctoral thesis, its contributions, the transferability and generalization of the findings, their implications, limitations and insights about further research.

Figure 2: Structure of the doctoral thesis

Chapter 1

- Learning about TI project investments
- Identifying the key TI project objectives
- Defining success
- Identifying research gap
- Defining research objective, research questions and target audience

Chapter 2

- Reviewing literature to identify which factors affect the performance of TI projects (to be used as ''independent variables'' in chapter 6)

Chapter 3

- Reviewing literature to identify the main methods of analysis to investigate causality in TI projects
- Presenting the steps followed in the doctoral thesis

Chapter 4

- Presenting the TI project cases used

Chapter 5

- Developing the indicator for the transport mode element of the TI project system, to be used as one of the ''independent variables'' in the empirical analysis

Chapter 6

- Conducting an empirical analysis using the fsQCA method to identify combinations of conditions that affect the performance of TI projects (for different samples)

Chapter 7

- Demonstrating the application of the ''Project objectives' achievement compass'' (POAC)

Chapter 8

- Conclusions

2. Factors affecting the performance of TI projects in literature

Chapter 2 presents the results of the literature review conducted to identify the factors that affect the performance of TI projects, i.e. success and failure, worldwide (with a focus on Europe) for the time period 1988-2019. The factors that have been identified in literature are used, in Chapters 6 and 7, as conditions to examine their impact on the outcomes of cost, time, traffic and revenues. The outcomes/key TI project objectives are identified via a literature review, as shown in Chapter 1.

Among all the sources that have been studied and all the factors identified in them, the following sources stood out, i.e. from Soecipto, Willems and Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018). This source was selected to be the conceptual framework of the present thesis because it recognizes the complexity of the transport system and thus it understands that the TI project performance cannot be achieved and affected only by one factor but by multiple factors (combinations of factors) at the same time. Specifically, based on this theoretical framework, six key elements affect the performance of TI delivery and operation: governance arrangements, business model (BM), funding scheme, financing scheme, implementation context and transport mode typology. For each of these elements, one or two composite indicators were developed, being **the institutional indicator, the financial-economic indicator, the cost saving indicator, revenue support indicator, governance indicator, remuneration attractiveness indicator, revenue robustness indicator, reliability and availability indicator and financing scheme indicator**. The reliability and availability indicator is developed in the present doctoral thesis and presented in more detail in chapter 5. The majority of the success and failure factors found in literature could be clustered under these indicators that have been selected to be used as conditions in the empirical analysis of the doctoral thesis.

2.1 Methodology of literature review

The first step in the literature review is identifying and selecting the journals that will be used for further searching for the relevant articles. In the ScienceDirect, journals are searched using the keyword ‘transport’. The keyword led to several journals out of which the following have been selected as the most relevant **for transport related issues**, being:

- International Journal of Transport Management
- Research in Transportation Business & Management
- Research in Transportation Economics
- Transport Policy

The second step is checking each of the selected journals for finding relevant articles. For this purpose, the following keywords are used:

- project success and failure
- success and failure factors
- project performance
- cost overruns and delays
- demand & revenue underruns[4]

[4] For this keyword, four papers are found only, when checking in ScienceDirect the four journals selected. These four papers are found only from the Transport Policy Journal. The other three journals gave zero papers as a result or they gave one paper as a result, which is a paper co-written by the author of the present doctoral thesis. From these four papers, two were

- traffic underruns
- demand underruns
- revenue underruns
- accuracy of demand forecast

Additionally to the keyword 'transport' and the relevant Journal papers that have been examined, the keyword 'project management' has been also tested and papers from the following Journals have been also reviewed and presented below with respect to **project management related issues**:

- Journal of Construction Engineering and Management
- International Journal of Project Management
- Project Management Journal
- Construction Management and Economics

The results found are shown in the following section 2.2. In addition to the papers found for each of these journals, additional papers have also been used, based on the ''snowball'' method, i.e. pursuing references of references.

2.2 Findings of literature review

The review of the relevant literature led to the collection of a broad range of factors that affect the performance of TI projects. There are numerous factors that affect the performance of TI projects, as shown in the text below and in Table 2.1. From this broad range of factors, the most appropriate ones for this research are selected to be used as independent variables (i.e. conditions in fsQCA terms) (see Section 2.3).

Before presenting the findings of the literature review, it is important to define performance. In this doctoral thesis, project performance (i.e. success and failure) is defined in the following way. A project is considered successful, if it is delivered on the cost and time that have been initially estimated (or with less cost and in less time) and with the traffic and revenues initially forecast (or with higher traffic and revenues). A project is considered non-successful if it is delivered with higher cost and time than the estimated one and with lower traffic and revenues than the forecast ones (see also Chapter 1 for the definition of success used in the present doctoral thesis). In many studies in literature, success is defined in terms of cost, time, traffic and revenues outcomes, as shown in Table 1.1 in Chapter 1. The findings of the literature review of Chapter 2 are the following and presented in a chronological order.

Hayfield (1979) identifies two groups of **factors that affect the success of projects**, a macro group of factors that refers mostly to factors related to the owner and a micro group of factors that are mostly related to the constructor (as cited in de Wit, 1988).

Arditi et al. (1985) examine the **causes of cost overruns** (in the construction phase) in Turkish public construction projects between 1970 and 1980 via the usage of a national survey. The main causes of cost overruns identified are inflationary pressures, increases in material prices and workmen's wages,

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about cost overruns and not about demand and revenue underruns. These four papers were the following: (Cantarelli et al., 2012), (Welde, 2018), (Salling & Leleur, 2015) and (Odeck, 2004).

Due to the limited number of papers found, search in Science Direct has been conducted also without any journal selection this time. However, the papers that were found were either not relevant to demand and revenue underruns (e.g. they were relevant to cost overruns) or they were the same papers with the four papers presented above. Since only four relevant papers have been found, the search of additional papers have been attempted via using a new keyword, being ''accuracy of demand forecast'' for each of the four journals examined in Chapter 2.

difficulties in obtaining materials at current official prices, construction delays and errors in first estimates.

Morris et al. (1986) conduct a literature survey about **project success and failure in UK**, which leads to 80 factors in total, based on which the following 10 main overall groups were created: project definition, finance, planning and design, legal agreements, politics, contracting, schedule duration, project management, schedule urgency and human factors (as cited in de Wit, 1988).

Ashley et al. (1987) show the following **main success factors of construction projects**: planning effort (construction), planning effort (design), project manager goal commitment, project team motivation, project manager technical capabilities, scope and work definition, control systems (as cited in de Wit, 1988).

Morris (1988) examines major projects in Europe (not TIs but major projects such as civil construction; power station; North Sea oil and gas; in-company product development; aircraft and spacecraft computerization) to take **lessons in managing major projects successfully** in a European context. Success is not defined but the focus is on the success factors. The key factors for managing major projects successfully are: 1) effective definition and sound establishment of the projects, consistent government support, and attention to the broader "systems" issues; 2) technology and design management; 3) organization and contracting strategy, habitual solutions should not necessarily be assumed as the most appropriate; 4) leadership and effective communications (for implementation); 5) industrial relations among management, unions and workers (specifically for construction industries) and 6) schedule and finance (especially in the planning stages).

Mansfield et al. (1994) identified the main **causes of cost and time overruns** in Nigerian construction projects via the usage of a survey questionnaire. The main causes of cost and time overruns found are finance and payment arrangements, poor contract management and materials' shortages. The main causes of cost overruns (only) found are inaccurate estimating and overall price fluctuations.

Semple et al. (1994) studied 24 Western Canadian civil, institutional, high-rise apartment building, and petrochemical projects, to identify common causes of contractual construction claims and disputes. Contractual construction claims and disputes are found to be a **key reason of delays and as a result of cost overruns** as well. The main reason of claims for the majority of the projects was the increase of project scope. A claim is submitted when one party in the contract feels that the other party did not fulfill the contractually expected obligations and thus a monetary or/and time compensation is asked.

The British Standard for project management BS6079 (1996) identifies the following frequently observed **causes of failure with planning and constructing megaprojects** (general projects): 1) appraisal biases (too high benefits, too low-cost estimations), 2) inaccurate planning in the early planning phase, 3) approval before project is mature, 4) major changes during construction, 5) technological experiments, 6) no strict controlling, no risk management, 7) no solid financial framework and 8) failures with procurement and governance.

Richardson & Haywood (1996) examine the English Pennines road and rail infrastructures to take lessons about the **reasons of failure of strategic transport planning**. The reason of failure was not taking into account the complex and transient social, political, economic and environmental contexts that surround the policy process. Performance was defined mostly in terms of revenues because the focus for the further improvement of both road and rail projects was on estimating the financial viability of the projects. Environmental performance was examined only at a limited extent for rail and not at all for road. Performance in terms of traffic was also considered because the aim for developing further the road project and considering developing further the rail as an alternative to road, was the dramatic increase of traffic expected for road. This increase would have a significant environmental impact. This is the reason why an increase of road capacity was planned. The potential modal shift from road to rail was also measured. The project aim was to reduce traffic on road and shift it to rail and thus improve also the environmental impact.

Kaming et al. (1997) identify **variables that cause construction time and cost overruns** through a survey questionnaire and group these variables into factors and analyze the relationship of these factors via the application of the principal component factor analysis (PCFA) technique. The main factors causing cost overruns are inflationary increases in material cost, inaccurate material estimating and project complexity. The main factors causing delays are design changes, poor labor productivity and inadequate planning. The study has been conducted for construction projects in Indonesia. The main factors causing both time and cost overruns are materials cost increases due to inflation, inaccuracy of estimates and lack of experience of project type.

Mackie & Preston (1998) identify twenty-one **sources of error and bias in the appraisal of transport projects** that are related to data, models, objectives, definitions and evaluation agreements. These are factors that affect in general the appraisal of transport projects, with the main problem being optimism bias.

Trujillo et al. (2002) define TI project performance in terms of traffic demand. Trujillo et al. (2002) present **the sources of uncertainty of the traffic demand forecasts** in the context of transport privatization, being either purely scientific uncertainty or strategic forecast bias. On the one hand, scientific uncertainty is due to three factors: the inadequacy of the model structure, the inaccuracy and non-availability of the current data (mostly for developing countries), and the uncertainty of prediction of the future value of exogenous variables (Quinet, 1998, as cited in Trujillo et al., 2002). A reason for underestimation of traffic forecasts is the failure to recognize that the users will have a demand for quality. When a transport service is privatized, this could mean an increase in the price of the service and thus forecasters might think that users might be unwilling to pay. However, they should also consider that users pay for the increased quality and reliability of the transport service (e.g. Argentinean passenger suburban train). Another reason of traffic underestimation is not taking into account the interactions with a wider transport network. Not only overestimating (optimism bias) but also underestimating traffic (pessimism bias) is important because its main consequence is insufficient transport capacity and thus congestion. Strategic bias is mostly due to over-optimistic traffic forecasts by the actors of the privatization process. However, a strategical biased behavior would be not only to overestimate the traffic forecast but also it would be to underestimate the traffic forecast. Traffic forecast could be overestimated when, e.g. the actor wants the project to be approved. Traffic forecast could be underestimated when, e.g. a candidate operator faces low competition and is aware that the public sector wants the project to be implemented for environmental or other reasons. Thus, by announcing lower traffic forecasts than expected, it is shown that there will be less cost recovery and thus subsidies could be provided.

Lay & Daley (2002) examine the **performance** of the Melbourne City Link Project (road project) **in terms of traffic**, focusing on the electronic toll collection, as a main factor affecting it. The success of the project is based on the sound application of technology. Thus, it is concluded that where there is an appropriate assessment of customer and business needs, electronic toll collection is profitable for both operators and users.

Bruzelius, Flyvbjerg, & Rothengatter (2002) examine large infrastructure investments in Denmark and Germany (transport projects only) and identify four **measures to increase accountability in decision**

making: 1) transparency, 2) performance specifications approach (instead of conventional approach), 3) explicit formulation of regulatory regimes and 4) involvement of risk capital. Transparency refers to making all the relevant documents available to the public. Performance specifications approach is recommended instead of a conventional approach because the former would allow for innovative technical designs to be introduced by the bidders, which might lead to cost savings compared to the conventional approach in which the final design is usually prepared before the calling for bids. Thus, there is no potential for cost savings, since in the conventional approach decisions are taken in advance. Explicit formulation of regulatory regimes refers to specification of the means of funding and financing of the project ex ante. Involvement of risk capital refers to having also private financing except only public because this helps in having a better cost control, a better control against construction delays because lenders are more involved during the final design, construction and operation of the project, and it helps also in more effective monitoring. The types of risks in large TI investments are differentiated into: cost risk (construction, maintenance, operation), demand risk (traffic forecast, revenues), financial market risk (future interest rates) and political risk (regulation, parallel public investment, pricing on adjacent parts of the network). Inefficient monitoring of a project is indicated as a **cause of cost overruns and delays**, while on the other hand involvement of risk capital reduces the likelihood of the occurrence of cost overruns and delays.

In literature, there is a fierce discussion with respect to **cost underestimations and bias** between Flyvbjerg, Skamris Holm, & Buhl (2002) and Love & Ahiaga-Dagbui (2018). Flyvbjerg, Skamris Holm, & Buhl (2002) claimed that cost underestimations in TI projects are due to either error (optimism bias) or lie (strategic misrepresentation) of the forecasters, i.e. due to the planning fallacy (Love et al., 2019) which is also called the malevolent hiding hand, i.e. a hiding hand that hides initial costs and difficulties of a project so as the project to be approved, but these costs will not be overcome by later benefits later, opposed to what Albert Hirshman, the creator of the principle of the benevolent hiding hand supported (Love et al., 2019a). Love & Ahiaga-Dagbui (2018) supported that these claims are not valid but fake, aiming to only provoke and attract the attention. Love & Ahiaga-Dagbui (2018) support that the findings of Flyvbjerg, Skamris Holm, & Buhl (2002) lack empirical evidence and have methodological flaws. One of the methodological flaws is that Flyvbjerg, Skamris Holm, & Buhl (2002) used as a reference time to define the cost estimations the decision-to-build time. This is an early stage in a project's life cycle to use as a reference point to estimate costs because during the earlier phases of a TI project, i.e. planning phase and developing the business case and strategy, little information is known about the costs of the project and thus if this time of a project's life is selected so as to estimate costs, there might be a bigger deviation between the cost estimations and the actual costs.

Since the reference point ''decision-to-build'' to estimate costs is too early in the project life cycle, which might lead to bigger deviation between the cost estimations and the actual costs, in the present doctoral thesis estimated costs are defined not at the point of decision-to-build but at the point of the official time when the contract has been signed after procurement and tendering took place.

Phang (2003) examines rail and airport development investments in Singapore. One of the most important **factors in the success of the investments** reviewed in this paper have been the much higher than expected growth of the Singapore economy. Success was not defined explicitly though.

Frimpong et al. (2003) identified and evaluated the main **causes of cost overruns and delays** in groundwater drilling and construction projects in Ghana via a survey questionnaire. The main causes identified are: monthly payment difficulties from agencies, poor contractor management, material procurement, poor technical performances and escalation of material prices due to inflation.

Odeck (2004) examines the statistical relationship between estimated and actual costs of Norwegian road construction projects over the years 1992-1995. Findings show a significant variation between estimated and actual costs and the **causes of cost overruns**, being the size of the road projects (i.e. cost overruns are found to be more predominant in smaller than larger projects); the completion time of the projects, i.e. cost overruns increase up to medium sized projects when the completion time is longer, but then cost overruns decrease; and the regions where the projects are located.

Flyvbjerg, Holm, & Buhl (2004) define **success in terms of the cost development**, i.e. the difference between the actual and estimated construction costs in percentage of estimated construction costs. Three variables are tested to see if they cause cost escalations: length of implementation phase, size of project and type of ownership. Only the first is found to lead to cost escalations. Length of implementation phase is defined as the time period when decision to build is made until construction is completed and operations have started. With respect to the third variable, the authors conclude that the main problem that causes cost escalations is not the type of ownership, public vs private, but a specific type of public ownership, called state-owned enterprises that lack transparency and public control.

May (2005) state that the **barriers limiting infrastructures' progress** are practical and technological barriers, i.e. engineering design, availability of technology, management and information systems, land acquisition and lack of skills and expertise.

Li et al. (2005) examine the **critical success factors for PPP/PFI projects in the UK construction industry**. Based on a questionnaire survey research, the most relevant out of the 18 success factors included in total in the survey are the following three: 'a strong and good private consortium', 'appropriate risk allocation' and 'available financial market'. Moreover, a factor analysis is conducted that shows five underlying factor groupings for the 18 critical success factors being the: effective procurement, project implementability, government guarantee, favorable economic conditions and available financial market.

King, Manville, & Shoup (2007) discuss about **congestion/road pricing to affect traffic demand**, to reduce congestion. The 'difference' of this paper of King, Manville, & Shoup (2007), compared to other papers examining also the use of congestion/road pricing to affect traffic demand, is the argument about who should receive the revenues coming from the congestion pricing. It is suggested that for increasing the chances of political success (i.e. having political support) of the congestion pricing, congestion revenues need to be distributed to cities through which the freeways pass (earmarking revenues).

Allport, Brown, Glaister, & Travers (2008) in their study **''Success and failure in urban transport infrastructure projects''** described several urban TI projects, European and non-European and scored their performance based on six performance factors and three success criteria (outcomes as called in Chapter 1). The authors analyzed these scores (a scale of 1 (favorable) to 5 (unfavorable)) and examined if there is a relationship between them. The three success criteria are the financial success, policy impact and durability success. There is financial success when the actual and forecast costs and revenues at the commitment stage are similar. The project has policy success, if the planned policy impacts at the commitment stage, i.e. economic, social, environmental, developmental, are delivered. The sustainability success is achieved when the transport service is provided over the medium and long term, in a way that the policy objective of the TI is met in a sustainable way. The six **success factors** are: project environment turbulence, political control/sponsorship, national government guidance, planning effectiveness, procurement/ financing effectiveness and organizing for operations. The success factor 'project environment turbulence' refers to the environment in which the project is planned and delivered, i.e. if there were any unexpected disruptive events. The ‘political control and sponsorship’ factor refers to the existence or not of political control or sponsorship and of explicit goals and leadership during the development and operation of the project. The ‘role of national government’ (national government guidance) shows how able and appropriate the national government is to provide guidance. The factor ‘effectiveness of planning’ shows the quality of the infrastructure and transport planning to provide good input for the decision-making process. The ‘effectiveness of procurement and financing’ factor shows the quality of the contract, including good or not procurement, financing structures and performance incentives. The sixth and last factor of ‘organizing for operations’ focuses again to the quality of the contract, this time from the perspective of having a strong operator contract.

Le-hoai et al. (2008) identified the **causes of cost and time overruns** for large building and industrial construction projects in Vietnam via the usage of a survey questionnaire. Then the factor analysis technique was used, which clustered these causes into seven factors: slowness and lack of constraint; incompetence; design; market and estimate; financial capability; government; and worker.

Chan et al. (2010) identified 18 **critical success factors of PPP infrastructure projects in China** that could be grouped into the following underlying factors: Factor 1—stable macroeconomic environment; Factor 2—shared responsibility between public and private sectors; Factor 3—transparent and efficient procurement process; Factor 4—stable political and social environment; and Factor 5—judicious government control.

Parthasarathi & Levinson (2010) use Minnesota data to estimate the traffic demand inaccuracy in roadway forecasts and identify the reasons for inaccuracy ex-post (post construction evaluation). The analysis shows a trend of underestimation in roadway forecasts. The **causes of traffic forecast inaccuracy** (underestimation) are the following: errors in the socio-economic inputs; errors in demographic forecasts; inability of the traffic demand model to incorporate the occurred changes in trip generation and travel behavior (i.e. increase of trip generation and decrease of auto occupancy and persons per household) and differences between the assumed highway network and the actual in-place network. The latter refers to the change of roadway alignment plans that cause a difference between the initial and actual roadway alignment. This difference is problematic because the forecasts are made including the initial roadway alignment. For example, the forecasts assume that the complete roadway will have been completed within the expected year of construction completion, but in some projects, due to construction delays funding issues, public opposition, shift in regional planning goals etc., the completion of the entire roadway is not achieved by the expected year. Parthasarathi & Levinson (2010), similarly to Nicolaisen and Naess (2015) support that it would be good decision makers to have a better understanding of the forecasting process before making decisions based on the model results.

Olsson, Krane, Rolstadås, & Veiseth (2010) identify the **factors that affect the performance** (performance is not defined) of four rail Norwegian infrastructure projects, namely punctuality, frequency, travel time, and number of travelers (ex post evaluation).

Bhargava et al. (2010) investigate the **factors that affect cost and time overruns** in highway construction projects, by considering simultaneously cost and time overruns in the three-stage least-squares approach used. Some of the factors that have been found to be statistically significant in the models are: the contract size, project duration, expected weather conditions, and results of the contract bidding process.

Welde (2011) examines **the performance of Norwegian toll road projects**, which is defined in terms of traffic. Inaccurate traffic forecast is identified as a main risk for toll road projects. The **causes of the**

inaccurate traffic forecasts are either over-optimism or dishonesty of the planners. The latter cause is more difficult to be mitigated than if the cause is inaccuracies in the transport model. Although optimism bias is more usual to happen, pessimism bias can also happen in the ex ante appraisals (Welde, 2018).

Carpintero & Gomez-Ibañez (2011) examine Mexico's toll road program and define performance in terms of: costs (cost overruns calculated for each of the concessions), traffic (forecast vs annual average daily traffic) and revenues (not actual vs forecast but referring to the factors that caused financial difficulties and factors that affected the financial profitability of the project). Mistakes in the design of the concessions were **key causes of the financial problems**. More specifically, these mistakes in the design of the concessions were the too many concessions that were too short, with too high tolls, with too optimistic demand forecasts and cost estimates and awarded to investors (construction companies and banks) lacking strong incentives to perform as they should on the projects and carefully evaluate risks.

Attard & Enoch (2011) examine the **road pricing** in Valletta, Malta, **to reduce traffic demand and to generate revenues** for the government. The reason why was congestion due to the increased number of vehicles per km of road.

Cantarelli et al. (2012) examine the characteristics of cost overruns in 78 Dutch large-scale TI projects (road, rail, tunnel and bridge projects). By characteristics, they mean the frequency and magnitude of cost overruns. They also examine whether cost estimates have improved over time and also whether projects are more prone to cost increases during different project phases, i.e. during the pre-construction or construction phase. Performance is defined only in cost terms, meaning if the TI projects have cost overruns or underruns (actual (at the time of project completion) vs estimated costs (at the Time of formal Decision to build (ToD)). It is found that in the Netherlands, the projects with cost overruns are almost as common as the ones with cost underruns. However, cost underruns are lower than cost overruns. Also, it is found that the magnitude and frequency of cost overruns in the pre-construction phase is importantly higher than in the construction phase. Some of **the main reasons of cost overruns** are the appraisal optimism, i.e. forecasters and promoters are overly optimistic about the project cost outcomes; deliberate underestimation of costs, i.e. planners and promoters intentionally underestimate the project costs to win the approval of the project; due to different methodology used and due to the use of the formal decision to build as the basis for the estimated costs[5]. Some additional main reasons of cost overruns are big delays in the development plan procedures that increase the length of the pre-construction phase and possibly the costs, difficult decision-making process or large scope changes. The latter two are reasons causing cost overruns during the pre-construction phase of a project.

Chung, Song, & Park (2012) examine the freeway booking **policy** in Korea, **as a way to reduce traffic**. There are similar other policies around the world. For example, in London congestion pricing is used as a policy to reduce traffic congestion. Thus, performance is defined in terms of traffic demand and revenues because of the impact of the booking policy on traffic.

Park & Papadopoulou (2012) identify and analyze the **causes of cost overruns in TI projects in Asia**. They also evaluate their significance and relationship with project size, using regression analysis. The

[5] Different way of definition of actual and estimated costs: i.e. other studies define estimated costs at the time of the official decision to build but others earlier, this is important because the earlier the decision to build is taken in the decision making process, the lower the cost estimates are and thus possible cost overruns increase.

most important cause of cost overruns identified was awarding contracts to the lowest bidder. Also the contract type mostly associate with cost overruns has been found to be lump-sum contracts.

Love et al. (2012) identify the **key causes of cost overruns in social infrastructure projects**. A distinction is made between cost overruns in economic infrastructures, such as TI projects and social infrastructures, such as schools, hospitals, museums etc. Flyvbjerg and his colleagues identified strategic misrepresentation and optimism bias as the main causes of cost overruns for economic infrastructures (i.e. TI projects). However, Love et al. (2012) support that these causes do not adequately explain why social infrastructure projects underperform in terms of time and cost. Love et al. (2012) support that **design errors are the key reasons for social infrastructures' cost overruns** and this is the reason why attention needs to be paid in the design process. Design reviews, checks, and verifications are necessary throughout the design process. Good communication and collaboration is important among the client, design consultants and the contractor to avoid any design errors. The involvement of the contractor in the design phase would be beneficial.

Odeck (2013) evaluates the accuracy of the annual Norwegian road traffic growth-rate forecasts. The objective is to examine forecasts of the national and regional traffic growth rates, in contrast to project-specific traffic forecasts that are mostly examined by other studies. It is important for traffic forecasts to be accurate because they are used as inputs for policy making and thus, they may lead to inappropriate policies. Odeck (2013) studies the road Norwegian projects' traffic forecasts for the period 1996-2008. Forecasting methods were revised in 2002. He finds that there is a difference in the actual and forecast road traffic and that underestimation is more dominant. The following **factors** are **identified to affect positively the accuracy of traffic forecasts**: 1) revising the forecasting models annually by entering the most current data, 2) incorporating the effects of international traffic and the impact of immigration on the population.

Sanko, Morikawa, and Nagamatsu (2013) describe the case study of the Tokadai Line rail service in a suburb of Nagoya, Japan, and specifically they conduct a post-project evaluation of travel demand forecast. The authors find that the **forecast of travel demand was overestimated**. A key conclusion of this case study is that the uncertainties with respect to inputs need to be prioritized. However, this does not mean that the **uncertainties related to the inputs** cause larger errors than the **uncertainties related to model uncertainties**.

Gordon, Mulley, Stevens & Daniels (2013) examine the Sydney Metro (public–private contracting) for taking lessons. Performance (success) is measured in multiple ways. In terms of improved access, mobility and service; in terms of customer satisfaction; environmental performance, safety, reliability and network effectiveness – growth of services (traffic). Failure, on the other hand, is defined in terms of the key risks, such as the cost and revenue risks. Having a ''good'' contract in transport projects is an important **factor for the achievement of the project performance outcomes**. The following factors make a good contract: including incentive elements, i.e. performance payments and penalties, appropriate risk allocation and competitive tendering. However, a good contract might not be sufficient to guarantee the performance of a project due to human ''tendencies" (deliberate underestimation of costs etc.) (Flyvbjerg, Holm, & Buhl, 2002).

Hoffman, Berardino, & Hunter (2013) examine also how congestion pricing can affect traffic demand. Thus, performance is defined indirectly as the traffic demand, and congestion pricing is the **factor that can affect traffic demand performance**. Particularly, an increase of congestion pricing can decrease traffic demand. In this way, traffic demand in different TIs such as roads, airports, canals etc. can be controlled (i.e. decrease). Not only traffic demand can be affected by an increase in congestion pricing, but also the environmental performance, i.e. reduction of emissions, and the economic welfare of a region etc.

Doloi (2013) conducted a research to identify the **root causes of cost overruns of Australian construction projects** from the perspective of the three key project stakeholders, i.e. the client, the contractor and the consultant. A questionnaire survey was used to collect the causes of cost overruns from the three stakeholder groups. The questionnaire was designed based on an extensive literature review. Confirmatory factor analysis and multivariate regression analysis was used to cluster the relevant causes into key factor groups and find the causal relation between the factors and the cost performance outcome. The most critical factors of cost overruns found are three: robust control procedures and adequate programming, along with efficient design and effective site management.

Flyvbjerg (2014) supports that the **main causes due to which megaprojects fail** to achieve their planned performance outcomes, is the deliberate misrepresentation of costs and benefits and the optimism bias. This means that in order for the megaprojects to be approved to be realized, their costs are underestimated and their benefits are overestimated, either on purpose or due to the optimism that characterizes humans. Thus, megaprojects end up with cost overruns and benefit shortfalls.

Rosenfeld (2014) conducted a research to identify the **main root causes of cost overruns** in construction projects. Literature review and a brainstorming workshop was used to identify the causes of cost overruns and root cause analysis to identify the root causes, i.e. the main causes of cost overruns. The three main causes identified are: premature tender documents, too many changes in owners' requirements or definitions and tender-winning prices that are unrealistically low (suicide tendering).

Ahiaga-Dagbui & Smith (2014) investigate the use of data mining techniques to develop cost models that can be used for more reliable cost estimating during the early project stages, instead of traditional cost estimation approaches. **Unreliable estimation is a main cause of cost overruns**. Unreliable estimate of costs could be due to technical errors when estimating, or due to optimism bias or due to strategic misrepresentation. Managerial incompetence and risk and uncertainty are also mentioned as key causes of cost overruns.

Verweij (2015) examine twenty-seven Dutch road construction projects to identify the **factors that produce satisfactory outcomes in the implementation phase of PPP infrastructure projects**, using the fsQCA method. Results showed that externally-oriented management and close public–private cooperation are important factors for achieving satisfaction.

Nicolaisen & Næss (2015) examine the **accuracy of the traffic demand forecasts of the do-nothing alternatives** for road projects in Denmark and England, whereas literature mostly focuses on the traffic demand forecast accuracy of the do-something alternatives. The authors point out the importance also of the traffic forecast of the do-nothing alternative because these forecasts are compared with the forecasts of the do-something alternatives, so as policy makers to take a decision about increasing or not the road capacity, for example. If the traffic forecast of the do-nothing alternative is negatively biased (pessimism bias), i.e. showing that if the road capacity is not increased, this will lead to intolerable congestion, then this does not give another choice to the decision makers, than actually select the do-something alternative that is as a result favorably biased. Therefore, the traffic forecast inaccuracies are due to bias, optimism bias for the do-something alternative and pessimism bias for the do-nothing alternative. The authors state that a likely reason of the bias is assuming a fixed growth rate for the do-nothing alternatives, thus ignoring the behavioral changes of road users when congestion is increased. When decision makers decide upon the approval or not of a TI project, they need to take into consideration the assumptions used for the traffic forecast model, so as to be able to correctly interpret the model's results.

Salling and Leleur (2015) point out the inaccuracies in demand forecasts and construction cost estimations for TI project evaluation, which are present even when CBA is used, which is the most commonly used method for TI project evaluation. Thus, it is important to assess the uncertainties that are present in the CBA approach, with regard to cost overruns and demand shortfalls and support the decision-making process (taking into account these uncertainties/risks). For this purpose, they suggest a newly developed decision support model, based on quantitative risk analysis, Monte Carlo simulation and CBA. Therefore, the performance of TI projects is defined in terms of cost overruns and demand shortfalls and the **main factor that affects the performance** is bias. However, it is not specified if bias that causes benefit shortfalls and cost underestimations is intentional or not.

Bonnafous (2015) examines the changes in five economic regulations for the French toll highways from 2000 onwards. France's highways market, after the transition period of 2000-2005, changed from monopolistic to competitive and the focus is now in financial profitability and not in socio-economic profitability, as it was before the transition period. Now the principle of user-payer is reinforced, and investment choices are oriented to projects that have little need for public funds (aiming to decrease net present value/subsidy ratio). Therefore, it is observed that performance in this study is defined in terms of revenues. Changes in the existing economic regulations are used as a means for the improvement of the performance. The five **economic regulations as factors that affect the performance/competitiveness of TI projects** are: 1) monopolistic or competitive market, i.e. thus either the government owns only the infrastructure or ownership and rights of management and operation are also transferred to private companies as well (now competitive), 2) financing of the infrastructure by subsidies or the users (user payer principle reinforced); 3) pricing/charging for using the infrastructure (e.g. via tolls) (tolls aiming to maximize revenues and not to optimize welfare), which can affect traffic demand and the need for subsidies; 4) evaluation methods either focusing on the socio-economic or financial profitability (now focusing on the financial profitability) and 5) investment decisions either focusing on socio-economic or financial profitability (now focusing on the financial profitability).

Rouhani, Oliver Gao, & Richard Geddes (2015) examine the transportation road network in the region of Fresno, in California, in particular tolling roads PPPs, to take lessons on how to regulate PPP tolling schemes in urban environments. Performance is defined in terms of traffic and revenues (profitability). **Tolling schemes can affect traffic and revenues** in the following way. If tolls are too high, they could reduce demand because people will prefer to travel longer to use a free toll road than paying too high tolls. If tolls are too low, this will reduce revenues/profitability.

Macário, Ribeiro, & Costa (2015) identify the **pitfalls in the application of PPPs in TIs in Portugal**. Although performance is not clearly defined, the focus of the paper is mostly on demand overestimations (actual demand being lower than the expected) and as a result on the revenues, i.e. less revenues than expected due to lower demand. Cost overruns are also indicated because of poor information with respect to the actual costs of the project. Pitfalls of the Portuguese experience identified by the Court of Auditors (TC, 2005, TC, 2007, as cited by Macário, Ribeiro, & Costa, 2015) are the: 1) poor preparation of contracts, thus affecting cost because due to the lower traffic than expected, the contracts were renegotiated with the private partners and then the state had to pay compensations to the private partners for the lower traffic than expected; 2) technical competence of public partner (i.e. lack of skills that made them not see the optimism bias of the overestimated demand); 3) finance costs (weakness: high costs of private finance); 4) political commitment (weakness: failures in the alignment and involvement of public entities), which had an impact on costs due to changes in the project and additional costs (transaction costs to the State); 5) tools for projects' evaluation (weakness: lack of a 'Public Sector Comparator' (PSC) model to evaluate whether a project should follow a PPP model); 6) guidelines (practical consequence: difficulties in law interpretation, especially in a context of poor public sector skills); 7) knowledge transfer (weakness: lack of a regular system to collect and disseminate information on PPP experience in all stages including socio-economic impacts) and 8) transparency (weakness: poor information on PPP costs in the State budget, which led to cost overruns).

Lind & Brunes (2015) develop a new theory-based framework for analyzing cost overruns, and use this framework for an empirical study of cost overruns in infrastructure projects in Sweden. The questionnaire survey that was used showed that **cost overruns are due to design changes and increases in the amount of inputs needed because of technical and administrative problems, lack of competence and optimism bias**. It has been also found that most cost overruns occur during the initial planning stages of the project till the final design.

Olaniran et al. (2015) provide a critical review of the literature to better understand the **causes of cost overruns in hydrocarbon megaprojects**. Their findings showed that the interaction among the following factors contribute to the occurrence of cost overruns: project characteristics, people, technology, and structure and culture, using the chaos theory.

Goenka, Vasudevan, & Garvin (2016) defined **success and failure based on two outcomes, cost and time outcomes** (actual vs estimated, at the time of financial closure). The authors examine road PPP projects in India, using four conditions ('condition' is a term used in the fsQCA for the independent variable): complexity, leverage, toll reliance and industrial output. Complexity is a composite indicator, composed by the actual project cost divided by the length (in km) multiplied by the number of lanes added. Leverage is defined as the debt equity ratio. Toll reliance shows the source of revenues of the project. A high degree of toll reliance shows that the project has a high dependence on tolls. The industrial output shows the health of the secondary sectors of the economy (i.e. construction, manufacturing) and the net state domestic product per capita is used as a proxy to measure the industrial output (a five-year average is used, 2007-2012).

Sismanidou and Tarradellas (2017) conduct an ex post evaluation of the traffic demand forecasts that have been included in the Madrid-Barajas master plan, for the airport's capacity expansion in 2006. They identified the following **flaws in traffic forecast model**: 1) GDP was used as the almost sole variable to predict the future, which is insufficient; 2) not many stakeholders have been engaged in the planning process, something that if it was done, could improve the demand forecasting; 3) dominant market trends have been omitted or underestimated, e.g. growing number of long haul destination point-to-point flights, due to growing liberalization in the aviation market; 4) only one baseline scenario has been used for estimating demand, instead of multiple alternatives and decision has been made for expanding the airport capacity with a big new terminal based on this single scenario.

Babatunde & Perera (2017) define performance in terms of traffic revenues in a research study about BOT (Build-Operate-Transfer) PPP (Public-Private Partnership) road projects in developing countries. This study grouped 25 identified **traffic revenue risk factors** into three principle factors via factor analysis, namely 1) tolling related problems; 2) public resistance and inadequate governmental actions; and 3) taxation constraints and weak capabilities of concession teams.

Rodrigue, Comtois, & Slack (2017) focus on the **transport policy instruments that can affect the performance of transport systems**. Performance is not explicitly defined though. Transport policy instruments that can affect the performance of the transport 'industry' are the following: public ownership (of the TI), subsidies (revenue generation), regulatory control (i.e. government public agencies overseeing how transport system is functioning: environmental regulation is very important for the development, operation and maintenance of the TI), research and development etc.

Garrido, Gomez, Baeza, & Vassallo (2017) define performance in terms of revenues (namely economic profitability) in their study about road PPP projects in Spain. The two main **factors affecting performance** are the European financial support and type of road PPPs, concluding that shadow tolls and availability payments (to a greater extent) are types of funding of road PPPs that have higher economic returns than explicit toll concessions.

Ramos, Cantillo, Arellana, & Sarmiento (2017) examine road congestion charging for Medellin, Colombia. The focus in this study is on policies such as **congestion charge policy** that is used **to reduce traffic congestion, pollution and other externalities**. A demand elasticity analysis is conducted to see the impact that this policy of congestion charge has on traffic, or in other words on the behavior of the car users: i.e. what % of the car users are willing to pay the toll (thus meaning that they are not willing to change their behavior, thus not reducing traffic at certain peak hours), what % of the car users are willing to depart earlier to avoid paying the toll and what % would switch to a mode of public transport to avoid paying the toll. These results will contribute in identifying an appropriate schedule and toll for the congestion charge policy in Medellin. Thus, performance is defined in terms of traffic demand and consequently also revenues. Although the congestion charge policy (road pricing) has an impact on traffic congestion, the policy of restricting the use of cars by license plate numbers is not successful in long term because people find other ways, such as buying a second car to deal with this policy/avoid the ban. As part of the feasibility study for a congestion charge proposal in Medellin, a stated preference (SP) survey was conducted on car users to show the perception of users for a mode, using the following variables. These variables are 'perception indicators', being safety/security, comfort and reliability for each mode and they were formed using a Likert scale from 1 to 7.

Kumar, Jindal, & Velaga (2018) examined in their study 30 PPP based Indian highway infrastructure projects (BOT) and defined performance as traffic revenues. The **risk factors** tested to examine their impact **on the traffic revenues of the projects** are discount rate, growth in traffic, inflation rate, project cost and operations and maintenance cost. All of them, except the last, are found to be the most critical ones. It was pointed out that the appropriate risk allocation among the stakeholders is key success factor. Cost, time and traffic are considered as factors that affect the profitability/revenues of the TI project.

Beria, Grimaldi, Albalate, & Bel (2018) define success in terms of cost and traffic demand (mismatch between the actual and forecast figures) in their work about high-speed rail (HSR) in Italy and Spain. The authors state that the **problem is not due to the wrong estimations but due to deliberate choices of overinvestment, overdesign and overquality**, as the factors of failure for the two specific cases of HSR tested.

Dotti (2018) defines performance in terms of having or not cost overruns, delays and benefits, while examining a rail case infrastructure in Brussels, namely the Watermael-Schuman-Josaphat (WSJ) rail junction in Brussels. He concludes that a **main success factor** to deal with the high uncertainty of the rail infrastructure in Brussels is the advanced skills and experience of the constructors/engineers or in other words the technical and political know how. This conclusion goes beyond the concept of Flyvbjerg (2009) of strategic misrepresentation due to which benefits are overestimated and costs and risks are underestimated, thus leading to the survival of the 'unfittest' projects.

Welde (2018) shows that there are different measures of success, but all of them can be captured in a broad goal-oriented evaluation framework that aims to demonstrate if the original objectives have been met. Success is defined in different ways, from different perspectives, based on the different stakeholders and at different levels: operational, tactical, strategic (Welde, 2018 and Samset, 2003). Firstly, success is defined as efficiency (operational success) that can be examined right after the project is completed and examines to what degree the outputs achieved (cost, time, quality) derived from an efficient use of resources, financial etc. Secondly, success is defined as effectiveness (tactical success) examining the extent to which the project has achieved its original goals and whether the impacts are mostly positive. Tactical success cannot be measured right after the completion of the project, but later on, only after the affects had time to materialize. Impact, relevance and sustainability are all success criteria from the strategic perspective. Strategic success focuses on the long term effects and examines if these effects can be sustained in the long-term (i.e. if the project has any other impacts, positive or negative, other than the ones planned (impact); if the project is in line with the needs and priorities of the involved stakeholders (relevance) and if the positive effects generated by the project are likely to continue in the long term (sustainability). Value for money is the last success criterion and examines if the project delivered a positive net present value (NPV), like CBA does. Although the focus of this paper is mostly on the measures of success, or in other words success criteria, there is also some attention paid on the **success factors of the specific Norwegian project** under examination (E6 project) being the following: more favorable than expected soil conditions led to cost underruns; competent personnel that managed to work with economies of scale during the construction phase; authorities agreed to toll financing for the motorway and good cost estimation methodology. Overall, the main point of the paper was that success factors are the achievement of the goals initially set. For example, for the E6 project, the main project objective was reduction of traffic accidents, which have been achieved.

Roumboutsos, Voordijk, & Pantelias (2018) state that the **key elements that affect the performance of TI delivery and operation** are six: governance arrangements, business model (BM), funding scheme, financing scheme, implementation context and transport mode typology. For each of these elements, one or two composite indicators have been developed, being the Governance Indicator (GI); Cost Saving Indicator (CSI) and Revenue Support Indicator (RSI); Remuneration Attractiveness Indicator (RAI) and Revenue Robustness Indicator (RRI); Financing Scheme Indicator (FSI); Institutional Indicator (INI); Financial Economic Indicator (FEI) and Reliability/Availability Indicator (IRA) (Soecipto, Willems and Verhoest, 2018; Roumboutsos, 2018; Cardenas and Voordijk, 2018; Pantelias and Mitusch, 2018; Bernadino and Roumboutsos, 2018; Vanelslander and Moschouli, 2018). These indicators and the whole conceptual framework developed in Roumboutsos, Voordijk, & Pantelias (2018) constitute the state of the art with respect to the factors that affect the project performance of TI projects. **This conceptual framework understands the complexity of TI projects and interprets them as a system of the six interrelated elements, which interact to produce performance outcomes.**

Ahmadabadi & Heravi (2019) examine case studies of PPP highway projects in Iran. **Success for a PPP project** is defined as the achievement of predetermined objectives. Among these objectives there are the following ones: reducing construction costs, delivering the project on time or earlier, having actual revenues as forecasted and in general achieving high quality standards. Four **key success factors** are identified: 'adopting an appropriate risk management framework' (as a component of 'reliable private consortium') (for construction stage), 'appropriate risk allocation' (as a component of 'reliable contractual arrangement') (for construction stage), 'government guarantee and experience' (as the components of 'government capability') (for operation stage) and 'favorable legal and political support' (as the components of 'government capability') (operation stage). Their model confirmed that success during the transfer stage (stage at which the infrastructure is transferred to public after its operation) has a high dependence on the success during the operation stage.

Markolf, Hoehne, Fraser, Chester, & Underwood (2019) examine the existing knowledge about the vulnerability of the transportation system to climate change and extreme weather events and show how these phenomena affect the transportation system and particularly mobility (reducing it) and closures/delays (increasing them). Thus, performance of TIs is interpreted as mobility (traffic demand) and closures/delays (i.e. availability and reliability). Other **factors that can affect the performance of TIs**, apart from the climate change and extreme weather events, are 1) the flexibility in the design of a TI, which allows the alteration of the existing TI in order to react to foreseeable changes and uncertainties; and 2) integration (physical or ICT) can also have an impact on the performance of a TI/transport system, if extreme phenomena happen: e.g. if there is a physical (geographical) connection of the TI (e.g. road) with another infrastructure e.g. electric cables along the street or water mains underground the street and due to extreme heat phenomena, there is a failure of these infrastructure systems, this will also affect the operation of the TI and as a result the revenues as well. Also, if the transmission of data or communication is achieved via ICT systems on a TI and there is a failure of these systems (e.g. underground equipment) due to extreme phenomena, this will cause problems also in the operation of the TI.

Table 2. 1: Success and failure factors of (TI) projects identified in literature

Title of paper/book	**Type of project and country**	**Success/Failure in terms of what**	**Success and failure factors**
(1985) Arditi et al.	Turkey: public construction projects	Cost	**Main causes of cost overruns** • inflationary pressures • increases in material prices and workmen's wages • difficulties in obtaining materials at current official prices • construction delays and • errors in first estimates
(1988) Morris	General Projects in Europe (e.g. civil construction, power station; North Sea oil and gas; in-company product development; aircraft; spacecraft computerization)	Project management success	Key areas for managing major projects successfully • effective definition and sound establishment, consistent government support, and attention to the broader "systems" issues • technology and design management • organization and contracting strategy; habitual solutions not to be assumed as necessarily the most appropriate • leadership and effective communications (for implementation) • industrial relations (among management, unions and workers). • schedule and finance (especially in the planning stages)
(1988) de Wit	General projects	Project success	FACTORS AFFECTING PROJECT SUCCESS Success factors of projects • project definition • finance, planning and design • legal agreements • politics • contracting • schedule duration • project management • schedule urgency

			• human factors (Morris et al.,1986) Macro success factors of projects • Realistic and thorough definition of project • What: Efficient manner of project execution • How: Comprehension of project 'environment' • Context: Selection of organization realizing project - By whom Micro success factors of projects • Formulation of sound project policies - Policies • Clear and simple project organization - Framework • Selection of key personnel - Human resources • Efficient and dynamic management controls - Controls • Reliable management information systems – Information (Hayfield, 1979) Success factors of construction projects • planning effort (construction), • planning effort (design), • project manager goal commitment, • project team motivation, • project manager technical capabilities, • scope and work definition, • control systems (Ashley et al., 1987)
(1994) Mansfield et al.	Nigeria: construction projects	Cost and time	Causes of cost and time overruns • finance and payment arrangements • poor contract management • materials shortages Causes of cost overruns • inaccurate estimating and • overall price fluctuations
(1994) Semple et al.	Western Canada: civil, institutional, high-rise apartment building, and petrochemical projects	Cost and time	Key cause of cost and time overruns • contractual construction claims and disputes Main cause of claims and disputes in the 24 project cases studied: • increase in project scope
(1996) The British Standard for project management BS6079	Projects in general (project management)	Project planning and construction failure	Main causes of failure frequently observed with planning and constructing megaprojects • appraisal biases (too high benefits, too low-cost estimations) • inaccurate planning in the early planning phase • approval before project is mature

			• major changes during construction • technological experiments • no strict controlling, no risk management • no solid financial framework • failures with procurement and governance

(1996) Richardson & Haywood	UK - trans-Pennine transport links
	
	road and rail transportation (studies)
	
	(improvements to trans-Pennine infrastructure)
		Transport planning failure	Reasons of failure of strategic transport planning initiatives:
			
			• Not taking into account the following complex and transient contexts:
			  • social
			  • political
			  • economic and
			  • environmental
			(which envelop the decision-making process).

(1997) Kaming et al.	Indonesia: high rise construction projects (apartments, schools, offices, hospitals, shopping, auditorium)	Cost and time	Main factors causing cost overruns • inflationary increases in material cost • inaccurate material estimating and • project complexity Main factors causing delays • design changes • poor labor productivity and • inadequate planning Main factors causing both time and cost overruns • materials cost increases due to inflation • inaccuracy of estimates and • lack of experience of project type
(1998) Mackie & Preston	Transport projects	Transport project appraisal failure	Factors affecting the quality of transport project appraisal • errors (in data, models etc.) • bias (mainly optimism bias)

Trujillo et al. (2002)	Transport projects – demand forecasting
	
	(examples for worldwide projects)
		Traffic demand	Sources of uncertainty of the traffic demand forecasts in the context of transport privatization
			• scientific uncertainty
			  • inadequacy of the model structure
			  • inaccuracy and non-availability of the current data and
			  • uncertainty of prediction of the future value of exogenous variables
			  • underestimation due to: failure to recognize the existence of a demand for quality and not taking into account the interactions with a wider transport network
			• strategic forecast bias (optimism or pessimism bias)

(2002) Lay & Daley	Melbourne City Link Project (road)	Traffic demand	Main factor affecting success of the Melbourne City Link Project (road project) in terms of traffic: • electronic toll collection

(2002) Bruzelius, Flyvbjerg, & Rothengatter	Large infrastructure investments in Denmark and Germany (transport projects only)	Cost and time	Cause of cost overruns and delays • inefficient monitoring of a project Factor reducing likelihood of cost overruns and delays • involvement of risk capital (i.e. having also private financing not only public) Measures to increase accountability in decision making on very large infrastructure investments • transparency • performance specifications approach (instead of conventional approach) • explicit formulation of regulatory regimes (i.e. means of funding and financing of the project) • involvement of risk capital (i.e. having also private financing not only public) Types of risks/failure factors • cost risk (construction, maintenance, operation) • demand risk (traffic forecast, revenues) • financial market risk (future interest rates) • political risk (regulation, parallel public investment, pricing on adjacent parts of the network)
(2002) Flyvbjerg, Skamris Holm, & Buhl	TI projects	Cost	Causes of cost underestimations** in TI projects are due to: • either error (optimism bias) or • lie (strategic misrepresentation) of the forecasters **Love & Ahiaga-Dagbui (2018) support that these findings lack empirical evidence and have methodological flaws.
(2003) Phang	Rail and airport development investments in Singapore	Overall success	Main success factor in rail and airport development investments in Singapore • national growth of economy
(2003) Frimpong et al.	Ghana: Groundwater construction (drilling) projects	Cost and time	Main causes of delay and cost overruns • monthly payment difficulties from agencies • poor contractor management • material procurement • poor technical performances and • escalation of material prices (due to inflation)
(2004) Odeck	Norwegian road construction projects	Cost	Factors influencing the size of cost overruns: • size of the projects (smaller projects, higher cost overruns) • completion time of the projects (increase of cost overruns up to medium sized projects when the completion time is longer, but then decrease of the cost overruns). • regions where the projects are located
(2004) Flyvbjerg, Holm, & Buhl	TI projects: **258** rail, bridge, tunnel and road projects in 20 nations (including Europe, North America and other geographical areas, also developing)	Cost	Causes of cost escalations • length of implementation phase • size of project** • type of ownership** ** findings showed no impact of the ** factors on cost escalations.
(2005) Li et al.	Projects in the UK construction industry	Overall success	Three critical success factors (based on research survey) out of the 18 ones examined:

			• 'a strong and good private consortium', • 'appropriate risk allocation' and • 'available financial market'. Five underlying factor groupings for the 18 CSFs (based on factor analysis) • effective procurement, • project implementability, • government guarantee, • favorable economic conditions and • available financial market.
(2005) May	TIs (mainly Europe)	Overall success	Barriers limiting infrastructures' progress are: • practical and technological: • management and information systems • engineering design and availability of technology • lack of key skills and expertise
(2007) King, Manville, & Shoup	Road: data from several metropolitan areas (e.g. Los Angeles)	Traffic demand	Factor affecting traffic demand • congestion pricing
(2008) Allport, Brown, Glaister, & Travers	Urban TI projects: European and non-European	Overall success: - financial success - policy success - Sustainability success	Success factors in urban TI projects • project environment turbulence • political control/sponsorship • role of national government (guidance) • planning effectiveness • procurement/financing effectiveness • organizing for operations
(2008) Le-hoai et al.	Vietnam: large building & industrial construction projects	Cost and time	Seven factors causing cost and time overruns (during construction phase) • slowness and lack of constraint • incompetence • design • market and estimate • financial capability • government and • worker
(2010) Chan et al.	Infrastructure projects, China	Overall success	Critical success factors (CSFs) of PPP infrastructure projects: <u>18 CSFs were grouped into five underlying factors:</u> • Factor 1—stable macroeconomic environment; • Factor 2—shared responsibility between public and private sectors; • Factor 3—transparent and efficient procurement process; • Factor 4—stable political and social environment; • Factor 5—judicious government control.
(2010) Parthasarathi & Levinson	Road TI projects in Minnesota	Traffic demand	Causes of traffic demand forecast inaccuracies (underestimation) • errors in the socio-economic inputs • errors in demographic forecasts • inability of the traffic demand model to incorporate the occurred changes in trip generation and travel behavior (i.e. increase of

			• trip generation and decrease of auto occupancy and persons per household) • differences between the assumed highway network and the actual in-place network. Main conclusion: the cause of inaccuracies is **errors** in the forecast model
(2010) Olsson, Krane, Rolstadås, & Veiseth	Norwegian rail TI projects	Overall success	Factors that affect the performance: • punctuality • frequency • travel time • number of travelers
(2010) Bhargava et al.	Indiana: highway construction projects	Cost and time	Factors that affect cost and time overruns • the contract size (i.e. project cost) • project duration • expected weather conditions and • results of the contract bidding process
(2011) Welde	Norwegian toll road projects	Traffic demand	Causes of the inaccurate traffic forecasts: • over-optimism or • dishonesty among planners

(2011) Carpintero & Gomez-Ibañez	Mexico's toll road	Overall success	Causes of financial problems
			• mistakes in the design of the concessions
			
			Defects in the design of the program
			• too many concessions that were too short
			  • (with) too high tolls
			  • (with) too optimistic demand and cost forecasts
			  • awarded to investors (construction companies and banks) lacking strong incentives to perform as they should on the projects & carefully evaluate risks

(2011) Attard & Enoch	Road pricing in Valletta, Malta	Traffic demand & revenues	Factor that affects traffic demand and revenues • road pricing
(2012) Cantarelli et al.	Dutch TI projects (road, rail, tunnel and bridge projects)	Cost	The main reasons of cost overruns are: • appraisal optimism • deliberately and strategically underestimating costs • due to the methodology and due to the use of the formal decision to build as the basis for the estimated costs • big delays in the development plan procedures • difficult decision-making process or large scope changes (during the pre-construction phase of a project)
(2012) Chung, Song, & Park	Road: freeway booking policy in Korea	Traffic demand	Factor affecting traffic demand: • policy (i.e. freeway booking policy to control the access on the highway)
(2012) Park & Papadopoulou	Asia: Transport infrastructure (TI) projects	Cost	Main causes of cost overruns: • awarding contracts to the lowest bidder
(2012) Love et al.	Australia: Social infrastructure projects (i.e., hospitals, law and order,	Cost	Main cause of cost overruns of social infrastructures • design errors

	museums, schools, and recreational facilities)		
(2013) Odeck	Norwegian road traffic growth-rate forecasts	Traffic demand	Factors affecting positively the accuracy of traffic forecasts: • revising the forecasting models annually • incorporating the effects of international traffic and the impact of immigration on the population
(2013) Sanko, Morikawa and Nagamatsu	Japanese railway (ex-post evaluation)	Traffic demand	Factors behind the errors that led to the **overestimation** of the traffic demand forecast: • uncertainties related to the inputs • uncertainties related to the model

(2013) Gordon, Mulley, Stevens, & Daniels	Sydney Metro
	(public–private contracting)
		Overall success In terms of :
		
		-improved access, mobility and service;
		-customer satisfaction; -environmental performance, -safety,
		-reliability and network effectiveness – growth of services (traffic)
			Success factor in transport projects
			• having a good contract with:
			  • incentive elements
			  • appropriate risk allocation
			  • competitive tendering
			Failure factor
			• human ''tendencies'' (e.g. deliberate cost underestimation)
			(i.e. strategic misrepresentation)

(2013) Hoffman, Berardino, & Hunter	'Congestion pricing applications' for roadways, canal and bridges passage, port usage, access to city centers, and peak use of energy resources	Traffic demand	Factor affecting traffic demand • congestion pricing (policy)
(2013) Doloi	Australia: Construction projects	Cost	The most critical factors of cost overruns • robust control procedures and adequate programming, along with • efficient design and • effective site management
(2014) Flyvbjerg	Megaprojects	Overall success	Main causes due to which megaprojects fail to achieve their planned performance outcomes: • deliberate misrepresentation of costs and benefits • optimism bias
(2014) Rosenfeld	International: Construction projects (building and infrastructure projects)	Cost	Three main causes of cost overruns • premature tender documents • too many changes in owners' requirements or definitions • tender-winning prices are unrealistically low (suicide tendering)

(2014) Ahiaga-Dagbui & Smith	UK: Water infrastructure	Cost	Causes of cost overruns • technical difficulties (technical error in design or estimation) • optimism bias • managerial incompetence and • strategic misrepresentation • risk and uncertainty
(2015) Verweij	Dutch road construction projects	Overall success	Factors producing satisfactory outcomes in the implementation phase of PPP infrastructure projects • externally-oriented management and • close public–private cooperation
(2015) Nicolaisen & Næss	35 road projects in Denmark and England	Traffic demand	Causes of traffic demand forecast inaccuracies: • optimism bias in favor of the do-something alternative and • pessimism bias against the do-nothing alternative Reasons of the bias • **quality of the information and methods** (used to produce the forecast) • **structure of the transport models** (being too simple and incapable of capturing dynamic effects (e.g. changes in car ownership, changes in the traffic growth rate thanks to the investments in the road etc.)).
(2015) Salling & Leleur	TI projects (road, rail, air and fixed link projects) Denmark, Sweden , Estonia, through Latvia and Lithuania, Poland	Cost and traffic demand	The main factor that affects the performance in terms of cost and traffic demand is: • bias *** it is not specified if bias is intentional or not.
(2015) Bonnafous	French toll highways	Overall success	Economic regulations (five instruments of infrastructure policy) as factors that affect the performance/competitiveness of a TI project: • monopolistic or competitive market • financing of the infrastructure by subsidies or the users • pricing for infrastructure • evaluation methods focusing on either the socioeconomic or financial profitability • choice of investment (investment decisions) of that project/investment with the higher ''value for money, with a progressive decrease of the net present value/subsidy ratio''
(2015) Rouhani, Oliver Gao, & Richard Geddes	Transportation road network in Fresno, California Tolling roads PPPs	Traffic demand and revenues	Factor affecting traffic demand and revenues • tolling schemes (policy)

(2015) Macário, Ribeiro, & Costa	TIs: Portuguese PPPs	Overall success	Pitfalls of the Portuguese experience identified by the Court of Auditors (TC, 2005, TC, 2007, as cited by Macário, Ribeiro, & Costa , 2015) • poor preparation of contracts • technical competence of public partner • finance costs (weakness: high costs of private finance) • political commitment (weakness: failures in the alignment and involvement of public entities) • tools for projects' evaluation (weakness: lack of a Public Sector Comparator model to evaluate whether a project should follow a PPP model) • guidelines (practical consequence: difficulties in law interpretation, especially in a context of poor public sector skills) • knowledge transfer (weakness: lack of a regular system to collect and disseminate information on PPP experience in all stages including socio-economic impacts) • transparency (weakness: poor information on PPP costs in the state budget (financial compensations are not included))
(2015) Lind & Brunes	Sweden: infrastructure projects (mostly road and railways)	Cost	Causes of cost overruns • design changes and • increases in the amount of inputs needed because of technical and administrative problems • lack of competence and • optimism bias
(2015) Olaniran et al.	Internationally :Hydrocarbon Megaprojects (oil and gas infrastructures)	Cost	Causes of cost overruns (i.e. their interaction cause cost overruns) • project characteristics (project scale, project schedule, project type, project location, project delivery process & site conditions) • people • technology and • organizational structure and culture (organizational setting, communication, project governance, leadership, contractual interactions)
(2016) Goenka, Vasudevan, & Garvin	Indian road PPP projects	Cost and time	Factors affecting cost and time performance: • complexity • leverage • toll reliance • industrial output
(2017) Sismanidou and Tarradellas	Airport capacity expansion in Spain	Traffic demand	Causes of traffic forecast inaccuracies: • too simplistic demand forecast models • use of GDP as the almost sole variable to predict traffic • engaging not many stakeholders in the planning process • omitting or ignoring dominant market trends

			• estimating demand for only one baseline scenario instead of multiple alternatives
(2017) Babatunde & Perera	PPP project, Nigeria	Revenues (from traffic demand)	Traffic revenue risk factors: • tolling related problems • public resistance and inadequate governmental actions • taxation constraints and weak capabilities of concession teams
(2017) Rodrigue, Comtois, & Slack	Transport systems	Overall success	Transport policy instruments that can affect the performance of the transport 'industry': • public ownership (of the TI) • subsidies (revenue generation) • regulatory control (environmental regulation is very important) • research and development

(2017) Garrido, Gomez, Baeza, & Vassallo	Road PPP projects in Spain	Revenues	The two main factors affecting performance in terms of revenues are:
			• European financial support
			• type of funding of road PPPs with higher economic returns than explicit toll concessions
			    • shadow tolls
			    • availability payments (to a greater extent)

(2017) Ramos, Cantillo, Arellana, & Sarmiento	Road congestion charging for Medellin, Colombia	Traffic demand	Factor that affects traffic demand:
			• demand policies
			    • restricting the use of cars by license plate numbers
			    • congestion charge policy (road pricing)
			
			'Perception indicators' that show the perception of users for a mode
			• safety/security
			• comfort
			• reliability

(2018) Kumar, Jindal, & Velaga	30 PPP based Indian highway infrastructure projects (BOT)	Revenues	Risk factors influencing revenues of a project: • discount rate • growth in traffic • inflation rate • project cost • operation and maintenance costs** **found to have no impact Key success factor • appropriate risk allocation
(2018) Beria, Grimaldi, Albalate, & Bel	High-speed rail in Italy and Spain	Cost and traffic demand	Factors of failure in terms of cost and traffic demand performance: • deliberate choices of overinvestment • overdesign • and overquality

(2018) Dotti	Rail infrastructure in Brussels	Cost, time and overall benefits	Failure factors in terms of cost overruns, delays (risks) and benefits: • overestimation of benefits • underestimation of costs • underestimation of risks Success factor • advanced skills and experience
(2018) Welde	Norwegian motorway project (E6 project)	Success in terms of the achievement of initial project objectives	Success factors of the E6 project: • more favorable than expected soil conditions • competent personnel that managed to work with economies of scale during the construction phase • authorities agreed to toll financing for the motorway and • good cost estimation methodology
(2018) Soecipto, Willems and Verhoest (2018) Roumboutsos (2018) Cardenas and Voordijk (2018) Pantelias & Mitusch (2018) Bernadino and Roumboutsos (2018) Vanelslander and Moschouli	TI projects in Europe	Success in terms of the achievement of performance outcomes	Key elements that affect the performance of TI delivery and operation are: • implementation context • governance arrangements • business model (BM) • funding scheme • financing scheme • transport mode typology For each of them, indicators have been developed: Implementation context • Institutional Indicator (INI) • Financial Economic Indicator (FEI) Business model (BM) • Cost Saving Indicator (CSI) • Revenue Support Indicator (RSI) Governance arrangements • Governance Indicator (GI) Financing scheme • Financing Scheme Indicator (FSI) Funding scheme • Remuneration Attractiveness Indicator (RAI) • Revenue Robustness Indicator (RRI) Transport mode typology • Reliability/Availability Indicator (IRA)
(2019) Ahmadabadi & Heravi	A case study of highway projects in Iran-PPP	Success in terms of the achievement of initial project objectives	Key success factors in terms of the achievement of predetermined objectives: • **'appropriate risk management'** (as a component of 'reliable private consortium') (for construction stage) • **'appropriate risk allocation'** (as a component of 'reliable contractual arrangement') (for construction stage) • '**government guarantee and experience**' (as the components of 'government capability') (for operation stage) • **'favorable legal and political support'** (as the components of 'government capability') (operation stage)

(2019) Markolf, Hoehne, Fraser, Chester, & Underwood	Transportation system (for U.S. but conclusions broadly applicable)	Success in terms of: -mobility (traffic demand) and -closures/delays (i.e. availability and reliability)	Factors affecting the performance of TIs or transport systems in general: • climate change and extreme weather events • the flexibility into the design of the TI • integration (physical or ICT)

To sum up, in table 2.1 success is defined as either project management success, or overall success or success in terms of the cost, time, traffic, revenues and other project objectives.

