TÉCNICO LISBOA

*Extended Abstract*

# "Optimism bias" em projetos de engenharia: uma aplicação às concessões rodoviárias

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**Abstract:** Over the last decades, has been witnessed the development of the road infrastructure network in developed countries. Between 1990 and 2016, Portugal saw its motorway network increase from 303km to over 3000km, in this increase in the network, it was used a PPP system. Traffic forecasts produced for these projects have been extensively analyzed worldwide. Due to the large time horizon predicted in these estimates, they have shown to be not only inaccurate but also overly optimistic, overestimating the actual traffic at any given year. Thus, this study aims to quantify the magnitude of these deviations and their temporal evolution in the case of Portuguese road concessions. The results were in line with the results obtained internationally, with Portuguese concessions showing an average traffic overestimation of around 22.7%. Beyond this optimistic trend, the case study revealed that the estimation error tends to increase over time. Possible causes for this behavior include the introduction of tolls on SCUT concessions, traffic impacts from the financial crisis and the overly optimistic growth rate expected by the traffic forecasts. This last point mainly affects concessions whose shareholder returns are guaranteed by the State, since if forecasts growth is too high, eventually the returns will decline, and the State will be required to compensate the concessionaire.

## Keywords

Traffic forecasts; PPP; Road concessions; Forecast inaccuracy; Optimism bias

## 1. Introduction

### 1.1. Scope

Mobility, whether of goods or people, is a fundamental driver of the economy, thus, a robust and efficient infrastructure will positively influence a country's development. To achieve a such an infrastructure, the projects must be analysed by quantifying both its projected benefits and costs. This dissertation will only focus on the benefits, specifically on the traffic forecasts. The benefits brought by this type of project are mostly directly related to the volume of traffic that will use the infrastructure. Therefore, to quantify these benefits an estimate must be made of the volume of traffic that is expected to use a given infrastructure. Depending on these estimates the project will or will not proceed. However, the estimates suffer from inherent inaccuracy due to the long-time span of this type of project. So, if it turns out that the estimate was too optimistic, the benefits that the project was expected to bring are called into question and may lead to the wrong project implementation. Thus, the study of the forecasts deviations becomes relevant for its improvement.

### 1.2. Purposed goals

Considering the importance that the precision and accuracy of traffic estimates have for the correct evaluation of projects in the field of road infrastructure, the main objective of this dissertation is to quantify the deviations between the actual traffic and the traffic forecasts on Portuguese road concessions currently in operation. Although Portugal has been one of the countries that has invested the most in the development of its road network in recent decades, it is notorious that there is a lack of a general follow-up study to quantify and analyse the performance of the projects that make up this network. Given the complexity and the very long project horizon, 20 to 30 years, if we only consider the concession period, it is understandable the need to follow up on these projects. Only by learning from mistakes made or from phenomena that were totally unknown at the time of implementation of certain projects can one hope for an improvement and optimization of the design and development of future projects.

Thus, this dissertation intends to overcome this deficiency, making the broadest analysis, so far, of traffic deviations in Portuguese concessions. These deviations will be quantified annually and for each concession and then will be made a statistical analysis in order to understand the level of precision and accuracy of the set of projects in question, as well as to understand the trends and behaviour of the deviations over time. To this end, were consulted several reports, scientific articles and case studies on PPPs, regarding traffic forecast inaccuracy.

At the same time, it is proposed to understand how the opportunistic behaviour of the concessionaires can influence the traffic forecast. Using studies that have analysed the financial dimension of Portuguese concessions, namely regarding contract renegotiation, risk allocation and transfer, and financial rebalances, an attempt will be made to understand what the contractual mechanisms for this behaviour are and how they can be mitigated.

## 2. Literature review

### 2.1. Traffic forecasts

A traffic forecast is defined by estimating a demand, such as number of vehicles or number of passengers by a time scale which can be annual, daily or by peak hour.(Oliveira e Sarmento, 2019).

There are several methods for generating these forecast, some more complex than others, however the scope of this dissertation is to analyze traffic deviations, and as such, it will only be briefly explained the most used method in this area. The four-stage model is bases on the following steps:

- Generation/Attraction – Estimates the number of trips initiating and finishing in each zone.
- Distribution – Estimates de origin and destination of each trip
- Modal split – Allocates the total trips to different transports modes, such as railway, bus, or private vehicle
- Assignment – Tries to guess which route is each trip taking.

