COST OVERRUNS ON TRANSPORTATION INFRASTRUCTURE PROJECTS IN BRAZIL: HOW TO IMPROVE EFFICIENCY OF ESTIMATIONS

Mateus AGUIAR LIMA
Higher Education Institute of Brasilia
(Brazil)

Caio FREITAS RABER
Higher Education Institute of Brasilia
(Brazil)

David Christian Régis PEREIRA GRUBBA
Federal Court of Accounts
(Brazil)

ABSTRACT:

This paper aims to present the measurement of cost overruns on Brazilian highway projects, as part of transportation infrastructure projects. In addition, it shows the main causes of planning failures and potential tools to relieve these failures. On this way, it talks about an innovative method used to improve the decision-making process under uncertainties, named Reference Class Forecasting, based on theories from Daniel Kahneman and applied by Bent Flyvbjerg on estimations of new projects considering similar finished projects. With that, there is an outlook about the quality of public expenditure in transportation infrastructure projects and provides sources to develop viability studies of new projects with better accuracy.

Keywords: Project management, Road projects, Time and cost estimations.

1. INTRODUCTION

Deficiency on monitoring executed projects and its quality are disturbing points in Brazil. It is not clear for Brazilian society which development projects had positive performances and which were considered feasible or infeasible. Projects, like infrastructure ones, should be better supervised in terms of cost and time of construction since they receive public investments.

Recent studies, like those led by the professor, from the University of Oxford, Bent Flyvbjerg (2002; 2003; 2006; 2009; 2011) present that infrastructure projects, in their most, do not get executed on the initially estimated cost and time at the viability study stage.

Per Flyvbjerg, Holm e Buhl (2002), 90% of transport infrastructure projects overcome the costs predicted at the decision-making process. The benefits frequently get below the forecast and are as worrying as the costs. In some cases, the income of the investments is not significant, even to pay building and operational costs. Developments become unfeasible and mean loss for the investors, that are the taxpayers themselves in case of public constructions.

Money loss for investors could be reduced by monitoring viability of the project comparing it to past projects. Nevertheless, performances of past projects and how they were viable are not published in Brazil. This fact restricts following the results of decision-making

Thus, this paper aims to discuss the cost overruns on Brazilian highway projects, to present some causes for failed estimations and to introduce some methods that help on initial data accuracy. In this way, it announces the following two methods: Reference Class Forecasting and Continuous Monitoring of Viability. At last, it shows a case study with the cost overruns of some Brazilian highway projects.

2. VIABILITY STUDIES

In Brazil, the National Department of Transport Infrastructure – DNIT is responsible for preparing the prior feasibility analyzes for implementation of new highway segments and their improvements. This set of studies composes the Technical, Economic and Environmental Viability Study – EVTEA, required for projects of "big scope", class of projects budgeted greater than R$ 20 million, about US$ 6.3 million.

As opposed to good technique, in 2009, through the Ordinance of the General Director of DNIT n. 1562, the national authority decided to suspend the requirement of technical and economic viability studies for transport infrastructure projects benefited by the Growth Acceleration Program – PAC. The high demand for new developments was the excuse used for the interruption of viability studies.

3. FAILURE ON ESTIMATIONS

The largest statistical study of cost overruns in transport infrastructure projects was performed by Flyvbjerg, Holm and Buhl (2002). This study evaluated a group of 258 projects worldwide, over 20 countries in 5 continents, which reached about US$ 90 billion in projects, comprehending more than 80 years. The authors asserted that, for the first time, it was possible to reach valid conclusions about costs underestimation during the decision-making-process, because many projects were considered, in several places and different historic periods.

The authors concluded that about 90% of transport infrastructure projects presented final cost overruns for the contractors, when compared with initial estimations.

Morris (1990) developed another important study on this field. This scientist concluded that delays on execution and over costs have become common characteristics on projects of public sector and verified the average cost overrun on his sample of developments was higher than 82%.

Costa (2012) point on her paper an analyze of cost overruns on public projects in Portugal. The analyzed period comprehended thirteen years, between 1999 and 2011, with a sample of 164 projects with financial data. The main conclusions pointed that Portuguese developments have their costs increased on 32%. She affirmed also, without full statistical certainty, that overruns were more common close to election years.