With respect to the success of project management, it is observed that a good project scope and definition, schedule management, finance/cost management, human resources, communications management, legal agreements & contracting and leadership and risk management are the key factors affecting the project management success. These factors are the project management knowledge areas that lead to project success (Schwalbe, 2006).

With respect to overall success, i.e. success defined in general terms and not in a specific way, e.g. not in terms of the cost project objective, it has been found that the key main factors for its achievement are: stable political and regulatory environment, stable macro-economic environment, having a good contract with appropriate risk allocation, effective procurement process with competitive tendering and incentive elements, having a skilled consortium, availability of technology, planning effectiveness and a good methodology of estimations of e.g. costs, thus having unbiased and accurate estimates.

With respect to success in terms of cost, the key factors that have been found to affect the achievement of the cost project objective are: inefficient monitoring of project, having also private financing, bias (deliberate and non-deliberate) that lead to underestimation of costs, delays in the development plan procedures, the size of the project, length of implementation (completion time), region where the project is located, macro-economic environment and personnel skills and experience.

With respect to success in terms of time, the factors affecting the achievement of the time outcome overlap almost fully the factors of the cost outcome, since it is common in literature that the achievement of cost and time objectives is examined together.

With respect to success in terms of traffic demand, the key factors that affect its achievement are related to 1) errors in the traffic demand forecast models (i.e. in the model structure, inadequate data, uncertainty of predictions of future values of exogenous variables), 2) forecast bias, optimism or pessimism (i.e. non deliberate) or deliberate forecast bias and 3) factors that can affect traffic demand, such as pricing policies (e.g. tolling schemes, congestion pricing etc.) and the perception of users with respect to the safety/security, comfort and reliability.

With respect to success in terms of revenues, the key factors are: pricing policies, such as tolling schemes, public resistance, type of funding used (which can bring higher economic returns), traffic growth and project costs.

Therefore, for the achievement of the cost and time project objectives, project management is of key importance. While for the achievement of traffic demand and revenues, project management does not play a role, but it is the traffic forecast models, the forecast bias and the factors that affect demand such as pricing policies and perception of users that play a key role.

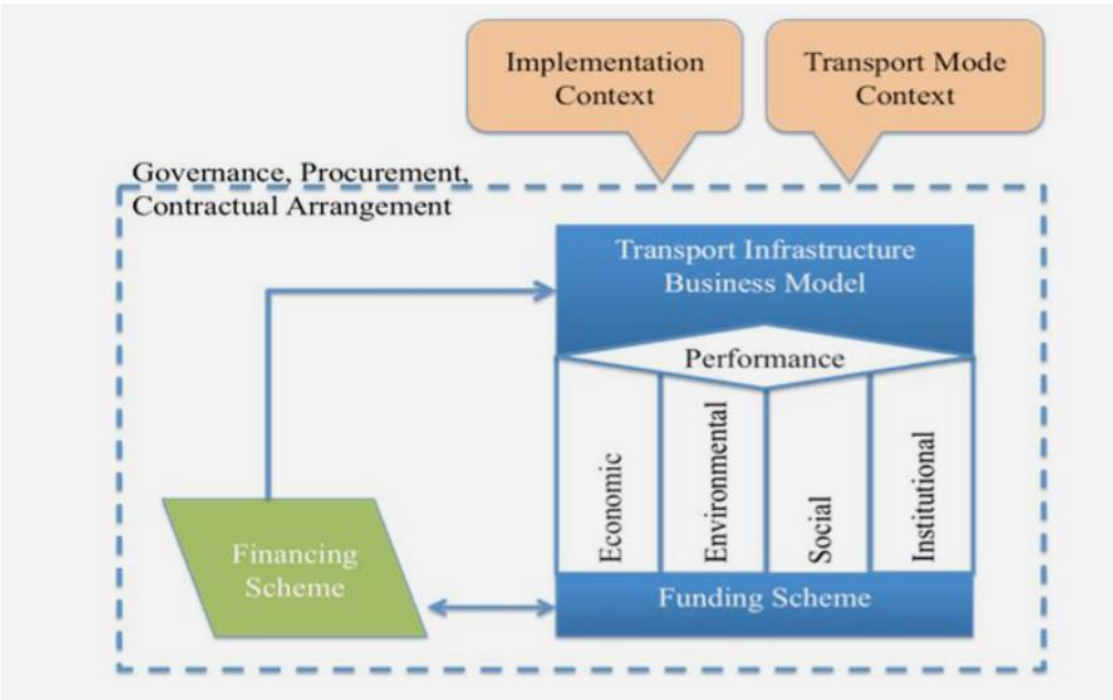
After having collected the factors that affect the performance of TI projects via a literature review, a decision needs to be made about which of these factors will be selected to be used as independent variables in the present doctoral thesis. Among all the sources that have been studied and all the factors identified in them, there was one source that stood out, i.e. from Soecipto, Willems and

Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018). This source has been selected to be the conceptual framework of the present thesis. The reason why is explained in the next section 2.3.

2.3 Selecting the factors that will be used as independent variables

The conceptual framework and indicators of Soecipto, Willems and Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018) are selected to be used as the independent variables (i.e. conditions in fsQCA terms) of the present doctoral thesis, among all the factors that were identified in literature. Based on this conceptual framework, six key elements affect the performance of TI delivery and operation: governance arrangements, business model (BM), funding scheme, financing scheme, implementation context and transport mode typology (Figure 3). For each of these elements, one or two composite indicators have been developed, being **the institutional indicator, the financial-economic indicator, the cost saving indicator, revenue support indicator, governance indicator, remuneration attractiveness indicator, revenue robustness indicator, reliability and availability indicator and financing scheme indicator**. The reliability and availability indicator is developed in the present doctoral thesis and presented in more detail in chapter 5. These indicators were developed under the **H2020 research project BENEFIT**. Their definitions are presented in Box 1. Figure 3 shows the interrelation of the six key elements for producing the performance outcomes. More specifically, **funding schemes** are considered successful or not depending on the **business model** that generates them and also the policy contexts and stakeholders. Business model's performance is influenced by the **implementation context** and the **transport mode context**. Business model is matched successfully or not by a **financing scheme**. **Contractual arrangements** (governance) describe partially the relations between actors (Roumboutsos, Voordijk, & Pantelias, 2018).

Figure 3: Key elements that affect the performance of TI delivery and operation



Source: Roumboutsos, Voordijk,& Pantelias (2018)

Box 1. Indicators developed to show how the key elements of the TI project system interrelate and interact to produce the performance outcomes of TI projects (Soecipto, Willems and Verhoest, 2018; Roumboutsos, 2018; Cardenas and Voordijk, 2018; Pantelias and Mitusch, 2018; Bernadino and Roumboutsos, 2018; Vanelslander and Moschouli, 2018).

''The Institutional Indicator (INI) captures the political, regulatory and administrative dimensions. The political dimension is composed by the governance indicators of i) political stability and absence of violence, ii) control of corruption and iii) voice and accountability; thus giving an overview of the general political situation of a country. The regulatory dimension is composed by the governance indicators of i) rule of law, ii) regulatory quality and iii) liberalization of markets; thus, showing the judicial and regulatory context of a country. The administrative dimension is composed by the indicator of government effectiveness. All indicators are World Bank Governance Indicators (WGIs), except the liberalization of markets indicator (the inverse of the ETCR developed by OECD).

The Financial Economic Indicator (FEI) measures more than just the macro-economic and macro-financial context of a country, but more broadly the business environment and can be seen as a proxy for the level of productivity of a country. The Growth Competitiveness Index of the World Economic Forum was selected to describe this indicator.

The Cost Saving Indicator (CSI) shows the robustness of the BM with respect to reducing costs during the construction and operation phase of the project (construction, operation, maintenance costs). It is a composite indicator taking into consideration the following elements for the construction phase: Level of civil works/technical difficulty; Capability to construct; Capability of the Contracting Authority to monitor the construction; Level of optimal construction risk allocation; Adoption of innovation; Capability to innovate and the Capability of the Contracting Authority to plan. For the operation phase, the following elements are examined: Life cycle planning; Capability to operate and Level of optimal operation risk allocation.

The Revenue Support Indicator is a measure of the project's ability to generate revenues. It is a composite indicator that includes: The level of coopetition of the new (greenfield) and existing (brownfield) parts of the project; revenue from transport and non-transport sources managerial assessment.

The Contractual Governance Indicator (GI) refers to factors setting the governance scene within a project. Governance focuses on the relationships between a contracting authority and a contractor or contractors. These relationships are usually formed by transactions during the procurement process and are reflected in a contract and its changes. In this respect, it is defined by the contractual conditions and the process leading to them.

The Remuneration Attractiveness Indicator (RAI) represents the various income sources with their assessed risk and potential cost coverage. Remuneration schemes refer to the revenue streams that are used as payments to the project actors that have incurred project related costs (being the construction and operational/maintenance costs), thus seeking to recover their investment.

The Revenue Robustness Indicator (RRI) represents the various revenue sources with their assessed risk and potential cost coverage. Revenue schemes concern the way the project produces revenues.

The Reliability/Availability Indicator represents the level of physical and operational reliability and availability of the infrastructure and the transport service (developed by Vanelslander and Moschouli, 2018, see Chapter 5).

The Financing Scheme Indicator (FSI) captures the risk-return profile of transport infrastructure financing schemes, based on the evaluation of the contribution of different financing sources. Financing refers to the raising of capital at the beginning of a project to pay for its development costs, e.g. construction costs. Financing schemes show whether a project is developed by a private or public sponsor. The financial viability condition of the transport infrastructure projects is the ability of the project to meet its financial targets, so as to repay fully and in due time the debt investors and additionally to generate sufficient returns for the equity investors. FSI reflects an expanded version of the weighted average cost of capital included in the project from both public and private sources (1-WACCad). It reflects the level of the cost of capital (low/cheap versus high/expensive).''

This source has been selected to be the conceptual framework (i.e. the indicators that will be used as conditions in the empirical analysis) of the present thesis because it recognizes the complexity of the transport system and understands that the TI project performance cannot be achieved and affected only by one factor but by the interaction by multiple factors. This is not under the attention of the relevant broad literature. Although literature identifies multiple factors that could affect the performance of TI projects, no attention is paid in the interaction of these factors. The majority of the remaining (i.e. non-selected) success and failure factors that are presented in Section 2.2. could be clustered under the indicators that were selected to be used as conditions in the empirical analysis. Thus, considering that the research question of this doctoral thesis is ‘’which are the combinations of conditions that affect the achievement and non-achievement of TI project objectives?’’, this conceptual framework and its respective indicators constitute the most appropriate choice.

3. Methodology

Chapter 3 presents the research methodology of the doctoral thesis, the steps that are followed in the research, the scope of each step linked to the respective PhD chapter, the type of data used, a review of methods and justification for the selected method that is used in the empirical analysis of the present thesis.

In the present research, the following steps are followed, as shown in figure 4 below:

Figure 4: Steps followed in the doctoral thesis

step 1: acquiring a knowledge background of TI project investments (in general, not for the projects selected)

Scope of step 1: to have a good understanding of TI projects and ultimately **to identify the research gap in the existing decision support tools used to support the** decision **making process**

step 2: identifying the key project objectives of TI projects (in general, not for the projects selected)

Scope of step 2: **to use the key project objectives as dependent variables** in the empirical analysis and **to define success** based on these key project objectives

step 3: identifying the research gap in the existing decision support tools

Scope of step 3: to find a way to increase the likelihood of project success in terms of achieving project objectives

Chapter 1

Steps 1,2, 3: critically reviewing the literature in the field, from a new perspective, and identifying a new research gap to serve into more successful future TI investments

step 4: identifying the factors that affect the performance of TI projects **(chapter 2)** and developing an indicator **(chapter 5)**

Scope of step 4: to use the identified factors as independent variables in the empirical analysis, one of which is also the indicator that has been **newly** developed in this doctoral thesis

step 5: doing a literature review of the methods of analysis used currently in studies to find the cause and affect relationships between the key project objectives and the factors affecting performance of TI projects **(chapter 3)**

Scope of step 5: to identify a suitable method of analysis to be used in the present doctoral thesis, being the fsQCA method (i.e. a new analysis method has not been developed)

step 6: collecting data, cleaning them and calibrating them and running the analysis **(chapter 4 and 6)**

Scope of step 6: to use these data for doing the empirical analysis, using the fsQCA method, for different TI project samples and to find combinations of conditions (i.e. combinations of causally relevant ingredients) that affect the achievement of the TI project objectives

The data were collected for two TI projects in the present doctoral thesis and the rest of the TI projects' data have been retrieved from the H2020 BENEFIT project's database. The data were cleaned and calibrated in the present doctoral thesis to be appropriately formed for the fsQCA application. A new analysis has been conducted using the fsQCA and gave new findings, i.e. combinations of conditions that affect the achievement of the TI project objectives

step 7: developing the new three-step **''Project objectives' achievement compass''** (POAC) tool, based on the fsQCA findings, the indicators used and the fsQCA calibration method **(chapter 7)**

Scope of step 7: to increase the likelihood of achievement of four key project objectives, of the cost, time, traffic and revenues objectives

step 8: Demonstrating the application of the newly developed POAC and partially validating it, using cases used in the empirical analysis **(chapter 7)**

Scope of step 8: to show to the potential users of the tool, analysts, decision makers, financiers and academic scholars, how to apply the newly developed tool and how to interpret its results

step 9: wrapping up all the main thesis' outputs **(chapter 8)**

Scope of step 9: to have an overview of the new outputs of the present doctoral thesis and to further discuss about the transferability, implications and limitations of the thesis' findings

With respect to the data, primary data from semi-structured interviews and secondary data from desk research are used (see chapter 4 for more detailed information about the data). Section 3.1 below reviews the methods of analysis to examine causal relationships and section 3.2 justifies for the selected method and provides more methodological information about it.

3.1 Review of methods of analysis

The methods of analysis are reviewed that are currently used in the relevant literature to investigate the cause and effect relationships between the factors and the performance outcomes of TI projects. The methods that are found in literature are the following: **qualitative comparative analysis (QCA)**, **econometrics, importance analysis (or sensitivity analysis), factor analysis, artificial neural network (ANN), benchmarking, and qualitative analysis (Table 3.1).** These methods are presented below in more detail.

Table 3. 1: Methods of analysis investigating causality

Methods of analysis investigating causality
• qualitative comparative analysis (QCA) • econometrics • importance analysis (or sensitivity analysis) • factor analysis • artificial neural network (ANN) • benchmarking • qualitative analysis

Qualitative Comparative Analysis (QCA)

Qualitative Comparative Analysis (QCA) is a comparative method that offers a middle path between quantitative and qualitative measurement (Ragin, 2008, p. 71). It is comparative because *"it explores and finds similarities and differences in outcomes across comparable cases by comparing configurations of conditions"* (Marx & Dusa, 2011, p. 105). QCA is not very useful for very small samples (for example less than 12 cases) (Fiss, 2008). QCA encompasses three different comparative methods: the crisp set (csQCA), the fuzzy set (fsQCA) and the multi-value QCA (mvQCA).

The crisp set is ideal for binary conditions, with only two values, either "in" or "out" of a set, while the fuzzy set allows 'membership in the interval between 0 and 1' (calibration step) (see Annex A.6.71 for the calibration details). In mvQCA, the outcome still has to remain dichotomous, although this is not an obligation for the conditions (Rihoux & Ragin, 2009, p. 85).

A comparative case-based approach, such as QCA, is the most suitable way to study the relationship between outcomes and context in projects. QCA keeps the middle between a case-based and a variable-based approach, thus allowing to understand in depth the cases and also observe the interactions among the conditions explaining the achievement or not of a target of TI projects (e.g. cost target). The complexity of the (transport) infrastructure projects necessitates the use of a method, such as QCA, which treats appropriately this complexity (Verweij and Gerrits, 2013) (Gerrits, & Verweij, 2018). A few QCA applications are found in literature in the field of TI projects (Gross and Garvin, 2011), (Verweij, 2015) (Vasudevan et al., 2018).

Econometric analysis

Econometrics techniques are developed to answer practical questions, often related to economic issues, as the first five letters of the term denote, aiming at better understanding an observed phenomenon and sometimes also at providing forecasts (Franses, 2008). Econometric analysis is a method that is used in the relevant literature to identify the relationship between the independent and dependent variables (Odeck, 2004) (Parthasarathi & Levinson, 2010) (Garrido et al., 2017). A widely used statistical technique in econometrics is linear regression analysis, which studies linear additive relationships among variables. The simplest linear regression analysis is the simple regression analysis that uses one independent variable and there is also the multiple regression analysis, which uses more than one independent variables (Freund et al, 2006). Odeck (2004) conducts an econometric analysis to find the impacts that different variables had on the observed cost overruns in road construction projects in Norway. Parthasarathi & Levinson (2010) conduct also an econometric analysis to identify the factors affecting the traffic forecast inaccuracies (i.e. overestimation and underestimation of traffic) of road construction projects in Minnesota (ordinary least square (OLS) regression model is used). Garrido et al. (2017) investigate the relationship between economic profitability (dependent variable) and a set of success factors (independent variables) for road PPP infrastructure projects in Spain, using a multiple linear regression analysis, to find if the projects that receive financial support by the EU are more likely to be profitable. Roumboutsos et al. (2016a) also conduct an econometric analysis examining the effect of different independent variables on four different depending variables, i.e. cost, time, traffic and revenues outcomes for European TI projects of all types. The analysis shows which independent variables have the highest effect (highest coefficient) in the explanation of the dependent variables.

Importance analysis (or sensitivity analysis)

Importance analysis is a kind of sensitivity analysis that ranks relevant factors according to their influence on the output uncertainty and has been applied by Vanelslander et al. (2016a) to investigate cause and effect relationships in TI projects.

Factor analysis

Factor analysis is a statistical method that allows presenting large sets of factors more parsimoniously, i.e. as measures of one or few underlying factors (Fabrigar & Wegener, 2011). In the relevant literature, factor analysis is found to examine the interrelation between success factors and success criteria in (transport) (PPP) infrastructure projects (Ahmadabadi & Heravi, 2019) (Chan et al., 2010) (Park & Kwon, 2011) (Li et al., 2005) or to identify the interrelation among the traffic revenue risk factors and mitigation strategies in BOT road projects in developing countries (Babatunde & Perera, 2017) or to identify factors of satisfaction of a public bus service (in Kota Kinabalu, Malaysia) (Noor et al., 2018). For example, Park & Kwon (2011) performed a factor analysis using the 22 best practices for Korean infrastructure projects and found six critical success factors and the related best practices to them. Thus, factor analysis contributes to finding clusters of related variables and reducing the number of variables (Norusis, 2000, as cited in Park & Kwon, 2011).

Artificial Neural Networks (ANNs)

Artificial Neural Networks (ANNs) are nonlinear non-parametric models that are used to determine approximate functioning of a System for a real-life application (Gharehbaghi, 2016). The main advantage of ANNs is the ability to solve problems of complex systems, in which too many variables have to be simplified in a model, such as problems in Transportation Infrastructure Systems (Gharehbaghi, 2016). ANN is applied in construction management since the early 1980's to help contractors or managers making crucial construction decisions, such as cost estimating, decision making and predicting the percentage of markup (ElSawy et al., 2011). Other applications of the ANN in the construction industry include energy efficiency and energy consumption in buildings, construction materials (to predict the characteristics of building materials), safety in construction (such as safety assessment of megaprojects & evacuation tasks), soil mechanics, smart city (e.g. in smart house systems and waste management systems), building information modeling (BIM) technologies and structural analysis (e.g. assessment of concrete strength and performance of concrete structures)(Doroshenko, 2020). ANNs is also used as a part of damage detection and monitoring techniques régime (Gharehbaghi, 2016), as a technique to predict construction projects' performance, i.e. to show the factors that should be closely monitored so as project to be delivered with the required performance (Maya et al., 2021), or to determine the key management factors that affect the construction project effectiveness in terms of budget performance (Apanavičienė & Juodis, 2003). ANNs can identify the most influential factors affecting the performance of a construction project and rank them or in other words evaluate their severity/relative importance (as importance analysis also does). ANN is built on the principle of functioning of biological neural networks, i.e. networks of nerve cells of a living organism (Doroshenko, 2020). The basic steps of developing an ANN are the following: 1) defining the problem, deciding what information to use and what network to do, 2) deciding how to gather the information and represent it, 3) defining the network, selecting its inputs and specifying its outputs, 4) structuring the network (i.e. number of hidden layers and of nodes within each hidden layer), 5) training the network and 6) testing the network by involving new inputs to the network and comparing network's results with real life results (ElSawy et al., 2011).

Benchmarking

Benchmarking is an ''outward looking evaluation tool'' that is used to collect best practices and lessons learned from other projects or organizations to improve another future project's performance (Tang, 2010) (Griffith, 2006). This definition reflects the core elements of benchmarking, since there are numerous definitions in literature about what benchmarking is. Benchmarking is about comparing; comparing procedures, processes and practices and taking lessons from these comparisons (Tang, 2010).

In the transport sector, benchmarking is used to improve the efficiency, effectiveness and sustainability of transport projects (Išoraite, 2004) (European Court of Auditors, 2018). There are six steps that need to be followed for applying benchmarking: 1) planning of all the phases, 2) searching for potential benchmark project and designing a list of criteria based on which the comparison will be made against the benchmark, 3) observing the benchmark, i.e. studying the selected benchmark, 4) analyzing the findings, which is about uncovering the gaps and the causes of the gaps between the benchmark project and own project, 5) adapting the own project based on the benchmark findings and 6) recycling, i.e. using the benchmark as a continuous process and not as a one-time event (Išoraite, 2004). Thus, benchmarking requires significant resources in staff, time and money, especially if the staff involved in it is not familiar into applying this kind of exercise. But also the benefits that can be gained from applying benchmarking are high and can repay the costs put into this process (Tang, 2010). There is not one specific metric of project success that is used for the benchmarking, since there is not one universal metric of project success but multiple different metrics (Griffith, 2006), whose selection is part of the step 2 of ''searching'' of the benchmarking analysis (Išoraite, 2004).

Qualitative analysis

Qualitative analysis is used as a method to qualitatively describe a number of TI project cases, by identifying main performance factors, main success and failure criteria and the causal relationship between them (Allport, Brown, Glaister, & Travers, 2008). This is the case for the study of Allport, Brown, Glaister, & Travers (2008), who described a number of urban TI projects, European and non-European and scored their performance based on six performance factors and three success criteria. The authors analyzed these scores (a scale of 1 (favorable) to 5 (unfavorable)) and established if there is a relationship between them. de Jong et al. (2019) in their paper ''Ex-post evaluation of major infrastructure projects'' state that qualitative analysis is a useful complementary tool to CBA, when an appropriate monetization of effects is not possible and this is the reason why both methods, i.e. CBA and qualitative analysis, are used in their study. Also, the QCA method that has been described above is both qualitative and quantitative, thus accruing the advantages of both.

3.2 Justification for the selected method and more methodological information about it

The most important reason for which the (fs)QCA method has been selected among the methods presented in section 3.1 is the following.

1. QCA applies configuration thinking due to its also case-oriented/qualitative nature. The main issue is not which variable is the strongest (i.e. has the biggest net effect) but how different conditions combine to generate the outcome. **Being able to identify the interrelation and interaction among the factors of success or failure is a crucial explanatory feature for success or failure** of TI projects' due to their causal complexity. TI project performance is not achieved and affected only by one factor but by multiple factors (combinations of factors) at the same time. This is the case for most social phenomena and thus qualitative researchers think in terms of configurations and combinations of conditions because of their interest in understanding social phenomena **holistically** and because of their interest in **context** (Ragin, 2008). While in quantitative analysis independent variables are considered as separable causes of the outcome (i.e. net effect of an independent variable on the outcome).

More methodological information is presented below to enable the better understanding and interpretation of the fsQCA results presented in chapters 5 and 6. FsQCA is a set-theoretic approach with the assessment of causal complexity being based on three assumptions. First, a condition will only have an effect in combination with other conditions (conjunctural causation); second, an outcome can be elucidated by multiple, mutually non-exclusive (paths of) conditions (equifinality) and third, the presence of the outcome may have different explanations than its absence (causal asymmetry[6]).

Two types of analyses are conducted when applying fsQCA: firstly a necessity and secondly a sufficiency analysis. Necessity analysis shows the conditions that are necessary for an outcome to occur. This means that the outcome cannot occur when this condition is absent (Rihoux and Ragin, 2009). Sufficiency analysis shows the (combinations of) conditions that are sufficient for an outcome to occur. This means that when this combination is present the outcome will always occur, however the outcome can also result from other conditions (Rihoux and Ragin, 2009).

Aside from the benefit of the fsQCA compared to the mvQCA and csQCA, mentioned above in section 3.1, which is allowing the conditions and outcomes to take values in the interval between 0 and 1 instead of taking only dichotomous values, fsQCA has also the following additional benefits. Additional benefits of the fsQCA are that the assessment of consistency is more precise and also encompassing because it involves all cases in the assessment of each combination of conditions. Also, fsQCA does not exacerbate the problem of limited diversity[7] in contrast to mvQCA (Rihoux & Ragin, 2009, p. 119). The methodological steps that are taken within the fsQCA are 1) identifying the conditions and the outcome that will be used, 2) calibrating the outcome and conditions, 3) doing the necessity analysis, 4) doing the sufficiency analysis and 5) interpreting the result.

[6] Switching regression methods can also take into account asymmetry.

[7] In QCA, limited diversity is shown through the empty rows in the truth table, called "logical remainders" (i.e. possible combinations of conditions for which there is no empirically observed case) (Legewie, 2013) (Schneider & Wagemann, 2010, p.). Being able to identify logical remainders and in this way making limited diversity visible is one of the strengths of QCA (Legewie, 2013). The parsimonious solution uses any and all remainder rows so as to simplify the solution and should only be used if the researcher is certain that the assumptions made to create the solution are justified (Elliot, 2013).

Apart from a consistency threshold (>0.75), a frequency threshold is also used, being one case, because the data sample is of medium size (Ragin, 2008, pp. 143–144). Frequency threshold shows the minimum accepted, by the scientist, number of cases for a causal combination with greater than 0.5 membership. The cases with a greater than 0.5 membership in the specific causal combination are called *"relevant cases"* in terms of their membership in the causal combination (Ragin 2008, p.134).

For example, if the sample of cases is small, and it is decided to set a frequency threshold equal to 1, this means that the combinations of conditions without even one case with membership greater than 0.5 will be treated as remainders/counterfactual combinations of conditions, i.e. combinations of causal conditions with no empirical instances (Ragin, 2008, p.133 and 155). These remainders are not treated as false (excluded), which is the most conservative strategy used to treat this kind of truth tables (Ragin, 2008, p. 155), but simplifying assumptions on the remainders are used about the nature of causation. Having a large quantity of remainder rows is very often and is called the *''limited diversity problem''* (Ragin, 2008, p.158).

With respect to the simplifying assumptions, users of the fsQCA are asked to indicate what their expectations are, regarding the link of the causal condition and the outcome. Is it the presence of the outcome that is linked to causal condition's absence or is it the absence of the outcome that is linked to its absence; or either its presence or its absence? These are ''easy'' counterfactuals, which can be included in the intermediate solution (Ragin, p.173-174). In the present doctoral thesis, it is assumed that the presence of the conditions will explain the presence of the outcome and that the absence of the conditions will explain the absence of the outcome (simplifying assumptions), as it is recommended by Schneider and Wagemann (2010), except in the cases in which the absence of a condition is found to be a necessary condition for the presence of the outcome and vice versa. This selection of simplifying assumptions is made based on the existing research literature (see chapter 2) and the substantive knowledge of the author of the present doctoral thesis.

This is the reason why, for interpreting the QCA results, the intermediate solution is used and not the complex or the parsimonious solution. The intermediate solution only includes "easy" assumptions, when simplifying the solution. The complex solution does not use simplifying assumptions and considers all remainders as false (excluded) (Elliot, 2013). If a larger number of causal conditions are included, then quite complicated-complex solutions will be given (Elliot, 2013). The parsimonious solution uses any and all remainder rows, so as to simplify the solution. The parsimonious solution should only be used if social scientists are certain that the assumptions made to create the solution are justified (Elliot, 2013).

The results of the intermediate solution are presented either with the symbols ~ and +, or the term low and high respectively (fsQCA results in Chapters 5 and 6). If none of the symbols is used for a condition, this means that there is no causal relation between this condition and the outcome. Some conditions are presented in bold. These conditions are core. Core conditions are decisive causal conditions, which are included in both the parsimonious and intermediate solution. The additional conditions that are only included in the intermediate solution are the "complementary" or "contributing" conditions (Ragin, 2008, p.204) or peripheral conditions (Fiss, 2011).

Both these symbols (~ and +) and terms (low and high) refer to the absence and presence of a condition respectively. A condition is present (i.e. more present than absent or in other words more in than out), when its score in the set of memberships is higher than the cutoff point, which is equal to 0.5. It is considered absent (or more absent than present/more out than in), when its score is lower than the cutoff point (Ragin, 2008, p.31). The qualitative breakpoints that structure a fuzzy set (i.e. full non-membership, cross over/cutoff point and full membership) and their fuzzy membership scores (on a scale from 0, meaning ‘fully out of the set’, to 1, meaning ‘full membership in the set’) are defined through the calibration. Calibration is a key step of the fsQCA that identifies the degree to which different cases (TI projects in the present doctoral thesis) belong to a set (Rihoux & Ragin, 2009) (see Annex A.71 and A.72 of Chapter 6 for the calibration applied in this doctoral thesis). *‘’A fuzzy set can be seen as a continuous variable that has been purposefully calibrated to indicate degree of membership in a well-defined and specified set’’* (Ragin, 2008, p.30).

The software used is the fsQCA 2.5, which is developed by Ragin, the creator of the QCA method. The fsQCA 2.5 software is usually the front-runner with respect to innovations in set-theoretic analysis and will remain an essential tool for good QCA (Schneider and Wagemann, 2012).

4. Case selection

This chapter presents the TI project cases for each of which, data are collected to be used in the fsQCA. The number of cases used are 51. The data of the 51 cases were collected under the BENEFIT HORIZON 2020 research project of the European Commission and the COST TU1001 and are publicly available in the BENEFIT project website[8]. More specifically, the data have been collected for two TI projects in the present doctoral thesis and the rest of the TI projects' data have been retrieved from the H2020 BENEFIT project's database. BENEFIT stands for Business Models to Enhance and Enable Financing of Infrastructure in Transport. The data are collected via desk research and semi-structured interviews with project stakeholders. The collection of sufficient data for all the 51 cases is a difficult and time-consuming process. These data are calibrated in order to be able to apply the fsQCA and are checked for missing data. Having a good understanding of the cases used in the sample is important for the interpretation of the fsQCA results and for coming to conclusions.

Since knowledge from past experiences of TI projects is important to take lessons and to avoid repeating the same mistakes in the future planning of TI projects and considering how difficult it is (i.e. time and cost-consuming), as it is stated in the relevant literature, it was considered important to use for the ex post analysis all the cases for which sufficient data have been collected. This number of cases represents an intermediate sample size that brings a good balance with the used number of conditions, which are the causally relevant ingredients, i.e. up to eight conditions can be used for 51 cases (Marx and Dusa, 2011). Using an intermediate number of cases allows the researcher to achieve a higher degree of case knowledge and thus to better interpret the results (Legewie, 2013).

The conditions of Soecipto, Willems and Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018) that are used in the models are identified and defined in chapter 2. The conditions are nine in total. However, seven of them are used in the fsQCA because the other two, being the reliability and availability indicator (IRA) and the revenue support indicator (RSI) do not sufficiently vary across the cases. The cases that are not variable but constant are recommended not to be included among the conditions in the fsQCA (Rihoux and Ragin, 2009).

For the selection of the cases and variables (i.e. conditions in fsQCA terms) that are used for the fsQCA, the steps of research designs and techniques of Rixoux and Ragin (2009) are used. The *"universe of investigation"* within which the cases are selected has been defined already in chapter 1, in which the outcomes of interest are identified and defined, being the cost, time, traffic and revenues outcomes. The model building, i.e. the identification of the conditions to be included in the models, was done in chapter 2 via a literature review and by developing one of the conditions, i.e. IRA, in chapter 5. What is left to be done and thus is presented in this chapter, is the cases' selection.

Cases need to be comparable with respect to certain characteristics (Annexes: Table A.4.1). The cases that are compared are TI projects in European countries. Although the TI projects are of different modes, they can be compared concerning characteristics that they have in common. A main factor for the selection of the cases is the outcome, i.e. including cases of both ''positive'' and ''negative'' outcomes in order to achieve diversity in the sample of cases (Rigoux and Ragin, 2009). Specifically, both cases that have cost overruns and that are below or on the estimated budget are used; similarly for the time, traffic and revenues outcome. 16 cases with cost overruns and 35 cases with cost below or on the estimated cost are selected. 30 cases that are below and on time and 21 cases with delays

[8] BENEFIT website: http://www.benefit4transport.eu/. For detailed information for each of the 51 cases, see the e-book and wiki section in the BENEFIT website.

till their completion are used. 19 cases with traffic below and far below the forecast and 25 cases with traffic that exceeds or is as forecast are included[9]. 36 cases with revenues exceeding the forecasts or as forecast and 8 cases with revenues below the forecasts are included.

Table A.4.1 in the annexes shows the full sample of the 51 cases that are selected. TI projects from 15 European countries are used: Greece: 7; Germany: 2; Cyprus: 1; Poland: 2; UK: 5; Portugal: 8; Slovenia: 2; Serbia: 3; Spain: 8; Finland: 2; Norway: 1; Belgium: 4; France: 3; Czech Republic: 2 and The Netherlands: 1. The cases' allocation needs to be taken into account considering that almost half of the cases are South-European cases, i.e. Portugal, Greece and Spain, which were affected more by the economic recession of 2008 compared to the rest of the European countries.

Cases of all modes are used: Airport: 4; Road: 22; Rail: 3; Metro/rail: 3; Tram/light rail: 6; Seaport: 7; Bridge/tunnel: 4; Public transport depot: 1 and Bicycle sharing network: 1. Selecting cases of all the different types of TI, to the extent possible depending on the data availability, is important for the wider applicability and transferability of the analyses' results. However, considering that the majority are road cases, a big part of the results reflects combinations of conditions that affect the performance of road projects.

Cases of different investment sizes are included, i.e. ''megaprojects'', ''major projects'' and ''projects'', based on the definition of Flyvbjerg, (2014), according to which tens of millions (regular projects), hundreds of millions (major[10] projects) and billions of dollars (megaprojects) are required for the realisation of TI projects. In the sample, there are: mega: 8; major: 36 and regular: 7 projects.

Cases that are financed both publicly and via a public and private partnership (PPP) are included: 12 public projects and 39 PPPs. 22 projects were completed before crisis (i.e. in year 2008) and 25 projects were completed after the economic crisis[11].

The fsQCA analysis is conducted for the full sample of the 51 cases, but also for the sub-samples of road and PPP projects and for projects completed before and after the economic crisis of 2008.

With respect to the cost outcome, cost overruns range between 1% and 104%, while cost underruns were 6% and 10% for the two cases for which data were available out of the six cases in total having cost underruns in the sample. With respect to the time outcome, delays range between 12 months and 114 months. With respect to the traffic outcome, traffic underrun ranges between 11% and 66.80%. With respect to the revenues outcome, out of the eight cases reported as being below the forecast revenues, data of the exact % of revenues underrun were available only for one of them, being 7%.

The causes of cost overruns and underruns, delays and on/below time project completion, actual traffic less than the forecast or as forecast or exceeding the forecast and lastly the causes of actual revenues that are less that the forecast or as forecast/exceeding the forecast are collected and presented below. These causes are factors that can affect the achievement of the four key project

[9] Seven cases are not included in the traffic and revenues analysis, since they were not operational at the moment their data were collected.

[10] **Major projects** are defined in the following way by the European Commission: *''According to Article 100 (Major projects) of Regulation (EU) No 1303/2013, a major project is an investment operation comprising 'a series of works, activities or services intended to accomplish an indivisible task of a precise economic and technical nature which has clearly identified goals and for which the total eligible cost exceeds EUR 50 million.' The total eligible cost is the part of the investment cost that is eligible for EU co-financing. In the case of operations falling under Article 9(7) (Thematic objectives) of Regulation (EU) No 1303/2013, the financial threshold for the identification of major project is set at EUR 75 million'' (Sartori et al., 2015, p.15).*

[11] There are 47 cases, indicated instead of 51, that is the total number of cases presented above because there were four cases whose construction has not been completed at the time of collecting the data and conducting the analysis.

objectives and thus can be considered risks based on the risk definition adopted in the present thesis being the following: risk is an uncertain event or condition that if it occurs it might affect the achievement of project objectives. Identifying and gathering all the aforementioned causes has a dual role: firstly acquiring better knowledge for the overall case sample, thus contributing to the interpretation of the results and secondly, providing a complementary literature review to the review presented in Chapter 2. In the text below, the causes are presented per outcome for all cases to avoid repetition, but in Table A.4.2 in the Annexes, the causes are presented per case.

CAUSES OF COST UNDERRUNS AND OVERRUNS[12]

With respect to the cost outcome, the most common reasons were firstly the increased costs of land acquisition and secondly the complementary works and changes in the design. For cost underruns, the only cause available is the better geo-mechanical conditions (less construction) (see also Table A.4.2 in the Annexes).

Cost underruns causes

- better geo-mechanical conditions (less construction)

Cost overruns causes

- additional payments related to land acquisition / higher prices of land acquisition / problems with expropriation
- complementary/additional works
- problems with design/project improvements/changes concerning design, intermodal transfer and safety, as well as a political controversy mainly due to a new proposal about the central section of the project
- optimistic estimate of a smaller investment
- lack of financing
- estimated operating and maintenance costs, as well as replacement capital expenditures, were also increased
- acceleration costs
- inflation
- changes of pricing regulations[13]
- ill-prepared project conditions, faulty contracts with insufficient motivation for contractors and mismanagement
- imprecision of the original calculations (e.g. some items of the project that were indivisible were excluded from the calculations of the construction costs)

CAUSES OF DELAYS

With respect to the time outcome, also for the time overruns, problems with land acquisitions, changes in design and additional works are main causes (similarly for the cost overruns). However, for the delays, force majeure events play a key role too.

- problems with land acquisition/expropriation, (‘’there were unrealistic expectations that the state would be able to acquire the required land for the project in a short time frame’’)
- incomplete design

[12] BENEFIT website: http://www.benefit4transport.eu/. For detailed information for each of the 51 cases, see the e-book and wiki section in the BENEFIT website.
[13] This was a cause of additional investments in the project and not of cost overruns, together with the changes of design and complementary works (The Hague New Central Train Station).

- project improvements concerning design, intermodal transfer and safety, as well as a political controversy mainly due to a new proposal about the central section from the project
- additional works required
- construction difficulties and construction downtime term
- changes in construction works due to new European security regulations
- unfinished lay-by (in a road section)
- force majeure events (e.g. flooding of the station construction site)
- suspension of construction work (due to the discovery of unexploded bomb from WWII, archaeological artefacts, as well as adverse weather conditions)
- bankruptcy of construction planning company/bankruptcy of the main contractors
- new tenders for completion of works
- complaints on public procurement
- non-compliance with fire prevention standards (airport terminal)
- due to safety reasons: improper materials have been used (airport runway)
- economic crisis
- environmental claims
- unstable financing
- lower-than-expected traffic volumes (of the first sections of the project that became operational postponed the second section of the project)

CAUSES OF HAVING ACTUAL TRAFFIC HIGHER OR LOWER THAN FORECAST

With respect to the traffic outcome, the main reasons of having actual traffic that is less than the forecast are the economic crisis, reluctance to pay tolls and the delay in the completion and thus in the opening of the project to traffic.

Causes of having actual traffic higher than forecast

- many trucks driving

Causes of having lower traffic than forecast

- introduction of tolls/reluctance to pay tolls
- economic recession/crisis
- due to delay in completion of works and thus opening of the TI project to traffic/beginning of the operation
- overoptimistic traffic forecast
- less vehicles operated than the initially planned number due to technical problems (i.e. trams)
- higher fare/ticket price (i.e. in a tram service)
- political and economic instability
- internal causes (there have been discussions with respect to the high rates required by the concessioner)

CAUSES OF HAVING ACTUAL REVENUES HIGHER OR LOWER THAN EXPECTED

With respect to the revenues outcome, the main reasons of having actual revenues that are less than the forecasts are very similar with the ones of the traffic outcome: being the reluctance to pay tolls and the economic crisis. Also it is observed that there is a causal relationship between traffic and revenues, i.e. reduced traffic will cause reduced revenues. A similar observation was made for the cost and time outcomes, i.e. delays in the completion of the project can cause cost overruns.

Causes of having actual revenues higher than expected

- High traffic

Causes of having less revenues than the forecast

- Less traffic
- Reluctance to pay tolls/increase of tolls that affected negatively traffic & thus revenues
- Economic crisis

In conclusion, in the sample of TI project cases examined, there are multiple factors that affect the non-achievement of the project objectives of cost, time, traffic and revenues, thus having projects with cost overruns and time overruns compared to the initial estimates and with traffic and revenues underruns compared to the initial forecasts. Changes in the project objectives have been observed throughout the project phases, i.e. award, end of construction works and the operational phase. Thus, we could see projects with a different traffic and revenues project outcome during the operational phase compared to the award phase, we could see projects with a different cost and time outcome at the end of the construction works compared to the award phase and we could also see changes in the traffic and revenues outcomes throughout the different years of the operational phase. The reasons why causing the changes of the project outcomes are summarized in the text above per outcome and in the annexes per project case (Table A.4.2). The causes are reflected also by changes towards time of the relevant indicators. Three examples are given below.

1. **Berlin Brandenburg Airport (BER):** there were two snapshots available for this project case, one at the **award and one at the reporting time (operational phase)**. While the project was expected to be on time at the award phase because at the award phase you expect that everything will go as planned, at the reporting time/operational (2015) the **project outcome of time** was over than the expected, or in other words the project was delayed. The initial scheduled opening of the airport was in November 2011, five years after starting construction in 2006 but it was finally open for operation in October 2020. The indicator that has been changed significantly to the worst is the CSI, from -0.05 to 0.-3. The causes of **delays** were the bankruptcy of construction planning company and changes in terminal construction works (due to new European security regulations at airports) and the non-compliance with fire prevention standards.
2. **A23 motorway - Beira Interior:** In this project case, the project objective of traffic has been different not only compared to **the award phase (1999) but also between the different years of the operational phase** (i.e. 2011 & 2013) (the construction has been completed in 2003). In 2011, the traffic was below forecasted and in 2013 was even worse, far below forecasted. The causes of **lower traffic** than forecasted **of the A23 motorway in Portugal** were the economic recession, which caused a considerable drop of traffic in 2012 and the introduction of tolls in December 2011. These changes are reflected by the changes of the values of the FEI, the value of which has been reduced during the operation phase in 2011 and 2013 compared to the award year in 2009 and it is also reflected by the funding schemes indicators RAI & RRI, the value of which has been increase since now additional income sources are streamed into the project through the tolls.
3. **Eje Aeropuerto (M-12) Motorway:** In this project case, **none of the four key project objectives has been achieved**. This project located in Spain has been awarded in 2002 and its constructions was completed in 2005. The project had **cost overruns** due to additional payments related to land acquisition and additional works. These issues are reflected in the reduction of the value of the CSI, showing the lower ability of the contracting authority to

plan. The traffic objective was not achieved due to the economic downturn and the users' reluctance to pay tolls. The traffic was below forecast in 2005 (inauguration year) and 2008 and far below forecast in 2012 (crisis peak) and 2014. This evolution in the project outcome of traffic is reflected by the decrease of the FEI.

Abbreviations' meaning: NI: Institutional Indicator, FEI: Financial Economic Indicator, CSI: Cost Saving Indicator, GI: Contractual Governance Indicator, RAI: Remuneration Attractiveness Indicator, RRI: Revenue Robustness Indicator, FSI: Financing Scheme Indicator

5. The importance of the transport mode to produce performance outcomes

This chapter describes the indicator of Reliability and Availability (IRA) that was developed in the present doctoral thesis as part of the conceptual framework and indicators of Soecipto, Willems and Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018), which were selected to be used as the independent variables in the present doctoral thesis (see Chapter 2).

Roumboutsos, Voordijk, & Pantelias (2018) state that the key elements that affect the performance of TI delivery and operation are six: governance arrangements, business model, funding scheme, financing scheme, implementation context and **transport mode context**, as also stated in chapter 2. Indicators have been developed for all the first five key elements mentioned above, in Roumboutsos, Voordijk, & Pantelias (2018) and for the last key element of transport mode context an indicator is developed in this chapter. It is the interaction of these key elements that is important for the achievement or not of the key project objectives. This is the reason why this conceptual framework has been selected among all the findings of literature in chapter 2, because it recognizes the complexity of the transport system and understands that the TI project performance cannot be achieved and affected only by one factor but by the interaction by multiple factors. This is not under the attention of the relevant broad literature. Although literature identifies multiple factors that could affect the performance of TI projects, no attention is paid in the interaction of these factors.

The chapter presents the transport mode typology, the literature review conducted for its development and the empirical analysis's results (using the fsQCA method, as this has been the method selected as a very suitable one in Chapter 3), based on which IRA is developed.

The transport mode typology refers to the parameters/indicators collected via literature review as key parameters that affect the performance of TI projects in terms of their funding (i.e. collection of income streams for the TI project). The typology allows clustering the key parameters under a dimension (i.e. an overall category that encloses the parameters of the same kind). Since a long list of parameters is collected, a reduction methodology is applied, which allows reducing the number of the dimensions and of their respective parameters.

The selection of the following three dimensions is made based on a literature review, authors' knowledge, data availability and interrelation with the other key elements of the framework of Roumboutsos, Voordijk, & Pantelias (2018), as shown in 5.1. Then, using all the TI characteristics collected via the literature and having collected data for each of them for a middle-size sample of TI projects, the fsQCA is applied to identify the combinations of the TI characteristics that explain the overall success and failure in TI projects from the transport mode perspective. Success and failure are defined in a general way, compared to the specific in terms of outcome definition used throughout the doctoral thesis. The reason why success is defined in a general way here in chapter 5 is so as to allow the broad applicability of the indicator, i.e. applicability of the indicator for all the four outcomes of cost, time, traffic and revenues. More specifically, success in chapter 5 is defined as the general level of a project's perceived success, either high, medium or low level. Failure is defined as the absence of the success outcome.

This chapter is structured as follows. Section 5.1 presents the literature review conducted. Section 5.2 shows the transport mode typology dimensions and parameters per dimension. Section 5.3 shows the case and data collection. Section 5.4 finally presents the fsQCA results that led to the IRA development and section 5.5 shows the conclusions.

5.1 Literature review

For the development of the indicator that reflects the characteristics of the transport mode element, being one of the key elements of the conceptual framework adopted in the present doctoral thesis, the first step was doing a literature review to identify the characteristics of TIs. From these characteristics, the most significant ones would be then identified based on the empirical analysis, using the fsQCA method. The findings of literature are shown below.

Transport modes are the means by which freight and people achieve mobility. They are classically **subdivided into one of three basic types, depending on over what surface they travel** and the related equipment: (i) land transportation (road, rail and pipelines), (ii) water transportation (maritime transportation and inland navigation), and (iii) air transportation. As one can see, TIs (roads, rail networks, seaports, airports, etc.) are integral parts of the transport modes, so as to achieve mobility. When more than one mode is used for transport, then this type of transportation is called multi-modal/intermodal/synchro-modal[14]. Each mode is characterized by a set of operational, technical and commercial characteristics (Rodrigue et al, 2013).

Transport modes can also be classified by type of load: passenger transport and freight transport as the main distinction. Passenger transport is classified in terms of usage in (i) individual and common and in (ii) regular, irregular, special forms of regular[15] and taxi service. In terms of who makes the mode available, passenger transport is classified as private or public. Another classification could be scheduled (fixed routes, with fixed stops at fixed times) and non-scheduled transportation (for example chartering). With regard to goods/freight transportation, one possible classification is (i) own-account transportation versus (ii) professional transportation. Own account transportation refers to the transportation of freight using the organization's own vehicles, whereas professional transportation refers to the transportation of freight by calling on a third party to transport the organization's goods (Blauwens et al., 2014).

Other classifications of modes of transport in view of financing and funding could be by (i) transit time, and (ii) cost of transportation (Chamber of Commerce of the United States, 2006) or by (i) **life expectancy, (ii) volume of investments and (iii) maintenance costs** (Vergauwen et al., 2009).

Vanelslander and Farrell (2016) develop the Contextual W's Framework for port PPP's, which is structured according to 8 W's. 'What' contains seven relevant **TI characteristics**: nature, function, brownfield/greenfield character and physical characteristics, **budget, level of exclusiveness** and inclusion in TEN-T as relevant characteristics. 'Where' features **geographical location and market location**. 'Who' deals with the public initiator. 'Whom' refers to the **user**, and more in particular whether the project is meant to be a business developer or rather a business servicer. 'Which way' involves relevant items, such as **contract duration, design and construction risk, maintenance risk, risk of exploitation, commercial revenue risk, financial risk, regulatory risk and force majeure risk**.

[14] Multi-modal transport refers to the combination of different transport modes in any form. Intermodal transport refers to multi-modal transport in which the road leg is made as short as possible. Synchro-modal transport is intermodal transport, in which the different modes are well aligned, so that the shift between modes goes very smoothly.
[15] "Examples of the special form of regular passenger transport include transportation of schoolchildren and company employees" (Blauwens et al, 2014).

‘Whole’ finally contains the relevant item ‘impact of macro-economic environment’. ‘When’ and ‘why’ do not contain any relevant characteristics for TIs with respect to financing and funding.

Estache and de Rus (2000) deal with **regulation in different modes of transport**, and more in particular the need for and the way of regulating. They discern among four organizational forms for the delivery of transport services: programs/performance contracts, management contracts, concessions/licenses/franchises, and service contracts. The four forms are differentiated by the distribution of responsibility for the various **aspects of the business (investment and management/operations) and for the risks (design/construction; financial; operating cost; commercial or revenue; environmental)** associated with this business between the public sector and the private sector. Other relevant mode characteristics mentioned by Estache and de Rus are: traffic demand and revenues, **capacity, costs, competition**, ownership, market structure, price, quality and **safety** regulation, externalities, infrastructure, capital, labour and financial performance, financing, **exclusivity** and (un-)bundling.

Also with respect to the **regulation in road transport**, **technical harmonization** applies to four main areas: 1) dimension of vehicles, 2) maximum authorized weights of vehicles, 3) environmental norms like noise pollution and emission norms (externalities or external costs that should be internalized) and 4) safety norms (speed limitation). The indicators 1) “height and width meters” per vehicle, 2) tonnes per vehicle, 3) various indicators that measure the gas emissions and the noise levels and 4) km/hour (speed) or/and proportion of road accidents caused by freight transport could be used respectively.

With respect to **pricing**, there is complete **freedom on the fixing of rates** (tariffs are set between the parties). It is also important to stress that through pricing, externalities like pollution could be internalized. This means that for example the polluters (such as road haulage undertakings) will be charged with the damage costs of the pollution they generate.

With respect to **regulation in rail transport**, for many years the government regulation for European railways was strict but the last two decades (from 2001) **liberalization** of the railway market and competition are promoted (directive 2001/12) (Blauwens et al., 2014). It is evident that deregulation of railway sector is the goal. An indicator for assessing the deregulation/liberalisation of the railway market could be the **Rail Liberalisation Index- LIB index**. This indicator presents information on the relative degree of opening in the European rail transport markets.

Another worth mentioned **regulation** is a much older one, the regulation 1107/70 (1970), which laid down the conditions under which Member States can **grant aids to railway companies to cover infrastructure costs** (funding schemes).

Another regulation was proposed by the Commission in 2008 1) to strengthen European **integration of national rail infrastructures**, 2) to achieve a better balance between passenger and freight traffic (the proportion of passenger and freight traffic as a possible indicator) and 3) to achieve development of intermodality.

Additionally to regulatory characteristics, the following characteristics are also of importance from a transport mode characteristics point of view. Carbonara et al. (2016) refer in their development of a PPP decision framework to the following items. As to *project identification*, they concern affordability (to be linked to project **investment size**), feasibility (to be linked to project complexity), bankability (to be linked among others to project investment size and **risks**), value for money, **user requirements (to be linked to performance**). For the *project preparation*, relevant items are the various types of **risks: technical, environmental and financial**. Also, Carbonara et al. (2016b) add a number of transport mode characteristics that they identify as relevant in designing a tendering process: **commercial risk**, IRR (Internal Rate of Return), **maintainability**, design life, **noise** and dust reduction level.

Voordijk et al. (2016) identify the following relevant items, when analysing the performance objectives of different stakeholder perspectives of transport investment projects. Environment issues are the institutional and **regulatory framework, liberalization**, effectiveness and possibility of introducing user charges. A relevant relationship issue is project expectations (related to service quality). A technology transfer issue is innovation. The mentioned project risk item that is relevant is **demand risk.** The three economic objectives examined are: efficiency, costs and value for money. **User satisfaction** is the only relevant general project characteristic, including **accessibility, availability, comfort, reliability and safety**. A relevant network issue is the **level of competition to which the project is subject in the network.**

Rodrigue et al. (2015), in their **typology of transport networks**, include the following relevant elements with respect to transport mode typologies: relative **location**, extent, **number of edges and nodes**, distance, **link type**, type of traffic, **volume** and direction, **load and capacity**, type of correspondence and network pattern (mesh, hub and spoke, linear, tree). Furthermore, the authors discern among centrifugal and centripetal transport networks, centralized and distributed transport networks, point-to-point and hub-and-spoke networks.

Semina (2015) typed and classified **transport systems** by the following **features**: spatial size, configuration (the picture of its shape on a map), the set of modes of transport (taking into account the level of development of each mode), the nature of their combination (functional structure), the nature and intensity of the **interaction among different modes of transport**, spatial complexity, degree of internal coherence, continentality and free access to the sea, spatial **location** (geographical position), **the nature and degree of transport development of the territory** and the degree of openness/closedness of the system (transport permeability of the territory).

De Tilière and Kaplan (2013) for railway stations create a typology based on frequentation**, level of service** and role in the transport and urban network.

It is also important to point out the factors that determine the choice of a mode (for freight and for passengers), which are according to Blauwens et al. (2014): (i) the quantity, (ii) the type of commodity/passenger that should be transported, (iii) its value/willingness to pay, (iv) the distance that should be covered and (v) the **accessing capacity of the mode**. So as to make it more load-specific, it is also important to mention how we choose a mode of transport when we talk about passenger and freight transport. Referring to the former, the factors that are important seem to be price, speed, comfort, and accessibility, whereas for the latter, the type of goods and the distance are of a crucial importance.

Additional success criteria found in literature are **safety, reliability, closures (i.e. availability of the TI),** accessibility and comfort (Gordon, Mulley, Stevens, & Daniels, 2013) (Vickerman, 2000) (Ramos, Cantillo, Arellana, & Sarmiento, 2017) (Markolf, Hoehne, Fraser, Chester, & Underwood, 2019). More specifically, Markolf, Hoehne, Fraser, Chester, & Underwood (2019) examine the existing knowledge about the **vulnerability of the transportation system to climate change and extreme weather events and show how these phenomena reduce mobility and increase closures/delays**. These criteria are **perception indicators of the users** for a mode that can affect traffic demand (Ramos, Cantillo, Arellana, & Sarmiento, 2017).

Based on this literature review (and elements of the literature review presented in chapter 2), the typology of transport modes has been created from a funding and financing perspective, as developed in the next sections.

5.2 From a longlist to a shortlist: the methodological framework

Based on the literature review conducted, a long list of factors/variables/parameters/characteristics[16] for the transport mode context element has been developed (see Vanelslander et al.,2015 for the long list). This long list of parameters has been split into different groups, called dimensions. From the longlist of dimensions (i.e. overall groups) and respective parameters (i.e. factors categorized under these groups) proposed, three main dimensions were finally kept as the most critical ones for the performance of TI projects, in terms of their funding. In other words, the characteristics of the TIs that can affect their funding are identified. Focusing on funding (i.e. income streams for the repayment of the financing of the TI project during its operational life) is due to the interrelations among the six key elements mentioned above (Roumboutsos, Voordijk, & Pantelias, 2018). The transport mode context (i.e. the characteristics of the infrastructure transport mode) influences the performance of the BM. The BM shows how a project can generate revenues and identifies funding schemes for collecting the revenues. Therefore, the characteristics of a the transport mode context are important input to the BM and define the BM potential and boundaries. Taking into consideration the above, the selection of the following three dimensions is made based on literature review, authors' knowledge, data availability and interrelation with the other key elements of the framework of Roumboutsos, Voordijk, & Pantelias (2018), which affect the performance (i.e. success and failure) of TI projects:

- **Investment:** 'Total investment cost' is the first sub-dimension[17] (sub-group under the main overall group/dimension) suggested under the first dimension 'investment'. This sub-dimension is also taken into consideration by the financing scheme indicator of Roumboutsos, Voordijk, & Pantelias (2018), which examines the sources of financing, the cost of capital and the risk of each of the financing schemes (see Box 1, Chapter 2). 'Lifetime' is the second sub-dimension included under 'investment' and is measured through the 'contract duration'. This indicator is not overlapping with any other typology indicator developed by Roumboutsos, Voordijk, & Pantelias (2018).
- **Users:** Five key factors that affect the performance of TIs are identified: reliability, availability, maintainability, safety and security. These factors can affect the demand of the users for the infrastructure (either passengers/individual users, freight users or both) and as a result also the income streams (i.e. funding). Risk allocation, assessment and mitigation are also taken into consideration for the following risks: demand risk, regulatory risk, financial risk, revenue risk, design risk, construction risk, maintenance risk, exploitation risk, force majeure risk and climate change risk. Regulatory risk is taken into consideration by the implementation context, exploitation, revenue and financial risk is taken into consideration by the governance indicator (GI) and construction, operation, demand and revenue risks by the cost saving indicator (CSI).
- **Market strength/competitive position:** this includes[18] the location, the level of integration and the level of exclusivity of the project, which are taken into consideration by the revenue support indicator (RSI) (i.e. the BM element).

[16] These terms are used interchangeably.
[17] It is the second sub-dimension as presented in Table 5.1 below, however it is the first sub-dimension for which data are available and thus, the first one that can be used in the analysis. Similarly for the 'Lifetime' sub-dimension. It is the third sub-dimension based on Table 5.1 below, however it is the second one that can be used in the analysis thanks to data availability.
[18] It also includes the sub-dimension ''Level of regulation-deregulation'' as shown in Table 5.1, but there are no data available for this sub-dimension.

The interrelation between the transport mode context and the BM (i.e. the transport mode context influences the BM and defines its potential and boundaries) explains the overlap of some of their relevant factors. However, overlap has been found also between the relevant factors of the transport mode context and the financing scheme, implementation context and governance. This is due to the fact that the transport mode context influences all the above key elements (Roumboutsos, Voordijk, & Pantelias, 2018). The shortlist of factors considered under each dimension is presented in Table 5.1.

Table 5. 1. Transport mode context typology

Dimensions	**Sub-Dimensions**	**Factors**
Investment	Level of sunkness of investment	Non sunk/sunk investments
	Investments/costs	Construction – CAPEX
		Maintenance and Operation – OPEX
	Lifetime	Project/infrastructure (Investment) life cycle
		Contract duration over its infrastructure life
Users	Users	Number of freight vehicle-kms
		Number of passenger vehicle-kms
	Operational flexibility-continuity	Rerouting
	Performance	**Reliability (% time of disruptions)**
		Availability (% of days in year)
		Maintainability (% of not available)
		Safety & security (cost of accidents)
	Capacity	Vehicles/hour
	Risks	Demand risk
		Regulatory risk
		Financial risk
		Revenue risk
		Design risk
		Construction risk
		Maintenance risk
		Exploitation risk
		Force majeure
		Climate change risk
Market strength / competitive position	Location	**Type of connection:** ▪ **Interurban** ○ **International** ○ **National** ○ **Regional** ○ **Local** ▪ **Urban**
		▪ **Node within a Node** ▪ **Link within a Link** ▪ **Node** ▪ **Link**
	Level of regulation-deregulation	Technical Harmonisation Noise & pollution emissions ▪ Noise level per mode ▪ % of emissions per mode
		Pricing: degree of tariff freedom
		State grants ▪ Grants to cover infrastructure costs

Dimensions	Sub-Dimensions	Factors
		▪ Grants/subsidies to cover the operation of the infrastructure
		Market Liberalisation Index (LIB index)
	Level of integration	**Physical integration**
		Operational integration
		Information integration
		Authority integration
		Policy integration
	Level of exclusivity	Natural or induced monopoly and influence of the transport network

Source: Vanelslander et al. (2015)

5.3 Case selection and data collection

Based on the total project case dataset that was collected under the H2020 European Commission project BENEFIT, which contains 55 privately co-financed cases and 31 publicly financed cases (see chapter 4), the number of factors from Table 5.1 above was reduced due to data availability. Thus, only the factors for which a sufficient number of cases have values available were retained.