In short, the method seeks to estimate the number of trips between zones as well as their origin and destination, the modal split and the path taken by each trip. For this it is necessary to fill the model with some data. These are socioeconomic data such as resident population or number of jobs in each zone. The modal split considers data such as the purchasing power or motorization rate of each zone or technical details such as the quality of the infrastructure or traffic conditions such as congestion levels and alternative routes.(Nicolaisen, 2012)

### 2.2 Forecast inaccuracy

Considering the inaccuracy in these forecasts is inevitable, it is essential that the projects be evaluated ex post and that the deviations from the traffic forecasts should be quantified. With this in mind and given that different authors use different formulas to calculate the deviation, was important to establish a single formula to use and compare the following analyses. In this dissertation was used the following formula to measure the traffic deviation:

$$E_2 = \frac{Tr_i - Te_i}{Te_i} * 100$$

In this formula the error is expressed as a percentage of the deviation between actual traffic and forecasted traffic from year i, so an E value of -50% means that actual traffic is half of the forecasted traffic.

At the end of the century there was a proliferation of large-scale road projects in developed countries, consolidating and densifying their road networks. The results of the studies considering deviations analyses or tolled road projects showed a tendency of overestimating the traffic. In (Bain, 2009) the author compiles over 100 projects and concludes an average deviation of -23%. Similar studies on untolled projects show that the average deviation stands at 9,5%. (Flyvbjerg et al, 2005). Meaning the overestimation of traffic is a problem that only affects the tolled projects.

This optimistic tendency is shown to be more acute in countries with less history in the kind of projects. In these countries the average deviation was -42% whereas in countries more experienced in these projects the deviation was only -19%. (Bain, 2009).

On the other hand, the deviation on these projects is shown to be directly linked with volume of traffic in question. In (Horowitz & Emslie, 1978), the authors analyze 78 highway segments in the USA and concluded that in projects with higher traffic volume, the deviation was far less than in projects with lower volumes. Traffic deviations are also affected by the alternative existing infrastructure or by the procurement model used for the provision of this infrastructure as shown in (Baeza & Vassallo, 2012) and (Odeck & Welde, 2017) respectively. The first study analyzed Spain's tolled road network and presented an average deviation of -44%. This deviation was attributed by the existence of a similar road network which was untolled, thus stealing demand from the new tolled projects. The second study analyzes the Norwegian network which unlike many other countries, including Portugal and Spain, is managed by local public authorities. In this way mitigating the possible opportunistic behavior from the concessionaire. This study revealed an average deviation of 4% in the first year.

Lastly the deviation is largely affected in the project's first years of operation by the ramp up phenomenon, which can be described by an extraordinary increase of the demand. This phenomenon results, in most cases, in the decreased of the deviation. In the next graph it is shown for the three case studies referenced above, the evolution of the deviation in the first five years of operation.

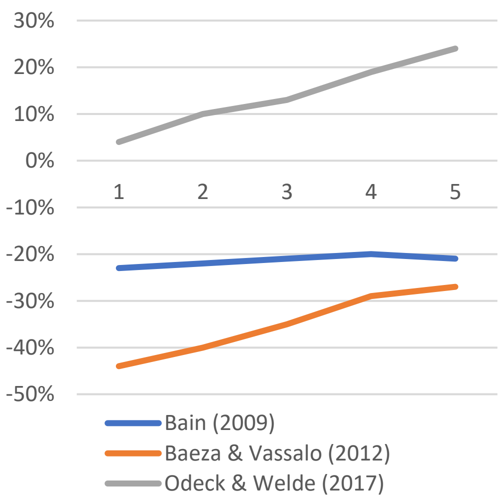


*Figure 1 - Ramp up effect*

Except for Bain's case, the ramp up effect is easy to see, as the average deviation raises from one year to the next.

## 3. Concessions and PPP models in Portugal

### 3.1. PPP

A public-private partnership is defined in Portuguese law by being "the contract or the union of contracts whereby private entities, designated by private partners, undertake, on a lasting basis, before a public partner, to ensure, in return, the development of an activity which meets a collective need, where the responsibility for the investment, financing, exploitation, and associated risks rests, in whole or in part, with the private partner.

In the case of road infrastructure, PPP is accompanied by a concession contract between the state, the grantor and the private partner, as the concessionaire. These concessions generally have a very long duration, and of the concessions operating in Portugal through PPP the average contractual period is 29.8 years.

In Portugal all the road PPP are contractual and most of them fall under the category of DBOFT, standing for Design-Build-Operate-Finance-Transfer. In terms of compensation for the private partner, there are three models of remuneration. Either the project is self-sustaining in which case the private partner is entitled to the toll revenues. Other case, based on the traffic, is the bands model introduced in the SCUT concessions, following the English system of shadow tolling. In this method the traffic of any given year is compared to pre-determined traffic bands and State pays a tariff for each car according to the given band (Tribunal de Contas, 2005). The last possibility consists in availability payments where the State pays a fix amount for each day the infrastructure is operational. These three cases reflect the different risk allocations that may exist in these projects regarding the demand risk.