4. CAUSES OF FAILURE ON ESTIMATIONS

The causes for the systematic lack of accuracy of cost estimation of large projects is target of numerous international studies. Flyvbjerg, Holm and Buhl (2002), based on a complex analyze, point four types of explanations as possible causes of so many failures: Technical, Politic-Economical, and Psychological explanations.

Technical explanations are often used to describe the cause of planning failure in a development. Those explanations point that errors are caused by lack of experience, inadequate data, as ineffective planning for the size of the project. However, if technical deficiency were the real cause for the failures, it was expected a normal distribution of the errors with an average close to zero, since could have an equivalence of overestimated and underestimated costs. Yet, as mentioned before, Flyvbjerg, Holm and Buhl (2002) demonstrated that 9 out of 10 transport infrastructure projects present costs overrun. Even though, it was expected an improvement over time, since the source of errors could be identified, making possible adjustments on accuracy by sophistication at data collection, more accurate forecast methods, among others.

Therefore, the technical explanations do not justify a cause of so many planning failures, and they are not the true causes of the lack of forecasts accuracy. So, economical, psychological, and political theories may explain better the troubles on estimations (FLYVBJERG; HOLM; BUHL, 2002).

Politic-economic explanations establish that strategic misrepresentation was the cause for these imprecisions. This misrepresentation occurs when the benefits are overestimated and the costs are underestimated, to increase the probability of acceptance and financing of projects, not giving competition to others competitors who analyze the real viability of a project. In most cases, the winner is that one which seems more feasible (FLYVBJERG; HOLM; BUHL, 2002).

Psychological explanations are responsible of imprecisions by the optimism bias, what means, a cognitive predisposition found in most of people who trends to presume future events without taking in account past experiences (FLYVBJERG, 2006).

In the Psychology, Lovallo and Kahneman (2003) define the people trending of underestimating time or cost needed to do a task as planning fallacy. This paradox reflects the conscious and overlay optimistic idea of people about the activities that will be carried out, even knowing, and remembering a contradictious historic about these forecasts. Per Kahneman, this occurs because people think on the details of the activity (inside view), while an analyze of external factors, those that can affect the execution of the activity meaning more realistic (outside view).

5. MECHANISMS TO IMPROVE DECISION-MAKING PROCESS

On this section, some methods available are explained as instruments to help on mitigate failures at the decision-making process based on forecasts. The first method explained is an innovative one, named Reference Class Forecasting, and the other method discussed is the Continuous Monitoring of Viability.

5.1. Reference Class Forecasting Method

The theoretical and methodological principles of the Reference Class Forecasting, were firstly described by Daniel Kahneman, Economic Nobel Prize of 2002, based on theories about decisions under uncertainty. This pioneering method of projects management aims to minimize the effects of the "optimism bias" and, in a lower level, the "strategic misrepresentation", allowing to mitigate the errors of cost-benefits forecasts used to evaluate the viability of new developments.

Kahneman and Tversky described this method in 1979, and it was modified by Lovallo and Kahneman in 2003 after recognizing that judgement errors are more predicable than random. Lovallo and Kahneman (2003) define the method by the difference between inside and outside views, applying the outside view for decision-making.

An outside view (Reference Class Forecasting) ignores project details and any forecast about happenings that could affect the future of the project. In opposite, it analyzes past experiences faced by similar projects with a results distribution from the reference class and compares it with the desired project (LOVALLO; KAHNEMAN, 2003).

Flyvbjerg, Holm and Buhl (2002) recommend to apply the Reference Class Forecasting method to decline both inaccuracies and worries. This method stablishes predictions from a reference class, meaning an outside view of an analyzed project. This external sight is based on information from a group of similar projects. It considers not their specifications and uncertainties that can affect each development individually, but the statistical distribution of their performance. Based on this sight, planners will not need to imagine scenarios, events, and precedents because it will produce more accurate results, since that focusing on details can narrow to inaccuracy.

The Reference Class Forecasting Method includes three steps, as it follows:

1) Identifying a relevant class of past similar projects; it needs to be wide enough to present significant results and to present a better comparative for the desired project.
2) Stablishing a probability distribution with the sample projects; empirical and trustworthy data from enough projects to present substantial statistical conclusions.
3) Comparing the desired project with the developed statistical distribution, to stablish a result most faithfully to the specific project.