Based on this factors' selection process, the final analysis sample contained 34 privately co-financed projects and 19 publicly financed projects (Annex A of chapter 5). Case data were collected through desk research and interviews and streamlined between cases on a qualitative scale, which, for the purpose of the fsQCA, was expressed on a numerical scale of 0 to 1 (see Table A.5.1 in the annexes of chapter 5).

5.4 Operationalization of the transport mode indicator

Section 5.4 comes to gather the findings of the literature review, i.e. the characteristics of the TI projects that could affect its overall success and do an empirical analysis, using the fsQCA method to identify the most significant characteristics. More specifically to identify, the combination of the key characteristics (i.e. the conditions as they are called in the fsQCA terminology) that could affect TI project performance. This combination of conditions will be used to create the transport mode context indicator, which will interrelate and interact with the rest of the key elements of the benefit conceptual framework to produce the performance outcomes. This is the process of operationalisation, during which quantitative research is conducted to find how the transport mode context will be measured.

In the dataset of TI projects used to conduct the fsQCA, there are both projects that are privately co-financed and also publicly financed projects. The fsQCA was applied to three dataset partitions: (1) only privately co-financed projects, (2) only publicly financed projects, and (3) privately co-financed and public projects together. However, the focus is mostly on the results of the third dataset partition, which combines all projects together, considering that **the aim of this chapter is to develop the transport mode context indicator that is applicable for all types of TIs,** being road, rail, port, airport, tramway, metro line, tunnel, bridge etc., being both privately co-financed and public.

The fsQCA has been conducted per group of conditions, based on the transport mode context typology shown in Table 5.1 above. As a first step, the list of the typology factors (i.e. conditions in fsQCA terms), shown in Table 5.1, needed to be split because based on the size of the project cases' sample, only a maximum number of conditions can be tested in the fsQCA, i.e. maximum eight conditions for the mixed sample of projects, including both the privately co-financed and publicly financed projects (53 projects), maximum seven conditions for the 34 privately co-financed projects and maximum five conditions for the 19 public projects. These three groups have been determined based on their overall dimensions and the maximum allowed number of conditions mentioned above. Initially the idea was to create a group per dimension in order to see the interactions of these factors to affect the overall success of TI projects: for the investments, users and market strength/competitive position dimensions. However, this was not possible due to the fact that the factors under the first dimension of investments were only two (too few) and under the second dimension of users too many, i.e. 13, considering that maximum eight conditions could be tested due to the size of the sample. Thus, some of the conditions of the second dimension have been included together with the conditions of the first dimension. For the last and third dimension, the number of conditions was ideal (i.e. eight conditions) and matching the maximum allowed number of conditions to be used. Mixing the first and second dimension of conditions to create the first group does not create a problem because the second step after doing the fsQCA analysis per group of conditions would be to redo the fsQCA, but this time including the conditions that have been found as relevant in the first round of fsQCA. Also so as to also see how the conditions of the second dimension of users will interact without including the conditions of the first dimension of investments, the latter conditions have been excluded (see model 1b vs model 1a in the Table 5.2 below). Subgroups have been also created later on (see models 1c and 1d in the Table 5.2 below) 1) using as conditions this time only the conditions that have been found to be relevant for the previous models tests, i.e. the models 1a and 1b and 2) from these relevant conditions finally keeping to test only the conditions that had a direct impact on the demand of the TI and as a result its funding (i.e. financial streams), while safety has an indirect impact (model 1d). Therefore, consecutive steps have been followed for the fsQCA, based on which the results of the initial analysis of larger groups of conditions show which conditions are the relevant to be kept and included for the next analysis of the smaller subgroups.

Thus, the three initial groups of conditions that have been created are the following:

- **1st group of conditions**: investment, contract duration and the performance indicators (reliability, availability, maintainability, safety and security) (**7 conditions**)
- **2nd group of conditions**: all risks except demand and climate change risk due to non-available data (i.e. regulatory risk, financial risk, revenue risk, design risk, construction risk, maintenance risk, exploitation risk and force majeure risk) (**8 conditions**). For each of the risks there are data for their assessment, allocation and mitigation. Thus, all the types of risks with respect to their allocation were tested together and similarly with respect to their assessment and mitigation.
- **3rd group of conditions**: type of connection, node/link, physical integration, operational integration, information integration, authority integration, policy integration and level of exclusivity (**8 conditions**)

As mentioned above, as a second step, initially it was planned to test models that include the key conditions found as results from each of the three groups of conditions of the first step. However, since no results are found when testing the conditions of the second and third group, this is not possible. This is not necessarily negative, considering that the second and third group of conditions include conditions that are already taken into consideration for the development and composition of the CSI, RSI and GI indicators of the key elements BM and contractual arrangements respectively. The factors that compose the transport mode context typology and do not overlap with the indicators developed by Roumboutsos, Voordijk, & Pantelias (2018) are the indicators measuring the performance of TI projects from the users' perspective (see the ''performance'' sub-dimension in

Table 5.1). None of the other indicators developed by Roumboutsos, Voordijk, & Pantelias (2018) takes into consideration the users' perspective. What the other indicators take into account is mostly the perspective of the stakeholders that are involved in the planning, management, construction and operation of the TI projects (GI, CSI), for whom the focus is on the recovery of the projects' costs (RAI), on the generation of revenues (RSI, RRI) and also on how to initially finance the project (FSI), which also affects the revenues of the projects. The users' perspective is of high importance for the transport mode context element. In other words, the users' perceptions for the TI are of critical importance for its performance and need to be also taken into consideration because traffic demand for the TI depends heavily on users' perception. Therefore, the difference that the transport mode context element brings into the whole framework developed by Roumboutsos, Voordijk, & Pantelias (2018), is the perspective of the users.

Although this study examines both the success and failure of TI projects, results are found only explaining the success and not the failure of the TI projects. This does not mean there is no added value of the newly developed indicator reflecting the transport mode context element. It would be indeed useful, if the fsQCA was also giving results of the combinations of conditions that lead to failure of TI projects. However, knowing the combination of conditions that contribute to the achievement of success is also important. Empirical analysis serves the role of the information provider to the decision makers in order to support the decision making process. The ''coin'' of decision support techniques and tools has two options; information can be given to the decision makers about lessons learnt on how to avoid failure, thus trying to take proactive actions in order to mitigate the likelihood of project failure (i.e. of the non-achievement of the project objectives) or/and it gives lessons learned on how to achieve success. The former information represents the potential negative risks in the project that if they might occur they might endanger the achievement of project objectives, and the latter ones they represent the success factors that increase the likelihood of the achievement of the project objectives. In the closing of the project, which is the last stage of the project management process, a key task is the preparation of a lessons-learnt report to show what has been learnt that can contribute to the success of future transport projects. Therefore, from the above it can be seen that it is also important to identify the factors that can lead to project success, as it is also important to identify the factors that can lead to project failure.

For the identification of the factors (i.e. conditions in fsQCA terms) that lead to the project success the following steps are followed. Necessity and sufficiency analyses of the fsQCA are conducted (see Annex B for the complete results of the necessity analysis).

The sufficiency analysis, presented in table 5.2 below, shows the results of the models tested[19]. Model 1a shows that 84% of the cases with the combination of **high security, safety, availability, reliability and investment of TI projects** display the success outcome (for the sample of the combined cases, i.e. private co-financed and publicly financed cases). 42% of the outcome can be explained by this combination of conditions (coverage score) (all conditions are core).

Model 1b of the combined cases showed (see Table 5.2) that 82% of the cases are explained by the combination of **high security, safety (core), availability, reliability (core)** and 94% of the cases are explained by the combination of **high safety (core), maintainability, availability and reliability (core),** with coverage scores of 61% and 43% respectively (solution consistency: 0.83, solution coverage: 0.65).

[19] The results that are presented in Table 5.2 show the results of the sufficiency analysis only of the first group of conditions as explained above. Sufficiency analysis has been conducted also for models composed with conditions of the second and third group but they are not presented in the Table 5.2 below because no results are found.

After comparing the three paths that were found from the analysis of the above two models (Models 1a and 1b) for the presence of the outcome (i.e. success) for the combined cases, it is observed that three conditions appear in all the three solution paths, being reliability, availability and safety. Reliability is found to be core in all the three solution paths, availability is found to be core for the one of the three solution paths and safety is found to be core in the three solution paths as well.

Based on this finding, two models are tested, being Model 1c and Model 1d. Model 1c includes as conditions the reliability, availability and safety, which shows that 83% of the cases with the combination of reliability (core), availability and safety (core) display the outcome (coverage: 67%). Model 1d includes as conditions only the reliability and availability because these indicators have a direct impact on the demand of the TI and as a result its funding (i.e. financial streams), while safety has an indirect impact.

More specifically, if users' reliability for a TI or a transport service is not high, this can affect the demand for the TI or the transport service and as a result the funding sources that are collected via its users, e.g. tolls, user charges, availability payments, fares etc. Availability of a TI is a key performance indicator, considering that it is also often used in the contracts as an incentive element, i.e. performance payments and penalties, to guarantee performance and has also a direct impact on funding. If the TI is not available, this will also reduce traffic and as a result also the funding collected via traffic. Safety and the other ''performance'' sub-dimension indicators presented in the transport mode context typology (see Table 5.1) have an indirect impact on funding, in the sense that they do not affect directly traffic demand and thus the funding collected via the traffic/TI users. They affect negatively the reliability of the users for a TI, which can reduce traffic and thus the collected funding. Thus, a model that includes only the reliability and availability conditions is tested (i.e. Model 1d). Model 1d showed that 82% of the cases (combined cases) with the combination of availability and reliability (core) display the success outcome (coverage = 0.69) (see Table 5.2).

Although the focus of this fsQCA is on both private and public cases together (i.e. combined/mixed cases), since the indicator to be developed needs to be applicable to both cases, the sample of cases of only privately co-financed cases and only publicly financed cases are also tested to see how different or similar results they give, compared to each other.

Model 2a of the privately co-financed cases showed (see Table 5.2) that 89% of the cases with the combination **security (core), safety (core), maintainability (core), availability (core), reliability (core) and investment (core)** display the success outcome (coverage: 0.35). The difference with the findings of the combined case findings is that maintainability is a core condition for the privately co-financed cases (in combination with the other conditions), while it is not a relevant condition for the combined cases' findings (see Model 1a).

Model 2b of the privately co-financed cases shows that 92% of the cases with the combination **security (core), safety (core)**, **maintainability (core), availability and reliability (core)** display the success outcome (coverage: 0.45). The difference with the findings of the combined cases' sample is that for the privately co-financed cases all the conditions are relevant for displaying the success outcome, while for the combined cases two solution paths are found, meaning that it is either the one combination of conditions or the other one that displays the outcome (although for both solutions there were three common conditions, being reliability, availability and safety).

For the sample including only the privately co-financed projects, the models ''reliability and availability'' and ''reliability, availability and safety'' were tested (Model 2c and Model 2d), similarly with the sample of the combined cases, so as to compare their results (see Table 5.2). Thus, also for the privately co-financed cases, as for the combined cases, reliability and availability are sufficient conditions to display the success outcome. The consistency and coverage scores of the sufficiency analyses of the two samples are very similar (combined cases' consistency/coverage: 0.82/0.69 and privately co-financed cases' consistency/coverage: 0.80/0.71).

Model 2c of the privately co-financed cases shows (see Table 5.2) that 79% of the cases with the combination **availability, reliability (core) and safety (core)** display the outcome. 67% of the membership in the outcome can be explained by these conditions (i.e. coverage score). These results are similar to the results of the mixed cases (consistency/coverage: 0.83/0.67).

Model 2d of the privately co-financed cases showed that 80% of the cases with the combination **availability and reliability (core)** display the outcome. 71% of the membership in the outcome can be explained by these conditions (i.e. coverage score). These results are similar with the results of the mixed cases (consistency/coverage: 0.82/0.69).

For the publicly financed cases, in Model 3a, the first group of conditions has been tested (except the investments variable, because maximum five conditions could be tested). Thus, the five conditions under the users' dimension have been selected. The same conclusion that was extracted for the solutions of the mixed cases' model (Model 1b) can be extracted also for the Model 3a tested for the public cases. The conditions that appear in both found paths are the availability, reliability and safety. Particularly, Model 3a of the publicly financed cases showed that 93% of the cases with the combination of **security, safety (core), availability (core) and reliability (core)** display the outcome **and** 100% of the cases with the combination **safety (core), maintainability, availability (core) and reliability (core)** display the outcome (coverage 56% and 36% respectively). This means that either the first combination of conditions or **the second are sufficient for the outcome to occur** (overall consistency/coverage: 0.94/0.64).

Model 3b of the publicly financed cases showed (see Table 5.2) that 94% of the cases with the combination **availability, reliability and safety (all core)** display the outcome. 64% of the membership in the outcome can be explained by these conditions (i.e. coverage score). These results are similar to the results of the mixed cases Model 1c (consistency/coverage: 0.83/0.67). The difference that is observed compared to the results of the mixed cases (Model 1c) is that consistency is 83% for mixed cases, while for the publicly financed cases, it is 94%. Also, availability is found to be a core condition for the first time for the publicly financed cases for the Model 3b.

Model 3c of the publicly financed cases showed (see Table 5.2) that 89% of the cases with the combination of **reliability and availability (both core)** display the outcome (compared to 82% for the mixed cases). 64% of the membership in the outcome can be explained by this combination of conditions (compared to 69% for the mixed cases).

Table 5. 2: Results of the sufficiency analysis

Presence/ Absence of the outcome	**Sample**	**Model**	**Results/Solution Paths**	**Raw cov.**	**Unique cov.**	**Cons.**	**Overall cons./ cov.**
Presence	Mixed sample analysis (max 8 conditions allowed for 53 cases)	**Model 1a** Model: success = f(security, safety, maintainability, availability, reliability**, investment)**	**security*safety*availability*reliability*investment** [20]	0.42	0.42	0.84	0.84/0.42
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Mixed sample analysis	**Model 1b** Model: success = f(reliability, availability, maintainability, safety, security)	security***safety***availability***reliability** **safety***maintainability*availability***reliability**	0.61 0.43	0.22 0.04	0.82 0.94	0.83/0.65
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Same sample	**Model 1c** success = f(reliability, availability and safety)	**safety***availability***reliability**	0.67	0.67	0.83	0.83/0.67
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Mixed sample analysis	**Model 1d** success = f(availability, reliability)	availability***reliability**	0.69	0.69	0.82	0.82/0.69
Absence	Mixed sample analysis	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Privately co-financed cases (max 7 conditions allowed for 34 cases)	**Model 2a** Model: success = f(security, safety, maintainability, availability, reliability, investment)[21]	**security*safety*maintainability*availability*reliability*investment**	0.35	0.35	0.89	0.89/0.35
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Privately co-financed cases	**Model 2b** Model: success = f(security,	**security*safety*maintainability***availability***reliability**	0.45	0.45	0.92	0.92/0.45

[20] The core conditions are displayed in bold.

[21] Contract duration is not added in the model here because when it was added, there were no results (empty matrix). This is the reason why the model was run without ''contract duration''. This could be the case because of the non-variance of the values of this condition for all cases (i.e. almost all cases had the same value).

		safety, maintainability, availability, reliability)					
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Privately co-financed cases	**Model 2c** Model: success = f(safety, availability, reliability)	**safety***availability***reliability**	0.67	0.67	0.79	0.79/0.67
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Privately co-financed cases	**Model 2d** Model: success = f(availability, reliability)	availability*<u>**reliability**</u>	0.71	0.71	0.80	0.80/0.71
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Public cases (Max 5 conditions allowed for 19 cases)	**Model 3a** Model: success = f(security, safety, maintainability, availability, reliability)	security*<u>**safety*availability*reliability**</u> **safety***maintainability***availability*reliability**	0.56 0.36	0.28 0.08	0.93 1.00	0.94/0.64
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Public cases	**Model 3b** Model: success = f(safety, availability, reliability)	**safety*availability*reliability**	0.64	0.64	0.94	0.94/0.64
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x	x	x
Presence	Public cases	**Model 3c** Model: success = f(availability, reliability)	availability*reliability	0.64	0.64	0.89	0.89/0.64

Source: Own findings using fsQCA

The findings of the fsQCA presented in this chapter and summarized in Table 5.2 are found assuming that the missing values of some cases in the dataset equal zero. The reason why is that otherwise, if there are missing values for one or more variables, cases with missing values are not included in the configurations in the truth table (Ragin, 2008). There are 15 cases out of the 53 cases in total in the sample that have complete data for all the variables. All the rest cases have missing values for at least one variable (i.e. condition).

Analysis has been conducted also using the dataset with missing values (see Annex C). There are two differences between this analysis of Annex C and the one presented in chapter 5 that used a dataset with no missing values (i.e. missing values have been replaced by zero values). The first difference is the maximum number of conditions that can be used in the analysis, being maximum four conditions for 15 cases. This leads also to the second difference, which is testing different models (i.e. groups of conditions), because now up to four conditions could be tested (excluding the outcome).

Findings showed that 85% of the cases with the combination of high **safety, availability and reliability** of TI projects display the success outcome (coverage equals 90%). It is also found that 85% of the cases with the combination of high **availability and reliability** (both core) display the success outcome (93% coverage). 82% of the cases with high **security** display the success outcome or 85% of the cases with high **safety** display the success outcome (coverage 96% and 92% respectively) (overall coverage/consistency: 1.00/0.82) (Annex C). The former two solution paths are also found in the analysis conducted with the dataset in which missing values haven been replaced with zero values (the only difference is the core conditions, i.e. not the same conditions are core). Also, the coverage scores of these two solution paths are much higher than the ones shown in Table 5.2, i.e. they increased from 67% and 69% to 90 % and 93%. Similar paths for the two analyses are found since same or similar models are tested, i.e. the same model tested gave the same solution path of **availability and reliability** and a similar model tested gave the same solution path of **reliability, availability and safety.**

To sum up, the findings of the mixed cases are similar to the findings of the privately co-financed and publicly financed cases. Three conditions are found to be relevant for explaining the outcome in the majority of the solution paths, being reliability, availability and safety. Due to the direct impact on funding of two out of these three conditions, being reliability and availability, these two conditions are also tested for the three samples of cases and their combination is found to be sufficient to display the outcome for all the three of them. With respect to the importance of the combination of "availability-reliability", "availability" has a direct impact on the funding of TIs. Availability measures the time TI is available to the users over a unit period. Performance indicators, such as availability, are stated explicitly in many project contracts, and may affect the risk perception of investors because of its implications to the revenue-generating capacity of the project and thus its ability to deliver the forecast returns. Reliability is the other indicator coming back as a sufficient condition (in combination with other condition(s)) from the fsQCA sufficiency analysis. Reliability reflects the degree of trust for each mode's ability to deliver its intended service and is measured as the % time of disruptions during operation. Reliability is a key factor in users' mode choice.

Due to the above, the combination of "reliability" and "availability" is used to construct the transport mode context element indicator. Notably, both "reliability" and "availability" were included in the "performance dimension".

The qualitative assessment of the indicators is converted to a score in the range [0, 1] and combined to describe the overall indicator for reliability/availability (IRA):

$IRA = (1+IR)*(1+IA)/4$ (eq. 1)

with: IR: indicator of reliability, IA: indicator of availability, IRA: overall reliability/availability indicator

What makes IRA, as a resulting composite indicator, different from the indicators of the other key elements of the conceptual framework of Roumboutsos, Voordijk, & Pantelias (2018), is the fact that it is developed using the users' perception. Also, another difference is that IRA's sub-indicators can take discrete (e.g. 0, 0.5, 1) and not continuous values from 0 to 1 (GI can also take discrete values). Thus, when assessing the reliability and availability of a TI, it can be considered that:

(i) reliability was improved fully in line with expectations or even more (value 1), (ii) reliability was improved partially in line with expectations (value 0.5) and (iii) reliability was not improved or only marginally improved (value 0). A similar approach is used for “availability”. Notably, this was a required concession, as quantitative data for the reliability indicator were not always available. Stakeholders could only assess if reliability (availability) was better, in line or less than expectations.

5.5 Conclusions

The aim of this chapter was to develop an indicator composed out of key indicators that affect the performance of projects of all transport modes and of their respective infrastructures in terms of their funding (i.e. income streams that are used to repay incurred costs of the TI project). Performance (i.e. success and failure) in this chapter was defined as the general level of a project’s perceived success, either high, medium or low level. Failure was also examined and defined as the absence of the success outcome. A general definition of the success and failure was used so as to broaden the applicability of the indicator to all types of TIs and for all the performance outcomes (i.e. cost, time, traffic and revenues). For broadening its applicability, the results of the sample that combine both the privately co-financed and the publicly financed cases were used. Thus, the newly developed indicator for the transport mode contact element can be used for both types of project delivery. The method that was applied for the empirical analysis is the fuzzy set Qualitative Comparative Analysis (fsQCA), which was identified as a very suitable one, via literature in Chapter 3. The inputs for conducting the analysis (i.e. the conditions) were collected via literature review. From the literature review, all the main characteristics that affect the performance of TI projects in terms of their funding were collected and then they were clustered, i.e. groups of common factors are categorized by a common category (i.e. dimension). This ‘’construction’’ of a dimension with its respective factors represents what is called the ‘’transport mode context typology’’. Not all the factors identified via the literature review could be finally used in the fsQCA due to limited data availability. However, based on the available data tested, the fsQCA findings showed that the two indicators that are found to explain the success of the TI projects, in combination, are the availability and reliability indicators. Thus, the indicator IRA was developed, i.e. Indicator of Reliability and Availability that is calculated in the following way: $IRA = (1+IR)*(1+IA)/4$; with: IR: indicator of reliability, IA: indicator of availability, IRA: overall reliability/availability indicator. Availability measures the time TI is available to the users over a unit period and is often a performance indicator that is explicitly stated in project contracts. Reliability reflects the degree of trust for each mode’s ability to deliver its intended service and is measured as the % time of disruptions during operation. Reliability is a key factor in users’ mode choice. The difference of IRA from the other indicators of Roumboutsos, Voordijk, & Pantelias (2018) is the fact that it is developed using the users’ perception, which is of critical importance for the performance of TI projects because traffic demand for the TI depends heavily on users’ perception.

6. Success and failure of transport infrastructure projects: which combinations of conditions explain it? An ex post evaluation of transport infrastructure projects

6.1 Introduction

In the present chapter, fsQCA analysis of the different samples and outcomes is conducted. FsQCA identifies causal conditions or combinations/configurations of conditions that are linked to the outcome (Ragin, 2008) (see chapter 3 for further details on the fsQCA). In other words, fsQCA views cases as configurations of conditions. This chapter is structured as follows. Section 6.2 presents the approach used to apply the fsQCA. Sections 6.3-6.6 present the findings of the fsQCA per outcome and per sample, i.e. section 6.3 cost outcome findings, 6.4 time outcome findings, 6.5 traffic outcome findings and 6.6 revenues outcome findings. Section 6.7 presents the main conclusions.

6.2 Approach

In this section, the sufficiency analysis's results are presented for the four identified project outcomes, i.e. cost, time, traffic and revenues. The main models/set of conditions that are used are: 1) the full set of seven conditions and 2) reduced models with less conditions, as presented in Table 6.1 below.

Firstly, the full set of seven conditions is used for the samples of projects that are sufficiently large (Marx and Dusa, 2011), being the full sample of projects composed out of 51 cases and the PPP sample of projects, composed out of 39 cases. Also, for the two large size samples, reduced models, with less than seven conditions, are also tested, either because results were not found with the full set of conditions or so as to avoid exacerbating the problem of limited diversity and to avoid taking a complex solution (Schneider and Wagemann, 2010) (Table 6.1).

Secondly, reduced models of five conditions are used for the smaller in size samples, being the road projects and the projects completed before and after the financial crisis (i.e. the year of 2008). The conditions for the reduced models are selected based on the results of the necessity analysis, literature and the understanding of the author about which conditions are mainly linked to the planning and implementation phase of a TI project and thus could explain the cost and time outcome till its completion, and which conditions are mostly linked to the operational phase of the project, and thus could explain the traffic and revenues outcomes (see in the annexes Tables A.6.1-A.6.70 of chapter 6 for a detailed presentation of the necessity analysis) (Table 6.1).

The selection of the five conditions based on the results of the necessity analysis is made using the five conditions with the highest necessity consistency scores. Also, the findings of these analyses are used as models after adding also the initially excluded two conditions (i.e. with the lowest necessity scores), to also test their relevance for the occurrence and non-occurrence of the outcome (Table 6.1).

The detailed results of the necessity and sufficiency analysis, the calibration method and the truth tables are presented in the annexes for transparency reasons. Particularly, in the annexes A.6.1-A.6.70, the results of the necessity and sufficiency analyses are presented; Annex A.6.71 and A.6.72 present the calibration method and Annexes B.6.1-B.6.67 present the truth tables.

Table 6. 1: Summarizing table showing the models tested for the cost, time, traffic and revenues outcomes

Cost															
Full model (full sample & PPP)	*Reduced model n1 (full sample, PPP, road, before crisis)*	*Reduced model n2 (PPP sample)*	*Reduced model n3 (road sample)*	*Reduced model n4 (road sample)*	*Reduced model n5 (road & after crisis sample)*	*Reduced model n6 (road sample)*	*Reduced model n7 (before & after crisis sample)*	*Reduced model n8 (before crisis sample*	*Reduced model n9 (before crisis sample)*	*Reduced model n10 (before crisis sample*	*Reduced model n11 (before crisis sample*	*Reduced model n12 (after crisis sample)*	*Reduced model n13 (after crisis sample)*	*Reduced model n14 (after crisis sample)*	*Reduced model n15 (after crisis sample)*
INI FEI GI CSI RAI RRI FSI	INI FEI GI CSI FSI	INI FEI GI CSI	INI GI RAI RRI FSI	GI CSI RAI RRI FSI	INI FEI RAI RRI FSI	FEI GI RAI RRI FSI	INI FEI GI RAI FSI	INI FEI GI FSI RRI	FSI RAI RRI	FSI RAI CSI	FSI RAI RRI CSI	INI FEI FSI RRI	INI FEI FSI CSI	INI FEI FSI CSI RRI	INI FEI RAI FSI CSI

Time						
Full model: (full sample & PPP)	*Reduced model n1 (full sample)*	*Reduced model n2 (PPP sample, road, before crisis, after crisis)*	*Reduced model n3 (road sample, before crisis, after crisis)*	*Reduced model n4 (before crisis sample)*	*Reduced model n5 (PPP & after crisis sample)*	*Reduced model n6 (before & after crisis sample)*
INI FEI GI CSI RAI RRI FSI	INI GI CSI RAI FSI	INI FEI GI CSI	INI FEI GI CSI FSI	GI CSI RAI RRI FSI	INI FEI GI RAI FSI	INI FEI GI FSI RRI

Traffic					
Full model: (full sample & PPP)	*Reduced model n1 (PPP sample)*	*Reduced model n2 (before crisis sample)*	*Reduced model n3 (before crisis sample)*	*Reduced model n4 (before crisis sample)*	*Reduced model n5 (road, after & before crisis sample)*
INI FEI GI CSI RAI RRI FSI	INI FEI GI CSI RAI FSI	INI FEI RAI RRI CSI	INI FEI RAI RRI	INI FEI RAI RRI FSI	INI FEI GI RAI FSI
Revenues					
Full model: (full sample & PPP)	*Reduced model n1 (full sample)*	*Reduced model n2 (PPP & before crisis sample)*	*Reduced model n3 (road sample)*	*Reduced model n4 (road sample)*	*Reduced model n5 (after crisis sample)*
INI FEI GI CSI RAI RRI FSI	INI GI RRI	FEI GI CSI RRI FSI	FEI FSI RAI RRI GI	INI FEI GI RRI	INI FEI GI RAI FSI

6.3 Cost outcome

Section 6.3 presents the results of the sufficiency analysis for the cost outcome for all the five samples tested: full, PPP, road, completion before and after crisis sample. For the cost outcome, the sufficiency analyses' results are shown in Table 6.2.

Table 6.2: Overview of cost outcome results for all the samples of cases

<table>
<tr><td>Outcome - Sample</td><td colspan="2">COST FULL PRESENCE</td><td colspan="3">COST FULL ABSENCE</td></tr>
<tr><td>Model used</td><td>INI
FEI
GI
CSI
RAI
RRI
FSI</td><td>INI
FEI
GI
CSI
FSI</td><td colspan="2">INI
FEI
GI
CSI
RAI
RRI
FSI</td><td>INI
FEI
GI
CSI
FSI</td></tr>
<tr><td>Solution path & consistency/coverage</td><td>+INI[22]
+GI
+CSI
~RAI
+FSI
(0.80/0.41)
(11)[23]</td><td>+INI
+GI
+CSI
+FSI
(0.82/0.53)
(17)</td><td>+FEI
~CSI
~RAI
~FSI
(0.87/0.28)
(1)</td><td>+INI
+GI
~CSI
~RAI
~FSI
(0.84/0.31)
(1)</td><td>~CSI
~FSI
(0.87/0.33)
(3)</td></tr>
<tr><td>Overall consistency/coverage</td><td>(0.80/0.41)</td><td>(0.82/0.53)</td><td colspan="2">(0.85/0.31)</td><td>(0.87/0.33)</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Outcome - Sample</td><td colspan="5">COST PPP PRESENCE</td></tr>
<tr><td>Model used</td><td colspan="3">INI
FEI
GI
CSI
RAI
RRI
FSI</td><td colspan="2">INI
FEI
GI
CSI
FSI</td></tr>
<tr><td>Solution path & consistency/coverage</td><td>+INI
+FEI
+FSI
(0.91/0.57)
(14)</td><td>+GI
+CSI
+RRI
+FSI
(0.90/0.46)
(11)</td><td>+INI
+GI
+CSI
+FSI
(0.92/0.59)
(17)</td><td>+GI
+FSI
(0.95/0.77)
(20)</td><td>+INI
+FEI
+FSI
(0.97/0.57)
(14)</td></tr>
<tr><td>Overall consistency/coverage</td><td colspan="3">(0.92/0.75)</td><td colspan="2">(0.95/0.81)</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Outcome - Sample</td><td colspan="3">COST PPP ABSENCE</td><td>COST ROAD PRESENCE</td><td>COST ROAD ABSENCE</td></tr>
<tr><td>Model used</td><td>INI
FEI
GI
CSI
RAI
RRI
FSI</td><td>INI
FEI
GI
CSI</td><td>INI
FEI
GI
CSI
FI</td><td>INI
FEI
GI
CSI
FSI</td><td>INI
FEI
GI
CSI
FSI</td></tr>
<tr><td>Solution path & consistency/coverage</td><td>~CSI
~RAI
~FSI
(0.88/0.44)
(2)</td><td>~FEI
~GI
~CSI
(0.77/0.42)
(1)</td><td>~CSI
~FSI
(0.87/0.46)
(3)</td><td>+INI
+FEI
+GI
~CSI
+FSI</td><td>~CSI
~FSI
(0.83/0.37)
(1)</td></tr>
</table>

[22] In bold, the core conditions are presented.
[23] The number in the parenthesis shows the number of the relevant cases.

				(0.78/0.40) (3)	
Overall consistency/coverage	(0.88/0.44)	(0.77/0.42)	(0.87/0.46)	(0.78/0.40)	(0.83/0.37)
Outcome - Sample	**COST ROAD ABSENCE**				
Model used	INI GI RAI RRI FSI		GI CSI RAI RRI FSI		
Solution path & consistency/coverage	**~INI** **~RAI** (0.85/0.39) (2)	~RAI **~FSI** (0.88/0.36) (1)	~CSI ~RAI **~FSI** (0.86/0.36) (1)	**~GI** ~CSI **~RRI** (0.81/0.43) (1)	
Overall consistency/coverage	(0.84/0.48)		(0.78/0.54)		
Outcome - Sample	**COST ROAD ABSENCE**				**COST BEFORE CRISIS PRESENCE**
Model used	INI FEI RAI RRI FSI		FEI GI RAI RRI FSI		INI FEI GI RAI FSI
Solution path & consistency/coverage	~RAI **~FSI** (0.88/0.36) (2)	**~INI** ~FEI **+RRI** (0.87/0.47) (4)	~RAI **~FSI** (0.88/0.36) (1)	**~FEI** **~RAI** **+RRI** (0.91/0.32) (2)	**+INI** **~FEI** +GI +FSI (0.78/0.49) (5)
Overall consistency/coverage	(0.85/0.63)		(0.88/0.46)		(0.78/0.49)
Outcome - Sample	**COST BEFORE CRISIS ABSENCE**	**ADDITIONAL MODELS BEFORE CRISIS PRESENCE**		**ADDITIONAL MODELS BEFORE CRISIS ABSENCE**	
Model used	INI FEI GI RAI FSI	INI FEI GI FSI CSI	INI FEI GI FSI RRI	FSI RAI RRI	FSI RAI CSI
Solution path & consistency/coverage	~RAI **~FSI** (0.87/0.45) (1)	**~FEI** +GI +FSI **+CSI** (0.83/0.53) (7)	**+INI** **~FEI** +GI +FSI (0.78/0.49) (5)	~RAI **~FSI** (0.87/0.45) (1)	~RAI **~FSI** ~CSI (0.86/0.44) (1)
Overall consistency/coverage	(0.87/0.45)	(0.83/0.53)	(0.78/0.49)	(0.87/0.45)	(0.86/0.44)
Outcome - Sample	**ADDITIONAL MODELS BEFORE CRISIS ABSENCE**	**COST AFTER CRISIS PRESENCE**	**COST AFTER CRISIS ABSENCE**	**ADDITIONAL MODELS AFTER CRISIS PRESENCE**	**ADDITIONAL MODELS AFTER CRISIS ABSENCE**
Model used	FSI RAI RRI CSI	INI FEI GI RAI FSI	INI FEI GI RAI FSI	INI FEI FSI **CSI** INI FEI FSI	INI FEI RAI FSI RRI

				RRI	
				INI FEI FSI CSI RRI	
Solution path & consistency/coverage	**~FSI** ~CSI (0.85/0.48) (2)	+INI **+FEI** **+FSI** (0.85/0.56) (9)	**~INI** ~FEI **~RAI** +FSI (0.85/0.41) (1)	**+INI** **+FEI** +FSI (0.85/0.56) (9)	**~INI** ~FEI **~RAI** **+FSI** (0.85/0.41) (1)
Overall consistency/coverage	(0.85/0.48)	(0.85/0.56)	(0.85/0.41)	(0.85/0.56)	(0.85/0.41)
Outcome - Sample	**ADDITIONAL MODELS AFTER CRISIS ABSENCE**				
Model used	INI FEI RAI FSI CSI				
Solution path & consistency/coverage	~INI **~FEI** **~RAI** **+FSI** (0.85/0.41) (1)	**~FEI** **~RAI** **+FSI** ~CSI (0.81/0.380) (1)			
Overall consistency/coverage	(0.84/0.46)				

Abbreviations' meaning: NI: Institutional Indicator, FEI: Financial Economic Indicator, CSI: Cost Saving Indicator, GI: Contractual Governance Indicator, RAI: Remuneration Attractiveness Indicator, RRI: Revenue Robustness Indicator, FSI: Financing Scheme Indicator

With respect to the **"on & under cost- full sample",** it is found that TI projects have a high likelihood to be on/under cost, when they are located in a country with a favorable institutional context (+INI), have a good contract (+GI) and a robust business model with respect to reducing costs during the construction phase, thanks to e.g. capable contractors (+CSI), have a financing scheme with low cost of capital (+FSI) and have a non-attractive to investors remuneration scheme (~RAI).

With respect to the **"over cost-full sample",** it is found that TI projects are likely to be over cost, when their cost of capital is high, coming mostly from the private sector (~FSI) and when there is a non-robust business model in terms of its ability to reduce the project costs during its construction phase (~CSI). Also, TI projects are likely to be over cost when apart from these two conditions, they also have a non-attractive to investors remuneration scheme (~RAI) and either they are located in a country with a favorable macro-economic and macro-financial context (+FEI) or with a favorable institutional context (+INI) and a good contract (+GI). Thus, when the business model (CSI), funding scheme (RAI) and financing scheme (FSI) are not robust, positive exogenous factors (INI and FEI) and a positive structural condition (GI) still can explain TI projects that are over cost.

When comparing the findings of the on/under cost and over cost analysis **for the full sample**, it is observed that a key difference is the CSI and FSI. These two conditions are found to be positive/present (combined with other conditions) when explaining the on-cost outcome and they are found to be negative/absent (combined with other conditions) when explaining the over cost outcome. However, other conditions than these two are found to explain the presence of the outcome being absent (i.e. RAI) and to explain the absence of the outcome being present (i.e. INI, FEI, GI). Thus, it is seen that the presence of a condition combined with the absence of certain conditions can still explain the absence of the outcome and vice versa, the absence of a condition combined with the presence of certain conditions can still explain the presence of the outcome.

With respect to the **"on & under cost-PPP sample"**, it is observed that TI PPP projects are likely to be on/under cost, when their cost of capital is low (+FSI) and either they have a good contract (+GI) or they are located in a country with a favorable institutional (+INI) and macro-economic and macro-financial context (+FEI).

With respect to the **"over cost-PPP sample"**, results show that TI PPP projects are likely to be over cost, when their cost of capital is high (~FSI) and when their business model is non-robust in terms of its ability to reduce the project costs during its construction phase (i.e. ~CSI). Over cost outcome could be also explained for the PPP projects, when these two conditions are also combined with a non-attractive to investors remuneration scheme (~RAI). Additionally, a PPP project is likely to be over cost, when it has a non-good contract, a non-robust business model in terms of its ability to reduce costs during the construction phase and is located in a country with non-favorable financial-economic context.

With respect to the **"on & under cost-road sample"**, it is found that the road projects are likely to be on/under cost, when they are located in a country with favorable institutional and financial-economic context (+INI and +FEI), with a low cost of capital (+FSI), a good contract (+GI) and even when their business model is non-robust, in terms of its ability to reduce the project costs during its construction phase (i.e. ~CSI).

With respect to the **''over cost-road sample''**, the different models tested show that different combinations of conditions can each time explain the over cost outcome of road cases. What is interesting to observe is that in the three out of the four additional models tested, which include the condition RAI, the same solution path came as a result. All the results show the same, that having high cost of capital (most privately financed project) and a funding scheme that is non-attractive to its investors explain the majority of the projects that have cost overruns. The fourth model shows a similar result, that road projects with cost overruns additionally to the two conditions above, i.e. of high cost of capital and a non-attractive funding scheme, also have a non-robust business model, with a low ability to reduce costs during the construction phase (~CSI).The same result is found for the PPP projects that are over cost.

Also other different solutions are found to explain the road projects that were over cost: 1) having a high cost of capital (~FSI) and low ability to reduce costs during the construction phase (~CSI) (the same result is found for the PPP projects that are over cost), 2) having a non-favorable financial-economic context (~FEI) and high revenue robustness (+RRI) either a) combined with a non-favorable institutional context (~INI) or b) with a non-attractive remuneration scheme (~RAI), 3) having a non-favorable institutional context (~INI) and a non-attractive remuneration scheme (~RAI) and 4) having a non-good contract (~GI), low ability to reduce costs during the construction phase (~CSI) and low revenue robustness (~RRI).

With respect to the **"on & under cost-completed before crisis sample"**, TI projects that are completed before crisis are likely to be on/under cost, when their cost of capital is low (+FSI), when they have a good contract (+GI), when they are located in a country with a favorable institutional context (+INI) and an unfavorable macro-financial context (~FEI). It is also found that an additional similar solution path also explains the projects that are on/under cost and are completed before crisis, having the same conditions with the aforementioned ones, with one difference, instead of having a good institutional context, having a high ability to reduce costs during construction phase is a relevant condition (+CSI).

With respect to the **"over cost-completed before crisis sample"**, it is found that TI projects completed before crisis are likely to be over cost, when their cost of capital is high (~FSI) and 1) combined either with a non-attractive to investors remuneration scheme (~RAI) or 2) with a non-attractive remuneration scheme and a non-robust business model in terms of its ability to reduce project costs during its construction phase (~CSI) or 3) combined only with a low ability to reduce costs during the construction phase (~CSI). These results are the same with the results found for the PPP and road projects being over cost. As a conclusion for the absence of the cost outcome for the completed before crisis sample, the exogenous environment conditions (i.e. institutional and financial-economic context), the contract and revenue robustness conditions are of no relevance; the structural condition of the ability to reduce costs during the construction phase is of smaller relevance and the policy conditions (i.e. financing scheme and remuneration attractiveness) are the ones that mostly matter (i.e. RAI, FSI).

With respect to the **"on & under cost-projects completed after crisis"**, CSI, RRI, GI and RAI are of no relevance. TI projects completed after crisis are likely to be on/under cost, when they are located in country with good institutional (+INI) and financial-economic context (+FEI) and when they have low cost of capital (+FSI).

With respect to the **"over cost-projects completed after crisis"**, RRI and GI are not linked with the non-occurrence of the outcome. Results show that TI projects completed after crisis are likely to be over cost, when the institutional (~INI) and financial-economic context (~FEI) are not favorable, (oppositely to the findings for the occurrence of the outcome), when cost of capital is low (+FSI), (similarly to the findings for the occurrence of the outcome) and when there is a non-attractive to investors remuneration scheme (~RAI). Another solution explaining the projects completed after crisis that have cost overruns shows a non-favorable financial-economic context (~FEI), a non-attractive to investors remuneration scheme (~RAI) and low cost of capital (+FSI) either combined with a non-robust business model in terms of its ability to reduce project costs during its construction phase (~CSI) or with a non-favorable institutional context (~INI).

Some overarching conclusions are presented below that show the: 1) positive conditions that explain the absence of the outcome, 2) least relevant conditions (& most relevant), 3) overlapping paths among samples of the same outcome and 4) the importance of the exogenous environment (institutional & financial-economic context) for the two crisis samples, so as to compare how relevant the two exogenous conditions are for both samples of projects that are completed before and after crisis.

Overarching conclusions for the conditions contributing to the (non-) achievement of the cost outcome

- For the cost outcome, positive conditions explain the absence of the outcome. Although these conditions are positive, if combined with certain negative conditions, projects might still have cost overruns. Specifically, the following present conditions explain the absence of the cost outcome for the full sample, i.e. good institutional context, good financial-economic context and contract; good revenue robustness for the road sample and low cost financing scheme for the after crisis sample. Only two conditions are not found to explain the absence of the cost outcome while being present, i.e. the potential to save costs and the remuneration attractiveness.

- With respect to the absence of the cost outcome, cost saving potential, remuneration attractiveness and financing scheme are relevant conditions for all the samples. For the absence of the cost outcome, the least relevant condition is the revenue robustness. Specifically revenue robustness is not relevant for the full, PPP, before and after crisis samples for the cost outcome. The contract condition is not relevant only for one sample, i.e. for the before crisis sample. The least relevant condition for the presence of the cost outcome is the remuneration attractiveness (since it was an irrelevant condition for three out of the five outcomes, i.e. PPP, before and after crisis).
- For the presence of the cost outcome, the solution path explaining the PPP projects is the same for the crisis sample solution path. Particularly, the same solution path is found to explain two samples of projects, PPP projects and projects completed after crisis (presence of cost outcome) (i.e. good institutional context, financial-economic context, financing scheme). This could be also due to the fact that 17 out of 25 projects completed after crisis are PPP projects.
- With respect to the importance of the exogenous environment for the achievement of the cost outcome for the projects completed before and after crisis, it is observed that the presence of cost outcome is explained by a good institutional and financial-economic context for projects completed after crisis (in combination with other conditions), while for the projects completed before crisis, a good institutional context but a non-good financial-economic context explain the presence of the cost outcome (in combination with other conditions). For the absence of the cost outcome, institutional and financial economic context are not relevant conditions for the before crisis sample, while for the after crisis sample a non-good institutional and financial economic context are both relevant conditions (combined with other conditions).

6.4 Time outcome

Section 6.4 presents the results of the sufficiency analysis for the time outcome for all the five samples tested: full, PPP, road, before and after crisis sample. For the time outcome, the sufficiency analyses' results are shown in Table 6.3.

Table 6.3: Overview of time outcome results for all the samples of cases

Outcome - Sample	**TIME FULL PRESENCE**	**TIME FULL ABSENCE**	**TIME PPP PRESENCE**		**TIME PPP ABSENCE**
Model used	INI GI CSI RAI FSI	INI FEI GI CSI RAI RRI FSI	**INI** **FEI** **GI** **CSI** **RAI** **RRI** **FSI**	**INI** **FEI** **GI** **CSI**	INI FEI GI CSI RAI RRI FSI
Solution path & consistency/coverage	**+INI** +GI **+CSI** **~RAI** +FSI (0.78/0.46) (11)	**~INI** ~FEI **~GI** ~CSI (0.85/0.41) (3)	+INI **+FEI** +GI **+CSI** **~RAI** +FSI (0.80/0.38) (5)	+INI **+FEI** **+GI** (0.82/0.56) (13)	**~INI** ~FEI ~CSI ~RAI **~FSI** (0.80/0.34) (1)

Overall consistency/coverage	**(0.78/0.46)**	**(0.85/0.41)**	**(0.80/0.38)**	(0.82/0.56)	**(0.80/0.34)**
Outcome - Sample	**TIME PPP ABSENCE**	**TIME ROAD PRESENCE**	**TIME ROAD ABSENCE**	**TIME BEFORE CRISIS PRESENCE**	
Model used	**INI FEI GI RAI FSI**	INI FEI GI CSI FSI	INI FEI GI CSI	**INI FEI GI CSI FSI**	
Solution path & consistency/coverage	**~INI** ~FEI ~RAI **~FSI** (0.80/0.35) (1)	+INI +FEI +GI **~FSI** (0.77/0.34) (1)	~INI ~FEI **~GI** ~CSI (0.91/0.48) (3)	**+GI** +FSI (0.89/0.74) (15)	+INI +FEI **+GI** (0.86/0.53) (8)
Overall consistency/coverage	**(0.80/0.35)**	**(0.77/0.34)**	**(0.91/0.48)**	**(0.90/0.79)**	
Outcome - Sample	**TIME BEFORE CRISIS PRESENCE**	**TIME BEFORE CRISIS PRESENCE**			**TIME BEFORE CRISIS ABSENCE**
Model used	**INI FEI GI CSI**	INI FEI GI RRI FSI			GI CSI RAI RRI FSI
Solution path & consistency/coverage	**+GI** (0.89/0.84) (17)	**+GI** +RRI +FSI (0.87/0.53**)** (9)	+INI **+GI** +FSI (0.88/0.32) (1)	+INI +FEI **+GI** **+RRI** (0.84/0.41) (5)	**~GI** **~CSI** ~RAI **~RRI** **+FSI** (0.87/0.65) (1)
Overall consistency/coverage	(0.89/0.84)	**(0.90/0.75)**			**(0.87/0.65)**
Outcome - Sample	**TIME AFTER CRISIS PRESENCE**	**TIME AFTER CRISIS ABSENCE**			
Model used	INI FEI GI CSI	INI FEI GI CSI	INI FEI GI RAI FSI	INI FEI GI RRI FSI	INI FEI GI CSI FSI
Solution path & consistency/coverage	**No results are found.**	**~INI** **~FEI** (0.88/0.52) (5)	**~INI** ~FEI **~GI** (0.88/0.43) (3)	**~INI** **~FEI** (0.88/0.52) (5)	**~INI** **~FEI** **+FSI** (0.89/0.49) (4)
Overall consistency/coverage	-	**(0.88/0.52)**	(0.88/0.43)	(0.88/0.52)	(0.89/0.49)

Abbreviations' meaning: NI: Institutional Indicator, FEI: Financial Economic Indicator, CSI: Cost Saving Indicator, GI: Contractual Governance Indicator, RAI: Remuneration Attractiveness Indicator, RRI: Revenue Robustness Indicator, FSI: Financing Scheme Indicator

With respect to the **"on & below time-full sample"**, it is found that even with a non-attractive to investors remuneration scheme (~RAI), TI projects can be on time, if they are built in a country with good institutional context (+INI), if they have a good contract (+GI), a high potential of saving costs during the construction phase (+CSI) and a financing scheme with low cost of capital (+FSI).

With respect to "**over time-full sample**", the analysis shows that if TI projects are built in a country with a non-good institutional context (~INI), non-good financial-economic context (~FEI), a non-good contract (~GI) and with a low potential of saving costs during the construction phase (~CSI), they can be over time.

With respect to "**on & below time-PPP sample**", the sufficiency analysis of the full model of seven conditions shows that PPP TI projects are likely to be on/below time, when 1) either they have good institutional and financial-economic context (+INI, +FEI) together with a good contract (+GI) (which is the same solution that is found to explain also the "on/below time-full sample", with the only difference that for the PPPs a good financial economic context is also a relevant condition for the occurrence of the time outcome, while for the full sample it is not), 2) or when having the aforementioned conditions together also with a financing scheme with low cost of capital (+FSI), a robust business model in terms of its ability to save costs during the construction phase (+CSI) and a non-attractive to investors remuneration scheme (~RAI). The condition that was found not to be relevant for the occurrence of the time outcome for the PPP projects is the revenue robustness.

With respect to "**over time-PPP sample"**, the sufficiency analysis shows that PPP TI projects are likely to be over time, when all the conditions are not favorable (except two that are irrelevant, i.e. GI and RRI). In other words, PPP projects are likely to be over time, either when they are located in a country with unfavorable institutional and financial-economic context (~INI, ~FEI), with a non-attractive to investors remuneration scheme (~RAI), a financing scheme with high cost of capital or when they have all the aforementioned conditions plus a low potential of saving costs during the construction phase (~CSI).

With respect to "**on & below time-road sample"**, the results show that the road projects are likely to be on/below time, when having mostly private financing (with higher cost of capital) (~FSI), when also having a good institutional and financial economic context (+INI & +FEI) and when also having a good contract (+GI). CSI is found to be an irrelevant condition.

With respect to **"over time-road sample"**, road projects can be over time, when they are located in a country with a non-favorable institutional and financial-economic context (~INI and ~FEI), when they have low cost saving potential during the construction phase (~CSI) and when they have a non-good contract (~GI).

It is observed that FSI is an irrelevant condition for road projects to be over time, while it is relevant for road projects to be on/below time (its absence). Also, FSI (absence) is a relevant condition for road projects to be over cost but not for road projects to be over time.

With respect to "**on & below time-completed before crisis sample"**, findings show that for the projects completed before crisis having a good contract is very important so as to be on/below time, either standalone by itself, or when combined with other conditions, such as 1) a low cost of capital (+FSI), or 2) a good institutional and financial-economic context (+INI and +FEI), or 3) combined with revenue robustness (+RRI) and low cost of capital (+FSI), or 4) combined with low cost of capital (+FSI) and good institutional context (+INI), or 5) combined with good institutional and financial-economic context (+INI and +FEI) and revenue robustness (+RRI).

With respect to **"over time-completed before crisis"**, it is found that the majority of the TI projects that are completed before crisis and were completed with delay are explained by not having a good contract (~GI), not having a high potential of saving costs during its construction phase (~CSI), not having a good funding scheme, in terms of its remuneration attractiveness (~RAI) and revenue robustness (~RRI) and having a financing scheme with low cost of capital (mostly publicly financed) (+FSI).

With respect to **"on & below time-completed after crisis"**, no results are found. Thus, the time outcome cannot be explained for the projects that are completed after crisis.

With respect to **"over time-completed after crisis"**, it is found that the TI completed after crisis are likely to be delayed, when their institutional and financial-economic context is not favorable (~INI and ~FEI). It is also found that the projects completed after the crisis are likely to be delayed when together with the non-favorable institutional and financial-economic context, there is also either a non-good contract (~GI) or a financing scheme with low cost of capital (+FSI).

Therefore, it is observed how important the exogenous environment is for the projects that are completed after the crisis, in terms of having delays of delivery.

Overarching conclusions for the conditions contributing to the (non-) achievement of the time outcome

- For the time outcome, one condition being present explains the absence of the time outcome for the before and after crisis samples, being a financing scheme with low cost of capital. This means that even with this positive condition, TI projects that are completed before or after the financial crisis might still be completed with delay, when combined with a certain group of conditions that are absent.
- Most of the conditions were relevant for all samples. The least relevant condition for the presence of the time outcome is cost saving potential, which was irrelevant for two samples, the road and the before crisis sample. With respect to the absence of time, while for the absence of the cost outcome cost saving potential, remuneration attractiveness and financing scheme are relevant conditions for all the samples, this is not the case for the absence of the time outcome, for which these conditions are not relevant for the 1) after crisis sample, 2) for the full and after crisis sample and 3) for the full sample respectively. For the absence of the time outcome, it is the institutional context and the financial-economic context that are relevant for all samples. For the absence of both the cost and time outcome, the least relevant condition is the revenue robustness. Specifically, revenue robustness is not relevant for the full, PPP and after crisis sample for the time outcome. The contract condition is not relevant only for one sample, i.e. for the PPP sample for the time outcome.
- With respect to the time outcome, the same solution path is found to explain two samples of projects, PPP projects and projects completed before crisis (i.e. good institutional context, financial-economic context and contract). This could be also due to the fact that 21 out of 22 projects completed before crisis are PPP projects.
- The presence of the time outcome is explained by a good institutional context and financial-economic context for the completed before crisis projects. While for the presence of the cost outcome, a good institutional context but a non-good financial-economic context explain the outcome (in combination with other conditions). For the absence of the time outcome, both a non-good institutional and financial-economic context are relevant conditions for the projects completed after crisis, while for the projects completed before crisis none of the conditions are relevant due to the fact that this model did not include these two conditions, thus they are not taken into consideration in this analysis.

6.5 Traffic analysis

Section 6.5 presents the results of the sufficiency analysis for the traffic outcome for all the five samples tested: full, PPP, road, before and after crisis sample. For the traffic outcome, the sufficiency analyses' results are shown in Table 6.4.

Table 6.4: Overview of traffic outcome results for all the samples of cases

Outcome - Sample	**TRAFFIC FULL PRESENCE**		**TRAFFIC FULL ABSENCE**	**TRAFFIC PPP PRESENCE**	
Model used	INI FEI GI CSI RAI RRI FSI		INI FEI GI CSI RAI RRI FSI	INI FEI GI CSI RAI RRI FSI	
Solution path & consistency/coverage	+INI +GI **+CSI** **+RAI** +FSI (0.85/0.47) (6)	+INI **+FEI** +GI **+RAI** +FSI (0.89/0.37) (4)	**~INI** ~FEI **+GI** **~CSI** **~RAI** +RRI **+FSI** (0.87/0.34) (1)	+INI +GI **+CSI** **+RAI** +FSI (0.87/0.51) (6)	+INI +FEI +GI **+RAI** **+RRI** +FSI (0.88/0.27) (2)
Overall consistency/coverage	**(0.85/0.52)**		**(0.87/0.34)**	**(0.87/0.55)**	
Outcome - Sample	**TRAFFIC PPP ABSENCE**				
Model used	**INI** **FEI** **GI** **CSI** **RAI** **FSI**				
Solution path & consistency/coverage	**~FEI** **~CSI** (0.86/0.55) (6)	**~FEI** **~RAI** (0.85/0.66) (10)	**~GI** **~CSI** **~RAI** (0.88/0.37) (2)		
Overall consistency/coverage	**(0.84/0.81)**				
Outcome - Sample	**TRAFFIC ROAD PRESENCE**	**TRAFFIC ROAD ABSENCE**		**TRAFFIC BEFORE CRISIS PRESENCE**	
Model used	INI FEI GI RAI FSI	INI FEI GI RAI FSI		INI FEI RAI RRI CSI	INI FEI RAI RRI
Solution path & consistency/coverage	+INI **+FEI** +GI +FSI (0.88/0.49) (3)	~INI **~FEI** **~RAI** (0.90/0.38) (2)	**~FEI** **~RAI** ~FSI (0.89/0.33) (1)	+INI **+RAI** **+CSI** (0.81/0.47) (2)	+INI **+FEI** **+RRI** (0.77/0.36) (3)
Overall consistency/coverage	**(0.88/0.49)**	**(0.90/0.47)**		**(0.81/0.47)**	**(0.77/0.36)**

Outcome - Sample	**TRAFFIC BEFORE CRISIS PRESENCE**	**TRAFFIC AFTER CRISIS PRESENCE**			**TRAFFIC AFTER CRISIS ABSENCE**
Model used	INI FEI RAI RRI FSI	INI FEI GI RAI FSI			INI FEI GI RAI FSI
Solution path & consistency/coverage	+INI **+FEI** **+RRI** +FSI (0.76/0.30) (2)	**~FSI** **(0.96/0.30)** **(2)**	~**GI** **~RAI** (0.96/0.29) (1)	+INI **+FEI** +GI +RAI (0.95/0.45) (3)	**~INI** ~FEI **+GI** **~RAI** **+FSI** (0.85/0.40) (1)
Overall consistency/coverage	**(0.76/0.30)**	**(0.96/0.58)**			(0.85/0.40)
Outcome - Sample	**TRAFFIC BEFORE CRISIS ABSENCE**				
Model used	INI FEI GI RAI FSI		INI FEI CSI RAI RRI		
Solution path & consistency/coverage	**~INI** ~FEI ~RAI (0.83/0.54) (4)	~FEI ~RAI **~FSI** (0.79/0.27) (1)	**~INI** ~FEI ~RAI (0.83/0.54) (4)	~FEI **~CSI** **~RRI** (0.84/0.44) (2)	**~CSI** ~RAI **~RRI** (0.85/0.40) (1)
Overall consistency/coverage	(0.82/0.60)		(0.83/0.69)		

Abbreviations' meaning: NI: Institutional Indicator, FEI: Financial Economic Indicator, CSI: Cost Saving Indicator, GI: Contractual Governance Indicator, RAI: Remuneration Attractiveness Indicator, RRI: Revenue Robustness Indicator, FSI: Financing Scheme Indicator

With respect to "**on & over traffic-full sample**", findings show that TI projects have a high likelihood to be on/over traffic, when they are located in a country with a favorable institutional context (+INI), have a good contract (+GI), have a good funding scheme, in terms of its remuneration attractiveness (+RAI), have a financing scheme with low cost of capital (+FSI), combined either with a robust business model with respect to reducing costs during the construction phase (+CSI) or with a favorable financial-economic context (+FEI).

With respect to "**below traffic-full sample"**, it is found that the majority of the TI projects that were below traffic are explained by being located in a country with a non-favorable institutional and financial-economic context (~INI and ~FEI), not having a high potential of saving costs during its construction phase (~CSI), not having a good funding scheme, in terms of its remuneration attractiveness (~RAI) but having a good contract (+GI), and revenue robustness (+RRI) and having a financing scheme with low cost of capital (mostly publicly financed) (+FSI).

With respect to "**on & over traffic-road sample"**, the majority of the road projects that were on/over traffic are explained by being located in a country with a favorable institutional and financial-economic context (+INI and +FSI), having a good contract (+GI) and a financing scheme with low cost of capital (mostly publicly financed) (+FSI).

With respect to **“below traffic-road sample”**, the majority of the road projects that were below traffic are explained by being located in a country with a non-favorable financial-economic context (~FEI) and by not having a good funding scheme in terms of its remuneration attractiveness (~RAI), combined either with a non-favorable institutional context (~INI) or a financing scheme with high cost of capital (~FSI).

With respect to **“on & over traffic-before crisis”**, the majority of the TI projects completed before crisis that were on/over traffic are explained by being located in a country with a favorable institutional (+INI) and financial-economic context (+FEI) and having revenue robustness (+RRI). These conditions together with a financing scheme with low cost of capital (+FSI) also explain the majority of the projects completed before crisis that were on/over traffic. Lastly, the majority of the projects are also explained by being located in a country with a favorable institutional context (+INI), with a good funding scheme in terms of remuneration attractiveness (+RAI) and also with having a high potential of saving costs during its construction phase (+CSI).

With respect to **“below traffic-before crisis”**, the majority of the projects completed before the crisis that were below traffic are explained by being located in a country with a non-favorable financial-economic context (~FEI) and by not having a good funding scheme in terms of its remuneration attractiveness (~RAI), either with a non-favorable institutional context (~INI) or with a financing scheme with high cost of capital (~FSI). A non-favorable financial-economic context (~FEI) and a not good funding scheme in terms of its remuneration attractiveness (~RAI) are not only relevant as a combination to explain the below traffic outcome of the projects completed before crisis but also they are relevant when each of them is combined with not having revenue robustness (~RRI) or with not having a high potential of saving costs during the construction phase (~CSI).

With respect to **“on & over traffic-after crisis”**, the majority of the TI projects completed after crisis that were on/over traffic are explained by either being located in a country with a favorable institutional and financial-economic context (+INI and +FEI), having a good contract (+GI) and a good funding scheme in terms of remuneration attractiveness (+RAI) or by having a not good contract (~GI) and not good funding scheme in terms of remuneration attractiveness (~RAI) or by having a financing scheme with high cost of capital (~FSI).

It is interesting to observe that having a good contract (+GI) and a good funding scheme in terms of the remuneration attractiveness (+RAI), combined with a favorable exogenous environment (i.e. +INI and +FEI) explain the on/over traffic outcome for the projects completed after crisis, but a non-good contract (~GI) and non-good funding scheme in terms of the remuneration attractiveness (~RAI) also explain the on/over traffic outcome for the projects completed after crisis. Thus, projects can be also on/over traffic when they do not have a good contract and funding scheme with respect to the remuneration attractiveness.

With respect to **“below traffic-after crisis”**, the majority of the projects completed after the crisis that were below traffic are explained by being located in a country with a non-favorable institutional and financial-economic context (~INI and ~FEI), not having a good funding scheme in terms of its remuneration attractiveness (~RAI), by having a good contract (+GI) and a financing scheme with low cost of capital (+FSI).

It is interesting to compare the findings between the presence and absence of outcome for the traffic outcome for the sample of TI projects completed after crisis. +INI, +FEI +RAI are ‘’critical’’ conditions for the projects completed after crisis to be on/over traffic (+GI is also a relevant condition in this solution path). Also their absence (i.e. ~INI, ~FEI ~RAI) explains the absence of the traffic outcome

(+GI, +FSI are also relevant conditions in this solution path, but still even with these present conditions, these TI projects are below traffic).