The first compensation model is generally associated with a private demand risk allocation, whereas if the demand risk is shared by the private and public sector the traffic band system has been used. Finally, if the demand risk falls under the public partner, then its more common to be used an availability payment system.

Lastly, there are a few scenarios where the public partner may be contractually obligated to compensate the concessionaire (REF) or the terms of the contract may be renegotiated.

There are many causes that can lead to both outcomes, such as unilateral decisions, major force, legislative changes, low demand (Cruz & Marques, 2013).

## 3.2. Portuguese concessions

Since the early 1990s there has been massive densification of the motorway network in Portugal from 303km in 1990 to 3070km in 2016, according to official data on the PORDATA portal. Currently the network is fully concessionary with the following distribution, about 2530km are privately owned and 541km are owned by Infraestruturas de Portugal (IP) which acts as a public manager. The densification of the motorway network was only possible with the introduction of private investment, as the investment costs would be unbearable for the public sector. This funding came in the form of public-private partnerships (PPP). The concessions in Portugal can be grouped into three distinct generations.

### 3.2.1. Traditional concessions

Traditional concessions are those in which the concessionaire's remuneration model is based exclusively on the charging, with real tolls, of a tariff to the user. This model is based on the user-pays principle and does not entail charges for public partner.

This was the first concession model to be used in Portugal when, in 1972, Brisa was given the first concession of its kind, followed by the LusoPonte, Oeste, Douro Litoral and Litoral Centro and Norte concessions.

### 3.2.2. SCUT concessions

The idea of SCUT was introduced in Portugal in 1997, and these concessions are based on the English model of "Shadow Toll". The model consists of the contributor-pays principle, and as such there is no direct cost to the user. The concessionaire's remuneration system is based on payments by the State according to the volume of traffic circulating in the concession.

In 2010 this regime was revised, and the decision was taken by the State to insert tolls in SCUT concessions changing the remuneration model of the concessionaires to a payment model for availability. That is to say, the concessionaires started to receive periodic payments from the State depending on the number of days the road in question was operational. It is therefore rent and the amount in question does not vary depending on the volume of traffic flowing. On the other hand, the concessionaire charges the toll to the user and returns these revenues to the public partner, namely Infrarastruras de Portugal. The concessions that are covered by this model, will be called ex-SCUT, are: Algarve, Beira Interior, Beira Litoral e Alta, Costa de Prata. Grande Porto, Interior Norte e Norte Litoral.

### 3.2.3. Sub concessions

A Infraestruturas de Portugal (IP) is a public company founded in 2015 with the objective of integrating REFER and Estradas de Portugal under one roof and thus being responsible for managing the road and rail infrastructure in Portugal. IP currently has the concession of about 15253km of the 17874km of the national road network, of these, 541km are under sub concessions. IP uses, sub-concessions to guarantee the investment, development, maintenance and operation of these infrastructures. This is the case of the Algarve Litoral, Baixo Tejo, Baixo Alentejo, Douro Interior, Oeste Coast, Pinhal Interior and Transmontana Freeway concessions.

# 4. Methodology e data collection

## 4.1. Methodology

The proposed analysis for this dissertation is based on five main topics. Firstly, the quantification of the average traffic deviation of each concession and the evaluation of the deviation tendency, both temporal and optimistic / pessimistic behaviour revealed by the base case traffic forecasts. For this, real traffic data and estimated traffic will be collected for each concession and in each year of operation. Then a statistical analysis will be performed using calculation tables to determine means, standard deviations, medians and also visual aids, in the form of graphs and diagrams.

The second point will be to analyse how traffic deviations vary with certain factors, which I will call deviation factors, which may influence the magnitude of the deviation. Factors such as geographic location of projects, traffic volume and concessionaire compensation model.

The third aspect to be analysed will be the traffic forecasts in the base case and how they relate to factors that will be in their genesis, such as the population covered, GDP per capita, purchasing power, business density or number of overnight stays in the influence zone of each project. Considering this area to be composed by the municipalities that are crossed by each concession. Being these factors, elements on which traffic forecasts are based and generated by, it is expected to find a correlation between the forecast and these factors.

The last point of the analysis focuses on actual traffic and how it is affected by macro and socioeconomic factors. Notably how traffic reflects GDP growth, or motorization rate, and what are the impacts on traffic of political and economic events like the introduction of tolls or the 2010-2014 financial crisis.

Finally, is assessed the existence of a correlation between the magnitude of the deviations and the amounts paid to the concessionaires in REF requests.