The Reference Class Forecasting does not seek to forecast future uncertain events that may happen to a project, but to stablish this desired project into a reference class distribution enabling a more accurate estimate (FLYVBJERG, 2006).

Studies and researches developed by Lovallo and Kahneman (2003), and Flyvbjerg, Bruzelius, and Rothengatter (2003) support the method's ability. These authors led their attention also to possible failures on the method in extreme cases, where occur unknowing misrepresentations. As difficulty on applying this method, they highlighted the correct selection of analog cases for development of the reference class, mainly when planning innovations without precedents and applying new technology.

5.1.1. Example of Reference Class Forecasting: United Kingdom (UK)

Based on studies from Flyvbjerg (2002), the UK Department for Transport, with the HM Treasury, applied the method as valuation for transport projects. In 2003, the HM Treasury published the first version of "The Green Book: Appraisal and Evaluation in Central Government", where it explains the structures of valuating projects, policies, and programs benefitted by National Government investments, not only construction projects. This guidebook suggests to consider economic, financial, social, and environmental impacts during the viability studies, also identifying different alternatives, evaluating cost impacts, and analyzing cost-benefit of all options.

Practicing concepts presented at the Green Book, they developed a study with establishing a reference class for transport infrastructure projects in the United Kingdom. They followed the procedure as three steps presented before.

1) The UK Department for Transport divided the projects in different categories to develop the classes per type of construction, as shown on the Table 1. Consequently, a reference class was developed for each category.

Category	Types of Projects
Roads	Motorway Trunk roads Local roads Bicycle facilities Pedestrian facilities Park and ride Bus lane schemes Guided buses on wheels
Rail	Metro Light rail Guided buses on tracks Conventional rail High speed rail
Fixed links	Bridges Tunnels
Building projects	Stations Terminal buildings
IT projects	IT system development

Table 1: Categories and types of projects used as basis for Reference Class Forecasting. Source: Flyvbjerg (2006).

2) After that, they established the statistical distribution per cost overrun for similar projects. The roads reference class had 172 executed and comparable projects to elaborate the distribution as the Figure 1.

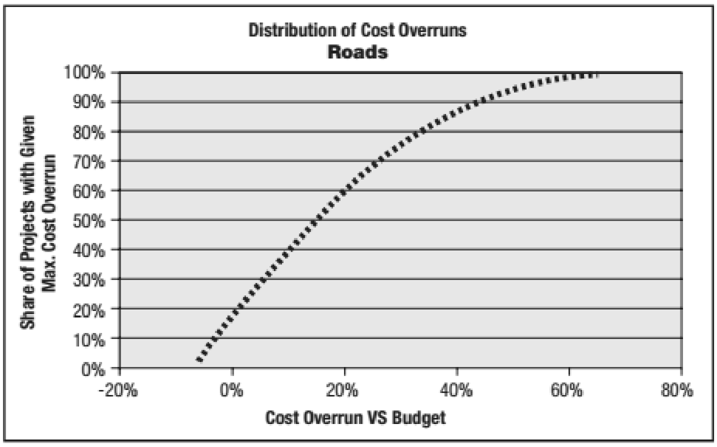

Figure 1: Probability distribution of cost overrun for roads. Source: Flyvbjerg (2006).

On this case, 80% of the projects had an overrun up to 32% of the initial cost, what means that 20% had a cost overrun for the contractors greater than 32%.

3) Based on the statistical distribution developed earlier, they calculated the estimation required uplift as a correction index.

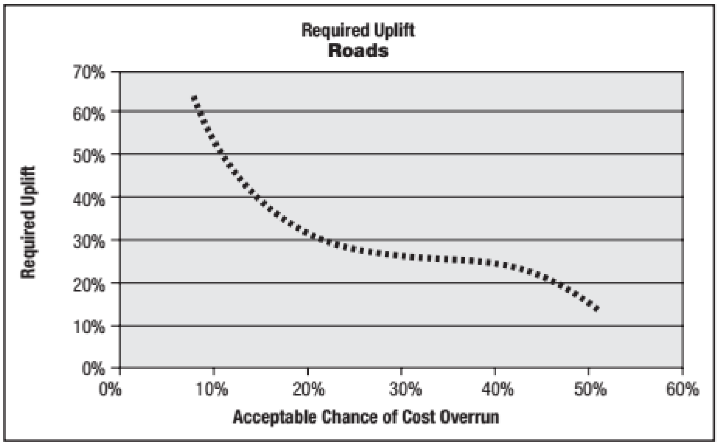

Figure 2: Required uplift for roads as function of the maximum acceptable level of risk for cost overrun. Source: Flyvbjerg (2006).