Overarching conclusions for the conditions contributing to the (non-) achievement of the traffic outcome

- For the traffic outcome, four present conditions (in combination with others being absent) were found to explain the absence of the outcome, being a good contract and financing scheme (with low cost of capital) for the after crisis sample, and for the full sample a good contract, financing scheme and a high revenue robustness. This means that even with these positive conditions, TI projects might still not achieve having the estimated traffic, if the rest of the conditions are absent.
- For the presence of the traffic outcome, revenue robustness is not a relevant condition for the full sample. The contract and the potential to save costs during the construction and operation phase were found to be irrelevant only in one sample (each of them) as well, i.e. in the before crisis and after crisis sample respectively. Also, the remuneration attractiveness was found to be irrelevant only for the road sample. For the absence of the traffic outcome, the contract was not a relevant condition for two samples, the road and before crisis sample. The institutional context and financing scheme were found not to be relevant conditions in one sample, i.e. the PPP sample.
- For the presence of the traffic outcome, the same solution path is found to explain two samples of projects, i.e. the full and PPP sample, being a good institutional context, contract, cost saving potential, remuneration attractiveness and financing scheme. This could be also due to the fact that 36 out of 43 projects of the full sample are PPP projects. For the absence of the traffic sample, the same path is found to explain two samples of projects, being the road and before crisis sample, i.e. non-good institutional context, financial-economic context and remuneration attractiveness. This could be also due to the fact that 11 out of 22 projects of the before crisis sample are road projects.
- The presence of the traffic outcome is explained by a good institutional context and a good financial-economic context for both the samples of projects completed before and after crisis. For the absence of the traffic outcome, a non-good institutional context and a non-good financial-economic context are relevant conditions for both samples before and after crisis.

6.6 Revenue analysis

Section 6.6 presents the results of the sufficiency analysis for the revenue outcome for all the five samples tested: full, PPP, road, before and after crisis sample. For the revenue outcome, the sufficiency analyses' results are shown in Table 6.5.

Table 6.5: Overview of revenue outcome results for all the samples of cases

Outcome - Sample	**REVENUE PPP PRESENCE**				
Model used	INI FEI GI CSI RAI RRI FSI				
Solution path & consistency/coverage	+INI +RRI	**~GI** +CSI	+CSI +RRI	+GI **~CSI**	**+INI** +GI

	(0.88/0.57) (18)	**+RRI** (0.90/0.26) (1)	**~FSI** (0.91/0.23) (3)	**+RRI** +FSI (0.88/0.33) (2)	**+CSI** +RAI +FSI (0.88/0.38) (6)
Overall consistency/coverage	(0.91/0.74)				
Outcome - Sample	**REVENUE FULL PRESENCE**		**REVENUE FULL ABSENCE**	**REVENUE PPP ABSENCE**	**REVENUE ROAD ABSENCE**
Model used	INI GI RRI		INI FEI GI CSI RAI RRI FSI	FEI GI CSI RRI FSI	FEI FSI RAI RRI GI
Solution path & consistency/coverage	**+INI** (0.97/0.73) (20)	**+GI** **+RRI** (0.97/0.56) (17)	**~INI** ~FEI **~GI** ~CSI +RAI **~RRI** +FSI (0.75/0.41) (1)	**+FEI** **+GI** ~CSI **~RRI** +FSI (0.76/0.41) (1)	~FEI +FSI +RAI **~RRI** **~GI** (0.81/0.52) (1)
Overall consistency/coverage	(0.97/0.80)		(0.75/0.41)	(0.76/0.41)	(0.81/0.52)
Outcome - Sample	**REVENUE ROAD PRESENCE**		**REVENUE BEFORE CRISIS PRESENCE**		
Model used	INI FEI GI RRI		FEI GI CSI RRI FSI		
Solution path & consistency/coverage	**~GI** **+RRI** (0.90/0.34) (2)	**+INI** **+RRI** (0.88/0.47) (8)	**+RRI** +FSI (0.88/0.60) (12)	**+GI** **+RRI** (0.90/0.62) (10)	+GI **+CSI** +FSI (0.89/0.54) (8)
Overall consistency/coverage	(0.89/0.56)		(0.89/0.82)		
Outcome - Sample	**REVENUE BEFORE CRISIS ABSENCE**	**REVENUE AFTER CRISIS PRESENCE**		**REVENUE AFTER CRISIS ABSENCE**	
Model used	FEI GI CSI RRI FSI	INI FEI GI RAI FSI		INI FEI GI RAI FSI	
Solution path & consistency/coverage	**~FEI** **+GI** **~CSI** **~RRI** +FSI (0.76/0.69) (2)	**~FEI** **~GI** (0.76/0.42) (5)	**+INI** **+GI** +FSI (0.80/0.65) (13)	**+INI** **+FEI** **~GI** **~RAI** **+FSI** (0.85/0.34) (1)	
Overall consistency/coverage	(0.76/0.69)	(0.78/0.79)		(0.85/0.34)	

Abbreviations' meaning: NI: Institutional Indicator, FEI: Financial Economic Indicator, CSI: Cost Saving Indicator, GI: Contractual Governance Indicator, RAI: Remuneration Attractiveness Indicator, RRI: Revenue Robustness Indicator, FSI: Financing Scheme Indicator

With respect to **"on & over revenues-full sample"**, the majority of the projects that were on/over revenues are explained either by being located in a country with a favorable institutional context (+INI) or by having a good contract (+GI) and revenue robustness (+RRI).

With respect to **"below revenues-full sample"**, the majority of the projects that were below revenues are explained by being located in a country with a non-favorable institutional and financial-economic context (~INI and ~FEI), not having a good contract (~GI), not having a high potential of saving costs during its construction and operation phase (~CSI), not having revenue robustness (~RRI), having a good funding scheme in terms of its remuneration attractiveness (+RAI) and a financing scheme with low cost of capital (+FSI).

With respect to "**on & over revenues - PPP sample**", the majority of the PPP projects that were on/over revenues are explained either by having revenue robustness (+RRI) combined with different conditions, present or absent, i.e. 1) either combined with being located in a country with a favorable institutional context (+INI), or 2) with having a high potential of saving costs during its construction and operation phase (+CSI) but not a good contract (~GI), 3) or with having a high potential of saving costs during its construction and operation phase (+CSI) but a financing scheme with high cost of capital (~FSI), 4) or with having a good contract (+GI) and financing scheme with low cost of capital (+FSI) but with low potential of saving costs during its construction and operation phase (~CSI).

Thus, when RRI is present, even if other conditions are absent, the PPP projects are still on/over revenues. When RRI is not a relevant condition, then all conditions need to be present for the PPP projects to be on/over revenues.

With respect to **"below revenues - PPP sample"**, the majority of the PPP projects that were below revenues are explained by being located in a country with a favorable financial-economic context (+FEI), having a good contract (+GI), a financing scheme with low cost of capital (+FSI) but not having revenue robustness (~RRI) and not having a high potential of saving costs during its construction and operation phase (~CSI).

The main two differences between the findings of the **''on & over revenues and below revenues - PPP sample''** are that 1) +FEI is a relevant condition to explain the absence of the outcome but it is not relevant to explain the presence of outcome and 2) RRI is absent explaining the absence of the outcome, whereas it is present explaining the presence of the outcome. The other three conditions, GI, CSI, FSI were both present and absent in the solution paths explaining the presence and the absence of the revenues outcome.

With respect to **"on & over revenues-road sample"**, the majority of the road projects that were on/over revenues are explained by having revenue robustness (+RRI), either combined with a favorable institutional context (+INI) or a non-good contract (~GI). Thus, when RRI is present, even if other conditions are absent, the road projects are still on/over revenues. The same conclusion is taken also for the PPP projects.

With respect to **"below revenues-road sample"**, the majority of the road projects that were below revenues are explained by not having revenue robustness (~RRI), not having a good contract (~GI), not having a favorable financial-economic context (~FEI) but having a good funding scheme with remuneration attractiveness (+RAI) and a financing scheme with low cost of capital (+FSI).

Thus, the key main difference between the presence and the absence of the revenues outcome also for the road sample is the RRI, like for the PPP sample, which is present explaining the presence of the revenues outcome and absent explaining the absence of the revenues outcome (in combination with other conditions). Another difference is that FEI, RAI and FSI are relevant conditions explaining the absence of the outcome but not for the presence of the outcome. Lastly, INI is found to be relevant explaining the presence but not the absence of the revenues outcome (in combination with another condition).

With respect to **"on & over revenue analysis-before crisis"**, the majority of the projects that were completed before crisis and were on/over revenues are explained by having revenue robustness (+RRI), either combined with a good contract (+GI) or with a financing scheme with low cost of capital (+FSI). When revenue robustness is not a relevant condition, the combination of having a good contract (+GI), a financing scheme with low cost of capital (+FSI) and a high potential of saving costs during its construction and operation phase (+CSI) explain the revenue outcome for the projects completed before crisis. The only condition that is not found relevant was the financial-economic context, which is an interesting finding, considering that the sample tested is the sample of projects that were completed before crisis.

With respect to **"below revenue analysis-before crisis"**, the majority of the projects that were completed before crisis and were below revenues are explained by having a low revenue robustness (~RRI), together with a non-favorable financial-economic context (~FEI), a low potential of saving costs during its construction and operation phase (~CSI) but a good contract (+GI) and financing scheme with lost cost of capital (+FSI).

Thus, the key difference between the presence and the absence of the revenues outcome for the sample of the projects completed before crisis is the RRI, which is present explaining the presence of the revenues outcome and absent explaining the absence of the revenues outcome (in combination with other conditions).

Another difference is that FEI is a relevant condition (its absence), explaining the absence of the outcome but it is not a relevant condition for the presence of the outcome. Therefore, although a favorable FEI is not a relevant condition for being on/over revenues, a non-favorable FEI is a relevant condition for the projects completed before crisis for being below revenues. Also, while the absence of the revenues outcome is explained by the absence of the CSI (in combination with other conditions), its presence explains the presence of the outcome (in combination with other conditions).

With respect to **"on & over revenue-after crisis"**, the majority of the projects that were completed after crisis and were on/over revenues are explained by either having a good contract (+GI), favorable institutional context (+INI) and financing scheme with low cost of capital (+FSI) or by having a non-favorable financial-economic context (~FEI) and not a good contract (~GI). The latter is an interesting finding considering that the projects that are completed after crisis can still be on/over revenues even with a non-favorable financial-economic context.

With respect to **"below revenue-after crisis"**, the majority of the projects that were completed after crisis and were below revenues are explained by having a favorable institutional and financial-economic context (+INI and +FEI), a financing scheme with low cost of capital (+FSI), not having a good contract (~GI) and not having a funding scheme with remuneration attractiveness (~RAI).

Two interesting observations are made: 1) +INI and +FEI explain the below revenues outcome and also 2) the RAI (i.e. its absence) is only relevant to explain the absence of the revenues outcome and not the presence. Thus, for projects completed after crisis, having a good exogenous environment (i.e.

+INI and +FEI) and a low cost of capital financing scheme is not sufficient for the projects to be on/over revenues due to having a non-good contract and funding scheme, with low remuneration attractiveness.

Overarching conclusions for the conditions contributing to the (non-) achievement of the revenues outcome

- For the revenues outcome, the absence of the revenues outcome was explained by the presence of the following conditions: good institutional context, financial-economic context, contract, remuneration attractiveness and financing scheme with low cost of capital throughout the five samples. Thus, even if these conditions are positive, when combined with specific negative conditions, the projects might still not achieve their revenue goal. The only two conditions that were not found to be present explaining the absence of the revenues outcome are two, which is the revenue robustness and the cost saving potential.
- The revenue robustness is a relevant condition for all the samples of projects except for the projects completed after crisis. For all the rest of the samples, a high revenue robustness is a success factor for projects to achieve their revenue goal (when combined with other conditions too) and low revenue robustness is a failure factor (when combined with other conditions too). For the presence of the revenues outcome, financial-economic context is not a relevant condition for the PPP, road and before crisis samples. Remuneration attractiveness is not a relevant condition for the after crisis sample. For the absence of the revenues outcome, all conditions were relevant.
- For the presence of the revenues outcome, the same solution path, i.e. good institutional context and revenue robustness, is found to explain two samples of projects, i.e. the PPP and road sample. There is an additional solution path that is the same for the presence of the revenues outcome for the full and before crisis sample, i.e. good contract and revenue robustness for the full and before crisis sample. For the absence of the revenues outcome, there is no same path among the samples. The common condition between these two paths is the success factor ''revenue robustness'' that is prominent in the achievement of the revenue outcome.
- With respect to the importance of the exogenous environment for the achievement of the revenues outcome for the projects completed before crisis, it is observed that for the presence of the revenues outcome neither a good financial-economic context or an institutional context are relevant conditions. It needs to be noted that the institutional context was not included as a condition in the model developed to examine how the presence and absence of the revenues outcome are explained for the TI projects completed before crisis. The reason why is that the institutional context condition has been found to have the lowest necessity consistency score in the necessity analysis and thus it was excluded from the model (also together with the remuneration attractiveness condition) because up to five conditions could be used for the sufficiency analysis. For the absence of the revenues outcome of the TI projects completed before crisis, a non-good financial-economic context is a relevant condition (combined with other conditions). For the after crisis sample, both conditions are included in the model. The presence of the outcome is either explained by a good institutional economic context or a non-good financial-economic context, when combined with other conditions. The absence of the revenues outcome is explained by both a good institutional and financial-economic context for the projects completed after crisis (in combination with other conditions). Thus, even with a positive exogenous environment, TI projects completed after crisis might still have actual revenues that are less than the forecast revenues (when

combined with specific negative conditions, such as a non-good contract and less attractive remuneration scheme).

6.7 Conclusions

This chapter presents the findings of the empirical analysis conducted to identify the combinations of conditions that explain the success and non-success as defined in the present doctoral thesis of different types of TI projects, i.e. roads, airports, seaports, rail, tram, metro, bridges/tunnels, public transport depot and bicycle sharing network. The method that has been used is the fuzzy set qualitative comparative analysis (fsQCA). The analysis is made for the four outcomes, cost, time, traffic and revenues, identified in literature, and for five different samples of projects/cases, i.e. a full sample, which includes all the types of TI projects, a PPP sample, which includes only the projects that were privately co-financed, a road sample, which includes only road projects and two samples that have as a reference point the initiation of the global financial crisis of 2008. Thus, the last two samples tested are the projects that have been completed before the financial crisis and the ones that have been completed after, respectively.

The analysis has been conducted testing the presence and the absence of the four outcomes, i.e. the achievement and non-achievement of the four key project objectives, the cost objective, the time objective, the traffic objective and the revenues objective. This is how success is defined in the present doctoral thesis, i.e. as the achievement of the four key project objectives. Thus, if a project achieves all or some of these objectives, it is considered successful or partially successful.

The above findings are results of an ex post analysis, via which the experiences of existing TI projects are collected. Via this ex post analysis, lessons learned are taken based on how already developed TI projects achieved (or they did not achieve) their cost, time, traffic and revenues goals, i.e. delivering a project with actual costs that are equal or less than estimated (or more than estimated), with delivery time equal or less than estimated (or more than estimated), and with traffic and revenues equal or more than what was forecast (or less than forecast). These lessons can be and are being used for the successful future planning and operation of new TI projects.

These lessons learned from the fs QCA results together with the calibration method (see Annex A.6.71 and A.6.72) are the key inputs for the application of the POAC tool developed in the present doctoral thesis (for further details about the application of the POAC see Chapter 7). The key main findings of the fs QCA analysis are presented in the conclusions below per outcome and per sample.

Overall conclusion

The results of the fs QCA show that the presence and absence of the outcomes are explained via different combinations of conditions, both present and absent ones for all the outcomes, cost, time, traffic and revenues. Thus sometimes, even with a positive condition(s) combined with negative ones, a TI project might not be able to achieve its objectives and vice versa, i.e. a negative condition(s) combined with positive ones can still explain the achievement of the objectives. For example, so as a TI project to be delivered on or below the cost estimated, remuneration attractiveness is not of much importance because the projects even with low remuneration attractiveness are finally on cost, thanks to the rest of the positive conditions combined. This is an interesting finding that partially confirms literature, according to which it is positive factors that affect the success of TI projects and negative ones the failure of TI projects. In the next sections, the main findings for the different samples and outcomes are presented.

Conclusions per outcome

COST

After examining all the solutions for the cost outcome, for all the samples, it can be concluded that based on the TI projects tested, the cost outcome can be achieved under the following common main conditions: **being located in a country with a favorable institutional context, having good contractual arrangements and being mostly publicly financed**. Therefore, the institutional maturity of the country where the project is procured (i.e. favorable institutional context, having good contractual arrangements) is important for a project to achieve its cost outcome. In addition to these conditions, having a project that is heavily financially supported by the public sector is also a key condition for the cost outcome achievement because the cost of financing for the TI is low.

If these present conditions are combined, they can **compensate for a non-favorable financial-economic context**[24], which could otherwise (without the combinations of these conditions) influence the achievement of cost outcome during the construction phase.

If these conditions are present and also combined with a **positive financial-economic context**, they can compensate for a low capability of the actors involved in the infrastructure delivery and a high project technical difficulty.

If these conditions are also combined with a **high capability of the contractors involved** can trade off having a remuneration scheme with low level of cost coverage. Thus, although projects can be completed on the budgeted cost, the remuneration schemes can be still insufficient to pay back the incurred costs. Having low level of cost coverage could be linked with the delayed completion of an infrastructure project, which could thus lead to delayed starting of operation of the infrastructure and as a result it could also impact the achievement of traffic and revenues outcome as well.

The only time that the key combination of conditions **''being located in a country with a favorable institutional context, having good contractual arrangements and being mostly publicly financed''** did not explain the achievement of the cost outcome was for the sample ''completion after crisis''. In this sample' analysis, the cost outcome was explained by the combination of **''being located in a country with a favorable institutional context, with a favorable financial-economic context and being mostly publicly financed''**. Therefore, for the projects that have been completed after the crisis, having a strong contract is not a relevant condition for the achievement of the cost outcome but having a favorable financial-economic context is. Thus, an overall positive implementation context (i.e. institutional and financial-economic context) explains the achievement of the cost outcome for the completion after crisis sample. The same solution path has been also found to explain the cost achievement for the PPP sample as well.

TIME

After examining all the solutions for the time outcome, for all the samples, it can be concluded that based on the TI projects tested, the time outcome can be achieved under the following common main conditions: a **favorable institutional context and good contractual arrangements.** These two conditions are prerequisites for the achievement of the time outcome for all the samples tested. This shows the importance of having a high level of project implementation stability, with political stability, control of corruptions, regulations and accountability. Having good contractual arrangements reflects

[24] Cost presence: before crisis sample.

also the institutional maturity of the country where the project is located, thus enforcing even more the good institutional context.

These two conditions that are prerequisites are combined with various other (combinations of) conditions explaining the achievement of the time outcome. Firstly, they are combined with a favorable financial-economic context (or/and with projects being mostly privately financed for the road sample) (or/and with revenue streams with low level of riskiness and high cost coverage level estimated for the before crisis sample). Thus, an overall good implementation context with mature institutional context and positive macro-economic conditions, country competitiveness and productivity is significant for the projects to be completed on/below time, even in the case that the projects are heavily financed by the private sector and thus with a higher cost of financing. This higher cost of financing of the infrastructure project makes it even more important for the infrastructure projects to be completed on time, so as operation to begin on time and thus the collection of the income sources to start to recover the project costs. It is common that when private sector is included in the financing of the project, in the form of a PPP project delivery, the projects are more prone to be delivered on time, since the private partner closely monitors the implementation of the project because it is of its interest the project to be completed on time, so as operation to start and revenue streams to be injected in the project. Also, having revenue streams of low risk explains the achievement of the time outcome. Although high risk revenue streams would be expected to have an impact on the achievement of the time outcome, it is observed that projects with low risk revenue streams explain the achievement of the time outcome.

The two conditions that are prerequisites are also combined with low cost of financing for the TI projects. Therefore, also the projects that are mostly publicly financed are found to be delivered on/below time, when the institutional context is mature and the contractual arrangements are strong.

The two key conditions are also combined with the following conditions: contractors of high capability, projects with low cost of financing and remuneration income streams of high risk and low cost coverage estimated (and a positive financial-economic context). It can be observed that remuneration schemes of high risk and low cost coverage estimated enforce the achievement of the time outcome because in the case of a delay this will deteriorate the collection of income streams and recovery of the project costs due to belayed operational phase.

The only time that having a **favorable institutional context and good contractual arrangements** were not prerequisites were for some of the solution paths of the before crisis sample. In these solution paths, the main prerequisite is the good contractual arrangements for the time outcome achievement. In addition to that, low cost of financing or/and revenue streams with low level of riskiness and high cost coverage level estimated also explain the achievement of the time outcome.

TRAFFIC

The prerequisite condition for the achievement of the traffic outcome is **institutional maturity of the country where the project is procured**. Regulations are key characteristics of the institutional context and can affect demand for transport, such as congestion pricing (see also Chapter 2). Having a financial-economic context that is flourishing is also a key condition for all the samples' results. However, it was not sufficient for every single solution path of all samples, like the institutional maturity condition. A positive financial-economic context can influence positively demand in transport. Having a remuneration scheme with low level of riskiness and high cost coverage has been also found to explain the achievement of the traffic outcome (for all samples except for the road sample). Having a high value of the remuneration attractiveness indicators shows that there is significant public support and hence less expensive fares.

Having good contractual arrangements was found also to be a sufficient condition for the achievement of the traffic outcome (for all samples except for the before crisis sample). Having good contractual arrangements has been found to be a pre-requisite for the achievement of the time outcome, thus also having a positive impact on the achievement of the traffic outcome. A financing scheme of low cost financing, mostly coming from the public sector is also a sufficient condition for the achievement of the traffic outcome (for all the samples except the after crisis sample). Having operators of high capability to operate the infrastructure and also with an appropriate allocation of the operational risk, according to the capabilities, has been found to explain the achievement of the traffic outcome for all samples except the road and after crisis sample. Last but not least, having revenue streams with low level of riskiness and high cost coverage level explains the achievement of the traffic outcome objective only for the PPP and before crisis samples. This condition has the same effect with the remuneration attractiveness on achieving the traffic outcome.

REVENUES

For the revenues outcome, the prerequisite condition is having **revenue streams with low level of riskiness and high cost coverage level** for the achievement of the revenues outcome. This was an expected finding. When having high revenue streams with low income risk, this can contribute to achieving the revenues outcome. However, it should be noted that prerequisite in this outcome is considered the condition that appears in the majority of the solution paths, because none of the conditions was found to be sufficient for every single solution path (its presence is sufficient for 8/14 solution paths in all samples except the after crisis sample).

The second most relevant condition for achieving the revenues outcome is the contractual arrangements, either good or not. Good contractual arrangements could be the inclusion of clauses in the contract indicating that guarantees of performance were agreed upon (giving an extra guarantee that revenues target will be achieved) or inclusion of clauses such as the obligation of the contractors to pay a penalty if completion dates are not met (because if TI project is delivered with delay, this will delay the beginning of the operational phase and thus the revenues' collection). However, having non good contractual arrangements can be compensated for by having high revenue streams with low risk or/and by also having capable operators.

The third most relevant condition for achieving the revenues outcome is having a financing of low cost. Having a low cost of financing in the infrastructure means that less remuneration streams need to be collected to recover the project costs, thus indirectly influencing positively the revenues. However, it has been found in one solution path of the PPP sample, that even with a high cost of financing, the revenues target can be still achieved, if there are good contractual arrangements and high revenue streams with operators of high capability.

The fourth most relevant condition is having a mature institutional context. The pricing regulations could similarly play a role into the achievement of revenues as with the achievement of traffic. Pricing regulations could affect demand for transport and as a result also the revenues.

The fifth most relevant condition is having capable operators for the achievement of the revenues target. Having non capable operators and a non-appropriate allocation of the operational risk can be compensated for by having good contractual arrangements and high revenue streams with low risk.

The sixth and seventh most relevant conditions for the achievement of the revenues outcome are having a remuneration scheme of high cost coverage and low risk and deteriorating financial-economic context, which both of them appeared in only one solution path out of the 14 paths in total. Having a remuneration scheme of high cost coverage and low risk means that TI project costs are covered to a high percentage and thus this allows all the additional income streams to be injected in the project as revenues. The deteriorating financial-economic context condition has been found for the after crisis sample. This condition was combined with non-good contractual arrangements and still explained the achievement of the revenues outcome in the after crisis sample.

Conclusions per sample

FULL SAMPLE

The success factors for the TI projects of all types (full sample) are the same for the projects that were delivered on/below cost and on/below time. Similar success factors were found also for the projects that were delivered with an actual traffic equal or more than the estimated traffic. The only difference is that for the traffic outcome achievement, remuneration attractiveness is a present condition (i.e. positive factor), while for the cost and time outcomes, remuneration attractiveness is an absent condition (i.e. negative factor). This is an interesting finding, considering that in literature, a key factor that affects the traffic demand for a TI project is the pricing policy used, via which the investment costs incurred for the infrastructure are recovered. A present remuneration attractiveness condition means that the % of the costs recovered through the remuneration schemes is high and/or that the risk of the income source is not high. For example, some types of income sources have higher risk, such as user charges because they depend on the demand for the TI, while some others are less risky, such as the availability fees.

Thus, if TI project planners and decision makers “ensure” that the institutional context in which the TI project is located is good and in favor of the TI project, if the contract is good and flexible, if the potential to reduce costs is high thanks to mostly having skilled personnel involved (planners, managers, constructors, operators) and if the project is financed mostly through public sources, which have lower cost of capital, then there is a high likelihood that the TI project will be delivered within the cost that was estimated or even with cost underruns. If additionally to these success factors, a good funding scheme is also used for the project, good in terms of having a high % of remuneration of the incurred investment costs and/or in terms of a low risk of the income source, then there is a high likelihood that the project will be also delivered within the estimated traffic or with higher than the estimated traffic.

With respect to the revenues project goal, its achievement differs than the achievement of the three other outcomes, of the cost, time and traffic, discussed above. A first key difference is that revenue robustness is found to be a success factor only for the achievement of the revenues outcome, when combined with a good contract. A contract is considered good with respect to the achievement of the revenues outcome, if it includes certain clauses that could affect the achievement or not of the revenues target. For example, if there are clauses in the contract indicating that guarantees of performance are/were agreed upon, which gives an extra guarantee that revenues target will be achieved. Or if the key service providers (contractors) are obliged to pay a penalty, if completion dates are not met, which is important because if a TI project is delivered with delay, this will delay the beginning of the operational phase and thus the revenues.

Thus, if TI project planners and decision makers “ensure” that there is a good contract and that the potential cost coverage is high, via the various revenue sources (with their assessed risks), then there is a high likelihood that the project will achieve to have actual revenues that are equal or more than the estimated ones. Also, having a favorable institutional context of a country by itself could be sufficient for a project to achieve its revenues goal, mainly due to the national regulatory context. Regulations affect traffic demand for the TIs and as a result the revenues as well.

For the absence of all the four outcomes, for the full sample, not so prominent similarities are found among the combinations of failure factors. For the projects that were delivered with cost overruns, the main failure factors are: having a low potential to reduce costs during the construction phase due to mostly having less skilled personnel involved (planners, managers, constructor), a financing scheme with high cost of capital (and sometimes also a remuneration scheme that covers a small % of the incurred costs).

For the projects that were delivered with time overruns, the only common negative failure factor with the failure factors causing cost overruns is the low potential to reduce costs due to mostly having less skilled personnel involved (planners, managers, constructor). The rest of the failure factors causing time overruns are different than the ones of the cost overruns. More specifically, 1) a regulatory context that is not in favor of the project, 2) a macro-economic environment that is not flourishing, which could cause project delays due to insufficient funding sources to cover the costs of the project (for example due to increased cost of the materials, or the fluctuated prices) and 3) a non-efficient contract, which could cause delays, in the cases of example poor contract management, lengthy bidding and negotiation process, or in the case of not including a contract clause that says that the key service providers (contractors) are obliged to pay a penalty, if completion dates are not met.

In the contrary, these three failure factors for time overruns appear to be positive for the cost overruns. Thus, even if the contract is efficient and the regulatory framework is in favor of the TI project or the macro-economic environment is good, still these factors cannot prevent the TI projects from being delivered with cost overruns.

Some of the failure factors for projects to be delivered with actual traffic that is less than the estimated one are the same with the failure factors for projects to be delivered with actual revenues that are less than the estimated. These common failure factors are the unfavorable national regulatory framework, the macro-economic environment and the low capability of the contracting authority to operate the TI.

However, the main difference is that while for the projects to be delivered below the estimated traffic, a remuneration scheme that covers a low percentage of the incurred costs explains the negative traffic outcome, for the negative revenues outcome 1) it is the revenues scheme that has low revenue streams and/or high income risk and 2) a non-efficient contract, without guarantees of performance or pre-set penalties in case the completion dates are not met. While for the negative traffic outcome these two conditions are positive (i.e. present). The remuneration scheme is a positive condition that explains the negative revenues outcome, which means that the remuneration scheme covers a high percentage of the incurred costs, and thus this allows all the additional income streams to be injected in the project as revenues. However, still this does not have a positive impact on the revenues outcome that is finally negative.

PPP SAMPLE

When examining the results of the PPP projects for the achievement of all the outcomes, it is observed that the combinations of the conditions differ among the different outcomes. So, a common "recipe" of success cannot be retrieved for all outcomes but for two of them.

Specifically, a common combination of conditions is found for the achievement of the PPP projects to achieve both their traffic and revenue goals, being having a regulatory context in favor of the PPP TI projects, having an efficient contract with clauses that guarantee the performance and impose penalties in the case of a delay of the project completion, with an experienced contracting authority to operate the TI, with a remuneration scheme that covers the biggest percentage of the costs incurred and with a low cost capital financing scheme.

It should be also noted that there are other combinations of conditions that explain the achievement of the revenues outcome and the common success factor among all of them is the high revenues streams. With high revenue streams, no matter the other negative factors, such as a non-efficient contract, non-skilled infrastructure operators or a high cost of capital, still the projects are delivered on the revenues estimated or with more than the revenues estimated.

The same combination of conditions, when excluding the good remuneration scheme, explains the PPP projects that were delivered on/below cost. Thus, for PPP TI projects, a good regulatory framework, contract, skilled contractors and a low cost of capital financing scheme explain the achievement of the cost goal.

If in this combination of conditions a good macro-economic environment is also a condition, the PPP projects can be delivered on/below time. The remuneration scheme is a negative condition in this solution.

When examining the results of the PPP projects for the non-achievement of all the outcomes, it is observed that the combinations of the conditions differ among the different outcomes. So a common "recipe" of failure cannot be retrieved for all outcomes.

Although a same combination of conditions that explain all outcomes is not found, similarities are found among some of the outcomes. Firstly, the PPP projects that are delivered with cost overruns and delays are explained by three common failure factors: a non-efficient contract, low cost coverage remuneration scheme and high cost capital financing scheme. If a non-favorable regulatory and macro-economic context is also added to this combination, then the PPP projects that were delivered with a delay are fully explained.

Also some of the failure factors that explain the non-achievement of the traffic outcome are common with the ones explaining the non-achievement of the time outcome. The only difference is the non-efficient contract that is a relevant failure factor for the traffic outcome but not for the time.

Lastly, the combination of factors that explain the PPP projects that were having less revenues than estimated is the most differentiated one compared to the other outcomes. The only common failure factor compared to the other outcomes is the inexperienced operators of the TI PPP project. All the rest of the factors are different. Specifically, the failure factor of low revenue streams is found only to explain the revenues outcome. Also, the rest of the factors that explain the non-achievement of the revenues outcome are positive, being a good contract, macro-economic environment and low cost capital financing scheme.

ROAD SAMPLE

When examining the results of the road projects for the achievement of all the outcomes, it is observed that the combinations of the conditions differ among the different outcomes. So a common "recipe" of success cannot be retrieved for all outcomes for this sample of projects either.

The similarities found among some of the outcomes are the following. Firstly, for both the achievement of the cost and traffic outcome of the road projects, there are four common success factors, being a good regulatory context, macro-economic environment, contract and low cost capital financing scheme. The only difference between the two is that the achievement of the cost outcome is also explained by having a low cost reduction potential due to less skilled personnel involved (planners, managers, constructor) but even with this negative condition, road projects are still delivered on cost.

The road projects that are delivered on/below time are also explained by the same common factors that explain the achievement of both the cost and traffic outcome, mentioned above. The only difference is that while for the cost and traffic outcome, a low cost of capital financing scheme explains their presence, for the time outcome, a high cost of capital financing scheme explains its achievement.

The achievement of the revenues outcome also for the road projects is the most differentiated one, compared to the other outcomes. Also, for the road projects, the main success factor for the achievement of the revenues outcome is the high revenue streams.

For the absence of the outcomes for the road projects, not many similarities among the outcomes can be found. An observation that can be made for the cost outcome is that a high cost of capital financing scheme and a low cost coverage remuneration scheme explain the non-achievement of cost outcome, among other solution paths. These failure factors also explain the non-achievement of the traffic outcome together with an additional failure factor, being a non-good macro-economic environment, which is known to influence the travel patterns of the individuals and thus the traffic demand for an infrastructure.

It is interesting to observe that the same two factors explain also the non-achievement of the revenues outcome, but this time not as negative conditions but as positive conditions that in combination with key failure factors can explain the non-achievement of the revenues outcome, being a non-good macro-economic environment, a non-efficient contract and a revenue scheme with low revenue streams.

The combination of failure factors that explain the road projects that are delayed are quite different than the combinations of factors for the rest of the outcomes.

BEFORE CRISIS SAMPLE

The presence of the outcomes, for the before crisis sample, are explained by different success factors. The achievement of the cost and time outcome for the TI projects that are completed before crisis have three success factors in common, a good regulatory context, good contract and low cost of capital financing scheme. The only difference is that for the achievement of the cost outcome, there is also a non-good macro-economic environment, which finally does not negatively affect the cost of the projects completed before crisis.

The achievement of the traffic outcome shows also similar success factors with the achievement of the time outcome, specifically having a good regulatory context, macro-economic environment and revenue scheme with high revenue streams explain the achievement of the traffic outcome. The only difference is that for the achievement of the time outcome, an additional success factor explains the outcome, which is an efficient contract.

The revenue outcome shows also for this sample of projects that high revenue streams is the main success factor for the achievement of the revenue outcome. Similar success factors for the achievement of the revenues are found also for the time outcome achievement, mostly the high revenue streams, efficient contract and low cost of capital financing scheme.

For the absence of the outcomes, for the projects completed before crisis, not many similarities are found. Some common failure factors are observed for the non-achievement of the traffic outcome with the cost outcome, being a remuneration scheme with low cost coverage and an expensive financing scheme. The difference is that for the non-achievement of the traffic outcome, a non-good macro-economic environment is also a relevant condition.

Also very similar conditions explain the non-achievement of the traffic and revenues goal. The specific failure factors are a non-good macro-economic environment, less skilled operators and low revenue streams. The only difference between the two solutions is that for the non-achievement of the revenues outcome, two positive conditions are also present, being a good contract and low cost of capital financing scheme. Nevertheless, even with these positive conditions, the revenues outcome is still not achieved.

Similarities of the failure factors for the non-achievement of the traffic outcome are also found with the failure factors of the time outcome. These common failure factors are the less skilled personnel, the low cost coverage remuneration scheme and low revenue streams. The difference is that for the non-achievement of the time outcome, a non-good contract and a low cost of capital financing scheme also explain the outcome in combination with the common failure factors.

AFTER CRISIS SAMPLE

For the presence of the outcomes, for the after crisis sample, not many similarities are found among the combinations of conditions, so as to extract conclusions. Both the achievement of the traffic and the cost outcome have two common success factors, being a regulatory context and macro-economic environment that are in favor of the TI projects completed after the crisis. Thus, the importance of the exogenous environment for the projects that are completed after the global financial crisis is evident for the projects being delivered on the cost and traffic estimated.

However, the difference is that a financing scheme with low cost of capital explains the achievement of the cost outcome, while a good contract and high cost coverage remuneration scheme explains the achievement of the traffic outcome, in combination with the two common success factors above.

The results for the achievement of the revenues outcome show that it is not the combination of both a good regulatory context and financial-economic context that affect the achievement of the revenues outcome. Even with a non-good macro-economic environment and a non-good contract, the projects can still be delivered on/over revenues. Instead, a good regulatory context, a low cost of capital financing scheme and a good contract explain the achievement of the revenues outcome.

For the absence of the outcomes, for the projects completed after crisis, the following similarities are found. Firstly, the combination of conditions that explain the non-achievement of the cost outcome and of the time outcome is similar. The common failure factors are a non-good regulatory framework and a non-good macro-economic environment. Also in both cases, there is a low cost capital financing scheme but still the projects have a negative outcome, i.e. cost and time. The only difference between the two is that the projects that were delivered with cost overruns are explained also by a remuneration scheme with low cost coverage. Having cost overruns means that the remuneration scheme needs to recover a higher percentage of project costs. Therefore, the remuneration scheme may end up to finally have a low(er) cost coverage, like in this case.

It is also interesting to observe that the combination of failure factors explaining the non-achievement of the traffic outcome is similar with the ones explaining the non-achievement of the cost outcome (and similar to the time outcome based on the similarities mentioned above). The only difference is that for the traffic outcome, a good contract was also found to be a condition that explains the non-achievement of the traffic outcome. But still this positive condition could not reverse the negative traffic outcome.

The combination explaining the non-achievement of the revenues outcome is quite different than the combinations explaining the other outcomes, as it was also observed in the other samples of projects. A main difference is that while the absence of the other three outcomes is explained by a non-favorable regulatory and financial-economic context, the non-achievement of the revenues outcome is explained by a favorable regulatory and financial-economic context.

7. Demonstration of the application of the ‘’Project objectives’ achievement compass’’ (POAC)

Chapter 7 demonstrates how to apply the developed POAC tool at the operation phase of a project, via an example. However, POAC can be also applied at the feasibility phase already, assuming the values to be used in the indicators and creating different scenarios, considering that the indicators that POAC uses are available after contract award.

For demonstration purposes, the Brabo 1 project is used. Brabo 1 is a tram project, in Flanders, Belgium. Also an exercise of validation of the POAC model’s results is made for seven TI project cases of the dataset of the 51 TI projects, including Brabo 1, due to non-availability of other ‘’external’’ cases to do the comparison and thus validation, which is the main limitation of the thesis. The seven cases selected from the 51 cases to do the validation exercise are the least relevant ones in the fsQCA results. In this exercise of validation, the results of the POAC are compared with the results acquired from the real system, to see if there is a match that will validate the POAC tool. These seven cases have been kept and not excluded from the sample of 51 cases in chapter 6. Excluding these seven cases from the analysis would have no impact on the fsQCA results because these cases have been found in chapter 6 to be the least relevant, i.e. not to reflect the combinations of conditions. What could have been done instead is to exclude randomly e.g. seven cases before the fsQCA is conducted in chapter 6 and thus run the fsQCA with 44 cases instead of 51 and keep the seven randomly selected cases aside for the validation to take place after the fsQCA. However, this would mean that our sample of cases would be smaller, which on the one hand would limit the number of cases from which lessons could be learned and on the other hand it could also exacerbate the phenomenon of limited diversity. Limited diversity is shown through the empty rows in the truth table, called "logical remainders" (i.e. possible combinations of conditions for which there is no empirically observed case). This is the reason why all the 51 cases available have been kept and used for the fsQCA in chapter 6.

The POAC tool, as also mentioned in chapter 1, can be used ex ante at the planning and evaluation phase of the project and ex post during the construction and operational phase. In the ex ante application, POAC is used after the main appraisal methods, i.e. CBA, or/and MCA or/and CEA to provide more informed knowledge to the decision maker at the stage of examining the approval or not of the project, by showing if there is likelihood that all four key project objectives will be achieved. If POAC shows that that there is likelihood one or more objectives not to be achieved, at the same time it shows which conditions are the ones that cause the non-achievement of the project objectives. Thus, it shows which conditions need to change (if possible) in order project objectives to be achieved, which increases the likelihood that the project alternative will achieve its project objectives. In the ex post application, POAC is used to monitor & control performance in terms of achieving projects objectives, since projects are dynamic and they are continuously changing, thus regularly examining their conditions throughout their lifecycle is important, so as to see if there are any changed conditions that finally lead to the non-achievement of the objectives.

In order to show to the potential users how to use the POAC instrument, via the case study of Brabo 1, the award phase (i.e. the indicators’ values for the award phase) and the operating phase are examined (i.e. the indicators’ values for the operational phase). The chapter is structured in three sections. Section 7.1 provides a narrative of the case study Brabo 1 (i.e. project delivery). Section 7.2 shows how the proposed POAC is applied, using as demonstration example the Brabo 1 case. This section additionally compares the actual results of the Brabo 1 project’s outcomes with the resulted outcomes that the POAC showed, aiming to conduct a validation exercise. Section 7.3 continues the validation exercise of the POAC instrument for six additional TI project cases of the used dataset and section 7.4 gives the conclusions.

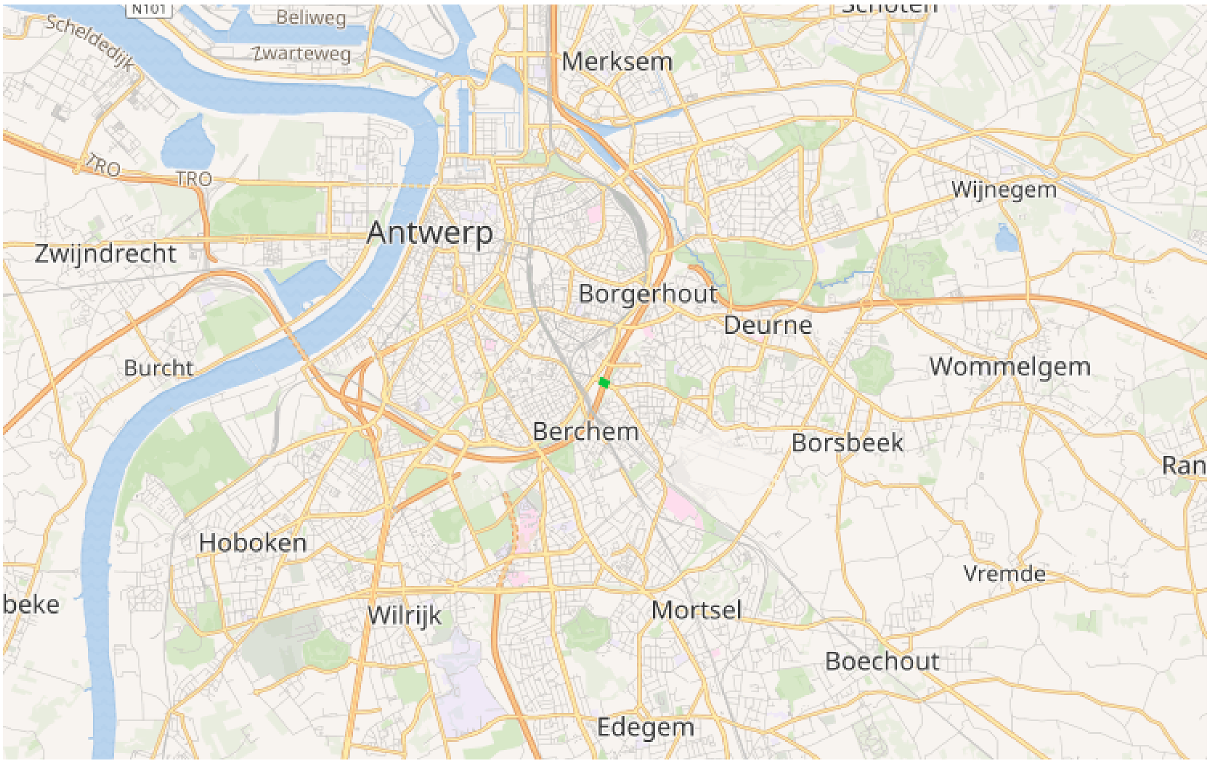
7.1 Project delivery of the case study Brabo 1

This section presents the narrative of the Brabo 1. The narrative shows how the project has been delivered and specifically its overall context, contractual governance, business model efficiency, funding & financing and outcomes.

7.1.1 Context

Brabo 1 was the first PPP for public transport in Flanders, Belgium. The investment size of this project equals 125.8 M EUR (2009). The project involves the design, financing, construction and maintenance of the civil, mechanical and electrical infrastructure associated with two separate tramway extensions in the eastern part of the city of Antwerp: (i) The Antwerp-Deurne section was extended to Wijnegem, (ii) The Antwerp-Mortsel section was extended to Boechout (Figure 5).

Figure 5: Antwerp tram network map



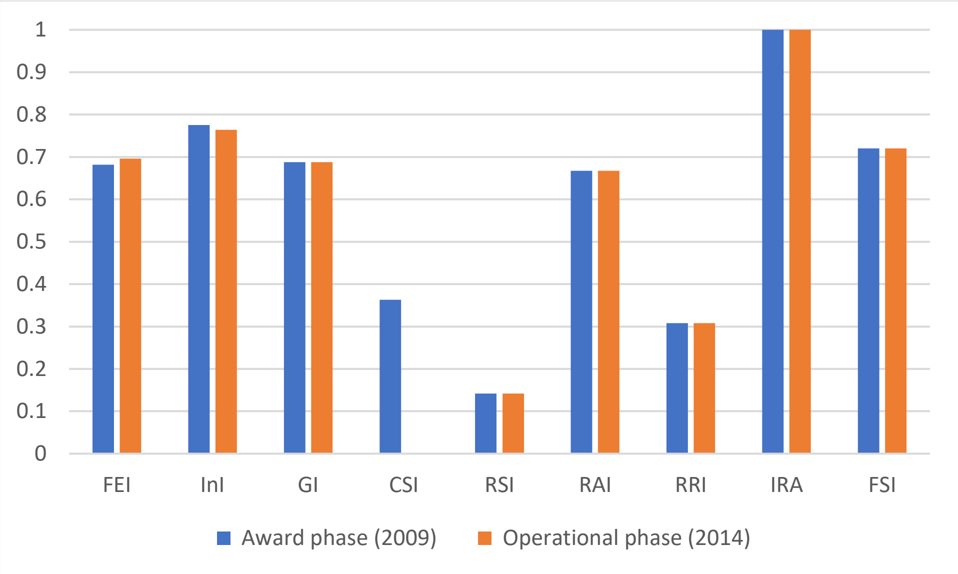
(source: https://www.wikiwand.com/en/Trams_in_Antwerp)

Additionally, the Brabo 1 project also includes an upgrade of the public space in general. Particularly, the project provides for a comprehensive renewal of all associated street infrastructure (including pavements and street furniture) for motor traffic, cyclists and pedestrians. A substantial tram stabling and maintenance depot, located on one of the lines (with office accommodation), is also included. Both trajectories are extended in favor of inhabitants of the Antwerp suburbs. People living in this first “circle” of municipalities around Antwerp are seeking rapid, punctual tramway connections, since heavy traffic congestion affects their day-to-day commuting to and from the city (Beheersmaatschappij Antwerpen Mobiel, 2013).

The idea of constructing the two tramway extensions in the eastern part of Antwerp city dates back to the year 2000. Although the Brabo 1 project has served the local interest, it was driven from the Flemish Government level. The Region announced the urgent need for improvements in the Master Plan 2020, which was launched in 2000. Tendering took place in 2007 and the project was awarded in 2009. The contract was approved in August 2009 and the construction works started on October 2009. The first section, Deurne-Wijnegem, was put in service in February 2012, while the second, Mortsel-Boechout, in August 2012.

Figure 6 illustrates the project's indicators' values at two project phases, at award (2009) and operation (2014) (indicators: FEI, INI, GI, CSI, RSI, RAI, RRI, IRA, FSI).

Figure 6: Brabo 1 Project Timeline



7.1.2 Contractual Governance

An open call for the expression of interest was announced in July 2007. Three (3) consortia were selected for negotiations for the DBFM tender, and, in April 2009, submitted their final offers: DANK, THV Silvius and Travant. Subsequently, THV Silvius was chosen as the contractor for the Brabo 1 Project. The procurement process was concluded within 26 months. The contract duration is 35 years.

The global financial-economic crisis between 2008 and 2012 delayed the procurement process; as bidders had failed to find the necessary external financing for their offers, contractual close and financial close were postponed. A new round for offers had to be arranged by the contracting authorities. The delay ultimately proved to be approximately six months, as the tendering procedure was halted between November 2008 and spring 2009. Further delays were caused by a lawsuit that was filed by one of the bidders (TRAVANT), claiming to be unfairly excluded from the tendering procedure.

The contractual regime was based on a fairly standard form of the DBFM agreement, based on English PFI standards and the Dutch standard DBFM contract of the Dutch Directorate-General for Public Works and Water Management (for an updated version of this contract, see Rijkswaterstaat, 2012). The contract for the Brabo 1 project was signed by the existing transport operator De Lijn nv, the Flemish Agency for Roads and Traffic AWV and the Special Purpose Vehicle (SPV), Project Brabo 1 nv. In this contract, a distinction was made between tramway availability fees and non-tramway availability fees. The former fees are being paid by De Lijn nv, whereas the latter are paid by AWV. The operation, maintenance and ownership of trams and buses will rest with De Lijn.

The contract can be considered efficient because: (i) it encourages competition between more than one bidder in the procurement process , (ii) there was an integration of design and construction in the services provided, (iii) the contractor had to solely carry the risks of rising costs, and (iv) it allowed for incentives for performance. Some contract inefficiencies were also observed because (i) revenue risks are not shared but concentrated only on one party (public), (ii) there was not a collective estimation for investments, and (iii) the contractor is not obliged to pay a penalty if completion dates are not met. The contract is also flexible because it includes clauses enabling either or both updating of service and price changes and, also, clauses indicating that the client has an option to terminate the agreement prematurely without cause.

Although the public authority has transferred quite a number of responsibilities, it has retained some of its financial activities; it has invested equity in the SPV, and therefore, the public sector shares significant financial risk. The same applies also to the allocation of maintenance risk, which is almost equally shared between the public and the private partner. Exploitation and revenue risks are borne entirely by the public sector and, also, regulatory and force majeure risks are mostly born by the public sector. The design and construction risks are almost entirely allocated to the private partner (see Table 7.1). In Table 7.1, if a risk is allocated (mostly) to the private partner, then the symbol ✓is indicated at the left side of the table, while if a risk is allocated (mostly) to the public partner, then the symbol ✓ is indicated at the right side of the table. When it is shared between the two partners, it is indicated in the middle of the table.

Based on the above, the Governance Indicator (GI) was 0.688 throughout the project life-time.

Table 7. 1: Brabo 1 – risk allocation

Risks	⟸ ⟹							
Design & construction	Totally Private		✓					Totally Public
Maintenance				✓				
Exploitation							✓	
Commercial/revenue							✓	
Financial				✓				
Regulatory						✓		
Force majeure					✓			

7.1.3 Business Model Efficiency

PROJECT INTEGRATION

The Brabo 1 is located in an urban area with multiple transportation alternatives for users (bus services, cycling). Brabo 1 connects to train stations, bus stations and Park-and-Ride facilities (physical integration). The project is well connected with the bus lines, which are the alternative public transport means in the city of Antwerp and a uniform ticket fare allows transit from the tram to the bus service for 60 mins (operational integration). De Lijn is the autonomous public authority that manages/operates both the tramway services and the bus services in the entire Flemish Region (authority integration). The project is also integrated into the transport and other planning policies (policy integration). The network integration influences somewhat positively the project with respect to control over demand.

COMPETENCE OF THE CONTRACTING AUTHORITY

De Lijn nv and the Flemish Agency for Roads and Traffic AWV are the two contracting authorities in this project. AWV is involved due to its responsibility for the renovation of roads, which was also part of the Brabo 1 project. The two authorities jointly signed a DBFM contract with the SPV. Notably, as this was the first PPP tramway-related project in Flanders, neither authority had extensive experience.

In general, the project was quite well planned. There was a clear policy with respect to the project, a political decision to adopt PPP and no inaccurate pre-project information identified, thus revealing the experience of the Contracting Authority in planning Brabo 1. However, during the project implementation phase, some issues were raised. An ex-ante evaluation in order to examine whether the PPP would be cheaper than traditional procurement was not carried out. A respective evaluation was made after deciding to deliver the project as a PPP.

De Lijn not only plans the infrastructure but also monitors its implementation (construction) and is also the operator. Regarding monitoring, the contracting authority has a good project management record and capable staff to monitor the project. It is also worth mentioning that there were no lengthy renegotiations and, in general, the project received positive press reviews and had the support from various stakeholders. Last but not least, the Contracting Authority is a highly experienced operator.

COMPETENCE OF THE PRIVATE SECTOR ACTOR(S)

Project sponsors are Lijninvest nv (equity) and DG Infra+ (equity). The latter is a Belgian investment fund, established by GIMV and Dexia. Four banks provided senior debt: KBC, Dexia Credit Local, Dexia Bank Belgium and the Bank of Dutch Municipalities (Bank Nederlandse Gemeenten). The SPV is Project Brabo 1 nv (Lijninvest nv (24%), Beheersmaatschappij Antwerpen Mobiel (24%) and THV Silvius (52%)). THV Silvius was also the consortium of subcontractors: DG Infra+ (investment fund), Heijmans Infra nv (construction company), FrateurDe Pourcq nv (construction company) and Franki Construct nv (construction company). All the companies of the construction consortium (THV Silvius, 52%) are top national players with a sufficient ability to construct and, therefore, the construction risk was appropriately allocated to the constructors. Innovation was adopted and successfully applied, which also mirrors the competence of the concessioner.

Based on the above, and in combination with the risk allocation structure, as presented in the previous section:

- The Cost Saving Indicator (CSI) was 0.363 at award (2009) and 0.000 at the operational phase (2014).
- The Revenue Support Indicator (RSI) remained stable at 0.142 at award (2009) and in 2014 (operational phase). The low level of project exclusivity has an impact on the level of coopetition, which reduces significantly the RSI values. Similarly, the business scope of the infrastructure (business servicer) and the absence of non-transport business activities within the project, that could bring revenues, contribute also to a low RSI value (Table 7.2).

7.1.4 Funding & Financing

FUNDING: REMUNERATION SCHEME AND PROJECT REVENUES

The Brabo 1 Project is available to private (passenger) traffic. The remuneration scheme is composed of availability fees. Project revenues are generated by passenger fares, which are collected by the operator (De Lijn nv).
Based on the above:

- The value of the RAI indicator is equal to 0.667 and remained unchanged in both snapshots (award: 2009 and operation: 2014).
- The RRI is equal to 0.308 for both snapshots. Notably, passenger fares are assumed to correspond to 30% cost coverage.

FINANCING SCHEME

Equity covered 10% of the total financing needs, of which Silvius (Tinc comm.v.) provided 52%, and Lijninvest and BAM each 24%, each. The size of the equity capital was 4.6 M EUR pure equity and 13.8 M EUR subordinated shareholder loan. Financing through debt (senior debt) was provided by the following Commercial banks: KBC, Bank Nederlandse Gemeenten (Bank of Dutch Municipalities), Belfius, and Caisse des Dépôts et Consignations, which together covered the remaining 90% of the total financing cost. The size of debt capital was 161.7 M EUR and the total capital was 180.1 M EUR. More specifically, the Leading bank (KBC Bank) provided debt finance equal to 53.9 M EUR senior debt, while the other banks together provided debt finance equal to 107.8 M EUR senior debt.

Based on the above, the Financing Scheme Indicator (FSI) was 0.720 at award (2009) and remained stable until its reported operational phase (2014) (see Table 7.2). The financing scheme used is a relatively low-cost financing scheme.

7.1.5 Outcomes

Brabo 1 is a successful project that achieved the time, traffic and revenues project objectives, as presented below. No renegotiations took place. The availability and reliability of the project were fully in line with the expectations (100%). The same applies to the maintenance costs, the safety and security (security incidents are within expected range). Also the economic, social, environmental and institutional impacts of the project were as expected.

COST AND TIME TO CONSTRUCTION COMPLETION

Brabo 1 was delivered ahead of schedule. However, the project faced a limited cost overrun (1% increased construction costs) because of the design modifications introduced by AWV and De Lijn. These modifications included inter alia (i) the construction of an extra traction station, (ii) a different planning of the construction in a shopping street and (iii) the addition of a junction to the project configuration.

ACTUAL VERSUS FORECAST TRAFFIC

The actual traffic of the project was as forecast.

ACTUAL FORECAST REVENUES

Actual revenues were also as forecast.

7.2 Demonstration of the application of the POAC, using the Brabo 1 case

The POAC tool is applied in three steps.

Step 1: Calculating the indicators' values of a TI project case (either using actual indicator values for the construction and operation phase or assumed/estimated values for the feasibility study phase of the project) (using the indicators of Roumboutsos, Voordijk, & Pantelias (2018) presented in chapter 2). Indicator values can be simply calculated online by the user, via the TIRESI tool that is available on the website www.benefit4transport.eu. TIRESI, which stands for Transport Infrastructure Resilience Indicator, aims to measure how resilient a project is with respect to achieving its planned outcomes. It is developed based on methodological elements from resilience models and on credit assessment methodologies (Roumboutsos and Pantelias, 2018).

Step 2: Using the developed calibration table (see Chapter 6) to convert the results of the indicators' values into present and absent conditions, like the ones shown in chapter 6 in the solution paths of the fsQCA. The calibrated values of this table serve as benchmark values, above which an indicator value is considered 'positive' (i.e. present condition) and below which an indicator value is considered 'negative' (i.e. absent condition).

Step 3: Comparing the indicators' values expressed as present and absent (from step 2) with the findings/solution paths of chapter 6. If the project case under examination shows same results with the ones found in the fsQCA analysis of chapter 6, e.g. same results for the ''on/below time project delivery'', then the project has high likelihood to be delivered on/below time.

The tram project case Brabo 1 in Belgium is used as an example to show how the above three steps are applied. Table 7.2 below shows these steps.

Table 7. 2 – Demonstration example of the application of the POAC: ex-post analysis's results for Brabo 1

POAC steps	INDICATOR VALUES[25]							COST		TIME		TRAFFIC		REVENUES	
	FEI	INI	GI	CSI	RAI	RRI	FSI	Outcome[26]	POAC	Outcome	POAC	Outcome	POAC	Outcome	POAC
Step 1: Award phase (2009)	0.682	0.775	0.688	0.363	0.667	0.308	0.720	ON COST		ON TIME		TRAFFIC AS FORECASTED		REVENUES AS FORECASTED/	
Step 1: Operational phase (2014)	0.696	0.764	0.688	0.000	0.667	0.308	0.720	OVER COST		AHEAD OF TIME		TRAFFIC AS FORECASTED		REVENUES AS FORECASTED	
Step 2a: Calibration of fuzzy sets	0.60	0.65	0.50	0.333	0.50	0.50	0.50								
Step 2b: conversion of indicators' values, Award phase (2009)	+	+	+	+	+	~	+								
Step 2b: Operational phase (2014)	+	+	+	~	+	~	+								
Step 3: Comparison of the indicators' values with the findings of chapter 6. Award phase (2009)	See also Table 7.3								On/below cost[27]		On/ahead of time[28]		Traffic as forecast[29] /exceeding the forecast		Revenues as forecast[30]/exceeding the forecast

Abbreviations' meaning: NI: Institutional Indicator, FEI: Financial Economic Indicator, CSI: Cost Saving Indicator, GI: Contractual Governance Indicator, RAI: Remuneration Attractiveness Indicator, RRI: Revenue Robustness Indicator, FSI: Financing Scheme Indicator

[25] RSI and IRA are not being presented in the table, since they are not used in the fsQCA as stated in Chapter 6.
[26] The outcome is the estimated outcome for the award phase and the actual outcome at the operational phase.
[27] Based on the 'On/below cost-full sample' results, 'On/below cost-PPP sample' and 'On/below cost-completion after crisis sample', it was found that Brabo 1 is expected to be on/below cost, although it was over cost by 1%.
[28] Based on the 'On/below time-PPP sample' results, it was found that Brabo 1 is expected to be on/ahead of time and it was actually ahead of schedule.
[29] Based on the 'On/over traffic-full sample' results, and the 'On/over traffic-PPP sample' results, and the 'On/over traffic-completion after crisis sample' results, it was found that Brabo 1 is expected to have traffic as forecast and its traffic was actually as forecast.
[30] Based on the 'On/over revenues-completion after crisis sample' results, the 'On/over revenues-PPP sample' results and the 'On/over revenues-full sample' results , it was found that Brabo 1 is expected to have revenues as forecast and its revenues were actually as forecast.

Step 3: Operational phase (2014)	See also Table 7.3		On/belo w cost[31]		On/ahead of time[32]		Traffic as forecast[33]/ /exceeding the forecast		Revenues as forecast[34]/ex ceeding the forecast

[31] Based on the 'On/below cost-completed after crisis sample' results and the 'On/below cost-PPP sample', it was found that Brabo 1 is expected to be on/below cost, although it was over cost by 1%.

[32] Based on the 'On/below time-PPP sample' results, it was found that Brabo 1 is expected to be on/ahead of time and it was actually ahead of schedule.

[33] Based on the 'On/over traffic-full sample' results and the 'On/over traffic-completion after crisis sample' results, it was found that Brabo 1 is expected to have traffic as forecast and its traffic was actually as forecast.

[34] Based on the 'On/over revenues-completion after crisis sample' results and the 'On/over revenues-full sample' results, it was found that Brabo 1 is expected to have revenues as forecast or more than the forecast, and its revenues were actually as forecast. It also needs to be noted that based on the 'Below revenues-PPP sample', it was found that Brabo is expected to have less revenues than forecast. However, the results of the former two samples' analysis are used due to their higher consistency/coverage, being 0.80/0.65 and 0.97/0.73 compared to 0.76/0.41 of the latter sample analysis. Thus, the user of the POAC needs to check all the findings per sample (presented in chapter 6) and by taking into consideration their consistency/coverage to select the ''strongest'' finding (i.e. with the highest consistency/coverage).

Table 7.2 shows the steps to be followed for the application of the POAC. This exercise of demonstration of the application of POAC can serve at the same time as **an exercise of validation**, by comparing the actual outcomes of the Brabo 1 tram project with the outcomes that the POAC estimated that that the project would show.

According to the POAC, Brabo 1 was expected to be on/below cost, while it had finally small cost overruns of 1%, to be on/ahead of time when it was actually ahead of time, to have traffic and revenues as forecast/more than forecast, while it had traffic and revenues as forecast.