Considering the data of road projects at the United Kingdom, to have a maximum of 50% of cost overrun, they need an uplift of 15% to the project. If the authority could face a risk of 10%, it should increase about 65% to initial estimations analyzed on decision-making process about investing on a road project. This procedure is valid only to measure if a development continuous being feasible or not after readjustments. Uncertainty

5.2. Continuous Monitoring of Viability

The continuous monitoring process aims to mitigate and diagnose failures, to evaluate failures tendencies, to help finding failures, to decrease time of failures and to verify if cost-benefit estimations are matching the predicted at initial stage of viability study.

Risks and uncertainties are widespread at the beginning of the project, decreasing along the execution when the stages are concluded. However, in other hand, the costs tend to increase as modifications and improvements are realized while the project gets closer to its conclusion stage. This hypothesis can be checked on Figure 3 below.

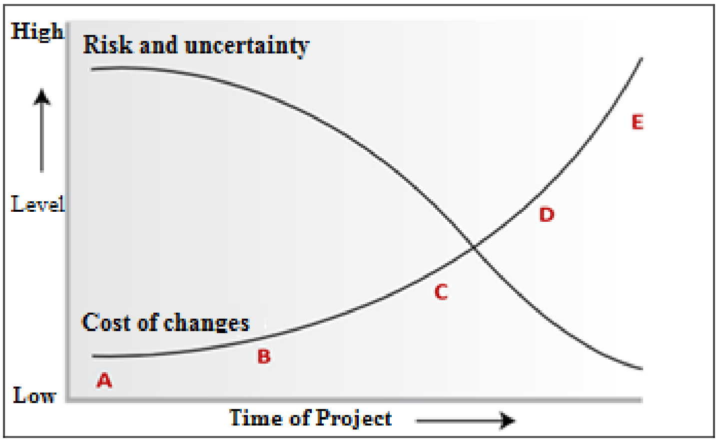

Figure 3: Risks impact along time of project. Source: Adapted from PMBOK (2014).

As showed on previous figure, how much more time it takes to make a modification, greater will be the costs. The points A, B, C, D, and E mean the costs involved to decide adjusting plans in different times of the construction: at the viability study, at the planning stage, at the beginning of the construction, at a more advanced stage, and closer to its ending.

Grubba, Berberian and Santillo (2016) recommend to realize a continuous monitoring of viability during the development along the life cycle of infrastructure projects. The authors understand that viability should be presented not only at the preliminaries studies of EVTEA, but also along the other stages of construction, from the plan for the finishing. The authors yet say this practice may mitigate possible losses for the founders, once it allows to evaluate the project's viability on all the construction's stages. By verifying continuously, the planners can decide if it is feasible to maintain the same scope without modifications, modify the scope, or as last option, abort the project when costs overcome benefits.

The continuous monitoring can be defined as analyzation of cost-benefit along all the project's stages, to mitigate failures at initial estimations. The Figure 4 brings the practical mode of how would be the organization of this idea, dividing the development on stages.

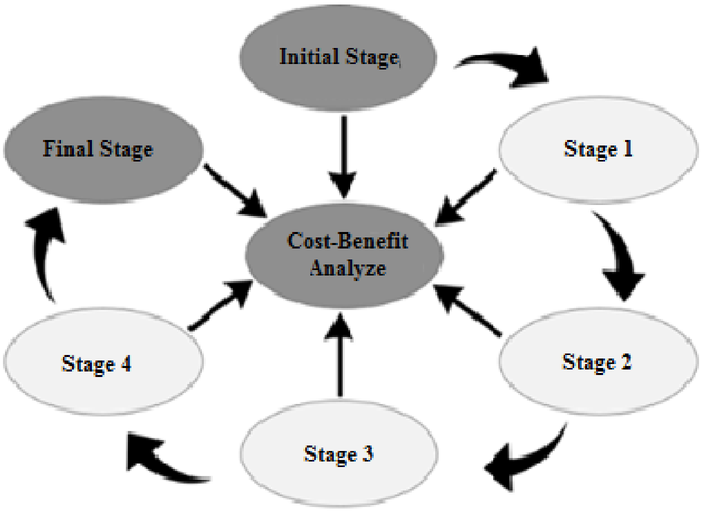

Figure 4: Continuous cost-benefit analyze.

Considering what was observed, the figure above presets a scheme demonstrating that cost-benefit analyze should be done in each stage of the project, so it can be verified if the benefits are getting better than costs along its execution.

6. CASE STUDY

This section, as an explanation of the problem, presents a case study about the evolution of estimated costs in some road infrastructure projects from the Growing Accelerating Program (*Programa de Aceleração do Crescimento)* – PAC, promoted by Brazilian Federal Government. PAC was created to stimulate the economic and social development by investments, mainly, on the urban and transport infrastructure areas. Therefore, the PAC aimed to accelerate the governmental management giving benefits quickly for the population. The billionaire investments for this program came from taxes and duties which all Brazilian citizens are subjected. Most part of this resource was applied on transport infrastructure, mainly the road axis, since it has the biggest between the other modes of the country's transportation.

Brazil has nearly 120 thousand kilometers of federal roads. This study will present data from PAC developments on the highways: BR-101 in the states of Rio Grande do Norte, Paraíba, Pernambuco, Rio Grande do Sul and Santa Catarina, BR-163 in the states of Pará and Mato Grosso, BR-319 in Amazonas, and BR-365 in Minas Gerais. This study comprehended an extension of 2521.5 km of roadways, involving pavement and twinning works estimated in more than R$ 6 billion, almost US$ 20 billion.

The highway BR-101 (Figure 5) cross the country North-South by its East Coast, it is the bigger Brazilian highway with 4,615 km lengthy, passing by twelve states and having high relevance in logistics for the Northeast, Southeast and

South regions of Brazil. At the Northeast, the project analyzed is a road twinning between the states of Rio Grande do Norte (RN) and Pernambuco (PE), a total of 409 km. Part of this road, that cross the states' capitals, was already twinned before the project's beginning. On the South, the project analyzes the part between the states of Santa Catarina and Rio Grande do Sul, a total of 337.5 km, since the part between Paraná and Santa Catarina's capital was already twinned before 2005.

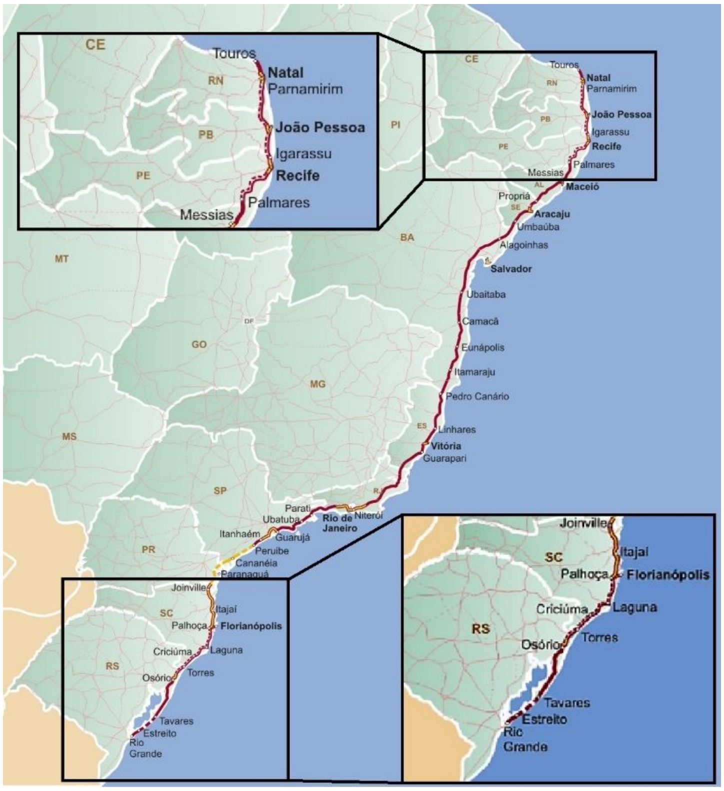

Figure 5: Highway BR-101 and its PAC projects. Source: Adapted from Brazil (2017).