The fact that the POAC found that the Brabo 1 project had a high likelihood to be on/below cost is due to the present CSI in the award snapshot, meaning the high ability to reduce costs during the construction phase of the project. In the operational phase, the CSI had a lower value (absent CSI) than the one estimated for the award phase, due to the operational risk allocation to the public party instead of the private. Nevertheless, although the value of the CSI is lower and absent for the operational phase, POAC shows that still the project Brabo 1 has a high likelihood to be on/below cost (see Table 7.3).

More specifically, Brabo 1 in its award phase was found to have high likelihood to be on/below cost based on the POAC instrument, based on the ''On/below cost-PPP sample'', ''On/below cost-full sample'' and ''On/below cost-completion after crisis sample'' results of chapter 6 (see Table 7.3), while there were actually cost overruns of 1% due to reasons related to the competence of the contracting authority and the planning efficiency.

In the operational phase snapshot, according to the POAC instrument and the results of the ''on/below cost-completed after crisis'' and ''on/below cost-PPP crisis'' sample, Brabo 1 should have been on/below cost. Although Brabo 1 also had all the ''needed'' indicators positive (present), it had cost overruns. This does not cancel the credibility of the instrument for two reasons. Firstly, because Brabo 1 has been almost on cost, i.e. the cost overrun was 1%, and secondly because the respective solution path was explaining 85%, 91%, 95% and 97% of the cases and not 100% of them. What is meant by that is that like with every instrument that is used to provide forecast/assessment ex ante, there is always the element of uncertainty. It might be the case that for the majority of the PPP projects and the projects completed after crisis tested in the sample, having +INI, +FEI and +FSI and +GI, +FSI is sufficient to explain the achievement of the cost outcome. However, for some TI projects these conditions might not be sufficient. Every TI project is different. Studying the past experiences of TI projects can give lessons with respect to the most often observed factors that explain their success or failure but these factors do not guarantee the success, i.e. the achievement of project objectives, of the future projects.

With respect to the revenues forecast, the POAC shows that Brabo 1 was expected to be on/over revenues based on the award snapshot, according to the results of the ''on/over revenues-completion after crisis sample'', ''on/over revenues-PPP sample'' and ''on/over revenues-PPP sample'', and the project was on revenues indeed. For the operational phase, based on the 'On/over revenues-completion after crisis sample' results and the 'On/over revenues-full sample' results, it was found that Brabo 1 was expected to have revenues as forecast and its revenues were actually as forecast. But based on the 'Below revenues-PPP sample', it was found that Brabo 1 was expected to have less revenues than forecast. However, the results of the former two samples are finally selected to be used, due to their higher consistency/coverage, being 0.80/0.65 and 0.97/0.73 compared to 0.76/0.41 of the latter sample. Thus, the user of the POAC instrument needs to check all the findings per sample and by taking into consideration the consistency/coverage, to select the ''strongest'' finding (i.e. finding with the highest consistency/coverage).

This was an ex post application of the POAC because the Brabo 1 project has been already approved, constructed and in operation. When POAC is used ex post, it is used to monitor and control performance in terms of achieving projects objectives and at the same time lessons can be learned for the success of future projects.

In the case of Brabo 1, the lesson that is learned is that during the operational phase more attention needs to be paid to the skills to operate and to the operational risk allocation, i.e. the operational risk was assigned to the public sector. If both these characteristics are improved, CSI value increases from 0.000 to 0.667 at the operational phase, while if only the parameter of operational risk allocation is changed (from the public to the private party), then the CSI value increases from 0.000 to 0.444 during the operational phase. With respect to the outcomes of time and traffic, the POAC instrument showed that the project should have been on/ahead of time and with traffic as forecast or more and it was actually ahead of time and with traffic as forecast for both the snapshots of the award and operational phase**.**

Table 7. 3: Detailed presentation of POAC's step 3: Comparison of the indicators' values expressed as present and absent (from step 2) with the findings of chapter 6.

Project phase	Outcome	Type of sample[35]	Findings of Brabo 1 (step 1 & 2)	Findings of chapter 6: Matching configuration of conditions of the respective sample analysis (fsQCA) (step 3)	Consistency/coverage of the configuration of conditions
Award	Cost	On/below cost-full	+FEI, +INI, +GI, +CSI, +RAI, ~RRI, +FSI	**+INI,** +GI, **+CSI**, +FSI	0.82/0.53 (17 relevant cases)
	Cost	On/below cost-PPP	Idem	+INI, **+FEI, +FSI**	0.91/0.57 (14 relevant cases)
	Cost	On/below cost-PPP	Idem	+INI, +GI, **+CSI,** +FSI	0.92/0.59 (17 relevant cases)
	Cost	On/below cost-PPP	Idem	+GI, **+FSI**	0.95/0.77 (20 relevant cases)
	Cost	On/below cost-PPP	Idem	+INI, +FEI, **+FSI**	0.97/0.57 (14 relevant cases)
	Cost	On/below cost-completion after crisis	Idem	**+INI, +FEI,** +FSI	0.85/0.56 (9 relevant cases)
	Time	On/below time-PPP	Idem	+INI, **+FEI, +GI**	0.82/0.56 (13 relevant cases)
	Traffic	On/over traffic-full	Idem	+INI, +GI, **+CSI, +RAI**, +FSI	0.85/0.47 (1a) (6 relevant cases)
	Traffic	On/over traffic-full	Idem	+INI, **+FEI,** +GI, **+RAI,** +FSI	0.89/0.37 (4 relevant cases)
	Traffic	On/over traffic-PPP	Idem	+INI, +GI, **+CSI, +RAI**, +FSI	0.87/0.51 (6 relevant cases)
	Traffic	On/over traffic-completion after crisis	Idem	+INI, **+FEI**, +GI, +RAI	0.95/0.45 (3 relevant cases)

35 Not all samples' fsQCA results are checked for the step 3 of the POAC due to non-applicability. This will depend each time on the type of the TI project under examination. For example, Brabo 1 is a PPP project that has been completed after the financial-economic crisis. Thus, the results of all samples' analysis can be tested, except the road sample and the sample of the projects that have been completed before the crisis, which are not applicable.

	Revenues	On/over revenues-full	Idem	**+INI**	0.97/0.73 (20 relevant cases)
	Revenues	On/over revenues-completion after crisis	Idem	**+INI, +GI,** +FSI	0.80/0.65 (13 relevant cases)
	Revenues	On/over revenues-PPP	Idem	**+INI**,+GI,**+CSI**, +RAI, +FSI	0.88/0.38 (6 relevant cases)
Operational	Cost	On/below cost-PPP	+FEI, +INI, +GI, ~CSI, +RAI, ~RRI, +FSI	+INI, **+FEI, +FSI**	0.91/0.57 (14 relevant cases)
	Cost	On/below cost-PPP	Idem	+GI, **+FSI**	0.95/0.77 (20 relevant cases)
	Cost	On/below cost-PPP	Idem	+INI, +FEI, **+FSI**	0.97/0.57 (14 relevant cases)
	Cost	On/below cost-completed after crisis	Idem	**+INI, +FEI,** +FSI	0.85/0.56 (9 relevant cases)
	Time	On/below time-PPP	Idem	+INI, **+FEI, +GI**	0.82/0.56 (13 relevant cases)
	Traffic	On/over traffic-full	Idem	+INI,**+FEI,** +GI,**+RAI,** +FSI	0.89/0.37 (4 relevant cases)
	Traffic	On/over traffic-completion after crisis	Idem	+INI, **+FEI,** +GI, +RAI	0.95/0.45 (3 relevant cases)
	Revenues	On/over revenues-completion after crisis	Idem	**+INI, +GI,** +FSI	0.80/0.65 (13 relevant cases)
	Revenues	On/over revenues-full	Idem	+INI	0.97/0.73 (20 relevant cases)
	Revenues	Below revenues-PPP	Idem	**+FEI, +GI**, ~CSI, **~RRI,** +FSI	0.76/0.41 (1 relevant case)

Abbreviations' meaning: NI: Institutional Indicator, FEI: Financial Economic Indicator, CSI: Cost Saving Indicator, GI: Contractual Governance Indicator, RAI: Remuneration Attractiveness Indicator, RRI: Revenue Robustness Indicator, FSI: Financing Scheme Indicator

Also, while applying the POAC, either ex ante or ex post, the user can repeat the step 1 of the instrument multiple times, each time trying to change some elements in the online TIRESI that led to lower scores of the indicator values in order to improve the potential outcome. By improving the values of one or more indicators (when possible), this increases the likelihood of the achievement of the project objectives. For example, in the case of Brabo 1, the user could modify parameters that led to lower values of CSI and RRI, e.g. for the CSI to consider allocating the operational risk to the private sector and improving the capability of the operators to operate (operational phase) and improving the capability of the constructors and the planning efficiency (i.e. conducting feasibility study) (at the award phase) and for the RRI to consider other types of revenue sources except passenger fares.

7.3 Exercise of validation of the POAC for other TI project cases

As it was also mentioned earlier, due to non-availability of additional cases to conduct the validation of the POAC, additionally to Brabo 1, project cases that were used in the fsQCA empirical analyses are used, i.e. the least relevant ones (found to be relevant <=5 times). These cases are the following six: Modlin Regional Airport, Eje Aeropuerto (M-12) Motorway, Metro de Malaga, Radial 2 Toll Motorway, Athens Tramway and Port of Agaete[36]. Thus, the selected cases are one airport, two motorways, two metros and one port. The same POAC steps presented in the section 7.2 for the Brabo 1 case have been also applied in this section for the additional selected six cases to do the exercise of validation. **Results show that POAC is partially validated**. **In other words, the POAC is validated for some of the project outcomes for each of the six project cases.**

This can be explained by the fact that not all TI projects are the same. The fact that some projects achieved the four examined outcomes under certain conditions, does not mean that other projects will ''behave'' in the same way. This could be considered a limitation of the thesis. However, this is a limitation of all the relevant social studies that attempt to plan the future based on the past experiences of projects.

The non-matching/non-validated results might be also because there are only four airports in the sample, three metros and seven seaports. The limited number of other than road project cases in the sample of cases could be considered as a limitation of the present thesis. However, also for the two road projects, the POAC has been partially validated, even if the majority of the projects in the sample are road projects, i.e. 22 out of 51 projects in total. The fact that these cases have been found to be the least relevant ones in the fsQCA results was a forerunner that these cases do not reflect the findings of the fsQCA and as a result of the POAC to a wide extent.

7.4 Concluding Remarks

The aim of chapter 7 was to demonstrate to the potential users how to apply the developed POAC instrument. For demonstration purposes, the Brabo 1 tram project in Belgium was used as an example. In this demonstration example, the simplicity of the POAC instrument can be understood, which is one of its main advantages.

While presenting the results of the Brabo 1, its actual outcomes were compared with the outcomes expected based on the POAC instrument. Thus, an exercise of validation was conducted at the same time. However, for the validation of the POAC, more than one case is needed. Therefore, six additional project cases were used to validate the POAC.

The project cases that were used for the validation of the POAC were cases that were included in the dataset of the 51 TI projects, due to non-availability of other ''external'' cases to do the comparison and thus validation. The seven cases selected from the 51 cases to do the validation exercise were the least relevant ones in the fsQCA results. These seven cases have been kept and not excluded from the sample of 51 cases in chapter 6. Excluding these seven cases from the analysis would have no significant impact on the fsQCA results because these cases have been found in chapter 6 to be the least relevant, i.e. not to reflect the combinations of conditions. What could have been done instead is to exclude randomly e.g. seven cases before the fsQCA is conducted in chapter 6 and thus run the fsQCA with 44 cases instead of 51 and keep the seven cases aside for the validation to take place after

[36] For detailed information for each of these six cases, see the e-book and wiki section in the BENEFIT website. BENEFIT website: http://www.benefit4transport.eu/.

the fsQCA. However, this would mean that our sample of cases would be smaller, which on the one hand would limit the number of cases from which lessons could be learned and on the other hand it could also exacerbate the phenomenon of limited diversity. Limited diversity is shown through the empty rows in the truth table, called "logical remainders" (i.e. possible combinations of conditions for which there is no empirically observed case). This is the reason why all the 51 cases available have been finally kept and used for the fsQCA in chapter 6.

Results showed that the POAC is partially validated. In other words, the POAC is validated for some of the project outcomes for each TI project case. However, the fact that these cases were found to be the least relevant ones in the fsQCA results was a forerunner that these cases do not reflect the findings of the fsQCA and as a result of the POAC to a wide extent.

The partial validation of the POAC could be also explained by the fact that the TI project cases other than road are limited in the sample of cases used in the empirical analysis and as a result the POAC could not be fully validated for the selected cases, being metros, airport and port and also by the fact that every project is unique. Therefore, the achievement of an outcome cannot be guaranteed even for road and PPP projects that represent the majority of the sample. Lessons of past experiences are used to increase the likelihood of achievement of the outcomes of future TI projects but this is not a guarantee.

8. Conclusions

Transportation systems are complex and they are composed by three elements, being the infrastructure, the means of transfer, and the load. Transport infrastructure (TI) is a vital economic and social asset, which absorbs high investments to be constructed and maintained and is highly centralized, i.e. one single entity controls everything. TI is mainly financed by the government, which allows the operation of the means of transport. Its realisation requires sometimes tens of millions (projects), hundreds of millions (major projects) and billions of dollars (megaprojects). The high costs of the TI investments increase the level of commitment of the decision makers into continuing the TI project, as soon as the project construction has been initiated. The amount of money that has been already invested into the project are sunk costs, which are costs that have been incurred but cannot be recovered. As a result of the sunk costs, the lock-in effect is created. Lock-in effect is defined as *"the over-commitment of parties to an inefficient project before the formal decision to build and to the inefficient specifications of the project after the formal decision to build has been made"*. Thus, the stakeholders involved are ''trapped'', ''locked in'' finishing the project that they have started.

This is the reason why the decision that decision makers are called to make before and after the approval of a TI project are critical. The decision that will be taken at the planning and evaluation phase of the project should be "correct'', meaning that the TI project that will be selected and approved should provide the economic and/or social benefits that it ''promised'' to provide and have the costs as they were initially estimated. In other words, the project that will be selected should meet its project objectives. This is how project success is defined in project management literature, as the achievement of the project objectives and/or the satisfaction of the project sponsors/customers.

This is how project success is also defined in the present doctoral thesis, as the achievement of four key project objectives, of the cost objective, the time objective, the traffic objective and the revenues objective. These are the four project objectives that have been found to be extensively presented in project management literature as the key project objectives for project success. Thus, if a project achieves all or some of these objectives, it is considered successful or partially successful in terms of project management. These project objectives are an extended version of the traditional project management triangle or Iron Triangle or triple constraints, which included only the objectives of cost, time and scope.

However, the success of a project depends on the stakeholder's perspective from whom it is examined. For example, a project might be delivered with cost overruns and with a delay and be a failure from a project management perspective but it might have achieved its project objective of e.g. reducing emissions and thus being considered a success for the society stakeholder. Therefore, success can be defined based on the achievement of various project objectives but the four ones selected in this thesis represent the core ones that need to be achieved.

Therefore, it can be seen that in the present doctoral thesis only the economic performance of the TI projects is examined and its performance in terms of the achievement of project management goals, and not the social and/or environmental performance. The ''Project objectives' achievement compass'' (POAC) tool that has been developed in the present thesis might be considered of having an indirect impact on the environmental performance of TI projects, via the traffic project objective. The POAC tool shows the likelihood of achieving the traffic objective (among the other three project objectives) and also shows the path towards achieving the traffic objective. Therefore, POAC indirectly contributes into the achievement of the estimated reduction of external costs, which are calculated based on traffic forecasts in the evaluation phase of a project. Transportation sustainability is not measured in the present doctoral thesis. However, since POAC takes into account transport modes that are also sustainable, such as rail and waterborne transport modes, and not only road projects, this could contribute to the successful development and improvement of projects of more sustainable modes.

As it has been understood also from the above, it is of great importance to approve projects that are able to meet their key project objectives. However, it is common that the approved projects finally do not meet their project objectives. Often the ''unfittest'' TI projects survive, these are ''bad'' TI projects that they look positive and good in paper, in their cost benefit analysis (CBA) results and thus approved but when they are actually implemented, they do not meet their project objectives and have cost overruns and/or benefit shortfalls. Flyvbjerg (2009, 2008b) supports that the reason is strategic misrepresentation of the CBA results, which means deliberately making an error in e.g. the cost estimation in order to get the project approved or the reason is optimism bias, which means a non-deliberate error due to the over-optimistic nature of humans to overestimate benefits and underestimate costs subconsciously. There are so many more factors, additionally to these two, that lead to cost and time overruns and traffic and revenues underruns, as it has been also found in the relevant literature and presented in chapter 2.

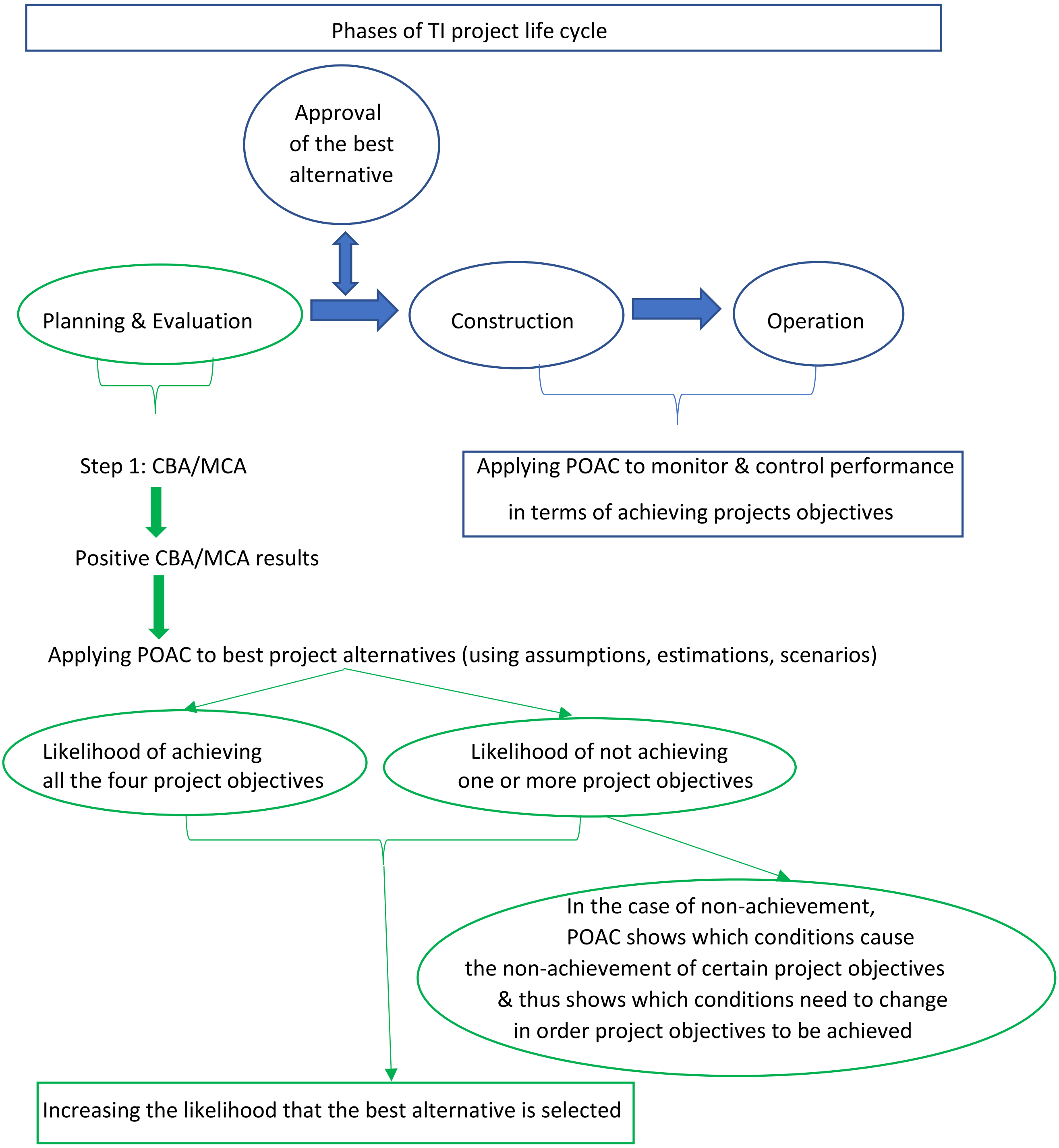
What makes things more difficult in terms of project objectives' achievement is the uncertainty involved in projects and especially in the TI projects, which have the highest level of uncertainty and zero-to-low levels of reversibility the minute the decision is implemented. *''Uncertainty can be defined as the entire set of beliefs or doubts that stems from our limited knowledge of the past and the present (especially uncertainty due to lack of knowledge) and our inability to predict future events, outcomes and consequences (especially uncertainty due to variability)''.*

The present doctoral thesis comes to support the process of TI decision making by identifying the combinations of conditions (i.e. combinations of factors) that affected the performance of past TI projects. This is the research objective of the present doctoral thesis that is investigated via the following **research questions: RQ1: Which are the combinations of conditions that lead to the achievement of the project objectives of TI projects? and RQ2: Which are the combinations of conditions that lead to the non-achievement of the project objectives of TI projects?** Non-achievement of project objectives means that a TI project is not realized as planned and delivered with costs more than the estimated ones, with a delay, with traffic and revenues less than the forecast ones. It thus contributes to a more informed decision making process throughout the project lifecycle and to a decrease of the level of uncertainty involved in TI projects.

Based on these findings, i.e. the combinations of conditions that lead to the achievement and non-achievement of the project objectives of TI projects, the **''Project Objective Achievement Compass'' (POAC) tool** is developed. POAC is a compass, because it shows to the interested parties the direction and more specifically the ''path'' towards the achievement or not, of key project objectives. POAC is a new decision support tool that complements the CBA and the risk analyses done within CBA and supports rational decision making by taking into account factors that are not included in CBA. It can be applied during the **construction and operation phase** of the project, to monitor and control its performance in terms of achieving its projects objectives (see also Figure 7). For the construction and operation phase of the project, no assumptions are needed for the calculation of the indicators' values, since the indicators are available after the contract award. Additionally, the POAC can be used at the **planning and evaluation phase** of the TI project, using estimations and assumptions to calculate the indicators' values, to show if the project is likely to achieve the project objectives or not and also to show due to which condition(s), one or more project objectives are not achieved, if the results show non-achievement of project objectives. Thus, in this way, the POAC shows to its users also what to change in their project, so as to increase the likelihood of achieving project objectives.

The POAC is applied in the following way **in the planning and evaluation phase** of a project. After the involved parties apply the CBA (or/and multi-criteria analysis (MCA) or/and cost-effectiveness analysis (CEA)) to the different project alternatives, then they need to evaluate the performance of the best project alternatives using the POAC. This is done by estimating or assuming the values of key information about the project with respect to its **contract, business model, financing scheme, funding scheme, transport mode context and implementation context** and by filling in a relevant questionnaire online. As soon as the questionnaire is submitted online, indicator values are calculated for each of the key elements mentioned above, the contract, business model etc. Then the stakeholders need to look at a set of similar projects and see which ones were successful in realising the objectives and why and to see which ones were unsuccessful and why they failed. Then after the stakeholders know under which combinations of conditions past similar projects were successful and non-successful, they apply that to their project to see if finally their project might be successful or not. Thus, it helps them make a more informed decision about which project alternative to select in the planning and evaluation phase of the TI project (see also Figure 7).

Figure 7: POAC as a supporting instrument for TI projects' decision-making process



Source: Own composition

More specifically, the POAC tool can be applied in three steps: firstly, calculating the values of the key indicators (either using actual indicator values for the construction and operation phase or assumed/estimated values for the feasibility study phase of the project) developed in Roumboutsos, Voordijk, & Pantelias (2018) by Soecipto, Willems and Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018)(see Chapter 2). Secondly, converting the results of the indicators' values into present and absent conditions and thirdly, comparing the indicators' values expressed as present and absent (from step 2) with the findings/solution paths of the ex post analysis conducted, using the fuzzy set qualitative comparative analysis (fsQCA) as method. An indicator value that is above the defined threshold value is considered 'positive' (i.e. present condition) and is considered 'negative' (i.e. absent condition) when it is below the threshold value.

The following six key elements are used in POAC and represent the conceptual framework used in the present thesis: **government arrangements, business model, funding scheme, financing scheme, implementation context and transport mode typology.** These key elements are interrelated and interact to produce the performance outcomes. A TI project is visualized and interpreted as a complex system, that is composed by these key elements, which have some risk characteristics that need to be considered and understood. This conceptual framework is called the **BENEFIT[37] framework** and is developed in Roumboutsos, Voordijk, & Pantelias (2018) by Soecipto, Willems and Verhoest, (2018); Roumboutsos, (2018); Cardenas and Voordijk, (2018); Pantelias and Mitusch (2018); Bernadino and Roumboutsos (2018) and Vanelslander and Moschouli (2018). For each of these elements, quantified indicators were constructed that capture the characteristics of these elements. These indicators are available after contract award, thus if we want to apply the POAC before the contract award, in the feasibility stage, estimations and assumptions can be made and scenarios can be used. One of these indicators was constructed in the present doctoral thesis. The aim for creating these indicators was to identify the combinations of these indicators that lead to the achievement and to the non-achievement of the key project objectives.

Therefore, the POAC developed in the present doctoral thesis provides added value to this research field, as a new decision support tool to be used complementarily with the existing decision support tools throughout the lifecycle of the TI projects. Specifically, POAC can be applied during the early stages of the development phase supporting the TI appraisal and during the later stages of the projects, the construction and operation phases, monitoring and controlling the performance of the projects for delivering a TI project on budget and on time and also for achieving the traffic and revenues that have been initially forecast. The core decision support tool that is used in the TI appraisal is the CBA. The newly developed decision support tool has the following advantages:

1. **it interprets the transport system from a holistic point of view**, as the composition of key elements that interrelate and interact to produce performance outcomes. This advantage is brought by the theoretical framework used, being the indicators used and by the method used, the fsQCA, which is a very suitable method to be used for causal complexities like the ones existing in TI projects. Thanks to the fact that the POAC tool is used based on the findings of the fsQCA, POAC gives as results combinations of conditions (i.e. factors) that can affect the achievement of the cost, time, traffic and revenues objectives. This is done by making use of the ''**outside view''**, i.e. by examining how past projects have achieved their project objectives, so as these lessons to be used also for the new ones. Making use of the outside view has been found to be very useful in the relevant literature, compared to focusing only on

[37] BENEFIT stands for Business Models to Enhance and Enable Financing of Infrastructure in Transport.

your own single project, i.e. ''inside view'', like CBA does. **By looking at the past, we avoid repeating the same mistakes and have higher likelihood to have successful projects**.

2. it is characterized by **simplicity**, thanks to which rationality of decision-making increases because it does not require someone to be an expert to be able to interpret its results.
3. it **takes into account the uncertainty due to changes in the exogenous environment**, the institutional and financial-economic context (as scenario analysis and real options do as well), while traditional risk methods often focus on the uncertainty due to model incompleteness. It needs to be clarified that further research on the uncertainty of the exogenous to the project environment cannot improve the quality of the scientific output, as it is the case with the further research on the uncertainty due to model incompleteness, because the uncertainty due to changes in the exogenous environment is out of the control of the managers. However, it is important to be taken into consideration because although managers cannot control it, they can know what the impact of these exogenous factors can be on the achievement of the project objectives.

With respect to challenges of the POAC for possible users, no major challenge is foreseen. This is thanks to the main advantage of the tool that is its simplicity, even for non-experts. Maybe a challenge that could arise is in the case of an ex-post application of the tool, related to the difficulty of collecting all the necessary data for the project under examination. But this is not necessary. For example, this was a challenge I faced when I aimed to apply the POAC to the existing high-speed rail (HSR) project Paris-Brussels-Amsterdam. In this case, collecting the data was not possible, due to either confidentiality reasons or obsolescence of the project, due to which data could not be found. This might be a difficulty for the academic scholars that would like to make use of the tool but for the directly involved stakeholders such as government, this is not an applicable challenge. A potential challenge could be also the difficulty to estimate and assume values to be used for the calculation of the indicators' values, when the POAC is applied at the feasibility stage.

The readers of the thesis aside to getting themselves familiar with the new POAC tool, they were shown the exact steps they should follow so as to apply the POAC. The demonstration of the tool's application is made for a TI project that is in its operation stage. This thesis does not apply the POAC at the feasibility stage of TI projects. However, POAC can be also applied at the feasibility stage already, assuming the values to be used in the indicators and creating different scenarios, considering that the indicators that POAC uses are available after contract award. The user could use sensitivity analysis of the various values used. Monte Carlo simulation could be also used to generate values for the factors included in the indicators.

The readers were also introduced to an overall background knowledge relevant to the thesis' topic. They also acquired knowledge for the overall sample of cases used in the analysis and for the reasons that caused cost and time overruns, traffic and revenue underruns in each of them.

In addition, they were able to gain knowledge about a new indicator that has been developed in this thesis, so as to be used as one of the independent variables. The new indicator developed was the Reliability/Availability Indicator (IRA), as one of the key indicators (Vanelslander and Moschouli 2018) of the BENEFIT framework. The indicator was composed by two key indicators, the reliability and availability indicators (i.e. their combination). The combination of these two indicators was found via the fuzzy set qualitative comparative analysis (fsQCA) to explain the performance of all transport modes and of their respective infrastructures in terms of their funding. The Reliability/Availability Indicator (IRA) was developed as an indicator reflecting the transport mode element, which is a critical element that affects the business model performance of a project (together with the implementation context element). The new additional characteristic that the transport mode element brought into this conceptual framework was the perspective of the users. The users' perceptions for the TI is of critical importance for its performance and need to be also taken into consideration because traffic demand for the TI depends heavily on users' perception. Funding schemes are considered successful or not depending on the business model that generates them and the business model is matched successfully or not by a financing scheme. Contractual arrangements (governance) describe the relations between actors involved in the development of a TI project. Thus, the transport mode element and its interaction with the other key elements is of high importance for the TI project performance.

Also, readers gained knowledge about the fsQCA analysis of different sub-samples of the overall sample of the 51 TI European projects. Thus, not only they saw how fsQCA method works and how its results were interpreted but they also took overall conclusions out of the fsQCA results showing the combinations of conditions under which project objectives can be achieved, which replied to the **two research questions** of the thesis, as shown below. These fsQCA results were key inputs for the application of the POAC tool.

Key findings of the fsQCA for the four project objectives

- There is not one common recipe (i.e. combination of conditions) to achieve all the outcomes.
- Low value conditions when compensated for by certain high value conditions still contribute to the achievement of project outcomes.
- The exogenous environment influences the non-achievement of outcomes, if not compensated for by other conditions.

Cost objective

- a good institutional context, a good contract, a high potential to save costs, a financing scheme with low cost of capital (a funding scheme with low remuneration attractiveness) explain the achievement of the cost outcome for the full and PPP sample and the achievement of the time outcome for the full sample.
- having a low potential to reduce costs can be compensated for by having a good financial-economic and institutional context, a good contract and a financing scheme with low cost of capital.
- a non-favorable financial-economic context can be compensated for by a favorable institutional context, a good contract and a financing scheme with low cost of capital **or** a good contract, a high potential to reduce costs and a financing scheme with low cost of capital.
- a low potential to save costs, (a funding scheme with low remuneration attractiveness) and a financing scheme with high cost of capital explain the non-achievement of the cost outcome (even with a good institutional context, a good contract or a good financial-economic context for the full sample). A non-good contract has been found also in other paths for the PPP and road samples to contribute to the non-achievement of the cost outcome and a non-good institutional and financial-economic context as well for the road and after crisis samples.

Time objective

- a good institutional context, a good contract, a high potential to save costs, a financing scheme with low cost of capital and a funding scheme with low remuneration attractiveness explain the achievement of the time outcome for the full sample.

- a good institutional context, a good financial-economic context and a good contract explain the achievement of the time outcome for the PPP sample and the before crisis sample and a financing scheme with high cost of capital for the road sample.
- a non-good institutional context and financial-economic context and a non-good contract and a low potential to save costs explain the non-achievement of the time outcome for the full and road sample.
- a non-good institutional context and financial-economic context explain the non-achievement of the time outcome for the after crisis sample.

Traffic objective

- a good institutional context, a good contract, a high potential to save costs, a funding scheme with high remuneration attractiveness and a financing scheme with low cost of capital explain the achievement of the traffic outcome for the full and PPP sample.
- a good financial-economic context and revenue robustness also contributed to the achievement of the traffic outcome in other paths and samples.
- a non-good financial-economic context and a low potential to reduce costs or a non-good financial-economic context and a funding scheme with low remuneration attractiveness explain the non-achievement of the traffic outcome for the PPP sample.
- a non-good institutional context and financial-economic context and a funding scheme with low remuneration attractiveness explain the non-achievement of the traffic outcome for the before crisis sample.

Revenues objective

- for the achievement of the revenues outcome, a good revenue robustness was relevant for almost all the paths and samples. Similarly for the non-achievement of the revenues outcome, a non-good revenue robustness was relevant.
- a good institutional context and revenue robustness explain the achievement of the revenues outcome for the PPP and road sample.
- when there is a good revenue robustness, a non-good contract can be compensated for by a high potential to save costs and vice versa and contribute to the achievement of the revenues outcome for the PPP sample.
- also a good revenue robustness can compensate for a non-good contract, explaining the achievement of the revenues outcome for the road sample.
- a good contract and revenue robustness explain the achievement of the revenues outcome for the full and before crisis sample.
- a non-good revenue robustness cannot be compensated for by a funding scheme with high remuneration attractiveness or a good contract and a good financial-economic context or a good contract and thus still explain the non-achievement of the revenues outcome for the full, PPP, road and before crisis sample.

The data that were used in the thesis are 51 TI project cases: 1) of all different modes (i.e. roads, airports, seaports, rail, tram, metro, bridges/tunnels, public transport depot, bicycle sharing network) 2) from 15 European countries (i.e. Greece, Germany, Cyprus, Poland, UK, Portugal, Slovenia, Serbia, Spain, Finland, Norway, Belgium, France, Czech Republic and The Netherlands), 3) both publicly financed and privately co-financed and 4) of different investment sizes. The data were collected under the BENEFIT HORIZON 2020 research project of the European Commission, via desk research and interviews with project stakeholders.

Transferability and generalization

The dataset used in the present doctoral thesis included only European projects of developed economies, thus the results are considered transferrable to other similar projects. Also, since projects of all types of TI were tested (i.e. roads, airports, seaports, rail projects, metro, tram, public transport depot, bridges/tunnels, bicycle sharing network) and of both project delivery ways (i.e. public or private co-financing delivery), this broadens the transferability of the results. Additionally, considering that the majority of the projects are public-private partnerships (i.e. PPPs), this provides an additional support to potential future PPP projects, which are expected to be the main means of project delivery. Transferability and generalization of the results of the fs QCA (step 3 of the POAC) is appropriate to TI projects with similar characteristics with the ones included in the dataset. It can be seen what ''went wrong'' in the past projects.

Saying what went wrong in terms of the fsQCA means which combinations of conditions led to the non-achievement of a project objective. This combination of conditions might include not only negative but also positive conditions. The key thing here is not only to avoid repeating the same mistake, e.g. this time, having a more skilled contractor, if a low value cost saving indicator was one of the conditions, but the key issue is the whole system into which this factor finally led the project to fail. One needs to know if for example, the contractual arrangements were also problematic, or if the institutional context was stable etc. This is what makes different the POAC than a ''lessons-learnt report'' that shows what has been learnt that can contribute to the success of future transport projects, by identifying the factors that led to project success and project failure. These lessons learnt reports identify success and failure factors of one single project (inside view), while POAC uses the outside view, meaning that it takes lessons from multiple projects and does not identify independent factors but combinations of factors that affected the success or failure of the transport project, taking into account the complexity of the TI projects. Due to the fact that TI projects are complex and heterogenous in their nature, this means that even if social scientists attempt to learn from the past experiences of similar projects, this does not guarantee the success of future TI projects.

Implications

POAC is recommended as a tool to be used during the implementation and operation phase of the project and during the planning and evaluation of the project (using assumptions and estimations), by the 1) government for decision making, 2) project evaluators and planners, who do the appraisal of the projects (i.e. the analysts), 3) financiers, who are the main risk takers in TI project investments, i.e. a private partner might hesitate about co-financing a TI project and wants to know if the project has likelihood to achieve its project objectives and in general by all the stakeholders that are involved in TI planning, construction and operation and 4) academic scholars working with similar scientific topics.

Limitations

The main limitation of this study is that the POAC tool has not been externally validated yet. An exercise of validation was conducted in chapter 7, in which the application of the POAC was demonstrated. In this exercise of validation, the results of the POAC were compared with the results acquired from the real system, to see if there is a match that will validate the POAC tool. In this exercise, the project cases that were used were cases that were included in the dataset of the 51 TI projects, due to non-availability of other ''external'' cases to do the comparison and thus validation. However, the seven cases selected from the 51 cases to do the validation exercise were the least relevant ones in the fsQCA results. Results showed that the POAC is partially validated. In other words, the POAC was validated for some of the project outcomes for each TI project case. However, the fact that these cases were found to be the least relevant ones in the fsQCA results was a forerunner that these cases do not reflect the findings of the fsQCA and as a result of the POAC to a wide extent.

These seven cases were kept and not excluded from the sample of 51 cases in chapter 6. Excluding these seven cases from the analysis would have no significant impact on the fsQCA results because these cases have been found in chapter 6 to be the least relevant, i.e. not to reflect the combinations of conditions. What could have been done instead is to exclude randomly e.g. seven cases before the fsQCA is conducted in chapter 6 and thus run the fsQCA with 44 cases instead of 51 and keep the seven randomly selected cases aside for the validation to take place after the fsQCA. However, this would mean that our sample of cases would be smaller, which on the one hand would limit the number of cases from which lessons could be learned and on the other hand it could also exacerbate the phenomenon of limited diversity. Limited diversity is shown through the empty rows in the truth table, called "logical remainders" (i.e. possible combinations of conditions for which there is no empirically observed case). This is the reason why all the 51 cases available were kept and used for the fsQCA in chapter 6. Therefore, although this exercise was not a proper external validation, i.e. using cases outside the sample, so as to say that POAC was validated, it was at least an exercise of validation that showed an indication of how POAC works compared to reality. This form of exercise was reliable since the cases that were selected are the cases that have been found to reflect the least the results.

Also, there are two additional limitations in the present doctoral thesis, of less severity in comparison with the validation limitation mentioned above. Firstly, this is a heuristic study. Thus, the more TI projects included in the study, the more lessons can be learned. The majority of the TI projects in the present thesis were road projects but there were not many port, rail, airport and bridge/tunnel projects. If more projects were included of different modes, this would allow doing the analysis per each mode and not only for road. This would further enrich the POAC. A second limitation is the inability of the POAC to guarantee the achievement of project objectives. POAC does not give a probability but the scores of consistency and coverage could be used to understand the % of the cases with a certain combination of conditions that display the outcome (i.e. consistency) and the % of the membership in the outcome that can be explained by these conditions (i.e. coverage). Learning from past experiences of projects can increase the likelihood of achieving the project objectives but without a guarantee. However, this is not the case only for the POAC but also for all the relevant tools that face the same limitation.

Further research

Further research is needed in order to validate the POAC. Also, an interesting continuation of the current doctoral thesis would be repeating the ex post analysis presented (in chapter 6) with an updated dataset, with more seaport, airport and rail cases, which were not many in the initial dataset. This updated dataset would allow running the fsQCA per mode, for all modes. Also, updating the dataset does not include only adding more cases of other than road cases, but going back to the same cases of the existing dataset and collect data for the current time period and re-run the analysis. TI projects can teach us lessons throughout their life-cycle and thus ex-post evaluation is not static but dynamic, i.e. it can provide lessons learned from different project phases. Currently in the doctoral thesis, for each of the cases, the indicator values are calculated for the following snapshots, i.e. for specific time references of the project case, mainly the award phase, end of construction phase and operation phase. POAC is based on the findings of the fsQCA and the fsQCA findings are found using the BENEFIT indicators' values for the different snapshots per project case. Thus, what would be useful to be done as further research is to calculate the indicator values for the latest project phase, because transport projects are dynamic and show different performance throughout their life cycle. However, this is not necessary for the value of POAC as such. POAC will be useful for future usage even with the present results as shown in the thesis. But it would add maybe some interesting findings with respect to the progress of the cases that have been already included in the sample (and some of them were not operational at the time of data collection). Furthermore, in the current doctoral thesis, the impact of the financial crisis that gained momentum in 2008 was examined. What would be interesting is to examine the impact of the financial crisis caused by the corona pandemic on the TI project success and failure. Last but not least, it would be interesting to also do the analysis for TI projects in developing economies, thus expanding the transferability and generalization of the findings and hence broadening the users of the POAC tool.

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Annexes

Chapter 4

Table A.4. 1: Cases selected to be included in the fsQCA

Project Title	Country	Principal Mode	Field	Investment in euro	PPP or private co-financed	Below/On/Over Cost	Below/On /Over time	Exceeding/On /Below traffic	Exceeding /On/Below revenues	Beginning-end of construction (beginning of operation)
1. Athens International Airport "Eleftherios Venizelos", Greece	Greece	Airport	Greenfield	2.2 billion	PPP	ON	ON	AS FORECASTED	AS	1995-2000 (2001)
2. Berlin Brandenburg Airport (BER)	Germany	Airport	Brownfield	8 billion	Public	OVER	OVER	X[38]	X	2006-2020 (2020)
3. Larnaca and Paphos International Airports	Cyprus	Airport	Both	640 million	PPP	ON	ON	BELOW	AS	2005-2009 (2008 & 2009)
4. Modlin Regional Airport	Poland	Airport	Brownfield	approx. 82 million	Public	ON	OVER	FAR BELOW	BELOW	2010-2012 (2012 & 2013)
5. A-19 Dishforth	UK	Road	Brownfield	29.4 million (GBP)	PPP	ON	ON	AS FORECASTED	AS	1997-1998 (1998)
6. A22 motorway - Algavre	Portugal	Road	Both	218.2 million	PPP	ON	ON	FAR BELOW FORECASTED	BELOW	2000-2003 (2003)
7. A23 motorway - Beira Interior	Portugal	Road	Both	590 million	PPP	ON	ON	FAR BELOW FORECASTED	AS	1999-2003 (2003)
8. A5 Maribor Pince motorway	Slovenia	Road	Both	630 million	Public	BELOW	OVER	EXCEEDING	EXCEEDING	2005-2008 (2008)
9. Athens Ring Road	Greece	Road	Greenfield	1300 million	PPP	ON	ON	BELOW	AS	1996-2004 (2001 & 2004)

[38] An ''X'' is indicated under traffic and revenues outcome for the cases that at the time of data collection, the cases were still under construction or they just became operational.

10. Belgrade By-pass Project, Section A: Batajnica-Dobanovci	Serbia	Road	Greenfield	67.8 million	Public	ON	OVER	FAR BELOW	BELOW	2010-2012 (2012)
11. BNRR (M6 Toll)	UK	Road	Greenfield	GBP 900 million (asset value) GBP 485M (Construction costs)	PPP	ON	ON	BELOW	AS	1992-2003 (2003)
12. C-16 Terrasa Manresa toll motorway	Spain	Road	Greenfield	233.1 million	concession of operation	OVER	ON	BELOW	AS	1987-1989-1991 (1989 & 1991)
13. E4 Helsinki-Lahti	Finland	Road	Both	240 million	PPP	ON	BELOW	EXCEEDING	EXCEEDING	1997-1999 (1999)
14. E18 Muurla-Lohja	Finland	Road	Greenfield	700 million	PPP	ON	ON	AS FORECASTED	AS	2005-2009 (2009)
15. E39 Orkdalsvegen Public Road	Norway	Road	Both	approx. 125–150 million (2001): estimated value of construction. 2 million per year: operating and maintenance costs	PPP	ON	ON	EXCEEDING	EXCEEDING	2003-2005 (2005)
16. Eje Aeropuerto (M-12) Motorway	Spain	Road	Greenfield	382 million (approx.): final construction cost 475 million: Final projected investment	PPP	OVER	OVER	FAR BELOW	AS	2002-2005 (2005)
17. Elefsina Korinthos Patra Pyrgos Tsakona Motorway	Greece	Road	Both	1.487 million	PPP/concession	OVER	OVER	X	X	2007-2017 (2017)
18. Koper - Izola Expressway	Slovenia	Road	Both	164 million	Public	BELOW	OVER	X	X	2008-2015 (2015)
19. Moreas Motorway	Greece	Road	Both	1,000 million	PPP	OVER	OVER	BELOW	BELOW	2007-2016 (2010 & 2016)

20. Motorway E-75: Section Donji Neradovac - Srpska kuca	Serbia	Road	Brownfield	21,847,838 (2010)	Public	OVER	OVER	AS FORECASTED	AS	2011-2013 (2013)
21. Motorway E-75: Section Horgos-Novi Sad (2nd phase)	Serbia	Road	Both	146 million (2009)	Public	OVER	OVER	BELOW	AS	2009-2011 (2011)
22. M-80 (Haggs)	UK	Road	Both	GBP 320 million	PPP	ON	ON	AS FORECASTED	AS	2009-2011 (2011)
23. M-25 Motorway London Orbital	UK	Road	Brownfield	900 million GBP (Construction cost)	PPP	ON	OVER	AS FORECASTED	AS	2009-2014 (2014)
24. M-45 Toll Motorway, Spain	Spain	Road	Greenfield	750 million[39]	PPP	OVER	ON	EXCEEDING	EXCEEDING	1998-2000 (2000)
25. Radial 2 Toll Motorway	Spain	Road	Greenfield	900 million	PPP	OVER	OVER	FAR BELOW	AS	2000-2003 (2003)
26. Via-Invest Zaventem	Belgium	Road	Both	219.85 million[40]	PPP	BELOW	BELOW	AS FORECASTED	AS	2007-2012 (2012)
27. Liefkenshoek Rail Link	Belgium	Rail	Greenfield	690 million[41]	PPP	ON	OVER	AS FORECASTED	AS	2008-2014 (2014)
28. FERTAGUS Train	Portugal	Urban/Rail	Both	161.7 million	PPP	BELOW	ON	AS FORECASTED	AS	1999-2010 (2004)
29. Metro de Malaga	Spain	Metro	Greenfield	762-795 million	PPP	OVER	OVER	AS FORECASTED	AS	2008-2017 (2014)
30. Metro do Porto	Portugal	Metro	Both	2,969,440,541 Investments 1st + 2nd Phases (1993-2005)	PPP	BELOW	ON	FAR BELOW	AS	1998-2008 (2002,2004, 2005, 2006, and 2011)
31. Warsaw's Metro II-nd line	Poland	Metro/rail	Greenfield	about 980 million	Public	OVER	OVER	AS FORECASTED	AS FORECASTED	2009-2014 (2015)
32. Metrolink LRT, Manchester	UK	Metro/tram	Brownfield	>GBP 1,000 million	PPP	ON	ON	EXCEEDING	EXCEEDING	1990-2020 (1992)

[39] Value of the contract (including capital costs and operating and maintenance costs).
[40] The amount includes 51.85 million euro for design and build and 5.6 million euro/year in availability payments.
[41] This budget includes only construction costs.

33. Athens Tramway	Greece	Tram/Light rail	Greenfield	260.8 million	Public	OVER	ON	FAR BELOW	BELOW	2001-2004 (2004, 2005 & 2009)
34. Brabo 1	Belgium	Tram/Light rail	Both	461 million[42]	PPP	OVER	BELOW	AS FORECASTED	AS	2009-2012 (2012)
35. MST-Metro Sul do Tejo	Portugal	Tram/Light rail	Greenfield	339 million[43]	PPP	ON	ON	FAR BELOW	BELOW	2002-2008 (2008)
36. Tram T4 (Line 4 of Lyon tramway)	France	Tram/Light rail	Both	185.3 million 2004	Public	ON	ON	EXCEEDING	EXCEEDING	2006-2009 (2009)
37. Reims tramway	France	Tram/Light rail	Both	372.6[44] million	PPP	ON	OVER	BELOW	BELOW	2008-2011 (2011)
38. Barcelona Europe South Terminal	Spain	Seaport	Greenfield	860 million	concession of operation	OVER	OVER	BELOW	AS	2006-2012 (2012)
39. Deurganckdock Lock	Belgium	Seaport	Greenfield	311.6 million[45]	PPP	ON	ON	X	X	2011-2016 (2016)
40. Muelle Costa Terminal at Port of Barcelona	Spain	Seaport	Greenfield	22 million	concession of operation	ON	ON	X	X	2011-2013 (2013)
41. Piraeus Container Terminal	Greece	Seaport	Both	153.6 million 620 million: including equipment costs	PPP	ON	OVER	EXCEEDING	EXCEEDING	2008-2015 (2009)
42. Port of Agaete	Spain	Seaport	Brownfield	5.7 million (1982 & 1987)	Public (construction); Concession (Operation)	ON	ON	EXCEEDING	EXCEEDING	1982-1993 (1994)
43. Port of Leixoes[46]	Portugal	Seaport	Both	-?	PPP	ON	ON	AS FORECASTED	AS	2000-? (?)
44. Port of Sines Terminal XXI	Portugal	Seaport	Greenfield	332.0 million[47]	PPP	BELOW	OVER	AS FORECASTED	AS	1999-2005 (2004)

[42] The amount includes 125 million euro for design and build and 9.6 million euro/year in availability payments.
[43] Values refer to investment in the first phase of the project: Corroios – Cacilhas; Corroios – Pragal; Cacilhas – Universidade.
[44] The budget covers total tramway construction costs (including the rolling stock, the maintenance centre, and expenses paid directly by Reims Metropole.
[45] This budget includes only the construction costs of the Lock.
[46] Non-available information for this case.
[47] The actual budget for investments until 2009 was 137 million euro (public sector contribution 62.3 million euro and private sector 74.7 million euro. The expected budget of investment after December 2009 is 195 million euro (public sector contribution 40 million euro and private sector 155 million euro).

45. Central Public Transport Depot of the city of Pilsen	Czech Republic	Depot	Brownfield	472 million[48]	PPP	ON	BELOW	AS FORECASTED	AS	2012-2014 (2014)
46. The Hague New Central Train Station	The Netherlands	Terminal (rail)	Brownfield	110 million (2010): Rail Station Construction only. 172 million (2015): Rail Station Construction and Urban Regeneration.	Public	ON	OVER	X	X	2011-2015 (2015)
47. Lusoponte Vasco da Gama Bridge	Portugal	Bridge/Tunnel	Both	645 million	PPP	ON	ON	AS FORECASTED	AS	1994-1998 (1998)
48. Rion-Antirion Bridge	Greece	Bridge/Tunnel	Greenfield	815 million[49]	PPP	ON	BELOW	BELOW	AS	1996-2004 (2004)
49. Blanka Tunnel Complex	Czech Republic	Bridge/Tunnel	Greenfield	1.56 billion	Public	OVER	OVER	X	X	2007-2014 (2014)
50. Herrentunnel Lübeck	Germany	Bridge/Tunnel	Brownfield	180 million (2005)	PPP	ON	ON	FAR BELOW	BELOW	2001-2005 (2005)
51. Lyon's VeloV	France	Bicycle	Greenfield	53 million 2004	PPP	OVER	ON	EXCEEDING	EXCEEDING	2004-2017 (2005)

Table A.4. 2: Causes of cost overruns, delays, traffic and revenues' underruns per case

Project Title	**Country**	**Principal Mode**	**Main reason of cost/time overruns (or underruns) and/or traffic/revenues underruns (or that exceeded the forecast).**
1. Athens International Airport "Eleftherios Venizelos", Greece	Greece	Airport	n.a.[50]
2. Berlin Brandenburg Airport (BER)	Germany	Airport	Causes of delays - bankruptcy of construction planning company - changes in terminal construction works (due to new European security regulations at airports) - non-compliance with fire prevention standards

[48] 12bn Czech Crowns. The amount includes the cost of building the new depot (about 1.6 billion crowns/ 63 million euro) and service costs (the rest).
[49] including construction, operating, financial costs and fees.
[50] N.a. stands for non-applicable and refers to the cases that had no cost overruns, no delays, and traffic and revenues as forecasted.

3.	Larnaca and Paphos International Airports	Cyprus	Airport	Causes of lower traffic than forecasted - internal (there have been discussions with respect to the high rates required by Hermes Airports ltd (concessioner). - political and economic instability.
4.	Modlin Regional Airport	Poland	Airport	Causes of delays - safety reasons: the construction was built using improper materials.
5.	A-19 Dishforth	UK	Road	n.a.
6.	A22 motorway - Algavre	Portugal	Road	Cause of reduced traffic - introduction of tolls
7.	A23 motorway - Beira Interior	Portugal	Road	Causes of lower traffic than forecasted - recession - introduction of tolls
8.	A5 Maribor Pince motorway	Slovenia	Road	Cause of cost underrun - better geo-mechanical conditions (less construction) Cause of cost overrun - complementary works Cause for actual traffic and revenue higher than forecasts - due to the many trucks driving
9.	Athens Ring Road	Greece	Road	Causes of reduced traffic - economic crisis
10.	Belgrade By-pass Project, Section A: Batajnica-Dobanovci	Serbia	Road	Cause of delay - land acquisition
11.	BNRR (M6 Toll)	UK	Road	Cause of reduced traffic - economic crisis - existing M6 toll free route is a competitor because provides an alternative service to the toll M6 (which is linked with the aversion to pay toll fees)
12.	C-16 Terrasa Manresa toll motorway	Spain	Road	Causes of less traffic & higher costs - over optimistic forecast for the traffic and cost
13.	E4 Helsinki-Lahti	Finland	Road	n.a.
14.	E18 Muurla-Lohja	Finland	Road	n.a.
15.	E39 Orkdalsvegen Public Road	Norway	Road	n.a.

16. Eje Aeropuerto (M-12) Motorway	Spain	Road	Cause of cost overrun - additional payments related to land acquisition/deviations in price of land use - additional works Cause of traffic reduction - economic downturn - users' reluctance to pay tolls
17. Elefsina Korinthos Patra Pyrgos Tsakona Motorway	Greece	Road	Causes of delay - economic crisis made project to pause (the Lenders have imposed a draw stop) - land acquisition - environmental claims
18. Koper - Izola Expressway	Slovenia	Road	Causes of delay - complaints on public procurement - bankruptcy of the two main contractors - new tenders for completion of works
19. Moreas Motorway	Greece	Road	Causes of delay - slow financing - economic crisis - archeological findings Causes for less revenues than forecasted - less traffic - reluctance to pay tolls - increase of toll prices
20. Motorway E-75: Section Donji Neradovac - Srpska kuca	Serbia	Road	Causes of cost overruns - unstable funding - problems with expropriation - problems with design Causes of delays - land acquisition - expropriation issues - unstable financing - incomplete design - archaeological findings
21. Motorway E-75: Section Horgos-Novi Sad (2nd phase)	Serbia	Road	Cause of delay - unfinished lay-by on one section of the road
22. M-80 (Haggs)	UK	Road	n.a.
23. M-25 Motorway London Orbital	UK	Road	Not available

24. M-45 Toll Motorway, Spain	Spain	Road	Cause of cost overrun - additional works - higher prices for land acquisition - projected operating and maintenance costs, as well as replacement capital expenditures, were also increased
25. Radial 2 Toll Motorway	Spain	Road	Cause of cost overruns - additional payments related to land acquisition Causes of reduced traffic - economic crisis - users' reluctance to pay tolls
26. Via-Invest Zaventem	Belgium	Road	n.a.
27. Liefkenshoek Rail Link	Belgium	Rail	Not available
28. FERTAGUS Train	Portugal	Urban/Rail	n.a.
29. Metro de Malaga	Spain	Metro	Causes of delay and cost overrun - project improvements concerning design, intermodal transfer and safety and political controversy mainly due to a new proposal about the central section of the project
30. Metro do Porto	Portugal	Metro	n.a.
31. Warsaw's Metro II-nd line	Poland	Metro/rail	Causes of delay - construction difficulties - construction downtime term - flooding of the station construction site - additional works - suspension of construction work due to the discovery of unexploded bomb from WWII, archaeological artefacts, as well as adverse weather conditions
32. Metrolink LRT, Manchester	UK	Metro/tram	n.a.
33. Athens Tramway	Greece	Tram/Light rail	Causes of less traffic - tram vehicle technical problems/poor service (only 20 vehicles running as opposed to 28 vehicles) - economic crisis and unemployment in the country - the higher fare used Causes for delay: • the need to: • clear the depot site of old mines and ammunition remains of WWII • make a divergence to avoid vibrations at the Zeus temple • restore problems with the utility provisions under the road (track setting), which were not GIS positioned Causes for cost overruns

			- design changes - acceleration costs - complementary works
34. Brabo 1	Belgium	Tram/Light rail	Cause of cost overrun - design modifications
35. MST-Metro Sul do Tejo	Portugal	Tram/Light rail	not available
36. Tram T4 (Line 4 of Lyon tramway)	France	Tram/Light rail	Causes of cost overrun - modifications, in most cases not linked directly to the tramway itself (public lighting, green areas, renovation of pavements, etc.) - inflation
37. Reims tramway	France	Tram/Light rail	not available
38. Barcelona Europe South Terminal	Spain	Seaport	Causes of less traffic - due to delays in the beginning of operations - and economic crisis
39. Deurganckdock Lock	Belgium	Seaport	n.a.
40. Muelle Costa Terminal at Port of Barcelona	Spain	Seaport	n.a.
41. Piraeus Container Terminal	Greece	Seaport	Not available
42. Port of Agaete	Spain	Seaport	n.a.
43. Port of Leixoes	Portugal	Seaport	n.a.
44. Port of Sines Terminal XXI	Portugal	Seaport	Cause of delay - lower-than-expected traffic volumes (of the first sections of the project that became operational postponed the second section of the project)
45. Central Public Transport Depot of the city of Pilsen	Czech Republic	Depot	n.a.
46. The Hague New Central Train Station	The Netherlands	Terminal (rail)	Not available ''There were <u>no cost overruns</u> for this project, but additional investments due to changes of design, complementary works and changes of pricing regulations''
47. Lusoponte Vasco da Gama Bridge	Portugal	Bridge/Tunnel	n.a.
48. Rion-Antirion Bridge	Greece	Bridge/Tunnel	Cause of reduced traffic & revenues - crisis

49. Blanka Tunnel Complex	Czech Republic	Bridge/Tunnel	Cause of cost overrun - ill-prepared project conditions - faulty contracts with insufficient motivation for contractors and - mismanagement by the City of Prague - imprecision of the original calculations (e.g. some items of the project that were indivisible were excluded from the calculations of the construction costs)
50. Herrentunnel Lübeck	Germany	Bridge/Tunnel	Not available
51. Lyon's VeloV	France	Bicycle	Not available

Chapter 5

Annex A

In this Annex, the following additional information regarding the identification of the key indicators of the TI mode typology is included:

- Cases and variables that fit the analysis and methodology are identified.
- The data for the respective cases are prepared in such way that the selected methodology could be executed.

Identification of suitable cases and indicators

Privately co-financed case studies and indicators

In the following, the variables of the privately co-financed case studies that are kept and the cases that are selected for the analysis are presented. The variables kept for the analysis, because of data availability, are the following 35:

1. Total investments
2. Contract duration
3. Reliability (scale)
4. Availability (scale)
5. Maintainability (scale)
6. Safety (scale)
7. Security (scale)
8. Regulatory risk allocation
9. Regulatory risk assessment
10. Regulatory risk mitigation
11. Financial risk allocation
12. Financial risk assessment
13. Financial risk mitigation
14. Revenue risk ex ante
15. Revenue risk ex post
16. Revenue risk (scale)
17. Design risk allocation
18. Design risk assessment
19. Design risk mitigation
20. Construction risk allocation
21. Construction risk assessment
22. Construction risk mitigation
23. Maintenance risk allocation
24. Maintenance risk assessment
25. Maintenance risk mitigation
26. Exploitation risk allocation
27. Exploitation risk assessment
28. Exploitation risk mitigation
29. Force majeure risk allocation
30. Force majeure risk assessment
31. Force majeure risk mitigation
32. Type of connection (project locality in template)
33. Node/link
34. Level of integration
35. Level of exclusivity

Based on the data selection, the cases with the highest availability of data, which are selected, are 34. The 34 privately co-financed case studies selected are the following:

1. Attiki Odos
2. Rion-Antirion Bridge
3. Piraeus Container Terminal
4. Ionia Odos Motorway
5. Central Greece (E65) Motorway
6. BNRR (M6 Toll)
7. M80 Haggs
8. A19 Dishforth To Tyne Tunnel
9. Metrolink Lrt, Manchester
10. Radial 2 Toll Motorway
11. Eje Aeropuerto (M-12)
12. M-45
13. A2 Motorway Poland
14. Istrian Y
15. Reims Tramway
16. Caen-Tvr
17. Velo'v
18. Elefsina Korinthos Patra Pyrgos Tsakona Motorway
19. Via-Invest Zaventem
20. Brabo 1
21. Athens International Airport “Eleftherios Venizelos”
22. Liefkenshoek Rail Link
23. Venice Offshore Port
24. Metro De Malaga
25. M-25 Motorway London Orbital
26. Moreas Motorway
27. Larnaka Port & Marina Re-Development
28. Larnaca And Paphos (Cyprus) International Airports
29. Millau Viaduct
30. The Oresund Link
31. Quadrante Europa Terminal Gate
32. E4 Helsinki-Lahti
33. E18 Muurla-Lohja
34. Central Public Transport Depot Of The City Of Pilsen

Publicly financed case studies and indicators

In the following, the variables and the publicly financed case studies selected based on their availability of data are presented. The public cases with the most available data selected are 19. The variables of each of these 19 public case studies are checked to see which of these variables have the least information available. The variables that are suggested to be kept are the same with the ones of the privately co-financed case studies, apart from the variable “contract duration”, which is not included in the public case studies dataset. The variables kept are the ones with more than 50% availability of data[51].

The 19 publicly financed case studies selected are the following:

1. Tram T4 (Line 4 of Lyon Tramway)
2. Port of Agaete
3. A5 Maribor - Pince Motorway
4. Combiplan Nijverdal
5. The Hague New Central Train Station
6. Koper - Izola Expressway

[51] However, even for the cases kept, some parameter values were not available (similarly for the privately co-financed cases), thus a zero value is assumed (the lowest value in the range of 0 and 1).