The highway BR-163 (Figure 6) integrates the South, Midwest, and North regions. It contains about 4,480 km, but most of it does not have pavements. It begins in Rio Grande do Sul and ends in the state of Pará. The analyzed project is the pavement construction between the states of Mato Grosso (MT) and Pará (PA), a total of 1,000 km.

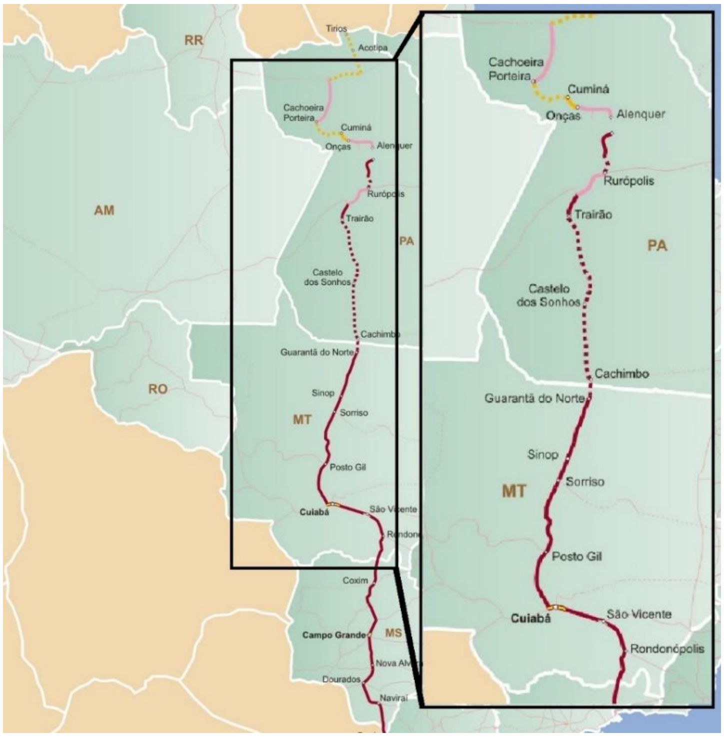

Figure 6: Highway BR-163 and its PAC project. Source: Adapted from Brazil (2017).

The highway BR-319 (Figure 7) connects the states of Amazonas (AM) and Rondônia (RO) in the Brazilian North region and has about 890 km crossing the Amazon Forest. The project analyzed is rebuilding pavements and implementation of new along 680 km.

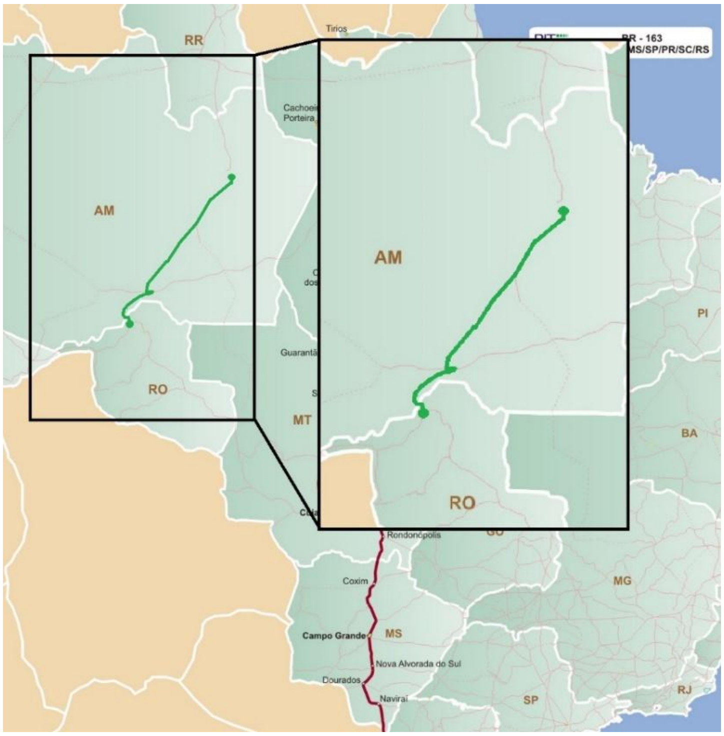

Figure 7: Highway BR-319. Source: Adapted from Brazil (2017).

At last, the highway BR-365 is placed in Minas Gerais (MG). The project analyzed is the road twinning of 95 km.