7. Gardermobanen (Airport Exprestrain)
8. Athens Tramway
9. Warsaw's Metro II-nd line
10. Motorway E-75, Section Horgos – Novi Sad (second phase)
11. Belgrade By-pass Project, Section A: Batajnica-Dobanovci
12. Motorway E-75, Section Donji Neradovac - Srpska kuca
13. Météor
14. Attiko Metro (Athens Metro Base Project)
15. Neubaustrecke (Nbs)
16. Sodra Lanken (The southern Link)
17. OW-plan Oostende-Integrated Coastal and Maritime Plan for Oostende
18. MXP T2-Railink-up
19. Blanka Tunnel Complex

Apart from all these 35 indicators for the privately co-financed case sample and the 34 indicators for the publicly financed case sample, which are used as independent variables (conditions in fsQCA terms), the indicator used as dependent variable (outcome in fsQCA terms) is the 'General level of project's perceived success' (high=1, medium=0.5, low=0, similarly to the scaling of some of the conditions) (see Table A.5.1 below).

As it can been seen above, in the lists of variables that were selected to be used for the fsQCA analysis, not all the variables that were included in the typology list were included in the analysis for the validation of this typology because of restricted or no available data. Thus, the typology variables that were omitted because of no available data were the following:

1. Non sunk/sunk investments
2. Construction - CAPEX
3. Maintenance and Operation - OPEX
4. Project/infrastructure (investment) life cycle
5. Number of freight vehicle-kms
6. Number of passenger vehicle-kms
7. Rerouting
8. Vehicles per hour
9. Demand risk
   Risk assessment
   Allocation/mitigation
10. Climate change risk
    Risk assessment
    Allocation/mitigation
11. Technical Harmonisation
12. Noise & pollution emissions
    Noise level per mode
    % of emissions per mode
13. Pricing: degree of tariff freedom
14. State grants
    - grants to cover infrastructure costs
    - grants/subsidies to cover the operation of the infrastructure
15. Market Liberalisation Index - LIB index

Data preparation and Calibration

The calibration described in Table A.5.1 was applied to the 35 selected indicators and the success indicator (outcome).

Table A.5. 1: Calibration

VARIABLES [52]	SCALE	VALUE 0-1
Total investments	Big	1
	Medium	0.5
	Small	0
Contract duration	Long-term	1
	Short-term	0
Reliability	☐ Reliability was improved fully in line with expectations or even more	1
	☐ Reliability was improved only partially in line with expectations	0.5
	☐ Reliability was not improved or only marginally	0
Availability	☐ Availability was fully in line with expectations or even more	1
	☐ Reliability was only partially in line with expectations	0.5
	☐ Reliability was not in line with expectations	0
Maintainability	☐ Maintenance costs are below expectations	1
	☐ Maintenance costs are fully in line with expectations	0.5
	☐ Maintenance costs are more than expected	0
Safety	☐ Safety was improved fully in line with expectations or even more	1
	☐ Safety was improved only partially in line with expectations	0.5
	☐ Safety was not improved or only marginally	0
Security	☐ Security incidents are within expected range	1
	☐ Security incidents are more than designed for	0
Regulatory risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Regulatory risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Regulatory risk mitigation	☐ None	0

[52] These are the conditions, in fsQCA terms.

	☐ Managerially contained (managerial flexibility)	0.5
	☐ Financially contained (guarantees etc.)	1
Financial risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Financial risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Financial risk mitigation	☐ none	0
	☐ managerially contained (managerial flexibility)	0.5
	☐ financially contained (guarantees etc.)	1
Revenue risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Revenue risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Revenue risk mitigation	☐ None	0
	☐ Managerially contained (managerial flexibility)	0.5
	☐ Financially contained (guarantees etc.)	1
Design risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Design risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Design risk mitigation	☐ None	0
	☐ Managerially contained (managerial flexibility)	0.5

	☐ Financially contained (guarantees etc.)	1
Construction risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Construction risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Construction risk mitigation	☐ None	0
	☐ Managerially contained (managerial flexibility)	0.5
	☐ Financially contained (guarantees etc.)	1
Maintenance risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Maintenance risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Maintenance risk mitigation	☐ None	0
	☐ Managerially contained (managerial flexibility)	0.5
	☐ Financially contained (guarantees etc.)	1
Exploitation risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Exploitation risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Exploitation risk mitigation	☐ None	0
	☐ Managerially contained (managerial flexibility)	0.5

	☐ Financially contained (guarantees etc.)	1
Force majeure risk allocation	☐ Totally contractor	1
	☐ Mostly contractor	0.8
	☐ Rather contractor	0.6
	☐ Rather public	0.4
	☐ Mostly public	0.2
	☐ Totally public	0
Force majeure risk assessment	☐ Acceptable	1
	☐ Moderate	0.5
	☐ Catastrophic	0
Force majeure risk mitigation	☐ None	0
	☐ Managerially contained (managerial flexibility)	0.5
	☐ Financially contained (guarantees etc.)	1
Type of Connection	☐ Urban	1
	☐ Interurban	0.832
	☐ Outer-urban	0.666
	☐ Regional	0.499
	☐ Rural	0.333
	☐ Cross Boarder	0.167
	☐ International	0
Node/link	☐ 1- Node within a Node	1
	☐ 2 -Link within a Link	0.66
	☐ 3 - Node	0.33
	☐ 4 - Link	0
Level of integration	☐ Physical network integration	1 (yes), 0 (no)
	☐ Operational network integration	1 (yes), 0 (no)
	☐ Information integration	1 (yes), 0 (no)
	☐ Authority integration	1 (yes), 0 (no)
	☐ Policy integration	1 (yes), 0 (no)
Level of exclusivity	☐ 1 - Competitive environment	0
	☐ 2 - Not exclusive	0.2
	☐ 3 - Quite not exclusive	0.4
	☐ 4 - Somewhat exclusive	0.6
	☐ 5 - Rather Exclusive	0.8
	☐ 6 - Exclusive	1

Annex B

Table B.5. 1: Necessity analysis of the 'general level of project's perceived success' outcome for the mixed cases sample

Conditions	**General level of project's perceived success**	
	Presence	**Absence**
High Total investments	0.65 (0.73)	0.68 (0.33)
Low Total investments	0.41 (0.74)	0.45 (0.36)
High Contract Duration	0.57 (0.68)	0.59 (0.32)
Low Contract Duration	0.43 (0.70)	0.41 (0.30)
High Reliability (scale)	0.70 (0.81)	0.39 (0.19)
Low Reliability (scale)	0.30 (0.54)	0.61 (0.46)
High Availability (scale)	0.74 (0.80)	0.44 (0.20)
Low Availability (scale)	0.26 (0.51)	0.56 (0.49)
High Maintainability (scale)	0.47 (0.92)	0.34 (0.29)
Low Maintainability (scale)	0.64 (0.69)	**0.91 (0.43)**
High Safety (scale)	0.69 (0.84)	0.41 (0.21)
Low Safety (scale)	0.35 (0.58)	0.69 (0.49)
High Security (scale)	0.66 (0.79)	0.41 (0.21)
Low Security (scale)	0.34 (0.57)	0.59 (0.43)
High Regulatory risk allocation	0.21(0.82)	0.24(0.41)
Low Regulatory risk allocation	0.85(0.72)	**0.89(0.33)**
High Regulatory risk assessment	**0.91 (0.75)**	0.81(0.29)
Low Regulatory risk assessment	0.15 (0.65)	0.31(0.59)
High Regulatory risk mitigation	0.35(0.84)	0.44(0.45)
Low Regulatory risk mitigation	0.77(0.76)	0.84(0.36)
High Financial risk allocation	0.64(0.74)	0.64(0.32)
Low Financial risk allocation	0.41(0.74)	0.47(0.36)
High Financial risk assessment	0.81(0.82)	0.72(0.32)
Low Financial risk assessment	0.32(0.73)	0.59(0.58)
High Financial risk mitigation	0.43(0.66)	0.66(0.40)
Low Financial risk mitigation	0.57(0.79)	0.44(0.26)
High Revenue risk allocation	0.55(0.74)	0.51(0.29)
Low Revenue risk allocation	0.47(0.69)	0.54(0.34)
High Revenue risk assessment	0.66(0.79)	0.63(0.32)
Low Revenue risk assessment	0.43(0.73)	0.59(0.43)
High Revenue risk mitigation	0.45(0.79)	0.38(0.29)
Low Revenue risk mitigation	0.59(0.69)	0.72(0.36)
High Design risk allocation	0.66(0.73)	0.72(0.34)
Low Design risk allocation	0.41(0.77)	0.43(0.35)
High Design risk assessment	0.80(0.76)	0.77(0.29)
Low Design risk assessment	0.26(0.73)	0.37(0.42)
High Design risk mitigation	0.45(0.85)	0.59(0.49)
Low Design risk mitigation	0.73(0.81)	0.81(0.39)
High Construction risk allocation	0.82(0.73)	0.84(0.32)
Low Construction risk allocation	0.24(0.78)	0.31(0.43)
High Construction risk assessment	0.73(0.77)	0.66(030)
Low Construction risk assessment	0.34(0.69)	0.50(0.44)
High Construction risk mitigation	0.57(0.88)	0.59(0.40)
Low Construction risk mitigation	0.61(0.78)	0.81(0.45)
High Maintenance risk allocation	0.71(0.73)	0.68(0.31)
Low Maintenance risk allocation	0.33(0.71)	0.41(0.37)
High Maintenance risk assessment	0.91(0.72)	0.81(0.28)
Low Maintenance risk assessment	0.09(0.54)	0.19(0.46)
High Maintenance risk mitigation	0.43(0.80)	0.50(0.40)
Low Maintenance risk mitigation	0.68(0.76)	0.75(0.36)

High Exploitation risk allocation	0.51(0.72)	0.51(0.31)
Low Exploitation risk allocation	0.52(0.71)	0.56(0.33)
High Exploitation risk assessment	0.74(0.71)	0.88(0.36)
Low Exploitation risk assessment	0.34(0.86)	0.31(0.34)
High Exploitation risk mitigation	0.36(0.68)	0.50(.42)
Low Exploitation risk mitigation	0.69(0.76)	0.63(0.30)
High Force majeure risk allocation	0.37(0.80)	0.39(0.37)
Low Force majeure risk allocation	0.71(0.73)	0.78(0.35)
High Force majeure risk assessment	0.57(0.76)	0.53(0.31)
Low Force majeure risk assessment	0.49(0.71)	0.59(0.37)
High Force majeure risk mitigation	0.41(0.81)	0.41(0.35)
Low Force majeure risk mitigation	0.68(0.72)	0.78(0.36)
High Type of connection	0.76(0.71)	0.84(0.34)
Low Type of connection	0.31(0.82)	0.30(0.35)
High Node/link	0.30(0.70)	0.37(0.38)
Low Node/link	0.74(0.73)	0.71(0.30)
High Physical network integration	0.95(0.70)	0.94(0.30)
Low Physical network integration	0.05(0.67)	0.06(0.33)
High Operational network integration	0.38(0.70)	0.38(0.30)
Low Operational network integration	0.62(0.70)	0.63(0.30)
High Information integration	0.32(0.71)	0.31(0.29)
Low Information integration	0.68(0.69)	0.69(0.31)
High Authority integration	0.15(0.46)	0.41(0.54)
Low Authority integration	0.85(0.77)	0.59(0.23)
High Policy integration	0.43(0.70)	0.44(0.30)
Low Policy integration	0.57(0.70)	0.56(0.30)
High Level of exclusivity	0.70(0.81)	0.54(0.27)
Low Level of exclusivity	0.37(0.65)	0.63(0.48)

Table B.5. 2: Necessity analysis of the 'general level of project's perceived success' outcome for the privately co-financed cases sample

Conditions	**General level of project's perceived success**	
	Presence	**Absence**
High Total investments	0.65 (0.75)	0.74(0.32)
Low Total investments	0.39 (0.79)	0.37(0.29)
High Contract Duration	0.84(0.68)	1.0(0.32)
Low Contract Duration	0.16(1.0)	0.00(0.00)
High Reliability (scale)	0.71(0.80)	0.47(0.20)
Low Reliability (scale)	0.29(0.58)	0.53(0.42)
High Availability (scale)	0.80(0.76)	0.63(0.24)
Low Availability (scale)	0.20(0.59)	0.37(0.41)
High Maintainability (scale)	0.51(0.93)	0.42(0.30)
Low Maintainability (scale)	0.61(0.73)	0.89(0.41)
High Safety (scale)	0.69(0.79)	0.53(0.23)
Low Safety (scale)	0.33(0.64)	0.53(0.40)
High Security (scale)	0.69(0.77)	0.53(0.23)
Low Security (scale)	0.31(0.63)	0.47(0.38)
High Regulatory risk allocation	0.27(0.82)	0.33(0.38)
Low Regulatory risk allocation	0.79(0.75)	0.84(0.31)
High Regulatory risk assessment	**0.94(0.78)**	0.79(0.25)
Low Regulatory risk assessment	0.10 (0.56)	0.32(0.67)
High Regulatory risk mitigation	0.31(0.94)	0.21(0.25)
Low Regulatory risk mitigation	0.76(0.71)	0.95(0.35)
High Financial risk allocation	0.88(0.75)	0.89(0.30)
Low Financial risk allocation	0.17(0.81)	0.23(0.42)

High Financial risk assessment	0.82(0.85)	0.68(0.28)
Low Financial risk assessment	0.31(0.71)	0.63(0.57)
High Financial risk mitigation	0.49(0.75)	0.47(0.28)
Low Financial risk mitigation	0.53(0.72)	0.58(0.31)
High Revenue risk allocation	0.73(0.72)	0.81(0.31)
Low Revenue risk allocation	0.29(0.80)	0.25(0.27)
High Revenue risk assessment	0.71(0.85)	0.58(0.27)
Low Revenue risk assessment	0.39(0.70)	0.68(0.48)
High Revenue risk mitigation	0.51(0.81)	0.42(0.26)
Low Revenue risk mitigation	0.53(0.70)	0.68(0.35)
High Design risk allocation	0.85(0.75)	0.88(0.30)
Low Design risk allocation	0.22(0.83)	0.28(0.42)
High Design risk assessment	0.73(0.80)	0.63(0.27)
Low Design risk assessment	0.33(0.70)	0.53(0.43)
High Design risk mitigation	0.41(0.91)	0.42(0.36)
Low Design risk mitigation	0.71(0.76)	0.89(0.37)
High Construction risk allocation	0.89(0.74)	0.97(0.30)
Low Construction risk allocation	0.16(0.86)	0.19(0.41)
High Construction risk assessment	0.69(0.83)	0.63(0.29)
Low Construction risk assessment	0.41(0.74)	0.63(0.44)
High Construction risk mitigation	0.55(0.93)	0.47(0.31)
Low Construction risk mitigation	0.59(0.74)	0.89(0.44)
High Maintenance risk allocation	0.93(0.74)	0.96(0.29)
Low Maintenance risk allocation	0.07(0.82)	0.04(0.18)
High Maintenance risk assessment	0.92(0.76)	0.74(0.24)
Low Maintenance risk assessment	0.08(0.44)	0.26(0.56)
High Maintenance risk mitigation	0.39(0.86)	0.21(0.18)
Low Maintenance risk mitigation	0.63(0.67)	0.84(0.35)
High Exploitation risk allocation	0.67(0.70)	0.79(0.32)
Low Exploitation risk allocation	0.35(0.81)	0.25(0.23)
High Exploitation risk assessment	0.80(0.76)	0.84(0.31)
Low Exploitation risk assessment	0.29(0.82)	0.37(0.41)
High Exploitation risk mitigation	0.39(0.76)	0.37(0.28)
Low Exploitation risk mitigation	0.63(0.72)	0.68(0.30)
High Force majeure risk allocation	0.45(0.81)	0.43(0.30)
Low Force majeure risk allocation	0.61(0.74)	0.74(0.34)
High Force majeure risk assessment	0.53(0.74)	0.63(0.34)
Low Force majeure risk assessment	0.53(0.79)	0.53(0.30)
High Force majeure risk mitigation	0.41(0.91)	0.26(0.23)
Low Force majeure risk mitigation	0.65(0.70)	0.89(0.37)
High Type of connection	0.71(0.75)	0.74(0.30)
Low Type of connection	0.34(0.77)	0.39(0.34)
High Node/link	0.30(0.73)	0.38(0.37)
Low Node/link	0.74(0.76)	0.72(0.28)
High Physical network integration	0.96(0.71)	1.0(0.29)
Low Physical network integration	0.04(1.00)	0.00(0.00)
High Operational network integration	0.35(0.71)	0.37(0.29)
Low Operational network integration	0.65(0.73)	0.63(0.27)
High Information integration	0.31(0.63)	0.47(0.75)
Low Information integration	0.69(0.77)	0.53(0.23)
High Authority integration	0.06 (0.25)	0.47(0.75)
Low Authority integration	0.94(0.82)	0.53(0.18)
High Policy integration	0.45(0.69)	0.53(0.31)
Low Policy integration	0.55(0.75)	0.47(0.25)
High Level of exclusivity	0.72(0.88)	0.37(0.17)
Low Level of exclusivity	0.32(0.57)	0.74(0.51)

Table B.5. 3: Necessity analysis of the 'general level of project's perceived success' outcome for the publicly financed cases sample

Conditions	**General level of project's perceived success**	
	Presence	**Absence**
High Total investments	0.64(0.76)	0.54(0.33)
Low Total investments	0.44(0.65)	0.62(0.47)
High Reliability (scale)	0.64(0.84)	0.23(0.16)
Low Reliability (scale)	0.36(0.4)	0.77(0.53)
High Availability (scale)	0.64(0.89)	0.15(0.11)
Low Availability (scale)	0.36(0.45)	0.85(0.55)
High Maintainability (scale)	0.40(0.91)	0.23(0.27)
Low Maintainability (scale)	0.68(0.63)	0.92(0.44)
High Safety (scale)	0.68(0.94)	0.23(0.17)
Low Safety (scale)	0.40(0.50)	0.92(0.60)
High Security (scale)	0.60(0.83)	0.23(0.17)
Low Security (scale)	0.40(0.50)	0.77(0.50)
High Regulatory risk allocation	0.08(0.83)	0.12(0.67)
Low Regulatory risk allocation	0.97(0.68)	0.97(0.35)
High Regulatory risk assessment	0.84(0.70)	0.85(0.37)
Low Regulatory risk assessment	0.24(0.75)	0.31(0.50)
High Regulatory risk mitigation	0.44(0.73)	0.77(0.67)
Low Regulatory risk mitigation	0.80(0.87)	0.69(0.39)
High Financial risk allocation	**0.18(0.65)**	0.28(0.53)
Low Financial risk allocation	0.87(0.70)	0.82(0.34)
High Financial risk assessment	0.80(0.77)	0.77(0.38)
Low Financial risk assessment	0.36(0.75)	0.54(0.58)
High Financial risk mitigation	0.44(0.52)	0.92(0.57)
Low Financial risk mitigation	0.64(0.94)	0.23(0.17)
High Revenue risk allocation	0.19(0.92)	0.06(0.15)
Low Revenue risk allocation	0.82(0.63)	0.97(0.38)
High Revenue risk assessment	0.56(0.67)	0.69(0.43)
Low Revenue risk assessment	0.52(0.76)	0.46(0.35)
High Revenue risk mitigation	0.32(0.73)	0.31(0.36)
Low Revenue risk mitigation	0.72(0.67)	0.77(0.37)
High Design risk allocation	0.28(0.60)	0.48(0.53)
Low Design risk allocation	0.78(0.74)	0.65(0.32)
High Design risk assessment	0.92(0.70)	0.85(0.33)
Low Design risk assessment	0.12(0.60)	0.23(0.60)
High Design risk mitigation	0.52(0.76)	0.85(0.65)
Low Design risk mitigation	0.76(0.90)	0.69(0.43)
High Construction risk allocation	0.68(0.72)	0.69(0.38)
Low Construction risk allocation	0.42(0.72)	0.49(0.44)
High Construction risk assessment	0.80(0.69)	0.69(0.31)
Low Construction risk assessment	0.20(0.56)	0.31(0.44)
High Construction risk mitigation	0.60(0.79)	0.77(0.53)
Low Construction risk mitigation	0.64(0.84)	0.69(0.47)
High Maintenance risk allocation	0.27(0.89)	0.28(0.47)
Low Maintenance risk allocation	0.84(0.69)	0.94(0.40)
High Maintenance risk assessment	0.88(0.65)	0.92(0.35)
Low Maintenance risk assessment	0.12(0.75)	0.08(0.25)
High Maintenance risk mitigation	0.52(0.72)	0.92(0.67)
Low Maintenance risk mitigation	0.76(0.95)	0.62(0.40)
High Exploitation risk allocation	0.19(1.0)	0.09(0.25)
Low Exploitation risk allocation	0.86(0.64)	1.00 (0.39)
High Exploitation risk assessment	0.64(0.62)	0.92(0.46)

Low Exploitation risk assessment	0.44(0.92)	0.23(0.25)
High Exploitation risk mitigation	0.28(0.54)	0.69(0.69)
Low Exploitation risk mitigation	0.84(0.84)	0.54(0.28)
High Force majeure risk allocation	0.21(0.72)	0.34(0.61)
Low Force majeure risk allocation	0.89(0.72)	0.85(0.36)
High Force majeure risk assessment	0.64(0.80)	0.38(0.25)
Low Force majeure risk assessment	0.40(0.56)	0.69(0.50)
High Force majeure risk mitigation	0.40(0.67)	0.62(0.53)
Low Force majeure risk mitigation	0.72(0.78)	0.62(0.35)
High Type of connection	0.85(0.67)	0.9998(0.41)
Low Type of connection	0.24(0.997)	0.18(0.39)
High Node/link	0.29(0.65)	0.36(0.41)
Low Node/link	0.73(0.69)	0.70(0.34)
High Physical network integration	0.92(0.67)	0.85(0.32)
Low Physical network integration	0.08(0.50)	0.15(0.50)
High Operational network integration	0.44(0.69)	0.38(0.31)
Low Operational network integration	0.56(0.64)	0.62(0.36)
High Information integration	0.36(0.90)	0.08(0.100)
Low Information integration	0.64(0.57)	0.92(0.43)
High Authority integration	0.32(0.67)	0.31(0.33)
Low Authority integration	0.68(0.65)	0.69(0.35)
High Policy integration	0.40(0.71)	0.31(0.29)
Low Policy integration	0.60(0.63)	0.69(0.38)
High Level of exclusivity	0.60(0.70)	0.78(0.43)
Low Level of exclusivity	0.46(0.81)	0.46(0.42)

Annex C

Table C.5. 1: Solution paths of sufficiency analysis using a datasheet with missing values

Presence/ Absence of the outcome	**Sample**	**Model**	**Results /Paths**	**Scores** Raw coverage/ Unique coverage/ consistency	**Cases with greater than 0.5 membership**
Presence	Mixed sample analysis (max 4 conditions allowed for 15 cases out of 53 cases)	**Model 1** Model: success = f(total investments, contract duration, maintainability)[53]	No results: The 1 Matrix is empty.	x	x
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x
Presence	Mixed sample analysis	**Model 2a** Model: success = f(reliability, availability, safety, security)	safety*availability *reliability[54]	0.90 0.90 0.85	**20** (when 31/53 have full data) <u>Cases with greater than 0.5 membership in term</u>

[53] Same results are found if maintainability is not included in the model and only total investments and contract duration are included.
[54] No results for the parsimonious solution. Thus, no core conditions are found.

					safety*availability*reliability: 2Météor (1,1), Motorway ?-75 Section Horgos – Novi Sad (second phase) (1,1), Gardermobanen (Airport Exprestrain) (1,1), The Hague New Central Train Station (1,1), Combiplan Nijverdal (1,0.5), A5 Maribor - Pince Motorway (1,1), PORT OF AGAETE (1,1), E18 Muurla-Lohja (1,1), E4 Helsinki-Lahti (1,1), Larnaca and Paphos (Cyprus) International Airports (1,1), M-25 Motorway London Orbital (1,1), Metro De Malaga (1,0.5), Athens International Airport Eleftherios Venizelos (1,1), Elefsina Korinthos Patra Pyrgos Tsakona Motorway (1,0.5), M-45 (1,1), Eje Aeropuerto (M-12) (1,0), Radial 2 Toll Motorway (1,0.5), Metrolink LRT Manchester (1,1), A19 Dishforth to Tyne Tunnel (1,1), M80 Haggs (1,1)
Absence	Mixed sample analysis	Same model	No results: In the truth table, raw consistency < 0.75.	x	x
Presence	Mixed sample analysis	**Model 2b** success = f(availability, reliability)	**availability*reliability**[55]	0.93 0.93 0.85	**20** (when 33/53 have full data) Cases with greater than 0.5 membership in term reliability*availability: OW-plan Oostende- Integrated Coastal and Maritime Plan for Oostende (1,1), 2Météor (1,1), Motorway E-75 Section Donji Neradovac - Srpska kuca (1,0.5), Motorway ?-75 Section Horgos – Novi Sad (second phase) (1,1),

[55] Both conditions are core.

					Gardermobanen (Airport Exprestrain) (1,1), The Hague New Central Train Station (1,1), Combiplan Nijverdal (1,0.5), A5 Maribor - Pince Motorway (1,1), PORT OF AGAETE (1,1), E18 Muurla-Lohja (1,1), E4 Helsinki-Lahti (1,1), QUADRANTE EUROPA TERMINAL GATE (1,1), Larnaca and Paphos (Cyprus) International Airports (1,1), M-25 Motorway London Orbital (1,1), Metro De Malaga (1,0.5), Athens International Airport Eleftherios Venizelos (1,1), Elefsina Korinthos Patra Pyrgos Tsakona Motorway (1,0.5), M-45 (1,1), Eje Aeropuerto (M-12) (1,0), Radial 2 Toll Motorway (1,0.5)
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x
Presence	Mixed sample analysis	**Model 2c** Model: success = f(security, safety)	Security[56] Safety	0.96 0.08 0.82 0.92 0.04 0.85 Overall cov./cons: (1.00/0.82)	**23** <u>Cases with greater than 0.5 membership in term security:</u> 2Météor (1,1), Motorway E-75 Section Donji Neradovac - Srpska kuca (1,0.5), Motorway ?-75 Section Horgos – Novi Sad (second phase) (1,1), Athens Tramway (1,0.5), Gardermobanen (Airport Exprestrain) (1,1), The Hague New Central Train Station (1,1), Combiplan Nijverdal (1,0.5), A5 Maribor - Pince Motorway (1,1), PORT OF AGAETE (1,1), E18 Muurla-Lohja (1,1), E4 Helsinki-Lahti (1,1), QUADRANTE EUROPA TERMINAL GATE (1,1), Larnaca and Paphos

[56] No parsimonious solution and thus no core conditions (same for the safety solution path).

					(Cyprus) International Airports (1,1), 99.0 (1,1), M-25 Motorway London Orbital (1,1), Metro De Malaga (1,0.5), Athens International Airport Eleftherios Venizelos (1,1), Elefsina Korinthos Patra Pyrgos Tsakona Motorway (1,0.5), Istrian Y (1,1), M-45 (1,1) **20** **(when 32/53 have full data)** Cases with greater than 0.5 membership in term safety: 2Météor (1,1), Motorway ?-75 Section Horgos – Novi Sad (second phase) (1,1), Gardermobanen (Airport Exprestrain) (1,1), The Hague New Central Train Station (1,1), Combiplan Nijverdal (1,0.5), A5 Maribor - Pince Motorway (1,1), PORT OF AGAETE (1,1), E18 Muurla-Lohja (1,1), E4 Helsinki-Lahti (1,1), Larnaca and Paphos (Cyprus) International Airports (1,1), M-25 Motorway London Orbital (1,1), Metro De Malaga (1,0.5), Athens International Airport Eleftherios Venizelos (1,1), Elefsina Korinthos Patra Pyrgos Tsakona Motorway (1,0.5), M-45 (1,1), Eje Aeropuerto (M-12) (1,0), Radial 2 Toll Motorway (1,0.5), Metrolink LRT Manchester (1,1), A19 Dishforth to Tyne Tunnel (1,1), M80 Haggs (1,1)
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x
Presence	Mixed sample analysis	**Model 2d**	No results: The 1 Matrix is empty.	x	x

		Model: success = f(design, construction, maintenance, exploitation risk ALLOCATION) ***SAME FOR ASSESSMENT **(Model 2e)** & MITIGATION **(Model 2f)**			
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x
Presence	Mixed sample analysis	**Model 2g** Model: success = f(regulatory, financial, revenue, force majeure risk ALLOCATION) ***SAME FOR ASSESSMENT **(Model 2h)** & MITIGATION **(Model 2i)**	No results: The 1 Matrix is empty.	x	x
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x
Presence	Mixed sample analysis	**Model 3a** Model: success = f(type of connection, node/link, level of exclusivity)	No results: The 1 Matrix is empty.	x	x
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x
Presence	Mixed sample analysis	**Model 3b** Model: success = f(Physical integration, Operational integration, Information integration, Authority integration)	No results: The 1 Matrix is empty.	x	x
Absence	Same sample	Same model	No results: In the truth table, raw consistency < 0.75.	x	x

Presence	Mixed sample analysis	**Model 3c** Model: success = f(results of Model 3b and Policy Integration) *** Not applicable because model 3b gave no results	-	x	x
Absence	Same sample	Same model	-	x	x

Chapter 6

The annexes below present the calibration method, truth tables and the results of the necessity and sufficiency analysis of the fsQCA conducted and shown in the present chapter per sample and outcome (see Chapter 3 for further information about calibration).

Table A.6. 1: Necessity analysis of the 'on/below cost' outcome for the full sample

Conditions	**On/below cost**	
	Presence	**Absence**
High Institutional Context	0.78 (0.71)	0.65 (0.45)
Low Institutional Context	0.39 (0.60)	0.57 (0.66)
High Economic & Financial Context	0.59 (0.70)	0.57 (0.51)
Low Economic & Financial Context	0.59 (0.65)	0.66 (0.55)
High Governance	0.79 (0.72)	0.65 (0.44)
Low Governance	0.39 (0.60)	0.59 (0.68)
High Cost Saving	0.62 (0.75)	0.51 (0.46)
Low Cost Saving	0.56 (0.60)	0.72 (0.59)
High Remuneration Attractiveness	0.55 (0.64)	0.64 (0.55)
Low Remuneration Attractiveness	0.62 (0.69)	0.59 (0.49)
High Revenue Robustness	0.62 (0.63)	0.69 (0.52)
Low Revenue Robustness	0.53 (0.69)	0.52 (0.51)
High Financing Scheme	**0.8979** (0.65)	0.82 (0.45)
Low Financing Scheme	0.23 (0.64)	0.36 (0.72)

Table A.6. 2: Sufficiency analysis of projects being 'on/below cost' – full sample-with simplifying assumptions

	OUTCOME: Presence of On/below cost **with simplifying assumptions** (cons. cut off: 0.753061)	**With the exogenous & structural conditions plus the necessary cond. FSI** **With simplifying assumptions** (cons. cut off: 0.780946)	**With the exogenous & structural conditions plus the necessary cond. FSI** **<u>Excluding M-45</u>** **With simplifying assumptions** (cons. cut off: 0.804421)
Conditions	**Solution 1**		
INI	●	●	●
FEI			
GI	•	•	•
CSI	●	●	●
RAI	○		
RRI			
FSI	•	•	•
Individual Consistency	0.80	0.80	0.82
Coverage (Raw)	0.41	0.53	0.53
Coverage (Unique)	0.41	0.53	0.53
Number of cases	11	18	17
Relevant Cases	Metrolink LRT. Manchester (0.75,0.8), Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.69,0.8), FERTAGUS Train (0.67,1), Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.61,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), A22 motorway (0.59,0.8), A23 motorway (0.59,0.8), MST-Metro Sul do Tejo (0.55,0.8)	Metrolink LRT. Manchester (0.78,0.8), M-25 Orbital (0.75,0.8), Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.69,0.8), FERTAGUS Train (0.67,1), Deurganckdock Lock (0.66,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), Port of Leixoes (0.65,0.8), MST-Metro Sul do Tejo (0.65,0.8), Via-Invest Zaventem (0.64,1), M-45 (0.6,0), [57] E39 Orkdalsvegen Public Road (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), A23 motorway (0.59,0.8), A22 motorway (0.59,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), A-19 Dishforth (0.54,0.8)	Metrolink LRT. Manchester (0.78,0.8), M-25 Orbital (0.75,0.8), Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.69,0.8), FERTAGUS Train (0.67,1), Deurganckdock Lock (0.66,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), Port of Leixoes (0.65,0.8), MST-Metro Sul do Tejo (0.65,0.8), Via-Invest Zaventem (0.64,1), E39 Orkdalsvegen Public Road (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), A23 motorway (0.59,0.8), A22 motorway (0.59,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), A-19 Dishforth (0.54,0.8)
Overall Consistency/ Coverage	(0.80/0.41)	(0.80/0.53)	(0.82/0.53)

1) Black circle illustrates the presence of conditions and white circle indicates the absence of conditions. Large circles refer to core conditions and the small ones to peripheral conditions. Blank spaces show 'don't care'.
2) The Table A. includes only the intermediate solution.

[57] M-45 is a contradictory case, thus this case was excluded from the case data set and the model was re-examined.

Table A.6. 3: Sufficiency analysis of projects being 'over-cost' – full sample- with simplifying assumptions

	OUTCOME: Absence of On/below cost **with simplifying assumptions** (cons. cut off: 0.886326)		**With only the exogenous & structural conditions** **With simplifying assumptions** (cons. cut off: n.a.)	**With the exogenous & structural conditions plus the cond. FSI**[58] **With simplifying assumptions** (cons. cut off: 0.844538)	**With the exogenous & structural conditions plus the cond. FSI** **With simplifying assumptions** (cons. cut off: 0.845050)
Conditions	**Solution 1a**	**Solution 1b**			
INI		●	No solution found (consistency <0.75 in the intermediate solution)	●	
FEI	●				
GI		●			
CSI	○	○		○	○
RAI	○	○			
RRI					
FSI	◯	◯		◯	◯
Individual Consistency	0.87	0.84		0.82	0.87
Coverage (Raw)	0.28	0.31		0.34	0.33
Coverage (Unique)	0.002	0.32		0.34	0.33
Number of cases	1	1		4	3
Relevant Cases	C-16 Terrasa Manresa toll motorway (0.64,1)	C-16 Terrasa Manresa toll motorway (0.64,1)		Lyon's VeloV (0.72,1), C-16 Terrasa Manresa toll motorway (0.65,1), Muelle Costa Terminal Barcelona (0.62,0.2)[59] Barcelona Europe South Terminal (0.6,1)	Lyon's VeloV (0.79,1), C-16 Terrasa Manresa toll motorway (0.73,1), Barcelona Europe South [60]Terminal (0.6,1)
Overall Consistency/ Coverage	(0.85/0.31)			(0.82/0.34)	(0.87/0.33)

3) Black circle illustrates the presence of conditions and white circle indicates the absence of conditions. Large circles refer to core conditions and the small ones to peripheral conditions. Blank spaces show 'don't care'.
4) The Table A. includes only the intermediate solution.

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[58] The presence of the FSI is found to be necessary for the presence of the cost outcome to occur, not the absence that is tested here. However, it seems that also for the absence of the cost outcome is a relevant and core condition that is shown in two ways: firstly when it is not included in the analysis, no solution is found (see Table A.6.3, column 3) and secondly it is found as a core condition for the rest of the solution paths (see Table A.6.3).

[59] Muelle Costa Terminal Barcelona is a contradictory case, thus this case was excluded from the case data set and the model was re-examined.

[60] Apart from the Muelle Costa Terminal Barcelona case, also the case Piraeus Container terminal has been excluded. The reason why is that when initially the former contradictory case has been excluded, the solution found shows another contradictory case, being the Piraeus Container Terminal case. Thus, the sufficiency analysis has been conducted with 49 cases instead of 51 cases, with simplifying assumptions (absent conditions). 87% of the cases with ~CSI (peripheral) and ~FSI (core) display the absence of the cost outcome. Coverage equals 0.33.

Table A.6. 4: Necessity analysis of the 'on/below cost' outcome for the PPP sample

Conditions	On/below cost	
	Presence	**Absence**
High Institutional Context	0.81 (0.77)	0.75 (0.40)
Low Institutional Context	0.37 (0.72)	0.57 (0.63)
High Economic & Financial Context	0.60 (0.79)	0.60 (0.45)
Low Economic & Financial Context	0.58 (0.72)	0.72 (0.51)
High Governance	0.86 (0.76)	0.80 (0.40)
Low Governance	0.32 (0.74)	0.51 (0.68)
High Cost Saving	0.73 (0.80)	0.65 (0.40)
Low Cost Saving	0.45 (0.70)	0.68 (0.59)
High Remuneration Attractiveness	0.50 (0.76)	0.62 (0.53)
Low Remuneration Attractiveness	0.69 (0.77)	0.72 (0.45)
High Revenue Robustness	0.32 (0.72)	0.72 (0.47)
Low Revenue Robustness	0.53 (0.77)	0.56 (0.46)
High Financing Scheme	**0.8959** (0.74)	0.82 (0.38)
Low Financing Scheme	0.26 (0.72)	0.45 (0.71)

Table A.6. 5: Sufficiency analysis of projects being 'on-cost' – PPP sample- with simplifying assumptions

	OUTCOME: Presence of On/below cost **with simplifying assumptions** (cons. cut off: 0.754098) **(39 cases analysis)**	**OUTCOME: Presence of On/below cost** **with simplifying assumptions** (cons. cut off: 0.814930) **(35[61] cases analysis)**	**With the exogenous & structural conditions plus the necessary cond. FSI** **Excluding 4 contradictory cases more[62]** **(31 cases analysis)** **With simplifying assumptions** (cons. cut off: 0.912333)

[61] When re-testing the full model after excluding the three contradictory cases shown in solutions 1a and 1b of Table A.6.5, one more contradictory case has been found, being Moreas Motorway. Thus, four contradictory cases are now excluded and analysis is conducted with 35 cases instead of 39.

[62] When testing the reduced model INI, FEI, GI, CSI and FSI with the 35 cases used before, two contradictory cases more are found: Brabo 1 and Metro de Malaga. These two cases are excluded and the same model is tested with 33 cases this time. Lyon Velo case is found this time as a contradictory case. Thus, the model is now retested with 32 cases and Elefsina Korinthos Patra Pyrgos Tsakona Motorway is also found as a contradictory case. Hence, the model is tested with 31 cases, which gave the results presented in the last column of Table A.6.5.

Conditions	Solution 1a	Solution 1b	Solution 1a	Solution 1b	Solution 1c	Solution 1a	Solution 1b
INI	•	●	•		•		•
FEI	●		●				•
GI		•		•	•	•	
CSI		●		●	●		
RAI	○						
RRI				•			
FSI	•	•	●	•	•	●	●
Individual Consistency	0.81	0.83	0.91	0.90	0.92	0.95	0.97
Coverage (Raw)	0.46	0.59	0.57	0.46	0.59	0.77	0.57
Coverage (Unique)	0.07	0.21	0.12	0.04	0.06	0.24	0.04
Number of cases	11	18	14	11	17	20	14
Relevant Cases	E39 Orkdalsvegen Public Road (0.75,0.8), Larnaca and Paphos International Airports (0.72,0.8), BNRR (M6 Toll) (0.72,0.8), Eje Aeropuerto (M-12) Motorway (0.72,0), E4 Helsinki-Lahti (0.64,0.8), Port of Agaete (0.64,0.8), Herrentunnel Lübeck (0.63,0.8), Radial 2 Toll Motorway (0.62,0), Port of Sines Terminal XXI (0.59,1), Metro do Porto (0.56,1), MST-Metro Sul do Tejo (0.55,0.8)	Metrolink LRT. Manchester (0.78,0.8), M-25 Orbital (0.75,0.8), Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.69,0.8), FERTAGUS Train (0.67,1), Deurganckdock Lock (0.66,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), Port of Leixoes (0.65,0.8), MST-Metro Sul do Tejo (0.65,0.8), Via-Invest Zaventem (0.64,1), M-45 (0.6,0), E39 Orkdalsvegen Public Road (0.6,0.8), Herrentunnel Lübeck (0.6,0.8),	E18 Muurla-Lohja (0.86,0.8), E39 Orkdalsvegen Public Road (0.81,0.8), Larnaca and Paphos International Airports (0.72,0.8), BNRR (M6 Toll) (0.72,0.8), E4 Helsinki-Lahti (0.64,0.8), Port of Agaete (0.64,0.8), Herrentunnel Lübeck (0.63,0.8), Port of Sines Terminal XXI (0.59,1), Metro do Porto (0.56,1), MST-Metro Sul do Tejo (0.56,0.8), Reims tramway (0.56,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), A-19 Dishforth (0.54,0.8)	Larnaca and Paphos International Airports (0.75,0.8), Metrolink LRT. Manchester (0.75,0.8), Rion-Antirion Bridge (0.75,0.8), Lusoponte Vasco da Gama Bridge (0.74,0.8), Port of Leixoes (0.73,0.8), E4 Helsinki-Lahti (0.69,0.8), Deurganckdock Lock (0.66,0.8), MST-Metro Sul do Tejo (0.65,0.8), Central PT Depot of city of Pilsen (0.64,0.8), Athens International Airport (0.62,0.8),	Metrolink LRT. Manchester (0.78,0.8), M-25 Orbital (0.75,0.8), Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.69,0.8), FERTAGUS Train (0.67,1), Deurganckdock Lock (0.66,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), Port of Leixoes (0.65,0.8), MST-Metro Sul do Tejo (0.65,0.8), Via-Invest	Reims tramway (0.92,0.8), MST-Metro Sul do Tejo (0.89,0.8), Lusoponte Vasco da Gama Bridge (0.88,0.8), Port of Leixoes (0.84,0.8), E18 Muurla-Lohja (0.84,0.8), Athens International Airport (0.79,0.8), Rion-Antirion Bridge (0.78,0.8), Metrolink LRT. Manchester (0.78,0.8), FERTAGUS Train (0.78,1), Via-Invest Zaventem (0.78,1), Larnaca and Paphos Internationa	E18 Muurla-Lohja (0.86,0.8), E39 Orkdalsvegen Public Road (0.81,0.8), Larnaca and Paphos International Airports (0.72,0.8), BNRR (M6 Toll) (0.72,0.8), E4 Helsinki-Lahti (0.64,0.8), Port of Agaete (0.64,0.8), Herrentunnel Lübeck (0.63,0.8), Port of Sines Terminal XXI (0.59,1), Metro do Porto (0.56,1), MST-Metro Sul do Tejo (0.56,0.8), Reims tramway (0.56,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8),

		A23 motorway (0.59,0.8), A22 motorway (0.59,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), A-19 Dishforth (0.54,0.8)		E39 Orkdalsvegen Public Road (0.6,0.8)	Zaventem (0.64,1), E39 Orkdalsvegen Public Road (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), A23 motorway (0.59,0.8), A22 motorway (0.59,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), A-19 Dishforth (0.54,0.8)	l Airports (0.77,0.8), E4 Helsinki-Lahti (0.77,0.8), M-25 Orbital (0.75,0.8), BNRR (M6 Toll) (0.72,0.8), Deurganckdock Lock (0.7,0.8), A23 motorway (0.7,0.8), Central PT Depot of city of Pilsen (0.7,0.8), A22 motorway (0.7,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), Athens Ring Road (0.6,0.8)	A-19 Dishforth (0.54,0.8)
Overall Consistency/ Coverage	(0.82/0.66)		(0.92/0.75)			(0.95/0.81)	

Table A.6. 6: Sufficiency analysis of projects being 'over-cost' – PPP sample-with simplifying assumptions

	OUTCOME: Absence of On/below cost with simplifying assumptions (cons. cut off: 0.8822423) (37 cases)[63]	OUTCOME: Absence of On/below cost with simplifying assumptions (37 cases)[64] With the exogenous & structural conditions (cons. cut off: 0.770389)	**With the exogenous & structural conditions plus the necessary cond. FSI[65]** **With simplifying assumptions** (cons. cut off: 0.843077)
Conditions	**Solution 1**	**Solution 1**	**Solution 1**
INI			
FEI			

[63] When the full model has been tested for the over cost PPP sample analysis, two contradictory cases have been found, Muelle Costa Terminal Barcelona and Piraeus Container terminal. Thus, these two contradictory cases have been excluded and the same model has been tested for 37 cases.

[64] Two contradictory cases have been excluded: Muelle Costa Terminal Barcelona and Piraeus Container terminal.

[65] The presence of the FSI is found to be necessary for the presence of the cost outcome to occur, not the absence that is tested here. However, it seems that also for the absence of the cost outcome is a relevant and core condition (see Table A.6.6).

		◯	
GI		◯	
CSI	∘	∘	∘
RAI	∘		
RRI			
FSI	◯		◯
Individual Consistency	0.88	0.77	0.87
Coverage (Raw)	0.44	0.42	0.46
Coverage (Unique)	0.44	0.42	0.46
Number of cases	2	1	3
Relevant Cases	C-16 Terrasa Manresa toll motorway (0.73,1), Barcelona Europe South Terminal (0.6,1)	Barcelona Europe South Terminal (0.6,1)	Lyon's VeloV (0.79,1), C-16 Terrasa Manresa toll motorway (0.73,1), Barcelona Europe South Terminal (0.6,1)
Overall Consistency/ Coverage	(0.88/0.44)	(0.77/0.42)	(0.87/0.46)

Table A.6. 7: Necessity analysis of the 'on/below cost' outcome for the road sample

Conditions	**On/below cost**	
	Presence	**Absence**
High Institutional Context	**0.78** (0.69)	0.55 (0.42)
Low Institutional Context	0.35 (0.47)	0.60 (0.70)
High Economic & Financial Context	0.60 (0.68)	0.50 (0.50)
Low Economic & Financial Context	0.56 (0.56)	0.68 (0.59)
High Governance	**0.82** (0.70)	0.60 (0.45)
Low Governance	0.36 (0.51)	0.60 (0.74)
High Cost Saving	0.63 (0.68)	0.55 (0.51)
Low Cost Saving	0.55 (0.59)	0.65 (0.61)
High Remuneration Attractiveness	0.69 (0.65)	0.62 (0.51)
Low Remuneration Attractiveness	0.48 (0.59)	0.58 (0.62)
High Revenue Robustness	0.53 (0.53)	0.66 (0.57)
Low Revenue Robustness	0.57 (0.66)	0.45 (0.45)
High Financing Scheme	**0.9067** (0.63)	0.80 (0.48)

Low Financing Scheme	0.25 (0.60)	0.38 (0.78)

Table A.6. 8: Sufficiency analysis of projects being 'on-cost' – road sample- with simplifying assumptions

	With the exogenous & structural conditions plus the necessary cond. FSI With simplifying assumptions (cons. cut off: 0.775244)
Conditions	
INI	●
FEI	●
GI	•
CSI	○
RAI	
RRI	
FSI	●
Individual Consistency	0.78
Coverage (Raw)	0.40
Coverage (Unique)	0.40
Number of cases	3
Relevant Cases	E18 Muurla-Lohja (0.73,0.8), BNRR (M6 Toll) (0.69,0.8), A5 Maribor Pince motorway (0.59,1)
Overall Consistency/Coverage	(0.78/0.40)

Table A.6. 9: Sufficiency analysis of projects being 'over-cost' – road sample - with simplifying assumptions

	With the exogenous & structural conditions With simplifying assumptions (cons. cut off: -)	With the exogenous & structural conditions plus the cond. FSI[66] With simplifying assumptions (cons. cut off: 0.807882)	**Model 1** **INI, GI, FSI, RAI, RRI** Excluding Athens ring road as contradictory With simplifying assumptions (cons. cut off: 0.931271)		**Model 2** **RAI, RRI, FSI, GI, CSI** With simplifying assumptions (cons. cut off: 0.796334)		**Model 3** **RAI, RRI, INI, FEI, FSI** Excluding Athens ring road as contradictory With simplifying assumptions (cons. cut off: 0.836364)		**Model 4** **RAI, RRI, FEI, GI, FSI** Excluding Athens ring road as contradictory With simplifying assumptions (cons. cut off: 0.906158)	
Conditions			**1a**	**1b**	**1a**	**1b**	**1a**	**1b**	**1a**	**1b**

[66] The presence of the FSI is found to be necessary for the presence of the cost outcome to occur, not the absence that is tested here. However, it seems that also for the absence of the cost outcome is a relevant and core condition that is shown in two ways: firstly when it is not included in the analysis, no solution is found (see Table A.6.9) and secondly it is found as a core condition in the solution paths in Table A.6.9.

INI	No solution found since the consistency was <0.75.		○					○		
FEI								◦		○
GI						○				
CSI		◦			◦	◦				
RAI			○	◦	◦		◦		◦	○
RRI						○		●		●
FSI		○		○	○		○		○	
Individual Consistency		0.83	0.85	0.88	0.86	0.81	0.88	0.87	0.88	0.91
Coverage (Raw)		0.37	0.39	0.36	0.36	0.43	0.36	0.47	0.36	0.32
Coverage (Unique)		0.37	0.12	0.09	0.11	0.18	0.16	0.27	0.14	0.10
Number of cases		1	2	1	1	2	1	4	1	2
Relevant Cases		C-16 Terrasa Manresa toll motorway (0.73,1)	Elefsina Korinthos Patra Pyrgos Tsakona Motorway (0.66,1), Moreas Motorway (0.66,1)	C-16 Terrasa Manresa toll motorway (0.75, 1)	C-16 Terrasa Manresa toll motorway (0.73,1)	Motorway E-75. Section Donji Neradovac - Srpska kuca (0.75, 1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.75, 1)	C-16 Terrasa Manresa toll motorway (0.75,1)	Motorway E-75. Section Donji Neradovac - Srpska kuca (0.75,1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.75,1), Elefsina Korinthos Patra Pyrgos Tsakona Motorway (0.72,1),	C-16 Terrasa Manresa toll motorway (0.75,1)	Elefsina Korinthos Patra Pyrgos Tsakona Motorway (0.66,1), Moreas Motorway (0.66,1)

								Moreas Motorway (0.72,1)		
Overall Consistency/ Coverage		(0.83/0.37)	(0.84/0.48)		(0.78/0.54)		(0.85/0.63)		(0.88/0.46)	

Table A.6. 10: Necessity analysis of the 'on/below cost' outcome for the crisis _before completion sample

Conditions	On/below cost	
	Presence	Absence
High Institutional Context	0.76 (0.71)	0.75 (0.45)
Low Institutional Context	0.40 (0.72)	0.50 (0.58)
High Economic & Financial Context	0.56 (0.66)	0.71 (0.53)
Low Economic & Financial Context	0.60 (0.76)	0.55 (0.45)
High Governance	0.80 (0.73)	0.72 (0.42)
Low Governance	0.37 (0.67)	0.54 (0.64)
High Cost Saving	0.70 (0.79)	0.59 (0.420
Low Cost Saving	0.49 (0.65)	0.70 (0.60)
High Remuneration Attractiveness	0.31 (0.65)	0.54 (0.72)
Low Remuneration Attractiveness	0.87 (0.75)	0.74 (0.41)
High Revenue Robustness	0.61 (0.67)	0.70 (0.49)
Low Revenue Robustness	0.54 (0.74)	0.53 (0.47)
High Financing Scheme	**0.94** (0.74)	0.72 (0.37)
Low Financing Scheme	0.19 (0.52)	0.49 (0.84)

Table A.6. 11: Sufficiency analysis of projects being 'on/below cost' - completed before GFC

	OUTCOME: Presence of On/below cost[67] With simplifying assumptions (cons. cut off: 0.790524)
Conditions	**Solution 1**
INI	●
FEI	○

[67] The projects that were completed before crisis and that were on cost (and below cost: 1 case) were 17/22.

GI	●
RAI	
FSI	●
Individual Consistency	0.78
Coverage (Raw)	0.49
Coverage (Unique)	0.49
Number of cases	5
Relevant Cases	**Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), A22 motorway (0.59,0.8), A23 motorway (0.59,0.8), FERTAGUS Train (0.56,1)**
Overall Consistency/Coverage	(0.78/**0.49**)

1) Black circle illustrates the presence of conditions and white circle indicates the absence of conditions. Large circles refer to core conditions and the small ones to peripheral conditions. Blank spaces show 'don't care'.
2) The Table A. includes only the intermediate solution.

Table A.6. 12: Sufficiency analysis of projects being 'over cost' - completed before GFC

	OUTCOME: Absence of On/below cost With simplifying assumptions (cons. cut off: 0.859813)
Conditions	**Solution 1**
INI	
FEI	
GI	
RAI	○
FSI	◯
Individual Consistency	**0.87**
Coverage (Raw)	0.45
Coverage (Unique)	0.45
Number of case	1
Some relevant cases	**C-16 Terrasa Manresa toll motorway (0.75,1)**
Overall Consistency/Coverage	(0.87/**0.45**)

1) Black circle illustrates the presence of conditions and white circle indicates the absence of conditions. Large circles refer to core conditions and the small ones to peripheral conditions. Blank spaces show 'don't care'.
2) The Table A. includes only the intermediate solution.

Table A.6. 13: Additional models tested

Additional Models	Involved projects	Included conditions (a)	Included conditions (b)	Included conditions (c)
1. Models for the presence of the 'cost' outcome	Sample of projects completed **before** the GFC	INI FEI GI FSI **CSI**	INI FEI GI FSI **RRI**	
2. Models for the absence of the 'cost' outcome	Sample of projects completed **before** the GFC	FSI RAI **CSI**	FSI RAI **RRI**	FSI RAI **RRI** **CSI**

Table A.6. 14: An overview of the solutions of both the initial and additional models for the 'before crisis'- cost analysis

Sample					
Model	**Initial solution**	**Solutions of the additional models** With simplifying assumptions (cons. cut off**:** 0.771144)	(cons. cut off: 0.76282)	With the exogenous & structural conditions **Plus necessary condition** FSI[68] (cons. cut off: 0.771144)	
		1a	**1b**		
Conditions	**+INI**		Same with the initial solution	See 1a model and solution path	
	~FEI	**~FEI**			
	+GI	+GI			
	+FSI	+FSI			
		+CSI			
Consistency	0.78	0.83			
Coverage (raw)	0.49	0.53			
Coverage (unique)	0.49	0.53			
Number of relevant cases	5	7			
Relevant cases	Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), A22 motorway (0.59,0.8), A23 motorway (0.59,0.8), FERTAGUS Train (0.56,1)	Lusoponte Vasco da Gama Bridge (0.78,0.8), Port of Leixoes (0.73,0.8), A22 motorway (0.7,0.8), A23 motorway (0.69,0.8), Athens International Airport (0.62,0.8), FERTAGUS Train (0.56,1),			

[68] This is the same model with the model 1a. This is the reason why the same solution path has been found. The difference is the approach based on which the model has been created. On the one hand, model 1a has been created using the findings of Table A.6.11 plus the CSI and on the other hand the same model has been created based on the approach of using the exogenous and structural conditions plus the (necessary) condition, being the FSI.

		Rion-Antirion Bridge (0.55,0.8)			
Sample					
Model	**Initial solution**	**Solutions of the additional models** With simplifying assumptions (cons. cut off: 0.864254)	(cons. cut off: 0.861111)	With the exogenous & structural conditions (cons. cut off: -)	With the exogenous & structural conditions **Plus necessary condition FSI**[69] (cons. cut off: 0.832215)
		2a	**2b**		
Conditions			Same with the initial solution	No solution was found. Consistency was <0.75.	
	~RAI	~RAI			
	~FSI	**~FSI**			**~FSI**
		~CSI			~CSI
Consistency	0.87	0.86			0.85
Coverage (raw)	0.45	0.44			0.48
Coverage (unique)	0.45	0.44			0.48
Number of relevant cases	1	1			2
Relevant cases	C-16 Terrasa Manresa toll motorway (0.75,1)	C-16 Terrasa Manresa toll motorway (0.73,1)			Lyon's VeloV (0.79,1), C-16 Terrasa Manresa toll motorway (0.73,1)

Table A.6. 15: Necessity analysis of the 'on/below cost' outcome for the crisis _after completion sample

Conditions	On/below cost	
	Presence	Absence
High Institutional Context	0.78 (0.78)	0.59 (0.39)
Low Institutional Context	0.40 (0.59)	0.68 (0.67)
High Economic & Financial Context	0.60 (0.82)	0.47 (0.43)
Low Economic & Financial Context	0.59 (0.62)	0.81 (0.57)

[69] FSI is a necessary condition for the presence of the outcome only but it seems a significant condition to display the absence of the outcome as well, because when FSI is not included in the model, no solution found and when it is included it is a core condition.

High Governance	0.80 (0.75)	0.67 (0.42)
Low Governance	0.60 (0.67)	0.60 (0.67)
High Cost Saving	0.55 (0.48)	0.74 (0.70)
Low Cost Saving	0.60 (0.67)	0.69 (0.51)
High Remuneration Attractiveness	0.74 (0.70)	0.73 (0.46)
Low Remuneration Attractiveness	0.42 (0.70)	0.52 (0.57)
High Revenue Robustness	0.67 (0.67)	0.73 (0.49)
Low Revenue Robustness	0.50 (0.74)	0.51 (0.50)
High Financing Scheme	0.86 (0.65)	**0.89** (0.45)
Low Financing Scheme	0.28 (0.79)	0.32 (0.59)

Table A.6. 16: Sufficiency analysis of projects being 'on/below cost' - completed after the GFC

	OUTCOME: Presence of On/below cost (cons. cut off: 0.819372)
Conditions	**Solution 1**
INI	⬤
FEI	⬤
GI	
RAI	
FSI	●
Individual Consistency	0.85
Coverage (Raw)	0.56
Coverage (Unique)	0.56
Number of cases	9
Some relevant cases	**E18 Muurla-Lohja (0.86,0.8), Larnaca and Paphos International Airports (0.72,0.8), Lyon's tramway T4 (0.62,0.8), A5 Maribor Pince motorway (0.59,1),MST-Metro Sul do Tejo (0.56,0.8), Reims tramway (0.56,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), Modlin Regional Airport (0.53,0.8)**
Overall Consistency/Coverage	(0.85/**0.56**)

1) Black circle illustrates the presence of conditions and white circle indicates the absence of conditions. Large circles refer to core conditions and the small ones to peripheral conditions. Blank spaces show 'don't care'.
2) The Table A. includes only the intermediate solution.

Table A.6. 17: Sufficiency analysis of projects being 'over cost' – completed after GFC

	OUTCOME: Absence of On/below cost (cons. cut off: 0.855346)
Conditions	**Solution 1**
INI	○
FEI	◦
GI	
RAI	○
FSI	●
Individual Consistency	**0.85**
Coverage (Raw)	0.41
Coverage (Unique)	0.41
Number of cases	1
Some relevant cases	**Moreas Motorway (0.66, 1)**
Overall Consistency/Coverage	(0.85 /**0.41**)

5) Black circle illustrates the presence of conditions and white circle indicates the absence of conditions. Large circles refer to core conditions and the small ones to peripheral conditions. Blank spaces show 'don't care'.
6) The table includes only the intermediate solution.

Table A.6. 18: Additional models tested

Additional Models	**Involved projects**	**Included conditions (a)**	**Included conditions (b)**	**Included conditions (c)**
3. Models for the presence of the 'cost' outcome	Sample of projects completed **after** the GFC	INI FEI FSI **CSI**	INI FEI FSI **RRI**	INI FEI FSI **CSI** **RRI**
4. Models for the absence of the 'cost' outcome	Sample of projects completed **after** the GFC	INI FEI RAI FSI **CSI**	INI FEI RAI FSI **RRI**	

Table A.6. 19: An overview of the solutions of both the initial and additional models – after crisis completion

Sample	**After crisis-ON/BELOW COST**			
Model	**Initial solution**	**Solutions of the additional models**		
		3a	**3b**	**3c**
		(cons. cut off: 0.829882	(cons. cut off: 0.787425)	(cons. cut off: 0.77634)
Conditions	**+INI**	Same with the initial solution	Same with the initial solution	Same with the initial solution
	+FEI			
	+FSI			
Consistency	0.85			
Coverage (raw)	0.56			
Coverage (unique)	0.56			
Number of relevant cases	9			
Relevant cases	E18 Muurla-Lohja (0.86,0.8), Larnaca and Paphos International Airports (0.72,0.8), Lyon's tramway T4 (0.62,0.8), A5 Maribor Pince motorway (0.59,1),MST-Metro Sul do Tejo (0.56,0.8), Reims tramway (0.56,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), Modlin Regional Airport (0.53,0.8)			
Sample	**After crisis-OVER COST**			
Model	**Initial solution**	**Solutions of the additional models**		
		4a1	**4a2**	**4b**
		(cons. cut off: 0.809313)		(cons. cut off: 0.87191)
Conditions	**~INI**	~INI		Same with the initial solution
	~FEI	**~FEI**	**~FEI**	
	~RAI	**~RAI**	**~RAI**	
	+FSI	**+FSI**	**+FSI**	
			~CSI	
Consistency	0.85	0.85	0.81	
Coverage (raw)	0.41	0.41	0.38	
Coverage (unique)	0.41	0.08	0.05	
Number of relevant cases	1	1	1	
Relevant cases	Moreas Motorway (0.66, 1)	Moreas Motorway (0.66,1)	Metro de Malaga (0.75,1)	
Overall Consistency/Coverage		(0.84/0.46)		

Note: + means that condition is present; ~ means that condition is absent; bold means that it is a core condition, while non-bold refers to peripheral conditions.

Table A.6. 20: Necessity analysis of the 'on/below time' outcome for the full sample

Conditions	On/below time	
	Presence	Absence
High Institutional Context	0.81 (0.64)	0.62 (0.50)
Low Institutional Context	0.37 (0.48)	0.55 (0.75)
High Economic & Financial Context	0.61 (0.63)	0.52 (0.56)
Low Economic & Financial Context	0.56 (0.53)	0.65 (0.63)
High Governance	0.85 (0.66)	0.60 (0.48)
Low Governance	0.34 (0.45)	0.58 (0.80)
High Cost Saving	0.66 (0.68)	0.47 (0.50)
Low Cost Saving	0.52 (0.49)	0.71 (0.68)
High Remuneration Attractiveness	0.49 (0.49)	0.66 (0.69)
Low Remuneration Attractiveness	0.68 (0.66)	0.51 (0.51)
High Revenue Robustness	0.66 (0.57)	0.63 (0.57)
Low Revenue Robustness	0.51 (0.57)	0.52 (0.61)
High Financing Scheme	**0.86** (0.53)	0.85 (0.55)
Low Financing Scheme	0.27 (0.64)	0.28 (0.67)

Sufficiency analysis

Table A.6. 21: Sufficiency analysis of projects being 'on/below time' – full sample

	OUTCOME: Presence of On/below time With simplifying assumptions (cons. cut off: 0.776351)
Conditions	Solution 1
INI	⬤
GI	•
CSI	⬤
RAI	○
FSI	•
Individual Consistency	0.78
Coverage (Raw)	0.46
Coverage (Unique)	0.46

Number of cases	11
Relevant Cases	**Metrolink LRT. Manchester (0.75,0.8), Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.69,1), FERTAGUS Train (0.67,0.8), Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.61,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), A22 motorway (0.59,0.8), A23 motorway (0.59,0.8), MST-Metro Sul do Tejo (0.55,0.8)**
Overall Consistency/Coverage	(0.78/0.46)

Table A.6. 22: Sufficiency analysis of projects being 'over time' – full sample (same results also for the model including only the exogenous & structural conditions)

	OUTCOME: Absence of On/below time With simplifying assumptions (cons. cut off: 0.869616)
Conditions	**Solution 1**
INI	◯
FEI	○
GI	◯
CSI	○
RAI	
RRI	
FSI	
Individual Consistency	0.85
Coverage (Raw)	0.41
Coverage (Unique)	0.41
Number of cases	3
Relevant Cases	**Motorway E-75. Section Donji Neradovac - Srpska kuca (0.84,1), Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.78,1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.78,1)**
Overall Consistency/Coverage	(0.85/0.41)

Table A.6. 23: Necessity analysis of the 'time' outcome for the PPP sample

Conditions	**On/below time**	
	Presence	**Absence**
High Institutional Context	0.82 (0.73)	0.71 (0.42)
Low Institutional Context	0.35 (0.64)	0.56 (0.67)
High Economic & Financial Context	0.61 (0.76)	0.54 (0.45)
Low Economic & Financial Context	0.56 (0.65)	0.72 (0.55)
High Governance	0.85 (0.72)	0.75 (0.43)
Low Governance	0.33 (0.67)	0.52 (0.69)
High Cost Saving	0.68 (0.75)	0.60 (0.44)
Low Cost Saving	0.50 (0.65)	0.67 (0.58)
High Remuneration Attractiveness	0.48 (0.71)	0.55 (0.55)
Low Remuneration Attractiveness	0.70 (0.70)	0.71 (0.47)
High Revenue Robustness	0.66 (0.69)	0.69 (0.48)
Low Revenue Robustness	0.50 (0.70)	0.55 (0.52)
High Financing Scheme (NEW)	0.85 (0.69)	0.78 (0.42)
Low Financing Scheme (NEW)	0.29 (0.66)	0.43 (0.66)

Table A.6. 24: Sufficiency analysis of projects being 'on-time' – PPP sample

	OUTCOME: Presence of On/below time With simplifying assumptions (cons. cut off: 0.775309)	**OUTCOME: Presence of On/below time** With simplifying assumptions **Only with the exogenous & structural conditions** (cons. cut off: 0.7854)	**OUTCOME: Presence of On/below time With simplifying assumptions Only with the exogenous & structural conditions** **Excluding Reims tramway** (cons. cut off: 0.804572)
Conditions	**Solution 1**	**Solution 1**	**Solution 1**
INI	•	•	•
FEI	●	●	●
GI	•	●	●
CSI	●		
RAI	○		
RRI			
FSI	•		
Individual Consistency	0.80	0.79	0.82

Coverage (Raw)	0.38	0.56	0.56
Coverage (Unique)	0.38	0.56	0.56
Number of cases	5	14	13
Relevant Cases	Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.64,1), E39 Orkdalsvegen Public Road (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), MST-Metro Sul do Tejo (0.55,0.8)	E18 Muurla-Lohja (0.84,0.8), Larnaca and Paphos International Airports (0.78,0.8), BNRR (M6 Toll) (0.73,0.8), Central PT Depot of city of Pilsen (0.7,1), E4 Helsinki-Lahti (0.64,1), A-19 Dishforth (0.63,0.8), C-16 Terrasa Manresa toll motorway (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), M-45 (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), M-80 (Haggs) (0.56,0.8), MST-Metro Sul do Tejo (0.56,0.8), Reims tramway (0.56,0)[70], Lyon's VeloV (0.56,0.8)	E18 Muurla-Lohja (0.84,0.8), BNRR (M6 Toll) (0.73,0.8), Larnaca and Paphos International Airports (0.72,0.8), E4 Helsinki-Lahti (0.64,1), A-19 Dishforth (0.63,0.8), C-16 Terrasa Manresa toll motorway (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), M-45 (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), M-80 (Haggs) (0.56,0.8), MST-Metro Sul do Tejo (0.56,0.8), Central PT Depot of city of Pilsen (0.56,1), Lyon's VeloV (0.56,0.8)
Overall Consistency/Coverage	(0.80/0.38)	(0.79/0.56)	(0.82/0.56)

Table A.6. 25: Sufficiency analysis of projects being 'over-time' – PPP sample

	OUTCOME: Absence of On/below time With simplifying assumptions (cons. cut off: 0.797274)	**OUTCOME: Absence of On/below time** With simplifying assumptions **Only with the exogenous & structural conditions** (cons. cut off: -)	**OUTCOME: Absence of On/below time With simplifying assumptions Testing the five conditions with highest scores of necessity consistency** (cons. cut off: 0.798219)
Conditions	**Solution 1**	**Solution 1**	**Solution 1**
INI	◯	No solution was found. Consistency was <0.75.	◯
FEI	○		○
GI			
CSI	○		
RAI	○		○
RRI			
FSI	◯		◯
Individual Consistency	0.80		0.80
Coverage (Raw)	0.34		0.35
Coverage (Unique)	0.34		0.35
Number of cases	1		1

[70] This is a contradictory case because it explains the on time outcome, while this case was over time. Therefore, the analysis is re-done after excluding this case.

Relevant Cases	Piraeus Container Terminal (0.67,1)		Piraeus Container Terminal (0.67,1)
Overall Consistency/Coverage	(0.80/0.34)		(0.80/0.35)

Table A.6. 26: Necessity analysis of the 'on/below time' outcome for the road sample

Conditions	**On/below time**	
	Presence	**Absence**
High Institutional Context	**0.87** (0.65)	0.52 (0.47)
Low Institutional Context	0.29 (0.33)	0.62 (0.85)
High Economic & Financial Context	0.68 (0.66)	0.43 (0.50)
Low Economic & Financial Context	0.49 (0.42)	**0.71** (0.73)
High Governance	0.**88** (0.64)	0.57 (0.50)
Low Governance	0.31 (0.38)	0.58 (0.85)
High Cost Saving	0.70 (0.64)	0.50 (0.54)
Low Cost Saving	0.50 (0.45)	0.67 (0.73)
High Remuneration Attractiveness	0.56 (0.45)	**0.73** (0.71)
Low Remuneration Attractiveness	0.64 (0.66)	0.44 (0.54)
High Revenue Robustness	0.51 (0.43)	0.66 (0.67)
Low Revenue Robustness	0.61 (0.60)	0.44 (0.52)
High Financing Scheme	**0.82** (0.5)	0.**88** (0.62)
Low Financing Scheme	0.36 (0.72)	0.27 (0.64)

Table A.6. 27: Sufficiency analysis of projects being 'on-time' – road sample

	With the exogenous & structural conditions With simplifying assumptions (cons. cut off: -)	With the exogenous & structural conditions plus the cond. FSI which is not necessary but had the highest consistency score in the necessity analysis among RAI & RRI With simplifying assumptions (cons. cut off: 0.768473)
Conditions		
INI	No solution found since raw consistency was <0.75.	●
FEI		●
GI		●
CSI		

RAI		
RRI		
FSI		○
Individual Consistency		0.77
Coverage (Raw)		0.34
Coverage (Unique)		0.34
Number of cases		1
Relevant Cases		C-16 Terrasa Manresa toll motorway (0.6,0.8)
Overall Consistency/ Coverage		(0.77/0.34)

Table A.6. 28: Sufficiency analysis of projects being 'over-time' – road sample

	With the exogenous & structural conditions With simplifying assumptions (cons. cut off: 0.906793)	With the exogenous & structural conditions plus the cond. FSI . With simplifying assumptions (cons. cut off: 0.927302)
Conditions		
INI	○	Same solution path
FEI	○	
GI	○	
CSI	○	
RAI		
RRI		
FSI		
Individual Consistency	0.91	
Coverage (Raw)	0.48	
Coverage (Unique)	0.48	
Number of cases	3	
Relevant Cases	Motorway E-75. Section Donji Neradovac - Srpska kuca (0.84,1), Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.78,1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.78,1)	

Overall Consistency/ Coverage	(0.91/0.48)	

Table A.6. 29: Necessity analysis of the ‘on/below time’ outcome for the before crisis completion-sample

Conditions	On/below time	
	Presence	Absence
High Institutional Context	0.79 (0.85)	**0.83** (0.37)
Low Institutional Context	0.41 (0.86)	0.65 (0.56)
High Economic & Financial Context	0.59 (0.81)	**0.82** (0.46)
Low Economic & Financial Context	0.61 (0.89)	0.65 (0.39)
High Governance	**0.84** (0.89)	0.73 (0.32)
Low Governance	0.36 (0.77)	0.75 (0.65)
High Cost Saving	0.67 (0.87)	0.74 (0.40)
Low Cost Saving	0.54 (0.83)	0.77 (0.49)
High Remuneration Attractiveness	0.37 (0.88)	0.57 (0.56)
Low Remuneration Attractiveness	0.82 (0.82)	**0.88** (0.36)
High Revenue Robustness	0.67 (0.85)	0.72 (0.37)
Low Revenue Robustness	0.51 (0.81)	0.72 (0.47)
High Financing Scheme (NEW)	0.87 (0.80)	**0.896** (0.34)
Low Financing Scheme (NEW)	0.28 (0.87)	0.46 (0.59)

Table A.6. 30: Sufficiency analysis of projects being ‘on-time’ – ‘completed before crisis’ sample

	1st model With the exogenous & structural conditions With simplifying assumptions (cons. cut off: 0.843478)	2nd model With the exogenous & structural conditions plus the cond. FSI With simplifying assumptions (cons. cut off: 0.837174)		3rd model The 5 conditions with the highest necessity consistency	4th model The 5 conditions with the highest necessity consistency (replacing RAI with RRI) (cons. cut off: 0.818444)		
Conditions		**Solution 1a**	**Solution 1b**		**Solution 2a**	**Solution 2b**	**Solution 2c**
INI			•	Same solution with solutions 1a & 1b		•	•
FEI			•				•
GI	●	●	●		●	●	●

CSI							
RAI							
RRI					●		●
FSI		●			●	●	
Individual Consistency	0.89	0.89	0.86		0.87	0.88	0.84
Coverage (Raw)	0.84	0.74	0.53		0.53	0.32	0.41
Coverage (Unique)	0.84	0.26	0.05		0.08	0.17	0.05
Number of cases	17	15	8		9	11	5
Relevant Cases	Lusoponte Vasco da Gama Bridge (0.92,0.8), BNRR (M6 Toll) (0.89,0.8), Lyon's VeloV (0.84,0.8), Port of Leixoes (0.84,0.8), E4 Helsinki-Lahti (0.84,1), Athens International Airport (0.84,0.8), Athens Ring Road (0.78,0.8), FERTAGUS Train (0.78,0.8), A-19 Dishforth (0.78,0.8), Rion-Antirion Bridge (0.78,1), A23 motorway (0.7,0.8), A22 motorway (0.7,0.8), C-16 Terrasa Manresa toll motorway (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), M-45 (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), Athens Tramway (0.57,0.8)	Lusoponte Vasco da Gama Bridge (0.88,0.8), Port of Leixoes (0.84,0.8), Athens International Airport (0.79,0.8), FERTAGUS Train (0.78,0.8), Rion-Antirion Bridge (0.78,1), E4 Helsinki-Lahti (0.77,1), BNRR (M6 Toll) (0.72,0.8), A22 motorway (0.7,0.8), A23 motorway (0.7,0.8), Athens Ring Road (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), M-45 (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), Athens Tramway (0.57,0.8), A-19 Dishforth (0.54,0.8)	BNRR (M6 Toll) (0.73,0.8), E4 Helsinki-Lahti (0.64,1), A-19 Dishforth (0.63,0.8), C-16 Terrasa Manresa toll motorway (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), M-45 (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), Lyon's VeloV (0.56,0.8)		Athens International Airport (0.79,0.8), E4 Helsinki-Lahti (0.77,1), Port of Leixoes (0.75,0.8), Rion-Antirion Bridge (0.75,1), Lusoponte Vasco da Gama Bridge (0.74,0.8), BNRR (M6 Toll) (0.72,0.8), Athens Ring Road (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), Athens Tramway (0.57,0.8)	E4 Helsinki-Lahti (0.77,1), BNRR (M6 Toll) (0.72,0.8), FERTAGUS Train (0.67,0.8), Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), M-45 (0.6,0.8), Herrentunnel Lübeck (0.6,0.8), A22 motorway (0.59,0.8), A23 motorway (0.59,0.8), A-19 Dishforth (0.54,0.8)	BNRR (M6 Toll) (0.73, 0.8), E4 Helsinki-Lahti (0.64, 1), C-16 Terrasa Manresa toll motorway (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,0.8), Lyon's VeloV (0.56, 0.8)
Overall Consistency/ Coverage	(0.89/0.84)	(0.90/0.79)			(0.90/0.75)		

Table A.6. 31: Sufficiency analysis of projects being 'over-time' – 'completed before crisis' sample

	Excluding INI, FEI **Without**[71] simplifying assumptions (cons. cut off: 0.79434)	Re-running the model after excluding the Contradictory case With simplifying assumptions (cons. cut off: 0.871739)
Conditions		
INI		
FEI		
GI	◯	Same solution path
CSI	◯	
RAI	○	
RRI	◯	
FSI	●	
Individual Consistency	0.79	0.87
Coverage (Raw)	0.66	0.65
Coverage (Unique)	0.66	0.65
Number of cases	2	1
Relevant Cases	Metro do Porto [72](0.7,0.2), Port of Sines Terminal XXI (0.64,1)	Port of Sines Terminal XXI (0.64,1)
Overall Consistency/ Coverage	(0.79/0.66)	(0.86/0.65)

Table A.6. 32: Necessity analysis of the 'on/below cost' outcome for the crisis-after completion sample

Conditions	**On/below time**	
	Presence	**Absence**
High Institutional Context	**0.86** (0.54)	0.53 (0.55)
Low Institutional Context	0.29 (0.27)	0.56 (0.87)
High Economic & Financial Context	0.65 (0.57)	0.39 (0.56)

[71] This sufficiency analysis has been conducted without simplifying assumptions due to the necessity analysis findings that show that the presence of FSI explains the absence of the time outcome.
[72] This is a contradictory case because it is on time but explains the over time outcome. This is the reason why the model is re-tested after excluding this case from the sample. Thus not 22 but 21 cases are tested.

Low Economic & Financial Context	0.50 (0.33)	**0.70** (0.77)
High Governance	**0.86** (0.51)	0.60 (0.59)
Low Governance	0.30 (0.31)	0.50 (0.85)
High Cost Saving	0.64 (0.52)	0.44 (0.59)
Low Cost Saving	0.49 (0.35)	0.64 (0.75)
High Remuneration Attractiveness	0.69 (0.41)	**0.70** (0.68)
Low Remuneration Attractiveness	0.46 (0.48)	0.40 (0.68)
High Revenue Robustness	0.63 (0.40)	0.66 (0.69)
Low Revenue Robustness	0.51 (0.47)	0.43 (0.66)
High Financing Scheme (NEW)	**0.84** (0.40)	0.82 (0.65)
Low Financing Scheme (NEW)	0.27 (0.47)	0.25 (0.73)

Table A.6. 33: Sufficiency analysis of projects being 'on-time' – 'completed after crisis' sample

	With the exogenous & structural conditions With simplifying assumptions (cons. cut off: -)	The 5 conditions with the highest necessity consistency	The 5 conditions with the highest necessity consistency (replacing RAI with RRI)	The 5 conditions with the highest necessity consistency (replacing RAI with CSI)
Conditions				
INI	No results are found because consistency in the truth Table is <0.75.	No results are found because consistency in the truth Table is <0.75.	No results are found because consistency in the truth table is <0.75.	No results are found because consistency in the truth table is <0.75.
FEI				
GI				
CSI				
RAI				
RRI				
FSI				
Individual Consistency				
Coverage (Raw)				
Coverage (Unique)				
Number of cases				
Relevant Cases				
Overall Consistency/Coverage				

Table A.6. 34: Sufficiency analysis of projects being 'over-time' – 'completed after crisis' sample

	Model 1 With the exogenous & structural conditions With simplifying assumptions (cons. cut off: 0.817114)	**Model 2** The 5 conditions with the highest necessity consistency (cons. cut off: 0.891691	**Model 3a** The 5 conditions with the highest necessity consistency (replacing RAI with RRI) (cons. cut off: 0.819572)	**Model 3b** The 5 conditions with the highest necessity consistency (replacing RAI with CSI) (cons. cut off: 0.826816)
Conditions				
INI	○	○	○	○
FEI	○	◦	○	○
GI		○		
CSI				
RAI				
RRI				
FSI				●
Individual Consistency	0.88	0.88	0.88	0.89
Coverage (Raw)	0.52	0.43	0.52	0.49
Coverage (Unique)	0.52	0.43	0.52	0.49
Number of cases	5	3	5	4
Relevant Cases	Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.88,1), Motorway E-75. Section Donji Neradovac - Srpska kuca (0.88,1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.78,1), Moreas Motorway (0.72,1), Piraeus Container Terminal (0.67,1)	Motorway E-75. Section Donji Neradovac - Srpska kuca (0.88,1), Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.78,1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.78,1)	Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.88,1), Motorway E-75. Section Donji Neradovac - Srpska kuca (0.88,1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.78,1), Moreas Motorway (0.72,1), Piraeus Container Terminal (0.67,1)	Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.88,1), Motorway E-75. Section Donji Neradovac - Srpska kuca (0.88,1), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.78,1), Moreas Motorway (0.72,1)
Overall Consistency/ Coverage	(0.88/0.52)	(0.88/0.44)		(0.89/0.49)

Table A.6. 35: Necessity analysis of the 'on/over traffic' outcome for the full sample

Conditions	**On/over traffic**	
	Presence	**Absence**
High Institutional Context	0.81 (0.67)	0.68 (0.55)
Low Institutional Context	0.46 (0.59)	0.60 (0.75)
High Economic & Financial Context	0.48 (0.76)	0.37 (0.57)
Low Economic & Financial Context	0.33 (0.76)	0.85 (0.62)
High Governance	0.80 (0.61)	0.74 (0.56)
Low Governance	0.42 (0.62)	0.48 (0.71)
High Cost Saving	**0.70** (0.68)	0.59 (0.57)
Low Cost Saving	0.56 (0.58)	0.67 (0.69)
High Remuneration Attractiveness	0.69 (0.71)	0.55 (0.56)
Low Remuneration Attractiveness	0.57 (0.56)	0.72 (0.70)
High Revenue Robustness	0.71 (0.63)	0.66 (0.57)
Low Revenue Robustness	0.51 (0.60)	0.57 (0.66)
High Financing Scheme (NEW)	0.86 (0.56)	**0.89** (0.57)
Low Financing Scheme (NEW)	0.33 (0.76)	0.31 (0.68)

Table A.6. 36: Sufficiency analysis of projects being 'on-traffic' – full sample

	OUTCOME: Presence of On/over traffic With simplifying assumptions (cons. cut off: 0.84)	
Conditions	**Solution 1**	**Solution 2**
INI	•	•
FEI		●
GI	•	•
CSI	●	
RAI	●	●
RRI		
FSI	•	•
Individual Consistency	0.85	0.89
Coverage (Raw)	0.47	0.37
Coverage (Unique)	0.15	0.05
Number of cases	6	4

Relevant Cases	M-25 Orbital (0.75,0.67), Via-Invest Zaventem (0.64,0.67), FERTAGUS Train (0.59,0.67), Central PT Depot of city of Pilsen (0.56,0.67), M-80 (Haggs) (0.55,0.67), A-19 Dishforth (0.54,0.67)	E18 Muurla-Lohja (0.75,0.67), Lyon's tramway T4 (0.56,1), Central PT Depot of city of Pilsen (0.56,0.67)
Overall Consistency/Coverage		(0.85/0.52)

Table A.6. 37: Sufficiency analysis of projects being 'below-traffic' – full sample

	OUTCOME: Absence of On/over traffic Without simplifying assumptions[73] (absent or present) (cons. cut off: 0.874092)
Conditions	**Solution 1**
INI	○
FEI	◦
GI	●
CSI	○
RAI	○
RRI	•
FSI	●
Individual Consistency	0.87
Coverage (Raw)	0.34
Coverage (Unique)	0.34
Number of cases	1
Relevant Cases	Athens International Airport (0.65,0.67), Athens Ring Road (0.65,0.67)
Overall Consistency/Coverage	(0.87/0.34)

73 This sufficiency analysis has been run without simplifying assumptions (i.e. assumptions the absence of the conditions will explain the absence of the outcome) because the presence of the FSI is a necessary condition for the absence of the outcome).

Table A.6. 38: Necessity analysis of the 'on/over traffic' outcome for the PPP sample

Conditions	On/over traffic	
	Presence	**Absence**
High Institutional Context	**0.86** (0.68)	0.77 (0.56)
Low Institutional Context	0.44 (0.67)	0.56 (0.79)
High Economic & Financial Context	0.52 (0.79)	0.41 (0.58)
Low Economic & Financial Context	0.72 (0.57)	**0.85** (0.62)
High Governance	**0.85** (0.62)	0.83 (0.56)
Low Governance	0.40 (0.72)	0.43 (0.72)
High Cost Saving	**0.76** (0.70)	0.64 (0.55)
Low Cost Saving	0.51 (0.60)	0.65 (0.72)
High Remuneration Attractiveness	0.65 (0.76)	0.55 (0.60)
Low Remuneration Attractiveness	0.66 (0.61)	**0.78** (0.67)
High Revenue Robustness	0.71 (0.65)	0.67 (0.57)
Low Revenue Robustness	0.52 (0.63)	0.58 (0.65)
High Financing Scheme (NEW)	0.84 (0.59)	**0.88** (0.57)
Low Financing Scheme (NEW)	0.38 (0.77)	0.36 (0.68)

Table A.6. 39: Sufficiency analysis of projects being 'on-traffic' – PPP sample

	OUTCOME: Presence of On/over traffic With simplifying assumptions (cons. cut off: 0.86)	
Conditions	**Solution 1**	**Solution 2**
INI	•	•
FEI		•
GI	•	•
CSI	●	
RAI	●	●
RRI		●
FSI	•	•
Individual Consistency	**0.87**	0.88
Coverage (Raw)	**0.51**	0.27
Coverage (Unique)	**0.28**	0.04
Number of cases	**6**	2

Relevant Cases	**M-25 Orbital (0.75,0.67), Via-Invest Zaventem (0.64,0.67), FERTAGUS Train (0.59,0.67), Central PT Depot of city of Pilsen (0.56,0.67), M-80 (Haggs) (0.55,0.67), A-19 Dishforth (0.54,0.67)**	**E18 Muurla-Lohja (0.75,0.67), Central PT Depot of city of Pilsen (0.56,0.67)**
Overall Consistency/Coverage	(0.87/**0.55**)	

Table A.6. 40: Sufficiency analysis of projects being 'below-traffic' – PPP sample

OUTCOME: Absence of On/over traffic With simplifying assumptions (cons. cut off: 0.83)				
Conditions	**Solution 1**	**Solution 2**	**Solution 3**	**Solution 4**
INI			◯	◯
FEI		∘	∘	∘
GI				●
CSI	◯	◯		∘
RAI		∘	∘	
RRI	◯			
FSI		◯	●	
Individual Consistency	**0.85**	0.83	0.85	0.83
Coverage (Raw)	**0.49**	0.28	0.52	0.52
Coverage (Unique)	**0.16**	0.03	0.001	0.004
Number of cases	**5**	2	4	4
Relevant Cases	**A22 motorway (0.8,1), A23 motorway (0.8,1), Metro do Porto (0.7,1), Reims tramway (0.67,0.67), Brabo 1 (0.56,0.33)**	C-16 Terrasa Manresa toll motorway (0.66,0.67), Barcelona Europe South Terminal (0.6,0.67)	Rion-Antirion Bridge (0.72,0.67), Moreas Motorway (0.66,0.67), Athens International Airport (0.65,0.67), Athens Ring Road (0.6,0.67)	Athens Ring Road (0.72,0.67), Rion-Antirion Bridge (0.72,0.67), Moreas Motorway (0.66,0.67), Athens International Airport (0.65,0.67)
Overall Consistency/ Coverage	(0.82/0.72)			

Table A.6. 41: Sufficiency analysis of projects being 'below-traffic' – PPP sample

OUTCOME: Absence of On/over traffic With simplifying assumptions (cons. cut off: 0.83)			
Conditions	**Solution 1**	**Solution 2**	**Solution 3**
INI			
FEI	○	○	
GI			○
CSI	○		○
RAI		○	○
FSI			
Individual Consistency	0.86	0.85	0.88
Coverage (Raw)	0.55	0.66	0.37
Coverage (Unique)	0.11	0.21	0.04
Number of cases	6	10	2
Relevant Cases	Athens International Airport (0.84,0.67), A22 motorway (0.84,1), A23 motorway (0.84,1), Barcelona Europe South Terminal (0.8,0.67), C-16 Terrasa Manresa toll motorway (0.66,0.67), Eje Aeropuerto (M-12) Motorway (0.53,1)	Larnaca and Paphos International Airports (0.75,0.67), Athens Ring Road (0.75,0.67), C-16 Terrasa Manresa toll motorway (0.75,0.67), Eje Aeropuerto (M-12) Motorway (0.75,1), Radial 2 Toll Motorway (0.75,1), Barcelona Europe South Terminal (0.75,0.67), Rion-Antirion Bridge (0.75,0.67), Moreas Motorway (0.66,0.67), Athens International Airport (0.65,0.67), MST-Metro Sul do Tejo (0.52,1)	Metro do Porto (0.78,1), Barcelona Europe South Terminal (0.6,0.67)
Overall Consistency/ Coverage	0.84/0.81		

Table A.6. 42: Necessity analysis of the 'on/over traffic' outcome for the road sample

Conditions	**On/over traffic**	
	Presence	**Absence**
High Institutional Context	**0.81** (0.64)	0.62 (0.53)
Low Institutional Context	0.40 (0.50)	0.58 (0.76)
High Economic & Financial Context	0.56 (0.86)	0.28 (0.46)
Low Economic & Financial Context	0.65 (0.46)	**0.91** (0.69)
High Governance	**0.78** (0.58)	0.72 (0.58)
Low Governance	0.43 (0.59)	0.47 (0.69)

High Cost Saving	0.71 (0.65)	0.59 (0.57)
Low Cost Saving	0.53 (0.54)	0.64 (0.70)
High Remuneration Attractiveness	**0.79** (0.64)	0.65 (0.56)
Low Remuneration Attractiveness	0.46 (0.55)	0.58 (0.75)
High Revenue Robustness	0.61 (0.57)	0.60 (0.60)
Low Revenue Robustness	0.57 (0.57)	0.57 (0.61)
High Financing Scheme (NEW)	**0.88** (0.57)	**0.83** (0.57)
Low Financing Scheme (NEW)	0.34 (0.65)	0.38 (0.77)

Table A.6. 43: Sufficiency analysis of projects being 'on-traffic' – road sample

OUTCOME: Presence of On/over traffic With simplifying assumptions (cons. cut off: 0.87)	
Conditions	**Solution 1**
INI	•
FEI	●
GI	•
RAI	
FSI	•
Individual Consistency	0.88
Coverage (Raw)	0.49
Coverage (Unique)	0.49
Number of cases	3
Relevant Cases	E18 Muurla-Lohja (0.84,0.67), E4 Helsinki-Lahti (0.77,1), E39 Orkdalsvegen Public Road (0.6,1)
Overall Consistency/ Coverage	(0.88/**0.49**)

Table A.6. 44: Sufficiency analysis of projects being 'below-traffic' – road sample

OUTCOME: Absence of On/over traffic With simplifying assumptions (cons. cut off: 0.90)		
Conditions	**Solution 1a**	**Solution 1b**
INI	◦	
FEI	○	○
GI		
RAI	○	○
FSI		◦

Individual Consistency	0.90	0.89
Coverage (Raw)	0.38	0.33
Coverage (Unique)	0.14	0.09
Number of cases	2	1
Relevant Cases	Athens Ring Road (0.72,0.67), Moreas Motorway (0.66,0.67)	C-16 Terrasa Manresa toll motorway (0.75,0.67)
Overall Consistency/ Coverage	(0.90/0.47)	

Table A.6. 45: Necessity analysis of the 'on/over traffic' outcome for the before crisis completion-sample

Conditions	On/over traffic	
	Presence	**Absence**
High Institutional Context	**0.85** (0.61)	0.68 (0.59)
Low Institutional Context	0.44 (0.53)	0.56 (0.81)
High Economic & Financial Context	0.46 (0.69)	0.31 (0.56)
Low Economic & Financial Context	0.71 (0.46)	**0.83** (0.65)
High Governance	**0.80** (0.53)	0.75 (0.60)
Low Governance	0.40 (0.57)	0.41 (0.71)
High Cost Saving	0.70 (0.66)	0.52 (0.58)
Low Cost Saving	0.55 (0.49)	0.69 (0.74)
High Remuneration Attractiveness	0.55 (0.69)	0.43 (0.65)
Low Remuneration Attractiveness	0.73 (0.52)	**0.80** (0.68)
High Revenue Robustness	0.72 (0.57)	0.63 (0.60)
Low Revenue Robustness	0.50 (0.53)	0.54 (0.70)
High Financing Scheme (NEW)	0.82 (0.49)	**0.84** (0.61)
Low Financing Scheme (NEW)	0.35 (0.65)	0.30 (0.66)

Table A.6. 46: Sufficiency analysis of projects being 'on-traffic' – completion before crisis sample

OUTCOME: Presence of On/over traffic With simplifying assumptions			
Conditions	**Model 1** **Solution 1** (cons. cut off: 0.79)	**Model 2** **Solution 1** (cons. cut off: 0.76)	**Model 3** **Solution 1** (cons. cut off: 0.76)
INI	•	•	•
FEI		●	●
RAI	●		
RRI		●	●
FSI			•
CSI	●		
Individual Consistency	0.81	0.77	0.76
Coverage (Raw)	0.47	0.36	0.30
Coverage (Unique)	0.47	0.36	0.30
Number of cases	2	3	2
Relevant Cases	A-19 Dishforth (0.75,0.67), FERTAGUS Train (0.59,0.67)	E4 Helsinki-Lahti (0.92,1), E39 Orkdalsvegen Public Road (0.75,1), Lyon's VeloV (0.56,1)	E4 Helsinki-Lahti (0.77,1), E39 Orkdalsvegen Public Road (0.75,1)
Overall Consistency/ Coverage	(0.81/0.47)	(0.77/0.36)	(0.76/0.30)

Table A.6. 47: Sufficiency analysis of projects being 'below-traffic' – completion before crisis sample

OUTCOME: Absence of On/over traffic With simplifying assumptions **(cons. Cut off: 0.80)**		
Conditions	**Solution 1**	**Solution 2**
INI	○	
FEI	∘	∘
GI		
RAI	∘	∘
FSI		○
Individual Consistency	**0.83**	0.79
Coverage (Raw)	0.54	0.27
Coverage (Unique)	0.33	0.06
Number of cases	4	1
Relevant Cases	**Athens Ring Road (0.72,0.67),Rion-Antirion Bridge (0.72,0.67), Athens**	**C-16 Terrasa Manresa toll motorway (0.75,0.67)**

	Tramway (0.71,1), Athens International Airport (0.65,0.67)	
Overall Consistency/ Coverage	**(0.82/0.60)**	

Table A.6. 48: Sufficiency analysis of projects being 'below-traffic' – completion before crisis sample (new model 1)

OUTCOME: Absence of On/over traffic With simplifying assumptions **(cons. cut off: 0.82)**			
Conditions	**Solution 1**	**Solution 2**	**Solution 3**
INI	○		
FEI	◦	◦	
CSI		○	○
RAI	◦		◦
RRI		○	○
Individual Consistency	**0.83**	0.84	0.85
Coverage (Raw)	0.54	0.44	0.40
Coverage (Unique)	0.20	0.09	0.05
Number of cases	4	2	1
Relevant Cases	Athens Ring Road (0.72,0.67),Rion-Antirion Bridge (0.72,0.67), Athens Tramway (0.71,1), Athens International Airport (0.65,0.67)	A22 motorway (0.8,1), A23 motorway (0.8,1)	Metro do Porto (0.7,1)
Overall Consistency/ Coverage	**(0.83/0.69)**		

Table A.6. 49: Necessity analysis of the 'on/over traffic' outcome for the crisis _after completion sample

Conditions	**On/over traffic**	
	Presence	**Absence**
High Institutional Context[74]	**0.78** (0.73)	0.68 (0.51)
Low Institutional Context	0.49 (0.66)	0.65 (0.70)
High Economic & Financial Context	0.50 (0.83)	0.44 (0.58)
Low Economic & Financial Context	0.75 (0.63)	**0.87** (0.58)
High Governance	**0.80** (0.70)	0.73 (0.51)

[74] In bold, we indicate the six conditions selected for our model because of their high consistencies.

Low Governance	0.44 (0.67)	0.58 (0.70)
High Cost Saving	0.70 (0.71)	0.69 (0.56)
Low Cost Saving	0.56 (0.69)	0.64 (0.63)
High Remuneration Attractiveness	**0.82** (0.73)	0.70 (0.50)
Low Remuneration Attractiveness	0.44 (0.65)	0.62 (0.73)
High Revenue Robustness	0.70 (0.69)	0.69 (0.54)
Low Revenue Robustness	0.53 (0.68)	0.61 (0.62)
High Financing Scheme (NEW)	0.89 (0.62)	**0.95** (0.53)
Low Financing Scheme (NEW)	0.32 (0.89)	0.32 (0.70)

Table A.6. 50: Sufficiency analysis of projects being 'on/over traffic' (cut off: 0.77)

OUTCOME: Presence of On/over traffic With simplifying assumptions **(cons. cut off: 0.77)**		
Conditions	**Solution 1**	**Solution 2**
INI		●
FEI		
GI	○	●
RAI	○	●
FSI		•
Individual Consistency	0.78	0.84
Coverage (Raw)	0.31	0.64
Coverage (Unique)	0.05	0.39
Number of cases	3	9
Relevant Cases	**Modlin Regional Airport (0.6,0), Barcelona Europe South Terminal (0.6,0.33)[75], Piraeus Container Terminal (0.6,1)**	E18 Muurla-Lohja (0.75,0.67), M-25 Orbital (0.75,0.67), Via-Invest Zaventem (0.75,0.67), Brabo 1 (0.75,0.67), Lyon's tramway T4 (0.72,1), **Reims[76] tramway (0.72,0.33),** Central PT Depot of city of Pilsen (0.56,0.67), M-80 (Haggs) (0.55,0.67), A5 Maribor Pince motorway (0.53,1)

[75] These are contradictory cases because although they are below traffic, they explain the on traffic outcome. Therefore, the analysis is re-made after excluding these cases.
[76] Contradictory case.

Overall Consistency/ Coverage	(0.79/0.70)

Table A.6. 51: Sufficiency analysis of projects being 'on/over traffic' – <u>after excluding the three contradictory cases</u> (cut off: 0.95)

OUTCOME: Presence of On/over traffic With simplifying assumptions **(cons. cut off: 0.95)**			
Conditions	**Solution 1**	**Solution 2**	**Solution 3**
INI			•
FEI			●
GI		○	•
RAI		○	•
FSI	○		
Individual Consistency	0.96	0.96	0.95
Coverage (Raw)	0.30	0.29	0.45
Coverage (Unique)	0.02	0.03	0.21
Number of cases	2	1	3
Relevant Cases	Piraeus Container Terminal (0.79,1), Liefkenshoek Rail Link (0.57,0.67)	Piraeus Container Terminal (0.6,1)	E18 Muurla-Lohja (0.75,0.67), Lyon's tramway T4 (0.56,1), Central PT Depot of city of Pilsen (0.56,0.67)
Overall Consistency/ Coverage	(0.96/0.58)		

Table A.6. 52: Sufficiency analysis of projects being 'below traffic' – <u>after excluding one contradictory case</u> Metro de Malaga (cut off: 0.89)

OUTCOME: Absence of On/over traffic Without simplifying assumptions (absent/present)	
Conditions	**Solution 1**
INI	○
FEI	∘
GI	●
RAI	○
FSI	●
Individual Consistency	0.89
Coverage (Raw)	0.40
Coverage (Unique)	0.40
Number of cases	1

Relevant Cases	Moreas Motorway (0.66,0.67)
Overall Consistency/ Coverage	(0.85/0.40)

Table A.6. 53: Necessity analysis of the 'on/over revenues' outcome for the full sample

Conditions	**On/over revenues**	
	Presence	**Absence**
High Institutional Context	0.73 (0.81)	0.68 (0.36)
Low Institutional Context	0.43 (0.73)	0.64 (0.53)
High Economic & Financial Context	0.39 (0.82)	0.42 (0.43)
Low Economic & Financial Context	0.30 (0.92)	0.82 (0.39)
High Governance	0.75 (0.77)	0.78 (0.39)
Low Governance	0.40 (0.79)	0.53 (0.51)
High Cost Saving	0.62 (0.81)	0.61 (0.38)
Low Cost Saving	0.53 (0.74)	0.70 (0.47)
High Remuneration Attractiveness	0.56 (0.77)	0.67 (0.45)
Low Remuneration Attractiveness	0.60 (0.79)	0.65 (0.41)
High Revenue Robustness	0.71 (0.84)	0.57 (0.32)
Low Revenue Robustness	0.43 (0.67)	0.73 (0.55
High Financing Scheme (NEW)	0.82 (0.72)	**0.95** (0.40)
Low Financing Scheme (NEW)	0.30 (0.92)	0.32 (0.47)

Table A.6. 54: Sufficiency analysis of projects being 'on/over revenues' (cut off: 0.89)

Conditions	OUTCOME: presence of 'on/over revenues'		
	Solution 1	Solution 2	Solution 3
INI	•	●	•
FEI			●
GI	●	●	•
CSI		○	●
RAI		○	●
RRI	•	•	●
FSI	○		

Individual Consistency	0.91	0.85	0.91
Coverage (Raw)	0.22	0.27	0.17
Coverage (Unique)	0.03	0.08	0.03
Number of cases	4	1	1
Some relevant cases	**BNRR (M6 Toll) (0.75,0.8),** **Lyon's VeloV (0.72,1), C-16 Terrasa Manresa toll motorway (0.6,0.8), Liefkenshoek Rail Link (0.57,0.8)**	**C-16 Terrasa Manresa toll motorway (0.6,0.8)**	**Central PT Depot of city of Pilsen (0.56,0.8)**
Overall Consistency/Coverage	(0.87/0.35)		

Table A.6. 55: Sufficiency analysis of projects being 'on/over revenues' (cut off: 0.86)

Conditions	OUTCOME: presence of 'on/over revenues'
	Solution 1
INI	●
GI	●
RRI	●
Individual Consistency	0.86
Coverage (Raw)	0.48
Coverage (Unique)	0.48
Number of cases	15
Some relevant cases	**E4 Helsinki-Lahti (0.84,1), E18 Muurla-Lohja (0.84,0.8), Liefkenshoek Rail Link (0.78,0.8), BNRR (M6 Toll) (0.75,0.8), Metrolink LRT. Manchester (0.75,1), Lyon's VeloV (0.72,1), Larnaca and Paphos International Airports (0.67,0.8), Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), C-16 Terrasa Manresa toll motorway (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,1), Metro de Malaga (0.6,0.8), MST-Metro Sul do Tejo (0.59,0), Central PT Depot of city of Pilsen (0.56,0.8), A5 Maribor Pince motorway (0.53,1)**
Overall Consistency/Coverage	(0.86/0.48)

Table A.6. 56: Sufficiency analysis of projects being 'on/over revenues' (cut off: 0.949648)

Conditions	OUTCOME: presence of 'on/over revenues'	
	Solution 1a	Solution 1b
INI	●	
GI		●
RRI		•
Individual Consistency	0.97	0.97
Coverage (Raw)	0.73	0.56
Coverage (Unique)	0.25	0.07
Number of cases	20	17
Some relevant cases	Cases with greater than 0.5 membership in term inst_ind: E4 Helsinki-Lahti (0.93,1), E18 Muurla-Lohja (0.93,0.8), E39 Orkdalsvegen Public Road (0.91,1), A-19 Dishforth (0.84,0.8), BNRR (M6 Toll) (0.84,0.8), Metrolink LRT. Manchester (0.84,1), M-80 (Haggs) (0.84,0.8), M-25 Orbital (0.84,0.8), Brabo 1 (0.81,0.8), Liefkenshoek Rail Link (0.81,0.8), Via-Invest Zaventem (0.81,0.8), Lyon's VeloV (0.72,1), Lyon's tramway T4 (0.72,1), Larnaca and Paphos International Airports (0.67,0.8), Metro do Porto (0.65,0.8), A23 motorway (0.65,0.8), Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), Radial 2 Toll Motorway (0.62,0.8), M-45 (0.62,1)	Cases with greater than 0.5 membership in term rev_rob*gov: Lyon's VeloV (0.84,1), E18 Muurla-Lohja (0.84,0.8), E4 Helsinki-Lahti (0.84,1), Athens International Airport (0.79,0.8), Liefkenshoek Rail Link (0.78,0.8), Athens Ring Road (0.75,0.8), BNRR (M6 Toll) (0.75,0.8), Larnaca and Paphos International Airports (0.75,0.8), Metrolink LRT. Manchester (0.75,1), Port of Leixoes (0.75,0.8), Rion-Antirion Bridge (0.75,0.8), Lusoponte Vasco da Gama Bridge (0.74,0.8), Central PT Depot of city of Pilsen (0.7,0.8), C-16 Terrasa Manresa toll motorway (0.6,0.8), A5 Maribor Pince motorway (0.6,1), E39 Orkdalsvegen Public Road (0.6,1), Metro de Malaga (0.6,0.8)
Overall Consistency/Coverage	(0.97/0.80)	

Table A.6. 57: Sufficiency analysis of projects being 'below revenues' (cut off: 0.754929)

Conditions	OUTCOME: absence of 'on/over revenues' Without simplifying assumptions (present/absent) Excluding 1 contradictory case Metro do Porto (42 cases instead of 43)
	Solution 1
INI	○

FEI	∘
GI	○
CSI	∘
RAI	●
RRI	○
FSI[77]	●
Individual Consistency	0.75
Coverage (Raw)	0.41
Coverage (Unique)	0.41
Number of cases	1
Some relevant cases	**Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.64,1)**
Overall Consistency/Coverage	(0.75/0.41)

Table A.6. 58: Necessity analysis of the 'on/over revenues' outcome for the PPP sample

Conditions	**On/over revenues**	
	Presence	**Absence**
High Institutional Context	0.77 (0.83)	**0.79** (0.35)
Low Institutional Context	0.40 (0.82)	0.62 (0.53)
High Economic & Financial Context	0.41 (0.85)	0.48 (0.42)
Low Economic & Financial Context	0.72 (0.77)	**0.83** (0.37)
High Governance	0.80 (0.79)	**0.91** (0.38)
Low Governance	0.37 (0.91)	0.49 (0.50)
High Cost Saving	0.67 (0.85)	0.68 (0.35)
Low Cost Saving	0.49 (0.78)	**0.71** (0.47)
High Remuneration Attractiveness	0.50 (0.79)	**0.73** (0.48)
Low Remuneration Attractiveness	0.68 (0.86)	0.69 (0.36)
High Revenue Robustness	0.71 (0.88)	0.58 (0.30)
Low Revenue Robustness	0.44 (0.71)	**0.77** (0.52)

[77] Since high FSI is a necessary condition for the absence of the outcome, the sufficiency analysis is re-run not with simplifying assumptions of all conditions being absent this time but with all conditions being present or absent.

High Financing Scheme (NEW)	0.80 (0.76)	**0.95** (0.38)
Low Financing Scheme (NEW)	0.34 (0.94)	0.40 (0.46)

Table A.6. 59: Sufficiency analysis of PPP projects being 'on/over revenues' (cut off: 0.85)

Conditions	OUTCOME: presence of 'on/over revenues'				
	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5
Institutional Context	•				●
Financial-economic context					
Governance		○		•	•
Cost Saving		•	•	○	●
Remuneration Attractiveness					•
Revenue Robustness	•	●	•	●	
Financing scheme (NEW)			○	•	•
Individual Consistency	0.88	0.90	0.91	0.88	0.88
Coverage (Raw)	0.57	0.26	0.23	0.33	0.38
Coverage (Unique)	0.17	0.0	0.01	0.02	0.13
Number of cases	18	1	3	2	6
Some relevant cases	**E4 Helsinki-Lahti (0.93,1), E18 Muurla-Lohja (0.9,0.8), Liefkenshoek Rail Link (0.81,0.8), BNRR (M6 Toll) (0.75,0.8), Metrolink LRT. Manchester (0.75,1), E39 Orkdalsvegen Public Road (0.75,1), Lyon's VeloV (0.72,1), Larnaca and Paphos International Airports (0.67,0.8), Port of Leixoes (0.65,0.8), Lusoponte Vasco da Gama Bridge (0.65,0.8), Radial 2 Toll Motorway (0.62,0.8), Eje Aeropuerto (M-12) Motorway (0.62,0.8), Metro de Malaga (0.62,0.8), C-16 Terrasa Manresa toll motorway (0.62,0.8), Barcelona Europe South Terminal (0.62,0.8), Port of Agaete (0.62,1),**	**Piraeus Container Terminal (0.6,1)**	**BNRR (M6 Toll) (0.75,0.8), Piraeus Container Terminal (0.75,1), Liefkenshoek Rail Link (0.57,0.8)**	**Athens International Airport (0.79,0.8), E18 Muurla-Lohja (0.73,0.8)**	**M-25 Orbital (0.75,0.8), Via-Invest Zaventem (0.64,0.8), FERTAGUS Train (0.59,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), A-19 Dishforth (0.54,0.8)**

	Port of Sines Terminal XXI (0.59,0.8), Central PT Depot of city of Pilsen (0.56,0.8)				
Overall Consistency/Coverage	(0.91/**0.74**)				

Table A.6. 60: Sufficiency analysis of projects being 'below revenues' (cut off: 0.76)

Conditions	OUTCOME: absence of 'on/over revenues'
	Solution 1
FEI	●
GI	●
CSI	◦
RRI	○
FSI[78]	•
Individual Consistency	0.76
Coverage (Raw)	0.40
Coverage (Unique)	0.40
Number of cases	1
Some relevant cases	**Reims tramway (0.56, 1)**
Overall Consistency/Coverage	(0.76/0.40)

Table A.6. 61: Necessity analysis of the 'on/over revenues' outcome for the road sample

Conditions	**On/over revenues**	
	Presence	**Absence**
High Institutional Context	0.747 (0.84)	0.62 (0.32)
Low Institutional Context	0.39 (0.69)	0.69 (0.56)
High Economic & Financial Context	0.43 (0.94)	0.1 (0.31)
Low Economic & Financial Context	0.68 (0.68)	**0.94** (0.44)
High Governance	0.73 (0.77)	**0.79** (0.39)
Low Governance	0.42 (0.81)	0.53 (0.48)

[78] Since high FSI and high are necessary conditions for the absence of the outcome, the sufficiency analysis is re-run not with simplifying assumptions of all conditions being absent this time but with all conditions being present or absent. No case has been excluded when running the analysis.

High Cost Saving	0.64 (0.82)	0.61 (0.37)
Low Cost Saving	0.51 (0.74)	0.70 (0.48)
High Remuneration Attractiveness	0.65 (0.74)	**0.81** (0.44)
Low Remuneration Attractiveness	0.50 (0.85)	0.51 (0.40)
High Revenue Robustness	0.66 (0.87)	0.48 (0.30)
Low Revenue Robustness	0.46 (0.66)	**0.78** (0.52)
High Financing Scheme (NEW)	**0.81** (0.73)	**0.93** (0.40)
Low Financing Scheme (NEW)	0.34 (0.91)	0.38 (0.48)

Table A.6. 62: Sufficiency analysis of road projects being 'on/over revenues' (cut off: 0.86)

Conditions	OUTCOME: presence of 'on/over revenues'		
	Solution 1	Solution 2	Solution 3
FEI		●	
FSI	○		•
RAI			•
RRI	•	•	●
GI	•	•	○
Individual Consistency	0.87	0.93	0.88
Coverage (Raw)	**0.23**	**0.26**	**0.28**
Coverage (Unique)	0.06	0.12	0.13
Number of cases	2	3	2
Some relevant cases	**BNRR (M6 Toll) (0.75,0.8),** **C-16 Terrasa Manresa toll motorway (0.6,0.8)**	**E4 Helsinki-Lahti (0.84,1),** **E18 Muurla-Lohja (0.84,0.8), E39 Orkdalsvegen Public Road (0.6,1)**	**Motorway E-75. Section Donji Neradovac - Srpska kuca (0.75,0.8),** **Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.75,0.8)**
Overall Consistency/Coverage	(0.92/0.49)		

Table A.6. 63: Sufficiency analysis of road projects being 'on/over revenues' (cut off: 0.82)

Conditions	OUTCOME: presence of 'on/over revenues'	
	Solution 1	Solution 2
INI		●
FEI		
GI	○	

RRI	●	●
Individual Consistency	0.90	0.88
Coverage (Raw)	**0.34**	**0.47**
Coverage (Unique)	0.09	0.22
Number of cases	2	8
Some relevant cases	**Motorway E-75. Section Donji Neradovac - Srpska kuca (0.75,0.8),** **Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.75,0.8)**	E4 Helsinki-Lahti (0.93,1), E18 Muurla-Lohja (0.9,0.8), BNRR (M6 Toll) (0.75,0.8), E39 Orkdalsvegen Public Road (0.75,1), C-16 Terrasa Manresa toll motorway (0.62,0.8), Eje Aeropuerto (M-12) Motorway (0.62,0.8), Radial 2 Toll Motorway (0.62,0.8), A5 Maribor Pince motorway (0.53,1)
Overall Consistency/Coverage	(0.89/0.56)	

Table A.6. 64: Sufficiency analysis of road projects being 'below revenues' (cut off: 0.809756)

Conditions	OUTCOME: absence of 'on/over revenues' Without simplifying assumptions (present/absent)
	Solution 1
FEI	∘
FSI	•
RAI	•
RRI	○
GI	○
Individual Consistency	0.81
Coverage (Raw)	0.52
Coverage (Unique)	0.52
Number of cases	1
Some relevant cases	**Belgrade By-pass Project. Section A: Batajnica-Dobanovci (0.78,1)**
Overall Consistency/Coverage	(0.80/**0.52**)

Table A.6. 65: Necessity analysis of the 'on/over revenues' outcome for the completion before crisis sample

Conditions	**On/over revenues**	
	Presence	**Absence**
High Institutional Context	0.73 (0.82)	0.76 (0.37)
Low Institutional Context	0.43 (0.81)	0.62 (0.490
High Economic & Financial Context	0.36 (0.84)	0.40 (0.41)
Low Economic & Financial Context	0.75 (0.75)	**0.84** (0.36)
High Governance	0.77 (0.79)	**0.83** (0.36)
Low Governance	0.38 (0.84)	0.51 (0.49)
High Cost Saving	0.63 (0.90)	0.53 (0.33)
Low Cost Saving	0.53 (0.72)	**0.85** (0.50)
High Remuneration Attractiveness	0.40 (0.77)	0.64 (0.54)
Low Remuneration Attractiveness	0.76 (0.83)	0.72 (0.34)
High Revenue Robustness	0.74 (0.90)	0.55 (0.29)
Low Revenue Robustness	0.42 (0.68)	**0.80** (0.56)
High Financing Scheme (NEW)	0.80 (0.74)	0.94 (0.37)
Low Financing Scheme (NEW)	0.32 (0.93)	0.34 (0.42)

Table A.6. 66: Sufficiency analysis of projects being 'on/over revenues' (cut off: 0.82)

Conditions	OUTCOME: presence of 'on/over revenues'		
	Solution 1	Solution 2	Solution 3
FEI			
GI		•	•
CSI			●
RRI	●	●	
FSI	•		•
Individual Consistency	0.88	0.90	0.89
Coverage (Raw)	0.60	0.62	0.54
Coverage (Unique)	0.09	0.12	0.11
Number of cases	12	10	8
Some relevant cases	**Athens International Airport (0.79,0.8),** **E4 Helsinki-Lahti (0.77,1), E39 Orkdalsvegen Public Road**	**E4 Helsinki-Lahti (0.84,1),**	**Lusoponte Vasco da Gama Bridge (0.78,0.8),**

	(0.75,1), Eje Aeropuerto (M-12) Motorway (0.75,0.8), **Radial 2 Toll Motorway (0.75,0.8), Port of Agaete (0.75,1), Port of Leixoes (0.75,0.8),** **Port of Sines Terminal XXI (0.75,0.8), Rion-Antirion Bridge (0.75,0.8), Lusoponte Vasco da Gama Bridge (0.74,0.8),** **Athens Ring Road (0.6,0.8)**	**Lyon's VeloV (0.84,1), Athens International Airport (0.79,0.8), Athens Ring Road (0.75,0.8),** **BNRR (M6 Toll) (0.75,0.8), Port of Leixoes (0.75,0.8), Rion-Antirion Bridge (0.75,0.8),** **Lusoponte Vasco da Gama Bridge (0.74,0.8), C-16 Terrasa Manresa toll motorway (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,1)**	**Rion-Antirion Bridge (0.77,0.8), Port of Leixoes (0.73,0.8), FERTAGUS Train (0.7,0.8),** **E4 Helsinki-Lahti (0.66,1), Athens Ring Road (0.6,0.8), E39 Orkdalsvegen Public Road (0.6,1),** **A-19 Dishforth (0.54,0.8)**
Overall Consistency/Coverage	(0.89/0.82)		

Table A.6. 67: Sufficiency analysis of before crisis projects being 'below revenues' (cut off: 0.76)

Conditions	OUTCOME: absence of 'on/over revenues'
	Solution 1
FEI	○
GI	●
CSI	○
RRI	○
FSI	•
Individual Consistency	0.76
Coverage (Raw)	0.69
Coverage (Unique)	0.69
Number of cases	2
Some relevant cases	**A22 motorway (0.8,1),** **A23 motorway (0.8,1)**
Overall Consistency/Coverage	(0.76/**0.69**)

Table A.6. 68: Necessity analysis of the 'on/over revenues' outcome for the crisis _after completion sample

Conditions	On/over revenues	
	Presence	**Absence**
High Institutional Context	**0.73** (0.80)	0.61 (0.36)
Low Institutional Context	0.42 (0.66)	0.66 (0.57)
High Economic & Financial Context	0.42 (0.80)	0.44 (0.45)
Low Economic & Financial Context	0.71 (0.70)	**0.81** (0.43)
High Governance	0.73 (0.75)	**0.74** (0.41)
Low Governance	0.42 (0.75)	0.55 (0.53)
High Cost Saving	0.62 (0.73)	0.68 (0.44)
Low Cost Saving	0.53 (0.75)	0.58 (0.45)
High Remuneration Attractiveness	**0.74** (0.77)	0.69 (0.39)
Low Remuneration Attractiveness	0.41 (0.71)	0.58 (0.55)
High Revenue Robustness	0.69 (0.79)	0.58 (0.36)
Low Revenue Robustness	0.44 (0.66)	0.66 (0.53)
High Financing Scheme (NEW)	0.85 (0.69)	0.95 (0.42)
Low Financing Scheme (NEW)	0.28 (0.91)	0.30 (0.53)

Table A.6. 69: Sufficiency analysis of projects being 'on/over revenues' (cut off: 0.76)

Conditions	OUTCOME: presence of 'on/over revenues'	
	Solution 1	Solution 2
INI		●
FEI	○	
GI	○	●
RAI		
FSI		●
Individual Consistency	0.76	0.80
Coverage (Raw)	0.42	0.65
Coverage (Unique)	0.14	0.37
Number of cases	5	13
Some relevant cases	**Motorway E-75. Section Donji Neradovac - Srpska kuca (0.89,0.8), Motorway E-75. Section Horgos-Novi Sad (2nd phase) (0.89, 0.8), Barcelona Europe**	**E18 Muurla-Lohja (0.84,0.8),** **Via-Invest Zaventem (0.78,0.8), Metrolink LRT. Manchester (0.78,1), Brabo 1 (0.78,0.8),**

	South Terminal (0.6,0.8), Piraeus Container Terminal (0.6,1)	**M-25 Orbital (0.75,0.8), Lyon's tramway T4 (0.72,1), Larnaca and Paphos International Airports (0.67,0.8), Metro de Malaga (0.6,0.8), Central PT Depot of city of Pilsen (0.56,0.8), M-80 (Haggs) (0.55,0.8), A5 Maribor Pince motorway (0.53,1)**
Overall Consistency/Coverage	(0.78/0.79)	

Table A.6. 70: Sufficiency analysis of projects being 'below revenues' (cut off: 0.85)

Conditions	OUTCOME: absence of 'on/over revenues'
	Solution 1
INI	●
FEI	●
GI	○
RAI	○
FSI	●
Individual Consistency	0.85
Coverage (Raw)	0.34
Coverage (Unique)	0.34
Number of cases	1
Some relevant cases	**Modlin Regional Airport (0.53,1)**
Overall Consistency/Coverage	(0.85/0.34)

Table A.6. 71: Calibration Method

	SCORING	CALIBRATION	
		Scaling	fsQCA
1. OUTCOME			
• Cost	Below budget, on budget, over budget	Below budget	1
		On budget	0.8
		Over budget	0
• Time	Ahead schedule, on time, delayed	Ahead schedule	1
		On time	0.8
		Delayed	0
• Traffic (Actual vs forecasted)	Exceeding, as forecasted, below forecasted, far below forecasted	Exceeding	1
		As forecasted	0.67
		Below forecasted	0.33
		Far below forecasted	0
• Revenue (Actual vs forecasted)	Exceeding, as forecasted, below forecasted	Exceeding	1
		As forecasted	0.8
		Below forecasted	0
2. TYPOLOGY INDICATORS/CONDITIONS			
• Institutional Context	The value of the condition varies between 0 to 1 (Review of conditions' values of 26 countries from 1996 to 2013)	Threshold for full membership (0.95)	0.90
		Cross over point	0.65
		Threshold for non-full membership (0.05)	0.40
• Financial-Economic Context	The value of the condition varies between 0 to 1 (Review of conditions' values of 26 countries from 2001 to 2014)	Threshold for full membership (0.95)	0.80
		Cross over point	0.60
		Threshold for non-full membership (0.05)	0.40
• Governance	The value of the condition varies between 0 to 1	Threshold for full membership (0.95)	0.95
		Cross over point	0.50
		Threshold for non-full membership (0.05)	0.05

• Remuneration Attractiveness	The value of the condition varies between 0 to 1	Threshold for full membership (0.95)	0.95
		Cross over point	0.5
		Threshold for non-full membership (0.05)	0.05
• Financing Scheme	The value of the condition varies between 0 to 1	Threshold for full membership (0.95)	0.95
		Cross over point	0.50
		Threshold for non-full membership (0.05)	0.05
• Cost Saving	Index varies between -0.333 to 1	Threshold for full membership (0.95)	0.9335
		Cross over point	0.333
		Threshold for non-full membership (0.05)	-0.2665
• Revenue Robustness	Index varies between 0 to 1	Threshold for full membership (0.95)	0.95
		Cross over point	0.5
		Threshold for non-full membership (0.05)	0.05

Table A.6. 72: Calibration: "Defining the target category using set theoretic language"

Conditions	**Target categories using set theoretic language**
INI The set of countries with:	- favorable institutional context - average institutional context - less favorable institutional context
FEI The set of countries with:	- favorable financial-economic context - average financial-economic context - less favorable financial-economic context
GI TI projects with:	- flexible and efficient contract - a contract of average efficiency and flexibility - non-flexible and non-efficient contract

CSI TI projects with:	- high ability to reduce costs during the construction and operation phase of the project - average ability to reduce costs during the construction and operation phase of the project - low ability to reduce costs during the construction and operation phase of the project
RAI TI projects with:	- high ability to recover project related costs (paid by the project actors) through revenue streams - average ability to recover project related costs (paid by the project actors) through revenue streams - low ability to recover project related costs (paid by the project actors) through revenue streams
RRI TI projects with:	- high revenue streams - average revenue streams - low revenue streams
FSI TI projects:	- mostly financed by the public sector (low cost of capital) - financed by both the private & public sector (average cost of capital) - mostly financed by the private sector (high cost of capital)
OUTCOMES	
Cost Projects being:	- below the estimated budget - equal to the estimated budget - over the estimated budget
Time Projects being:	- ahead of the estimated time - on the estimated time - delayed
Traffic Projects with:	- actual traffic exceeding the forecasted traffic - actual traffic equal to the forecasted traffic - actual traffic below the forecasted traffic - actual traffic far below the forecasted traffic
Revenues Projects with:	- actual revenues higher than the estimated revenues - actual revenues equal to the estimated revenues - actual revenues below the estimated revenues

Source: Author's composition based on Rihoux & Ragin (2009)

Truth Tables

The number of rows is 2^k[79], thus 2^7=128 rows (combinations of causal conditions) in table B.6.1 below. 21 out of the 128 rows are configurations of conditions that are linked to and explained by at least one cases, while all the rest 107 they are not. These 107 rows are remainders, which are combinations of causal conditions that lack empirical cases (Ragin and Sonnett, 2005, p.3). This is due to the small number of cases and this is the problem of 'limited diversity' in the fsQCA. These remainders are treated by using simplifying assumptions on the remainders.