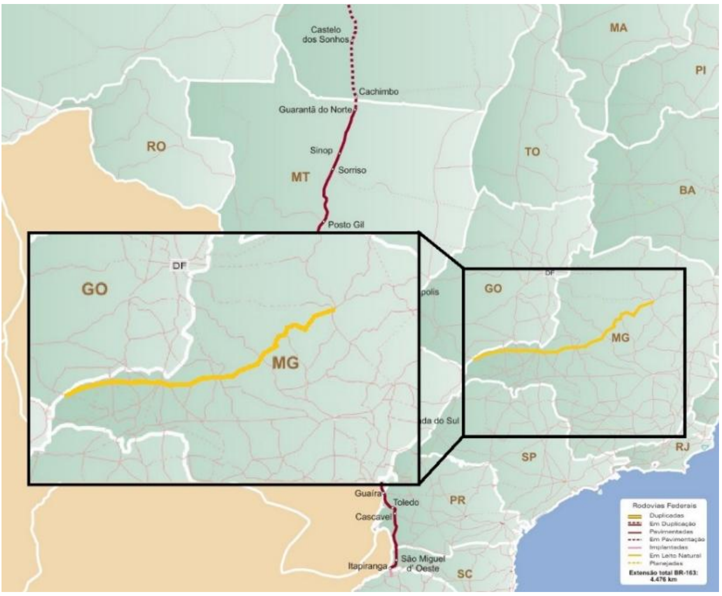

Figure 8: Highway BR-365. Source: Adapted from Brazil (2017).

6.1. Cost Overruns

Brazilian Federal Government do not spread studies comparing the evolution of the relation between costs and benefits for transport infrastructure projects. Up to 2015, the management of PAC use to publish four times a year the partial results of the program's execution. On this report was possible to evaluate synthetically the projects' estimated costs. Nowadays, those reports stopped being published, affecting the transparency.

To evaluate the cost evolution of the projects from the study case, the data from the PAC reports since 2007 up to 2015 were compiled on the Table 2 and briefed on the graph in Figure 8.

HIGHWAY	**Scope (km)**	**Estimated cost (R$ mi)**		**Cost Overrun (R$ mi)**	**Cost Overrun**
		2007	**2015**		
BR-101 RN	81	281	429.8	148.8	53%
BR-101 PB	129	415	679.5	264.5	64%
BR-101 PE	199	715	1,282.6	567.6	79%
BR-101 SC	249	1,500	2400	900.0	60%
BR-101 RS	88.5	750	850	100.0	13%
BR-163 PA/MT	1,000	1,500	2,252.8	752.8	50%
BR-319 AM	680	697	986.4	289.4	42%
BR-365 MG	95	225	471.2	246.2	109%

Table 2: Costs evolution and overruns for case study projects.

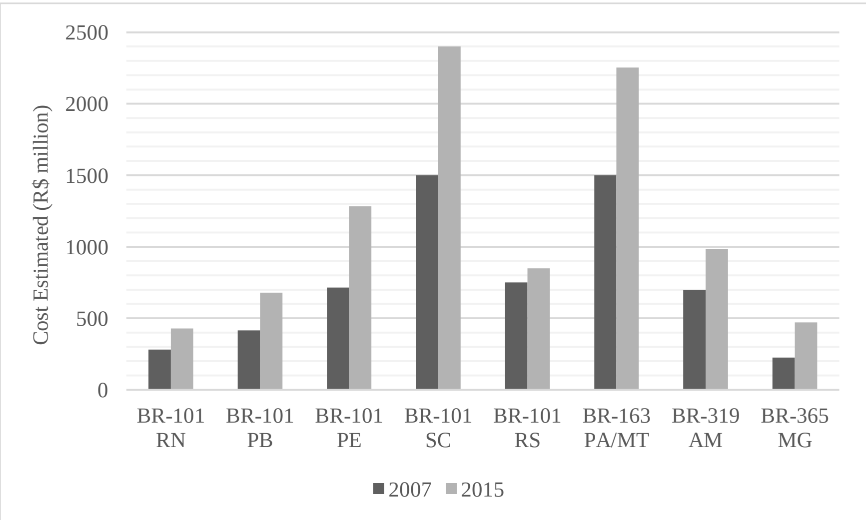

Figure 9: Costs evolution.