COST OUTCOME

Table B.6. 1: Truth table of on/below cost analysis- full sample – with simplifying assumptions – 7 conds

ins_ind	fin_ec	gov	cost_sav	rem_sch	rev_rob	fin_sch	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	1	0	1	1	4	1	0.78162	0.632279	0.63228
1	1	1	1	0	0	1	1	1	0.769932	0.530233	0.530233
1	0	1	1	0	0	1	3	1	0.75782	0.552239	0.552239
1	0	1	1	0	1	1	2	1	0.753061	0.576923	0.576923
1	1	0	0	0	0	1	2	0	0.732461	0.501109	0.501109
1	1	1	1	1	1	1	1	0	0.726218	0.484716	0.484716
1	1	1	0	1	0	1	2	0	0.706442	0.460194	0.460194
1	1	1	1	1	0	1	3	0	0.706287	0.463196	0.463196
1	1	1	0	0	1	1	1	0	0.70524	0.494382	0.494382
1	1	1	0	1	1	1	2	0	0.702703	0.48538	0.48538
0	0	1	1	0	1	1	3	0	0.690745	0.459566	0.459566
0	1	1	1	1	0	1	1	0	0.661147	0.284946	0.284946
1	1	0	0	1	0	1	2	0	0.640777	0.306792	0.306792
1	1	0	0	0	1	1	1	0	0.640199	0.370933	0.370933
1	0	1	0	0	1	1	1	0	0.63425	0.382143	0.382143
0	0	0	0	1	0	1	1	0	0.608847	0.3	0.3
0	0	1	0	0	1	1	3	0	0.604978	0.350534	0.350534
0	0	1	0	0	1	0	1	0	0.603503	0.308333	0.308333
1	1	1	0	0	1	0	1	0	0.601318	0.221865	0.221865
1	0	0	0	0	1	0	2	0	0.579968	0.261364	0.261364
0	0	0	0	1	1	1	2	0	0.521327	0.231939	0.231939

[79] This is the geometric function based on which the number of causal combinations/rows is calculated; where k is the number of causal conditions (Ragin and Sonnet, 2005, p.3).

Table B.6. 2: Truth table of on/below cost analysis- full sample – with simplifying assumptions – 5 conds-including the necessary FSI condition

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	1	1	8	1	0.812542	0.709812	0.709812
1	0	1	1	1	5	1	0.804421	0.699279	0.699279
1	1	1	0	1	5	0	0.770073	0.639175	0.639175
0	1	1	1	1	1	0	0.728042	0.479757	0.479757
0	0	1	1	1	3	0	0.722944	0.533528	0.533528
1	0	1	0	1	1	0	0.699545	0.5153	0.5153
1	1	0	0	1	6	0	0.687606	0.491713	0.491713
0	0	1	0	1	3	0	0.665251	0.448951	0.448951
1	1	1	0	0	2	0	0.656294	0.307692	0.307693
0	0	1	0	0	1	0	0.642229	0.338753	0.338753
1	0	0	0	0	2	0	0.632035	0.303279	0.303279
0	0	0	0	1	3	0	0.600997	0.387755	0.387755

Table B.6. 3: Truth table of over cost analysis-full sample – with simplifying assumptions – 7 conds

ins_ind	fin_ec	gov	cost_sav	rem_sch	rev_rob	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	1	1	0	0	1	0	1	1	0.886326	0.778135	0.778135
0	1	1	1	1	0	1	1	1	0.864968	0.715053	0.715054
0	0	0	0	1	1	1	2	1	0.85545	0.768061	0.768061
1	0	0	0	0	1	0	2	1	0.851373	0.738636	0.738636
1	1	0	0	1	0	1	2	1	0.841019	0.693208	0.693208
0	0	0	0	1	0	1	1	1	0.832363	0.7	0.7
0	0	1	0	0	1	0	1	1	0.823248	0.691666	0.691667
1	1	0	0	0	1	1	1	1	0.787841	0.629067	0.629067
0	0	1	0	0	1	1	3	1	0.786797	0.649466	0.649466
1	0	1	0	0	1	1	1	1	0.773784	0.617857	0.617857
1	1	1	0	1	0	1	2	0	0.749736	0.539806	0.539806
1	1	1	1	1	0	1	3	0	0.746562	0.536804	0.536804
1	1	1	1	1	1	1	1	0	0.742459	0.515284	0.515284
1	1	1	1	0	0	1	1	0	0.740319	0.469767	0.469767
0	0	1	1	0	1	1	3	0	0.73702	0.540434	0.540434
1	1	0	0	0	0	1	2	0	0.731272	0.498891	0.498891
1	1	1	0	1	1	1	2	0	0.719594	0.514619	0.51462
1	1	1	0	0	1	1	1	0	0.71179	0.505618	0.505618
1	0	1	1	0	0	1	3	0	0.701312	0.447761	0.447761
1	0	1	1	0	1	1	2	0	0.663265	0.423077	0.423077
1	1	1	1	0	1	1	4	0	0.624506	0.36772	0.36772

Table B.6. 4: Truth table of over cost analysis-full sample – with simplifying assumptions – 4 conds plus FSI as necessary condition_after deleting the contradictory cases 'Muelle Costa Terminal Barcelona' and Piraeus Container Terminal.

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	0	0	0	0	1	1	0.906602	0.826347	0.826347
1	1	1	0	0	2	1	0.84505	0.709677	0.709677
0	1	1	1	1	1	0	0.74814	0.543353	0.543352
0	0	0	0	1	3	0	0.744717	0.624378	0.624378
0	0	1	0	1	3	0	0.724287	0.565986	0.565986
1	1	0	0	1	6	0	0.695466	0.522788	0.522788
0	0	1	1	1	3	0	0.682056	0.485915	0.485915
1	0	1	0	1	1	0	0.677195	0.499402	0.499402
1	1	1	0	1	5	0	0.590007	0.376536	0.376536
1	1	1	1	1	9	0	0.550858	0.332023	0.332023
1	0	1	1	1	5	0	0.547094	0.326044	0.326044

Table B.6. 5: Truth table of on/below cost analysis-PPP sample – with simplifying assumptions full model after deleting four contradictory cases 'Eje Aeropuerto (M-12) Motorway; M-45 & Radial 2 Toll Motorway, Moreas Motorway.

ins_ind	fin_ec	gov	cost_sav	rem_sch	rev_rob	fin_sch	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	1	0	1	1	4	1	0.895171	0.807776	0.807775
1	1	1	1	0	0	1	1	1	0.878747	0.713827	0.713827
1	0	1	1	0	0	1	3	1	0.871671	0.732323	0.732323
1	1	1	1	1	0	1	2	1	0.866756	0.704478	0.704478
1	0	1	1	0	1	1	2	1	0.863248	0.743119	0.743119
1	1	0	0	0	0	1	2	1	0.856921	0.673759	0.673759
1	1	1	0	0	1	1	1	1	0.855282	0.704142	0.704142
1	1	1	1	1	1	1	1	1	0.852679	0.671097	0.671096
0	0	1	1	0	1	1	2	1	0.845706	0.681682	0.681682
1	1	1	0	1	0	1	1	1	0.821162	0.589041	0.589041
1	1	1	0	1	1	1	1	1	0.81493	0.604651	0.604651
1	0	1	0	0	1	1	1	0	0.734501	0.488312	0.488312
0	0	1	0	0	1	1	2	0	0.712871	0.457219	0.457219
0	0	1	0	0	1	0	1	0	0.689788	0.394737	0.394737
1	1	1	0	0	1	0	1	0	0.679842	0.28	0.28
1	0	0	0	0	1	0	2	0	0.662745	0.333333	0.333333

Table B.6. 6: Truth table of on/below cost analysis- PPP sample – with simplifying assumptions – 4 conds plus FSI after deleting eight contradictory cases

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	1	1	8	1	0.969244	0.948454	0.948454
1	0	1	1	1	5	1	0.968153	0.945568	0.945568
1	1	1	0	1	3	1	0.953409	0.909492	0.909492
0	0	1	1	1	2	1	0.953146	0.89645	0.89645
1	1	0	0	1	2	1	0.937405	0.848708	0.848708

0	0	1	0	1	1	1	0.912333	0.790036	0.790036
0	0	1	0	0	1	1	0.849174	0.619792	0.619792
1	1	1	0	0	1	1	0.845261	0.56044	0.560439
1	0	0	0	0	2	1	0.810651	0.522388	0.522388

Table B.6. 7: Truth table of over cost analysis - PPP sample – with simplifying assumptions – full model-37 cases

ins_ind	fin_ec	gov	cost_sav	rem_sch	rev_rob	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	0	0	0	0	1	0	1	1	0.931959	0.879121	0.879121
1	1	1	0	0	1	0	1	1	0.882243	0.778948	0.778947
0	0	1	0	0	1	1	2	0	0.77193	0.622768	0.622768
1	0	1	0	0	1	1	1	0	0.760309	0.594771	0.594771
1	1	1	0	1	0	1	1	0	0.758766	0.528767	0.528767
1	1	1	0	1	1	1	1	0	0.727545	0.490196	0.490196
1	1	0	0	0	0	1	2	0	0.722628	0.464789	0.464789
1	1	1	1	0	0	1	1	0	0.715749	0.426356	0.426356
1	1	1	1	1	0	1	3	0	0.713939	0.470852	0.470852
0	0	1	1	0	1	1	3	0	0.712468	0.511879	0.511879
1	1	1	1	1	1	1	1	0	0.711016	0.434174	0.434174
1	1	1	0	0	1	1	1	0	0.679245	0.433333	0.433333
1	0	1	1	0	0	1	3	0	0.675645	0.412601	0.412602
1	0	1	1	0	1	1	2	0	0.632954	0.388257	0.388257
1	1	1	1	0	1	1	4	0	0.591257	0.329749	0.329749

Table B.6. 8: Truth table of over cost analysis - PPP sample – with simplifying assumptions – 4 conds – 37 cases

ins_ind	fin_ec	gov	cost_sav	number	~cost	raw consist.	PRI consist.	SYM consist
1	0	0	0	1	1	0.770389	0.602174	0.602174
0	0	1	0	2	0	0.753639	0.593346	0.593346
1	0	1	0	1	0	0.712644	0.540582	0.540582
1	1	0	0	2	0	0.709962	0.477272	0.477273
0	0	1	1	3	0	0.68177	0.471103	0.471103
1	1	1	0	5	0	0.627486	0.419718	0.419718
1	0	1	1	5	0	0.5244	0.290993	0.290993
1	1	1	1	9	0	0.510052	0.279299	0.279299

Table B.6. 9: Truth table of over cost analysis - PPP sample – with simplifying assumptions – 5 conds (plus the FSI as necessary condition) – 37 cases

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	0	0	0	0	1	1	0.909408	0.831169	0.831169
1	1	1	0	0	2	1	0.843077	0.705203	0.705202
0	0	1	0	1	2	0	0.747706	0.576923	0.576923
1	1	0	0	1	2	0	0.702842	0.453681	0.453682
1	0	1	0	1	1	0	0.701789	0.512195	0.512195
0	0	1	1	1	3	0	0.679745	0.465486	0.465487

1	1	1	0	1	3	0	0.600775	0.352201	0.352201
1	0	1	1	1	5	0	0.525039	0.288394	0.288394
1	1	1	1	1	9	0	0.513227	0.278835	0.278835

Table B.6. 10: Truth table of on/below cost analysis - road sample – with simplifying assumptions – 5 conds (plus the FSI as necessary condition)

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	0	1	3	1	0.775244	0.660933	0.660934
1	1	1	1	1	5	0	0.728058	0.610309	0.610309
1	0	1	1	1	2	0	0.72549	0.620833	0.620833
1	1	1	0	0	1	0	0.647783	0.352941	0.352941
0	0	1	0	1	2	0	0.584677	0.394118	0.394118
0	0	1	1	1	1	0	0.577603	0.401114	0.401114
0	0	0	0	1	3	0	0.505654	0.341935	0.341936

Table B.6. 11: Truth table of over cost analysis - road sample – with simplifying assumptions – 5 conds (plus the FSI as necessary condition)

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	1	1	0	0	1	1	0.807882	0.647059	0.647059
0	0	0	0	1	3	0	0.743134	0.658064	0.658065
0	0	1	0	1	2	0	0.729839	0.605882	0.605882
0	0	1	1	1	1	0	0.717092	0.598886	0.598886
1	1	1	1	1	5	0	0.574101	0.389691	0.389691
1	1	1	0	1	3	0	0.561889	0.339066	0.339066
1	0	1	1	1	2	0	0.550528	0.379167	0.379167

Table B.6. 12: Truth table of over cost analysis - road sample – with simplifying assumptions – 5 conds (plus the FSI as necessary condition)

ins_ind	gov	rem_sch	rev_rob	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
0	1	0	1	1	2	1	0.971246	0.962343	0.962343
1	1	0	1	0	1	1	0.931271	0.892473	0.892473
0	0	1	1	1	2	0	0.79684	0.751381	0.751381
0	0	1	0	1	1	0	0.757647	0.644827	0.644828
1	1	0	0	1	2	0	0.697039	0.530035	0.530035
1	1	0	1	1	3	0	0.650759	0.538682	0.538682
1	1	1	0	1	5	0	0.606667	0.459954	0.459954
1	1	1	1	1	2	0	0.597374	0.455621	0.455621

Table B.6. 13: Truth table of over cost analysis - road sample – with simplifying assumptions – 5 conds (plus the FSI as necessary condition)

gov	cost_sav	rem_sch	rev_rob	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	0	0	1	0	1	1	0.878419	0.803922	0.803922
0	0	1	1	1	2	1	0.796334	0.72752	0.72752

0	0	1	0	1	1	0	0.769231	0.623693	0.623693
1	0	0	1	1	3	0	0.740654	0.625	0.625
1	1	0	1	1	3	0	0.701681	0.587209	0.587209
1	1	0	0	1	2	0	0.666667	0.469799	0.469799
1	1	1	0	1	5	0	0.621711	0.453682	0.453682
1	0	1	1	1	2	0	0.601695	0.432024	0.432024

Table B.6. 14: Truth table of over cost analysis - road sample – with simplifying assumptions – 5 conds (plus the FSI as necessary condition)

ins_ind	fin_ec	rem_sch	rev_rob	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
0	0	0	1	1	2	1	0.9699	0.961373	0.961373
1	1	0	1	0	1	1	0.922481	0.869281	0.869281
0	0	1	1	1	2	1	0.836364	0.80274	0.80274
0	0	1	0	1	1	0	0.736842	0.626623	0.643333
1	0	1	1	1	1	0	0.732938	0.632653	0.632653
1	0	0	0	1	2	0	0.692308	0.537906	0.537906
1	1	1	0	1	3	0	0.654321	0.479876	0.479876
1	1	0	1	1	5	0	0.629213	0.504504	0.504504
1	1	1	1	1	2	0	0.602241	0.403361	0.403361

Table B.6. 15: Truth table of over cost analysis - road sample – with simplifying assumptions – 5 conds (plus the FSI as necessary condition)

rem_sch	rev_rob	fin_ec	gov	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
0	1	1	1	0	1	1	0.92126	0.865772	0.865772
0	1	0	1	1	2	1	0.906158	0.875	0.875
1	1	0	0	1	2	0	0.824356	0.783237	0.783237
1	0	0	0	1	1	0	0.754386	0.63754	0.63754
0	0	0	1	1	2	0	0.66055	0.501684	0.501683
1	0	1	1	1	3	0	0.652174	0.471698	0.471698
0	1	1	1	1	3	0	0.621212	0.471831	0.471831
1	1	1	1	1	2	0	0.601671	0.39916	0.39916

Table B.6. 16: Truth table-before crisis sample-on/below cost-all conditions present – 5 conds with the highest necessity consistency

ins_ind	fin_ec	gov	rem_sch	fin_sch	number	cost	raw consist.	PRI consist.	SYM consist
1	0	1	0	1	5	1	0.790524	0.698925	0.698925
1	1	1	0	1	4	0	0.742893	0.635727	0.635727
0	0	1	0	1	4	0	0.733138	0.61194	0.61194
1	1	0	0	1	2	0	0.682812	0.516667	0.516667
1	1	1	1	1	2	0	0.652259	0.385417	0.385417
1	1	1	0	0	1	0	0.553738	0.239044	0.239044

Table B.6. 17: Truth table-before crisis sample-over cost-all conditions absent-5 conds with the highest necessity consistency

ins_ind	fin_ec	gov	rem_sch	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	1	1	0	0	1	1	0.859813	0.760956	0.760956
1	1	1	1	1	2	1	0.781925	0.614583	0.614583
1	1	0	0	1	2	0	0.660937	0.483333	0.483333
0	0	1	0	1	4	0	0.579179	0.38806	0.38806
1	1	1	0	1	4	0	0.551298	0.364273	0.364273
1	0	1	0	1	5	0	0.513716	0.301075	0.301075

<u>Additional models:</u> adding as conditions the conditions that were found as relevant in the solution paths of the initial models and adding CSI, RRI or both

Table B.6. 18: Truth table-before crisis sample-on/below cost-all conditions present-plus CSI

ins_ind	fin_ec	gov	fin_sch	cost_sav	number	cost	raw consist.	PRI consist.	SYM consist
1	0	1	1	1	5	1	0.807245	0.72045	0.72045
0	0	1	1	1	2	1	0.771144	0.649746	0.649746
1	1	1	1	1	5	0	0.731025	0.609284	0.609284
1	1	1	1	0	1	0	0.721966	0.568019	0.568019
1	1	0	1	0	2	0	0.694444	0.513812	0.513812
0	0	1	1	0	2	0	0.676895	0.48415	0.48415
1	1	1	0	0	2	0	0.563758	0.277778	0.277778

Table B.6. 19: Truth table-before crisis sample-over cost-all conditions absent-plus CSI

fin_sch	rem_sch	cost_sav	number	~cost	raw consist.	PRI consist.	SYM consist
0	0	0	1	1	0.864254	0.770993	0.770993
1	1	1	2	0	0.731579	0.537764	0.537764
1	0	0	7	0	0.557491	0.372323	0.372323
1	0	1	11	0	0.421003	0.235955	0.235955

Table B.6. 20: Truth table-before crisis sample-over cost-all conditions absent- structural and exogenous conds-plus FSI as necessary cond

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
1	1	1	0	0	2	1	0.832215	0.722222	0.722222
0	0	1	0	1	2	0	0.696751	0.51585	0.51585
1	1	0	0	1	2	0	0.677083	0.486188	0.486188
1	1	1	0	1	1	0	0.634409	0.431981	0.431981
1	1	1	1	1	5	0	0.580559	0.390716	0.390716
0	0	1	1	1	2	0	0.575456	0.350254	0.350254
1	0	1	1	1	5	0	0.503234	0.27955	0.27955

Table B.6. 21: Truth table-<u>after</u> crisis sample-on/below cost-all conditions present- conds with high necessity consistency

ins_ind	fin_ec	gov	rem_sch	fin_sch	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	0	1	2	1	0.861804	0.733333	0.733333
1	1	1	1	1	6	1	0.832938	0.756897	0.756897
1	1	0	0	1	1	1	0.819372	0.54	0.54
0	0	1	0	0	1	0	0.746479	0.479769	0.479769
0	1	1	1	1	1	0	0.741414	0.5	0.5
1	0	0	0	0	2	0	0.716456	0.442786	0.442786
1	0	1	0	1	1	0	0.693841	0.442244	0.442244
0	0	1	0	1	1	0	0.633124	0.282787	0.282787
0	0	0	1	1	3	0	0.589021	0.369021	0.369021

Table B.6. 22: Truth table-after crisis sample-over cost-all conditions absent- conds with high necessity consistency

ins_ind	fin_ec	gov	rem_sch	fin_sch	number	~cost	raw consist.	PRI consist.	SYM consist
0	0	1	0	1	1	1	0.855346	0.717213	0.717213
1	1	0	0	1	1	1	0.787958	0.46	0.46
1	0	0	0	0	2	1	0.774684	0.557214	0.557214
0	0	1	0	0	1	1	0.766197	0.520231	0.520231
0	0	0	1	1	3	1	0.759644	0.630979	0.630979
1	0	1	0	1	1	1	0.757246	0.557756	0.557756
0	1	1	1	1	1	0	0.741414	0.5	0.5
1	1	1	0	1	2	0	0.619962	0.266667	0.266667
1	1	1	1	1	6	0	0.479858	0.243103	0.243103

Table B.6. 23: Truth table-after crisis sample-on/below cost-all conditions present- solution of initial plus CSI-new model 3a

ins_ind	fin_ec	fin_sch	cost_sav	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	1	4	1	0.839309	0.748963	0.748963
1	1	1	0	5	1	0.829882	0.733179	0.733179
0	0	0	0	1	0	0.742857	0.494382	0.494382
0	1	1	1	1	0	0.731183	0.429224	0.429224
1	0	0	0	2	0	0.705263	0.44	0.44
1	0	1	0	2	0	0.698198	0.524823	0.524823
0	0	1	1	1	0	0.66055	0.372881	0.372881
0	0	1	0	3	0	0.614973	0.427435	0.432596

Table B.6. 24: Truth table-after crisis sample-on/below cost-all conditions present-solution of initial plus RRI-new model 3b

ins_ind	fin_ec	fin_sch	rev_rob	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	1	5	1	0.816062	0.727969	0.736434
1	1	1	0	3	1	0.787425	0.648515	0.648515
0	0	0	1	1	0	0.730539	0.457831	0.457831
0	1	1	0	1	0	0.713992	0.408511	0.408511
0	0	1	0	1	0	0.713073	0.47352	0.485623

1	0	0	1	2	0	0.709844	0.476635	0.476635
1	0	1	1	2	0	0.680731	0.509719	0.509719
0	0	1	1	3	0	0.520111	0.277662	0.277662

Table B.6. 25: Truth table-after crisis sample-on/below cost-all conditions present- solution of initial plus CSI & RRI-new model 3c

ins_ind	fin_ec	fin_sch	cost_sav	rev_rob	number	cost	raw consist.	PRI consist.	SYM consist
1	1	1	1	1	3	1	0.797659	0.662011	0.662011
1	1	1	0	1	2	1	0.79702	0.659375	0.659375
1	1	1	0	0	2	1	0.780115	0.606164	0.606164
1	1	1	1	0	1	1	0.77634	0.578397	0.578397
0	0	1	0	0	1	0	0.736842	0.517241	0.528169
0	0	0	0	1	1	0	0.71519	0.451219	0.451219
0	1	1	1	0	1	0	0.70726	0.327957	0.327957
1	0	0	0	1	2	0	0.667656	0.384615	0.384615
1	0	1	0	1	2	0	0.655477	0.444444	0.444444
0	0	1	1	1	1	0	0.627016	0.317343	0.317343
0	0	1	0	1	2	0	0.560976	0.326683	0.326683

Table B.6. 26: Truth table-after crisis sample-over cost-all conditions absent-solution of initial plus CSI-new model 4a

ins_ind	fin_ec	rem_sch	fin_sch	cost_sav	number	~cost	raw consist.	PRI consist.	SYM consist
0	0	0	1	1	1	1	0.880597	0.736264	0.736264
1	0	0	1	0	1	1	0.809313	0.638656	0.638656
0	1	1	1	1	1	1	0.797328	0.578704	0.578704
1	0	0	0	0	2	1	0.766756	0.562814	0.562814
1	1	0	1	0	1	0	0.745455	0.42353	0.423529
0	0	0	0	0	1	0	0.744186	0.505618	0.505618
0	0	1	1	0	3	0	0.710719	0.565121	0.572707
1	0	1	1	0	1	0	0.65445	0.429395	0.429395
1	1	0	1	1	2	0	0.635992	0.270492	0.270492
1	1	1	1	1	2	0	0.576865	0.303258	0.303258
1	1	1	1	0	4	0	0.547923	0.288945	0.288945

TIME OUTCOME

Table B.6. 27: Truth table-full sample-on/below time-INI GI CSI RAI FSI conditions present

ins_ind	gov	cost_sav	rem_sch	fin_sch	number	time	raw consist.	PRI consist.	SYM consist
1	1	1	0	1	11	1	0.776351	0.676125	0.676125
0	1	1	0	1	3	0	0.685958	0.488408	0.488408
1	1	0	0	0	1	0	0.674969	0.455115	0.455115
1	1	0	0	1	2	0	0.659768	0.45273	0.45273
1	1	1	1	1	7	0	0.658327	0.507724	0.507724
1	1	1	1	0	1	0	0.642565	0.383529	0.383529

0	1	0	0	1	3	0	0.623327	0.380503	0.380503
1	0	0	0	0	2	0	0.616644	0.346512	0.346512
1	1	0	1	1	5	0	0.610283	0.430903	0.430903
1	0	0	0	1	4	0	0.597595	0.350746	0.350746
0	1	0	0	0	1	0	0.596888	0.319809	0.319809
0	1	1	1	1	1	0	0.592223	0.342444	0.342444
1	0	0	1	1	2	0	0.50333	0.225519	0.225519
0	0	0	1	1	3	0	0.420958	0.158793	0.158793

Table B.6. 28: Truth table-full sample-over time-7 conditions absent

ins_ind	fin_ec	gov	cost_sav	rem_sch	rev_rob	fin_sch	number	~time	raw consist.	PRI consist.	SYM consist
0	0	0	0	1	1	1	2	1	0.893365	0.841828	0.841828
0	0	0	0	1	0	1	1	1	0.869616	0.786667	0.786667
1	1	0	0	1	0	1	2	1	0.856796	0.749469	0.749469
0	1	1	1	1	0	1	1	1	0.825478	0.680652	0.680652
1	1	0	0	0	0	1	2	1	0.812128	0.651982	0.651982
0	0	1	0	0	1	0	1	1	0.81051	0.697201	0.697201
1	1	0	0	0	1	1	1	1	0.797767	0.661825	0.661826
1	0	0	0	0	1	0	2	1	0.796446	0.681013	0.681013
0	0	1	0	0	1	1	3	1	0.779221	0.648881	0.648881
1	0	1	0	0	1	1	1	1	0.76427	0.621392	0.621392
1	1	1	0	1	0	1	2	0	0.744456	0.576182	0.576182
1	1	1	1	0	0	1	1	0	0.743736	0.506579	0.506579
0	0	1	1	0	1	1	3	0	0.735892	0.571428	0.571428
1	1	1	0	1	1	1	2	0	0.726351	0.573684	0.573684
1	1	1	1	1	1	1	1	0	0.716937	0.541353	0.541353
1	1	1	0	0	1	0	1	0	0.713344	0.505682	0.505682
1	0	1	1	0	0	1	3	0	0.705348	0.482269	0.482269
1	1	1	0	0	1	1	1	0	0.700873	0.511586	0.511586
1	1	1	1	1	0	1	3	0	0.699411	0.511182	0.511182
1	0	1	1	0	1	1	2	0	0.65102	0.450161	0.450161
1	1	1	1	0	1	1	4	0	0.61166	0.394453	0.394453

Table B.6. 29: Truth table-PPP sample-on/below time-7 conditions present

ins_ind	fin_ec	gov	cost_sav	rem_sch	rev_rob	fin_sch	number	time	raw consist.	PRI consist.	SYM consist
1	1	1	1	0	1	1	4	1	0.78072	0.655	0.655
1	1	1	1	0	0	1	1	1	0.775309	0.552826	0.552826
1	1	1	1	1	0	1	3	1	0.761124	0.590362	0.590362
1	0	1	1	0	0	1	3	1	0.758396	0.56699	0.56699
1	1	1	0	0	1	1	1	1	0.756792	0.573696	0.573696
1	0	1	1	0	1	1	2	0	0.746711	0.596859	0.596859
1	1	1	0	0	1	0	1	0	0.745583	0.54717	0.54717
1	1	1	1	1	1	1	1	0	0.743132	0.566125	0.566125
1	1	1	0	1	1	1	1	0	0.742489	0.569378	0.569378

1	1	0	0	0	0	1	2	0	0.722067	0.434659	0.434659
1	1	1	0	1	0	1	1	0	0.71371	0.477941	0.477941
0	0	1	1	0	1	1	3	0	0.678484	0.470825	0.470825
1	0	1	0	0	1	1	1	0	0.655257	0.417355	0.417355
0	0	1	0	0	1	1	2	0	0.624521	0.365011	0.365011
1	0	0	0	0	1	0	2	0	0.593426	0.349031	0.349031
0	0	1	0	0	1	0	1	0	0.591141	0.331476	0.331476

Table B.6. 30: Truth table-PPP sample-on/below time-4 conditions present (exogenous & structural) (excluding the contradictory case of Reims Tramway)

ins_ind	fin_ec	gov	cost_sav	number	time	raw consist.	PRI consist.	SYM consist
1	1	1	0	4	1	0.826087	0.721894	0.721894
1	1	1	1	9	1	0.804572	0.717785	0.717785
1	0	1	1	5	1	0.778287	0.676339	0.676339
1	1	0	0	2	0	0.734069	0.50905	0.50905
1	0	1	0	1	0	0.726002	0.558559	0.558559
0	0	1	1	3	0	0.721532	0.540956	0.540956
1	0	0	0	2	0	0.683673	0.460348	0.460348
0	0	1	0	3	0	0.65109	0.424658	0.424658

Table B.6. 31: Truth table-PPP sample-over time-7 conditions absent

ins_ind	fin_ec	gov	cost_sav	rem_sch	rev_rob	fin_sch	number	~time	raw consist.	PRI consist.	SYM consist
0	0	1	0	0	1	0	1	1	0.797274	0.668524	0.668524
1	1	0	0	0	0	1	2	1	0.786313	0.565341	0.565341
0	0	1	0	0	1	1	2	1	0.784163	0.634989	0.634989
1	0	0	0	0	1	0	2	1	0.782007	0.650969	0.650969
1	0	1	0	0	1	1	1	1	0.753056	0.582644	0.582645
1	1	1	0	1	0	1	1	0	0.737903	0.522059	0.522059
1	1	1	1	0	0	1	1	0	0.722222	0.447174	0.447174
0	0	1	1	0	1	1	3	0	0.713936	0.529175	0.529175
1	1	1	0	0	1	0	1	0	0.69258	0.45283	0.45283
1	0	1	1	0	0	1	3	0	0.68364	0.43301	0.43301
1	1	1	0	0	1	1	1	0	0.672704	0.426304	0.426304
1	1	1	1	1	1	1	1	0	0.664835	0.433875	0.433875
1	1	1	0	1	1	1	1	0	0.659514	0.430622	0.430622
1	1	1	1	1	0	1	3	0	0.655738	0.409638	0.409638
1	0	1	1	0	1	1	2	0	0.625	0.403141	0.403141
1	1	1	1	0	1	1	4	0	0.583686	0.345	0.345

Table B.6. 32: Truth table-PPP sample-over time-5 conditions absent (the conditions with the highest necessity consistency)

ins_ind	fin_ec	gov	rem_sch	fin_sch	number	~time	raw consist.	PRI consist.	SYM consist
0	0	1	0	0	1	1	0.798219	0.652174	0.652174
1	0	0	0	0	2	1	0.787572	0.637931	0.637931

1	1	0	0	1	2	0	0.734219	0.522863	0.522863
1	1	1	0	0	1	0	0.709352	0.465608	0.465608
0	0	1	0	1	5	0	0.696558	0.523471	0.523471
1	0	1	0	1	6	0	0.600784	0.395487	0.395487
1	1	1	1	1	6	0	0.581045	0.368491	0.368491
1	1	1	0	1	6	0	0.553104	0.310214	0.310214

Table B.6. 33: Truth table-road sample-on/below time-4 conditions present (exogenous & structural conditions plus FSI, because it has the highest necessity consistency score among RAI, RRI)

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	time	raw consist.	PRI consist.	SYM consist
1	1	1	0	0	1	1	0.768473	0.585903	0.585903
1	1	1	1	1	5	0	0.729496	0.620202	0.620202
1	1	1	0	1	3	0	0.692182	0.543478	0.543478
1	0	1	1	1	2	0	0.638009	0.510204	0.510204
0	0	1	1	1	1	0	0.500982	0.292479	0.292479
0	0	1	0	1	2	0	0.455645	0.219653	0.219653
0	0	0	0	1	3	0	0.311793	0.095541	0.095541

Table B.6. 34: Truth table-road sample-over time-4 conditions absent (exogenous & structural conditions)

ins_ind	fin_ec	gov	cost_sav	number	~time	raw consist.	PRI consist.	SYM consist
0	0	0	0	3	1	0.906793	0.87835	0.87835
0	0	1	0	2	1	0.823529	0.75	0.75
0	0	1	1	1	1	0.784466	0.69589	0.69589
1	0	1	1	2	0	0.617339	0.483871	0.483871
1	1	1	0	4	0	0.595712	0.417219	0.417219
1	1	1	1	5	0	0.548023	0.370079	0.370079

Table B.6. 35: Truth table-before crisis sample-on/below time-4 conditions present (exogenous & structural conditions)

ins_ind	fin_ec	gov	cost_sav	number	time	raw consist.	PRI consist.	SYM consist
1	0	1	1	5	1	0.884467	0.808917	0.808917
1	1	1	0	3	1	0.853793	0.739558	0.739558
0	0	1	1	2	1	0.852217	0.720497	0.720497
1	1	1	1	5	1	0.844037	0.741865	0.741865
0	0	1	0	2	1	0.843478	0.669117	0.669117
1	1	0	0	2	1	0.773109	0.542373	0.542373

Table B.6. 36: Truth table-before crisis sample-on/below time-5 conditions present (exogenous & structural conditions plus FSI as necessary condition)

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	time	raw consist.	PRI consist.	SYM consist
1	0	1	1	1	5	1	0.88357	0.806452	0.806452
1	1	1	0	0	2	1	0.856823	0.710407	0.710407
0	0	1	1	1	2	1	0.850746	0.71519	0.71519
1	1	1	1	1	5	1	0.841545	0.734966	0.734967

0	0	1	0	1	2	1	0.837545	0.641434	0.641434
1	1	1	0	1	1	1	0.837174	0.681682	0.681682
1	1	0	0	1	2	1	0.765625	0.510869	0.51087

Table B.6. 37: Truth table-before crisis sample-on/below time-5 conditions present (conditions with the highest necessity consistency & now replacing RAI with RRI to see if RRI is relevant)

ins_ind	fin_ec	gov	rev_rob	fin_sch	number	time	raw consist.	PRI consist.	SYM consist
1	0	1	0	1	3	1	0.873397	0.740131	0.740132
1	1	1	0	1	3	1	0.864407	0.710145	0.710145
1	0	1	1	1	2	1	0.862179	0.759776	0.759777
0	0	1	1	1	4	1	0.850174	0.730407	0.730407
1	1	1	1	0	2	1	0.828125	0.673267	0.673267
1	1	1	1	1	3	1	0.818444	0.709678	0.709677
1	1	0	0	1	2	1	0.796642	0.538135	0.538136

Table B.6. 38: Truth table-before crisis sample-over time-5 conditions absent (excluding INI & FEI since no results were found for the over time outcome) (there is 1 contradictory case)

gov	cost_sav	rem_sch	rev_rob	fin_sch	number	~time	raw consist.	PRI consist.	SYM consist
0	0	0	0	1	1	1	0.871739	0.65896	0.65896
1	1	1	0	1	2	0	0.699399	0.333333	0.333333
1	0	0	1	0	1	0	0.650538	0.329897	0.329897
1	1	0	0	1	4	0	0.607199	0.241692	0.241692
1	0	0	1	1	3	0	0.604651	0.3	0.3
1	1	0	1	1	6	0	0.486667	0.23	0.23

Table B.6. 39[80]: Truth table-after crisis sample-over time-conditions absent (structural & exogenous conditions)

ins_ind	fin_ec	gov	cost_sav	number	~time	raw consist.	PRI consist.	SYM consist
0	0	0	0	3	1	0.876056	0.854063	0.854063
0	0	1	1	1	1	0.827138	0.772616	0.772616
0	0	1	0	1	1	0.817114	0.772917	0.772917
1	1	0	0	1	0	0.797235	0.725	0.725
1	0	0	0	2	0	0.775438	0.719298	0.719298
0	1	1	1	1	0	0.755411	0.660661	0.660661
1	0	1	0	1	0	0.728198	0.669026	0.669027
1	1	1	0	4	0	0.622356	0.53271	0.53271
1	1	1	1	4	0	0.547369	0.43514	0.43514

[80] No results are found for the on time-completion after crisis sample have been found. This is the reason why an annex table has not been added.

Table B.6. 40: Truth table-after crisis sample-over time-conditions absent (conditions with the highest necessity consistency)

ins_ind	fin_ec	gov	rem_sch	fin_sch	number	~time	raw consist.	PRI consist.	SYM consist
0	0	0	1	1	3	1	0.891691	0.866055	0.866055
0	0	1	0	1	1	0	0.830189	0.772472	0.772472
0	0	1	0	0	1	0	0.794366	0.721374	0.721374
1	1	0	0	1	1	0	0.790576	0.69112	0.69112
0	1	1	1	1	1	0	0.777778	0.697802	0.697802
1	0	1	0	1	1	0	0.742754	0.661905	0.661905
1	0	0	0	0	2	0	0.741772	0.654237	0.654237
1	1	1	0	1	2	0	0.602687	0.462338	0.462338
1	1	1	1	1	6	0	0.581754	0.489146	0.489146

Table B.6. 41: Truth table-after crisis sample-over time-conditions absent (conditions with the highest necessity consistency: replacing RAI with RRI)

ins_ind	fin_ec	gov	rev_rob	fin_sch	number	~time	raw consist.	PRI consist.	SYM consist
0	0	0	1	1	2	1	0.909091	0.887755	0.887755
0	0	1	1	1	1	1	0.881154	0.849462	0.849462
0	0	0	0	1	1	1	0.863985	0.820707	0.820707
0	0	1	1	0	1	1	0.819572	0.759184	0.759184
0	1	1	0	1	1	0	0.799145	0.723529	0.72353
1	0	1	1	1	1	0	0.766382	0.712784	0.712785
1	0	0	1	0	2	0	0.755618	0.678967	0.678967
1	1	1	0	1	3	0	0.649924	0.555985	0.555985
1	1	1	1	1	5	0	0.58498	0.495192	0.498387

Table B.6. 42: Truth table-after crisis sample-over time-conditions absent (conditions with the highest necessity consistency: replacing RAI with CSI)

ins_ind	fin_ec	gov	cost_sav	fin_sch	number	~time	raw consist.	PRI consist.	SYM consist
0	0	0	0	1	3	1	0.894659	0.874779	0.87478
0	0	1	1	1	1	1	0.826816	0.772059	0.772059
1	1	0	0	1	1	0	0.797235	0.725	0.725
0	0	1	0	0	1	0	0.793003	0.726923	0.726923
0	1	1	1	1	1	0	0.755411	0.660661	0.660661
1	0	1	0	1	1	0	0.744292	0.685393	0.685393
1	0	0	0	0	2	0	0.731383	0.646853	0.646853
1	1	1	0	1	4	0	0.622356	0.53271	0.53271
1	1	1	1	1	4	0	0.543883	0.429285	0.429285

TRAFFIC OUTCOME

Table B.6. 43: Truth table-full sample-on/over traffic-conditions present (seven conditions)

inst_ind	fin_ec	gov	cost_sav	rem_att	rev_rob	fin_sch	number	traffic	raw consist.	PRI consist.	SYM consist
1	1	1	1	1	1	1	1	1	0.869245	0.706612	0.706612
1	1	1	0	1	1	1	1	1	0.857671	0.67234	0.689956
1	0	1	1	1	0	1	1	1	0.838415	0.632795	0.632794
1	1	1	0	1	0	1	2	1	0.837931	0.605042	0.605042
1	0	1	0	1	1	1	1	0	0.794195	0.509434	0.509434
0	0	0	1	0	1	0	1	0	0.793249	0.514851	0.514851
1	1	1	1	0	1	1	2	0	0.786062	0.622857	0.622857
0	0	0	0	1	1	1	2	0	0.763338	0.489675	0.501511
1	0	1	0	0	1	0	1	0	0.746241	0.394619	0.394619
0	0	0	0	1	0	1	1	0	0.741935	0.412141	0.41214
1	0	0	0	0	1	0	1	0	0.724211	0.314136	0.314136
1	0	1	0	1	0	1	2	0	0.722944	0.416857	0.416856
1	0	1	1	0	1	1	4	0	0.686132	0.414397	0.414397
1	0	0	0	0	1	1	1	0	0.654255	0.343434	0.343434
0	0	1	0	0	1	1	1	0	0.633172	0.255528	0.255528
1	1	0	0	0	0	1	1	0	0.624765	0.261993	0.261993
0	0	1	1	0	1	1	3	0	0.620495	0.246085	0.248869

Table B.6. 44: Truth table-full sample-below traffic-conditions absent (seven conditions)

inst_ind	fin_ec	gov	cost_sav	rem_att	rev_rob	fin_sch	number	~traffic	raw consist.	PRI consist.	SYM consist
0	0	1	0	0	1	1	1	1	0.874092	0.744472	0.744472
1	0	0	0	0	1	0	1	1	0.873684	0.685864	0.685864
0	0	1	1	0	1	1	3	1	0.870495	0.742729	0.751131
1	1	0	0	0	0	1	1	0	0.866792	0.738007	0.738007
1	0	1	0	0	1	0	1	0	0.834587	0.605381	0.605381
1	0	0	0	0	1	1	1	0	0.819149	0.656566	0.656566
0	0	0	0	1	0	1	1	0	0.819074	0.58786	0.58786
1	0	1	0	1	0	1	2	0	0.801948	0.583144	0.583144
1	0	1	0	1	1	1	1	0	0.78628	0.490566	0.490566
0	0	0	1	0	1	0	1	0	0.780591	0.485149	0.485149
1	0	1	1	0	1	1	4	0	0.777894	0.585603	0.585603
0	0	0	0	1	1	1	2	0	0.76197	0.486726	0.498489
1	1	1	0	1	0	1	2	0	0.751724	0.394958	0.394958
1	0	1	1	1	0	1	1	0	0.721545	0.367206	0.367206
1	1	1	0	1	1	1	1	0	0.696858	0.302127	0.310044
1	1	1	1	1	1	1	1	0	0.685083	0.293388	0.293388
1	1	1	1	0	1	1	2	0	0.646677	0.377143	0.377143

Table B.6. 45: Truth table-PPP sample-on/over traffic-conditions present (seven conditions)

inst_ind	fin_ec	gov	cost_sav	rem_att	rev_rob	fin_sch	number	traffic	raw consist.	PRI consist.	SYM consist
1	1	1	1	1	1	1	1	1	0.878788	0.708738	0.708738
1	1	1	0	1	1	1	1	1	0.866126	0.668342	0.689119
1	0	1	1	1	0	1	1	1	0.858101	0.653006	0.653005
1	1	1	1	0	1	1	2	0	0.843137	0.706667	0.706667
1	1	1	0	1	0	1	1	0	0.833333	0.505952	0.505952
0	0	0	1	0	1	0	1	0	0.81069	0.535519	0.535519
1	0	1	0	0	1	0	1	0	0.759369	0.401961	0.401961
1	0	0	0	0	1	0	1	0	0.737778	0.313954	0.313954
1	0	1	0	1	0	1	2	0	0.737685	0.389685	0.389685
1	0	1	1	0	1	1	4	0	0.727478	0.461025	0.461025
1	0	0	0	0	1	1	1	0	0.721805	0.412699	0.412698
0	0	1	0	0	1	1	1	0	0.708738	0.318182	0.318182
1	1	0	0	0	0	1	1	0	0.682979	0.303738	0.303738
0	0	1	1	0	1	1	3	0	0.659731	0.272251	0.275862

Table B.6. 46: Truth table-PPP sample-below traffic-conditions present (seven conditions)

inst_ind	fin_ec	gov	cost_sav	rem_att	rev_rob	fin_sch	number	~traffic	raw consist.	PRI consist.	SYM consist
1	0	0	0	0	1	0	1	1	0.88	0.686047	0.686047
0	0	1	1	0	1	1	3	1	0.866585	0.71466	0.724138
0	0	1	0	0	1	1	1	1	0.864078	0.681818	0.681818
1	1	0	0	0	0	1	1	1	0.861702	0.696262	0.696262
1	0	1	0	0	1	0	1	1	0.838265	0.59804	0.598039
1	0	1	0	1	0	1	2	1	0.832512	0.610315	0.610315
1	1	1	0	1	0	1	1	1	0.829317	0.494048	0.494048
1	0	0	0	0	1	1	1	0	0.804511	0.587302	0.587302
0	0	0	1	0	1	0	1	0	0.781737	0.464481	0.464481
1	0	1	1	0	1	1	4	0	0.766892	0.538976	0.538975
1	0	1	1	1	0	1	1	0	0.732961	0.346994	0.346994
1	1	1	0	1	1	1	1	0	0.718053	0.301508	0.310881
1	1	1	1	1	1	1	1	0	0.70505	0.291262	0.291262
1	1	1	1	0	1	1	2	0	0.622103	0.293333	0.293333

Table B.6. 47: Truth table-road sample-on/over traffic-conditions present (five conditions with highest necessity consistency)

inst_ind	fin_ec	gov	rem_att	fin_sch	number	traffic	raw consist.	PRI consist.	SYM consist
1	1	1	0	1	2	1	0.876033	0.769231	0.769231
1	1	1	1	1	1	1	0.873303	0.754386	0.781818
1	0	1	1	1	4	0	0.700935	0.5	0.5
1	0	1	0	0	1	0	0.68232	0.233333	0.233333

0	0	0	1	1	3	0	0.594982	0.350575	0.398693
0	0	1	0	1	2	0	0.539024	0.167401	0.167401

Table B.6. 48: Truth table-road sample-below traffic-conditions absent (five conditions with highest necessity consistency)

inst_ind	fin_ec	gov	rem_att	fin_sch	number	~traffic	raw consist.	PRI consist.	SYM consist
0	0	1	0	1	2	1	0.907317	0.832599	0.832599
1	0	1	0	0	1	1	0.903315	0.766667	0.766667
0	0	0	1	1	3	0	0.706093	0.528736	0.601307
1	0	1	1	1	4	0	0.700934	0.5	0.5
1	1	1	1	1	1	0	0.59276	0.210526	0.218182
1	1	1	0	1	2	0	0.586777	0.230769	0.230769

Table B.6. 49: Truth table before crisis sample sample-on/over traffic-conditions present (new model 1)

inst_ind	fin_ec	cost_sav	rem_att	rev_rob	number	traffic	raw consist.	PRI consist.	SYM consist
1	0	1	1	0	1	1	0.792829	0.57377	0.57377
1	1	1	0	1	2	0	0.755844	0.649254	0.649254
1	0	1	0	1	2	0	0.662609	0.403077	0.403077
1	0	0	1	0	2	0	0.607011	0.312903	0.312903
1	0	0	0	1	4	0	0.602273	0.37018	0.37018
0	0	1	0	1	2	0	0.583955	0.238908	0.243056
1	1	0	0	0	1	0	0.559172	0.283654	0.283654
0	0	0	0	1	2	0	0.541177	0.245856	0.245856

Table B.6. 50: Truth table before crisis sample sample-on/over traffic-conditions present (new model 2)

inst_ind	fin_ec	rem_att	rev_rob	number	traffic	raw consist.	PRI consist.	SYM consist
1	1	0	1	2	1	0.755656	0.667692	0.667692
1	0	1	0	4	0	0.660828	0.416438	0.416438
1	0	0	1	7	0	0.62417	0.423625	0.423625
1	1	0	0	2	0	0.541772	0.273092	0.273092
0	0	0	1	4	0	0.505007	0.211845	0.216783

Table B.6. 51: Truth table before crisis sample sample-on/over traffic-conditions present (new model 3)

inst_ind	fin_ec	rem_att	rev_rob	fin_sch	number	traffic	raw consist.	PRI consist.	SYM consist
1	1	0	1	1	2	1	0.763021	0.673835	0.673835
1	0	1	0	1	4	0	0.656452	0.416438	0.416438
1	0	0	1	1	6	0	0.640909	0.438389	0.438389
1	0	0	1	0	1	0	0.622535	0.319797	0.319797
1	1	0	0	1	2	0	0.537084	0.273092	0.273092
0	0	0	1	1	4	0	0.503771	0.207229	0.209756

Table B.6. 52: Truth table-before crisis sample-below traffic-conditions absent (5 conditions with the highest necessity consistency)

inst_ind	fin_ec	gov	rem_att	fin_sch	number	~traffic	raw consist.	PRI consist.	SYM consist
0	0	1	0	1	3	1	0.840746	0.733173	0.742092
1	0	1	0	0	1	1	0.796915	0.625592	0.625592
1	0	0	0	1	1	0	0.755725	0.620178	0.620178
1	0	1	1	1	4	0	0.744222	0.563158	0.563158
1	0	1	0	1	2	0	0.738806	0.551282	0.551282
1	1	0	0	1	1	0	0.728814	0.591489	0.591489

Table B.6. 53: Truth table-before crisis sample-below traffic-conditions absent (5 conditions- new model 1)

inst_ind	fin_ec	cost_sav	rem_att	rev_rob	number	~traffic	raw consist.	PRI consist.	SYM consist
0	0	1	0	1	2	1	0.860075	0.744027	0.756944
0	0	0	0	1	2	1	0.85042	0.754144	0.754144
1	1	0	0	0	1	1	0.825444	0.716346	0.716346
1	0	0	1	0	2	1	0.821033	0.687097	0.687097
1	0	1	0	1	2	0	0.772174	0.596923	0.596923
1	0	0	0	1	4	0	0.766234	0.62982	0.62982
1	0	1	1	0	1	0	0.721116	0.42623	0.426229
1	1	1	0	1	2	0	0.548052	0.350746	0.350746

Table B.6. 54: Truth table-after crisis sample-on/over traffic-conditions present (5 conditions with the highest necessity consistency)

inst_ind	fin_ec	gov	rem_att	fin_sch	number	traffic	raw consist.	PRI consist.	SYM consist
0	0	0	0	0	1	1	0.970833	0.909091	0.909091
1	1	1	1	1	3	1	0.949612	0.897233	0.926531
1	0	1	1	1	1	0	0.897436	0.786477	0.786477
1	0	1	0	1	3	0	0.803097	0.53886	0.53886
0	0	1	0	1	1	0	0.780627	0.384	0.384
0	0	0	1	1	3	0	0.701627	0.446309	0.519531

Table B.6. 55: Truth table-after crisis sample below traffic-conditions absent (5 conditions with the highest necessity consistency after excluding 1 contradictory case-Metro de Malaga)

inst_ind	fin_ec	gov	rem_att	fin_sch	number	~traffic	raw consist.	PRI consist.	SYM consist
0	0	1	0	1	1	1	0.8925	0.739394	0.739394
1	1	0	0	1	1	0	0.891228	0.683673	0.683674
1	0	0	0	0	1	0	0.864286	0.512821	0.512821
1	0	1	0	1	2	0	0.839917	0.638498	0.638498
0	0	0	0	0	1	0	0.749104	0.204545	0.204545
0	0	0	1	1	3	0	0.690265	0.42053	0.488462
1	0	1	1	1	1	0	0.650869	0.253378	0.253378
1	1	1	1	1	4	0	0.597603	0.160714	0.165441

REVENUES OUTCOME

Table B.6. 56: Truth table-full sample-on/over revenues -conditions present (7 conditions)

inst_ind	fin_ec	gov	cost_sav	rem_att	rev_rob	fin_sch	number	revenu	raw consist.	PRI consist.	SYM consist
1	1	1	1	1	1	1	1	1	0.904236	0.810909	0.810909
1	0	1	0	0	1	0	1	1	0.890978	0.736364	0.736364
1	0	0	0	0	1	0	1	0	0.882105	0.692308	0.692308
0	0	0	1	0	1	0	1	0	0.881857	0.688889	0.688889
0	0	0	0	1	1	1	2	0	0.878249	0.754143	0.754144
1	1	1	0	1	1	1	1	0	0.872458	0.750903	0.750903
1	0	1	1	1	0	1	1	0	0.868903	0.757519	0.757519
1	1	1	1	0	1	1	2	0	0.849271	0.72807	0.72807
1	1	1	0	1	0	1	2	0	0.841379	0.677193	0.677193
1	0	1	0	1	1	1	1	0	0.832454	0.653005	0.653006
1	0	0	0	0	1	1	1	0	0.825798	0.670025	0.670025
1	0	1	1	0	1	1	4	0	0.813347	0.688154	0.688153
0	0	0	0	1	0	1	1	0	0.805049	0.555911	0.555911
1	0	1	0	1	0	1	2	0	0.80303	0.633065	0.633065
0	0	1	0	0	1	1	1	0	0.802663	0.629545	0.629546
1	1	0	0	0	0	1	1	0	0.774859	0.502074	0.502075
0	0	1	1	0	1	1	3	0	0.769144	0.598826	0.598826

Table B.6. 57: Truth table-full sample-on/over revenues-conditions present (3 conditions, based on the results of the 7 conditions) (excluding 7 cases)

inst_ind	gov	rev_rob	number	revenu	raw consist.	PRI consist.	SYM consist
1	1	1	14	1	0.978261	0.96929	0.973025
1	1	0	9	1	0.97395	0.956091	0.961539
1	0	1	2	1	0.96748	0.940552	0.940552
1	0	0	1	1	0.963514	0.91	0.91
0	1	1	3	1	0.949648	0.914089	0.914089
0	0	1	3	1	0.944444	0.90099	0.90099

Table B.6. 58: Truth table-full sample-below revenues-conditions present (7 conditions, full sample)

inst_ind	fin_ec	gov	cost_sav	rem_att	rev_rob	fin_sch	number	~revenu	raw consist.	PRI consist.	SYM consist
0	0	0	0	1	0	1	1	1	0.754929	0.444089	0.444089
0	0	0	1	0	1	0	1	0	0.734475	0.311111	0.311111
1	0	0	0	0	1	0	1	0	0.730769	0.307692	0.307692
1	0	1	0	0	1	0	1	0	0.691429	0.263636	0.263636
1	0	1	0	1	1	1	1	0	0.683443	0.346994	0.346994
1	1	1	0	1	0	1	2	0	0.665511	0.322807	0.322807

1	0	1	0	1	0	1	2	0	0.659066	0.366935	0.366935
0	0	1	0	0	1	1	1	0	0.65796	0.372146	0.372146
0	0	1	1	0	1	1	3	0	0.649082	0.401174	0.401174
1	0	0	0	0	1	1	1	0	0.645429	0.338501	0.338501
0	0	0	0	1	1	1	2	0	0.625	0.245856	0.245856
1	1	1	0	1	1	1	1	0	0.613383	0.249097	0.249097
1	0	1	1	1	0	1	1	0	0.589195	0.242481	0.242481
1	1	1	1	1	1	1	1	0	0.587037	0.189091	0.189091
1	1	1	1	0	1	1	2	0	0.58569	0.27193	0.27193
1	0	1	1	0	1	1	4	0	0.581124	0.311847	0.311847

Table B.6. 59: Truth table-PPP sample-on/over revenues-conditions present (7 conditions)

inst_ind	fin_ec	gov	cost_sav	rem_att	rev_rob	fin_sch	number	revenu	raw consist.	PRI consist.	SYM consist
1	0	0	0	0	1	1	1	1	0.899248	0.795107	0.795107
1	1	1	1	1	1	1	1	1	0.89899	0.798387	0.798387
1	1	1	1	0	1	1	2	1	0.896613	0.807309	0.807309
1	0	1	0	0	1	0	1	1	0.885602	0.728972	0.728972
1	0	0	0	0	1	0	1	1	0.88	0.689655	0.689655
0	0	0	1	0	1	0	1	1	0.879733	0.686046	0.686046
0	0	1	0	0	1	1	1	1	0.875173	0.750692	0.750693
1	0	1	1	1	0	1	1	1	0.873743	0.765073	0.765073
1	1	1	0	1	1	1	1	1	0.864097	0.732	0.732
1	0	1	1	0	1	1	4	1	0.846847	0.740953	0.740953
1	1	0	0	0	0	1	1	0	0.834043	0.595855	0.595855
1	1	1	0	1	0	1	1	0	0.819277	0.598214	0.598214
0	0	1	1	0	1	1	3	0	0.801714	0.649351	0.649351
1	0	1	0	1	0	1	2	0	0.748768	0.521127	0.521127

Table B.6. 60: Truth table-road sample-on/over revenues-conditions present (5 conditions with the highest necessity consistency)

fin_ec	gov	cost_sav	rev_rob	fin_sch	number	~revenu	raw consist.	PRI consist.	SYM consist
1	1	0	0	1	1	1	0.758865	0.501832	0.501832
1	0	0	0	1	1	0	0.750529	0.397959	0.397959
0	1	0	0	1	2	0	0.743413	0.523404	0.523404
0	0	1	1	0	1	0	0.734066	0.308571	0.308571
0	0	0	1	0	1	0	0.733333	0.310345	0.310345
1	1	0	1	0	1	0	0.702997	0.268456	0.268456
0	1	0	1	0	1	0	0.678917	0.258929	0.258929
1	1	0	1	1	1	0	0.632163	0.291815	0.291815
0	0	0	1	1	1	0	0.604478	0.201807	0.201807
0	1	1	0	1	1	0	0.594187	0.249004	0.249004

0	1	0	1	1	1	0	0.566392	0.237603	0.237603
0	1	1	1	1	7	0	0.519337	0.278008	0.278008
1	1	1	1	1	3	0	0.510204	0.172414	0.172414

Table B.6. 61: Truth table-road sample-on/over revenues-conditions present (5 conditions with the highest necessity consistency)

fin_ec	gov	rem_att	rev_rob	fin_sch	number	revenu	raw consist.	PRI consist.	SYM consist
1	1	0	1	1	2	1	0.92029	0.871345	0.871345
1	1	1	1	1	1	1	0.901961	0.826389	0.826389
0	0	1	1	1	2	1	0.871465	0.781659	0.781659
0	1	0	1	0	1	1	0.86014	0.735099	0.735099
0	1	1	1	1	1	0	0.739394	0.519553	0.519553
0	0	1	0	1	1	0	0.717073	0.402062	0.402062
0	1	0	1	1	2	0	0.70137	0.526087	0.526087
0	1	1	0	1	3	0	0.681373	0.513716	0.513716

Table B.6. 62: Truth table-road sample-on/over revenues-conditions present (4 conditions based on the knowledge of the author)

inst_ind	fin_ec	gov	rev_rob	number	revenu	raw consist.	PRI consist.	SYM consist
1	1	1	1	3	1	0.925065	0.894928	0.908088
0	0	0	1	2	1	0.88345	0.815498	0.815498
1	0	1	1	2	1	0.817352	0.721254	0.721254
1	0	1	0	3	0	0.720339	0.564644	0.564644
0	0	1	1	2	0	0.716247	0.575342	0.575342
0	0	0	0	1	0	0.706329	0.389474	0.389474

Table B.6. 63: Truth table-road sample-below revenues-conditions present (5 conditions with the highest necessity consistency)

fin_ec	fin_sch	rem_att	rev_rob	gov	number	~revenu	raw consist.	PRI consist.	SYM consist
0	1	1	0	0	1	1	0.809756	0.597938	0.597938
0	1	1	1	1	1	0	0.718182	0.480447	0.480447
0	1	0	1	1	2	0	0.668493	0.473913	0.473913
0	1	1	0	1	3	0	0.663399	0.486284	0.486284
0	0	0	1	1	1	0	0.611888	0.264901	0.264901
0	1	1	1	0	2	0	0.539846	0.218341	0.218341
1	1	1	1	1	1	0	0.533333	0.173611	0.173611
1	1	0	1	1	2	0	0.460145	0.128655	0.128655

Table B.6. 64: Truth table-before sample-on/over revenues-conditions present (5 conditions with the highest necessity consistency)

fin_ec	gov	cost_sav	rev_rob	fin_sch	number	revenu	raw consist.	PRI consist.	SYM consist
0	1	1	1	1	4	1	0.898058	0.839695	0.839695
1	1	1	1	1	2	1	0.890855	0.821256	0.821256
0	1	0	1	0	1	1	0.882883	0.760736	0.760736

1	1	0	1	0	1	1	0.880851	0.78626	0.78626
0	1	1	0	1	1	1	0.880682	0.771739	0.771739
0	1	0	1	1	1	1	0.821124	0.70339	0.70339
0	0	0	1	1	1	1	0.819876	0.688172	0.688172
1	0	0	0	1	1	0	0.805921	0.628931	0.628931
0	1	0	0	1	2	0	0.662771	0.411079	0.411079

Table B.6. 65: Truth table-before sample-below revenues -conditions present (5 conditions with the highest necessity consistency)

gov	fin_ec	cost_sav	rev_rob	fin_sch	number	~revenu	raw consist.	PRI consist.	SYM consist
1	0	0	0	1	2	1	0.764608	0.588921	0.588921
0	1	0	0	1	1	0	0.671053	0.371069	0.371069
1	0	0	1	0	1	0	0.627628	0.239264	0.239264
0	0	0	1	1	1	0	0.602484	0.311828	0.311828
1	0	1	0	1	1	0	0.596591	0.228261	0.228261
1	0	0	1	1	1	0	0.575809	0.29661	0.29661
1	1	0	1	0	1	0	0.561702	0.21374	0.21374
1	1	1	1	1	2	0	0.498525	0.178744	0.178744
1	0	1	1	1	4	0	0.466019	0.160305	0.160305

Table B.6. 66: Truth table-after crisis sample-on/over revenues-conditions present (5 conditions with the highest necessity consistency)

inst_ind	fin_ec	gov	rem_att	fin_sch	number	revenu	raw consist.	PRI consist.	SYM consist
1	0	0	0	0	1	1	0.890785	0.724138	0.724138
0	0	0	0	0	1	1	0.890411	0.737705	0.737705
1	1	1	1	1	4	1	0.86745	0.804938	0.804938
1	0	1	1	1	1	1	0.793313	0.695749	0.695749
0	0	0	1	1	3	1	0.774576	0.644385	0.673184
1	0	1	0	1	3	1	0.756007	0.618497	0.618497
1	1	0	0	1	1	0	0.744108	0.366667	0.366667
0	0	1	0	1	1	0	0.636986	0.378906	0.378906

Table B.6. 67: Truth table-after crisis sample-below revenues-conditions present (5 conditions with the highest necessity consistency)

inst_ind	fin_ec	gov	rem_att	fin_sch	number	~revenu	raw consist.	PRI consist.	SYM consist
1	1	0	0	1	1	1	0.851852	0.633334	0.633333
0	0	1	0	1	1	0	0.778539	0.621094	0.621094
1	0	0	0	0	1	0	0.713311	0.275862	0.275862
0	0	0	0	0	1	0	0.691781	0.262295	0.262295
1	0	1	0	1	3	0	0.604436	0.381503	0.381503
0	0	0	1	1	3	0	0.564407	0.312834	0.326816
1	0	1	1	1	1	0	0.527356	0.304251	0.304251
1	1	1	1	1	4	0	0.45302	0.195062	0.195062