The results show that initial contractors' cost estimations were optimists. The road infrastructure projects in all states studied, initially estimated in R$ 6.08 billion, presented an overrun of more than R$ 3.27 billion, passing to cost for the public budget a total of R$ 9.35 billion and meaning an overrun of 54%.

Based on the presented data, the bigger cost overrun happened in the project of twinning the highway BR-101 in the state of Paraíba, where the initial cost grew from R$ 415 million to R$ 679.5 million (overrun of 64%).

The project's magnitude, by means of the extension, is not preponderant to the relative overruns. For example, the highway BR-101 in the state of Santa Catarina stretch, with 249 km extension, had an overrun (60%) less than those 64% of increase on the Paraíba's stretch, where the extension was a bit more than half of the South state's stretch. The same analyzation may be verified comparing other studied states.

Certainly, the final contractor's cost is underestimated at the decision-making stage according the technical literature and the Brazilian experience. However, it must be clear that it does not mean to say that the construction final cost would be the correct one and that the initial budget was incorrect.

There are many scenarios that may occur, as presented on Figure 9. In scenario 1, the cost overrun is fair because, as examples, rise of scope, or including of services not estimates before. However, cases where the overrun is caused part by fair factors and part by unfair factors, as overbilling, not allowed deviations and acts of corruption (scenario 2). Scenario 3, where the cost overrun at the end is improper totally. So, it is not beforehand clear that projects are estimated with values less than they really cost.

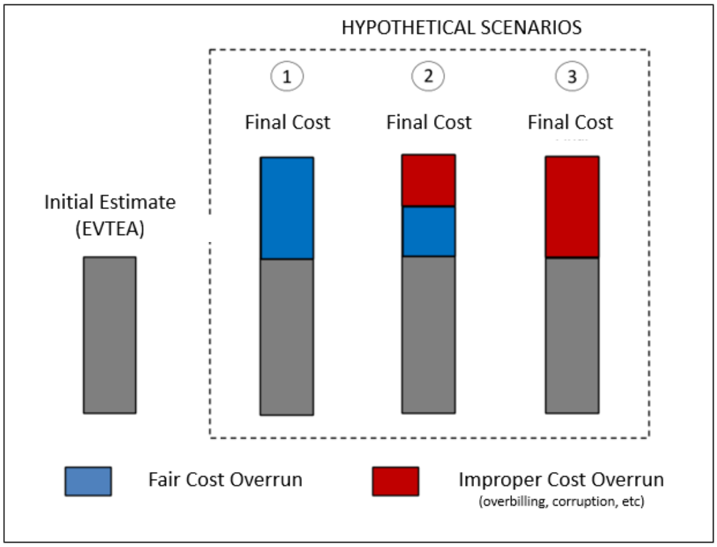

Figure 10: Hypothetical scenarios of cost overruns.

This way, the Reference Class Forecasting may not be used to readjust the construction budget, since it may cause a prejudice vicious cycle. With it, the bigger failure is not considering possible cost overruns, fairs or not, at the decision-making stage. Thus, in the moment of evaluating the development's viability should be done a risk analyze to discard projects that potentially will be unfeasible with prices' increase along the construction.

7. CONCLUSION

The contractors cost estimates for the development of transport infrastructure projects at the decision-making process are frequently, meticulously, and expressively illusory. The false estimates reflect on low performance on reaching the planning of the infrastructure constructions. Unfortunately, the management and the monitoring of these developments by the regulatory governmental companies are not efficient, since the achievement of the estimates is ignored, generating loss of resources that could be placed on other services.

However, mechanisms that may improve this problem are already applied on others countries. For example, the Brazilian traditional methods of viability analyze may be complemented with an empirical analyze, that considers the results of past similar projects, as the method explained and exemplified before: Reference Class Forecasting.

About mitigation of injury risk, the cost and benefit analyze should not be run only at the viability study (decision-making) stage. Therefore, it is indicated a continuous monitoring to evaluate the accuracy of initial estimates and if they continue with the same standard along all the project's stages.

This present paper evaluated the costs in eight stretches of infrastructure projects financed by PAC resources since 2007. The total cost increased from R$ 6 billion to more than R$ 9 billion. With cost overruns and lack of data about the development of public projects is not possible to ensure the real viability of them, it means, to measure if tax resources investments were set efficiently.

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