4.2. Data collection

The main data for the study are traffic forecasts present in the base case of each concession and the actual traffic values in each concession and year. The data for the traffic forecasts, as the base case is a confidential document and as such not publicly disclosed, in accordance with opinion No. 241/2013 of the Committee on Access to Administrative Documents, was made available to me by my thesis advisor. The acquisition of real traffic data was made by consulting quarterly traffic reports issued by IMT since 2008 as well as consulting the accounts of each concessionaire in the years when the traffic report did not cover a given project.

At the same time, deviation, forecasts and traffic factors were all collected on the PORDATA online portal. For this, the map of the national road network made available by IP, dated 25/01/2018, was consulted, followed by a list of municipalities covered by each concession. The resident population was then withdrawn in each municipality and in each year of operation for the different concessions.

Due to the lack of data in certain years, for certain municipalities, a NUTS II analysis was chosen for the remaining factors. The factors chosen to relate to the estimates were as follows.

• Resident population (Municipal) - Population is directly linked to travel generation, larger population means more travel).

• GDP per Capita and Purchasing Power (NUTS II) - Economic indicators that reveal the ability of the local population to support tariff charges, if applicable for a tolled project.

• Business Density (NUTS II) - Indicates the number of jobs in that area, which along with the resident population generates travel.

• Number of overnight stays per 100 inhabitants (NUTS II) - Tourist indicator that increases the population in a given area, even if seasonally. However, it is expected that the temporary increase in population will increase total trips.

Regarding traffic factors, the following factors were analyzed at national level:

• Annual GDP growth

•Unemployment rate

• Motorization rate

## 5. Traffic deviation analysis

### 5.1. Average deviation

In the more general context, the traffic forecasts were optimistic, with an average traffic deviation of -22.7% and a standard deviation of 25.4%. This overall average deviation is obtained by averaging the average error in each concession over its operating period. Table 1 shows the average errors of each concession.

| Concession | Average traffic deviation |
|---|---|
| Algarve | -18.8% |
| Baixo tejo | 27.0% |
| Beira Interior | -43.9% |
| Beiras Litoral e Alta | 2.6% |
| Costa da Prata | -48.6% |
| Douro Interior | -13.8% |
| Grande Lisboa | -30.4% |
| Grande Porto | -49.3% |
| Interior Norte | -41.9% |
| Litoral Oeste | -22.6% |
| Norte Litoral | -5.8% |
| Norte | -61.4% |
| Pinhal Interior | 10.8% |
| Transmontana | -22.1% |
| Average | -22.7% |

*Table 1 - Average deviation by concession*

Most of the concessions, ten out of fourteen, have an error of between 0% and -50%. Note the similarity between the figure and a normal distribution. The similarity is such that it was replicated, using the overall mean error of -22.7% as the average and the standard deviation of 25.4%, a normal distribution that should in theory represent the probability of a random project incur in a certain deviation. Coupled with this distribution is a normal distribution with the same standard deviation, but with an average of 0%. This second distribution attempts to represent a situation which, while maintaining the inherent inaccuracy level of traffic estimates, represented by the standard deviation, would present no optimistic/pessimistic tendencies, reflected in the mean. In this theoretical exercise the optimistic tendency of the estimates and the consequent error generated by them is clearly visible.

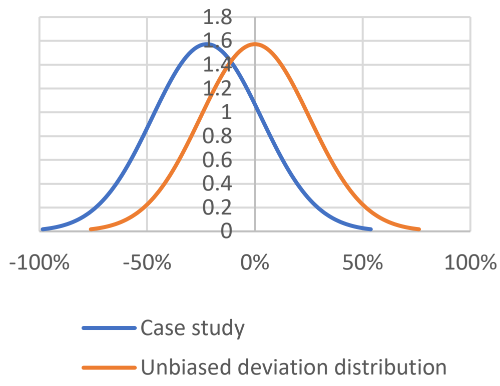


*Figure 2 -Traffic deviation distribution*

## 5.2. Temporal evolution

Regarding the temporal evolution of the traffic deviations it was concluded that the deviations tend of increase in the negative way. Figure 3 Shows us a linear regression with a determination coefficient of 0,87 which is highly atypical in these kinds of projects.

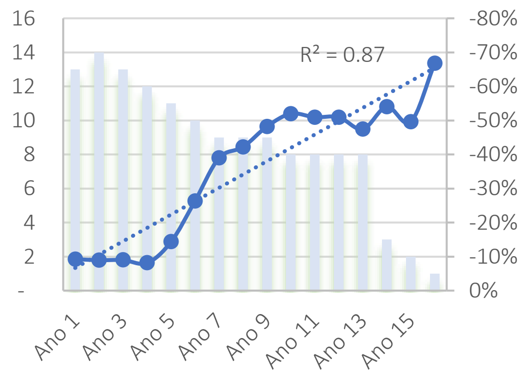


*Figure 3 - Temporal evolution of the average deviation*

## 5.3. Ramp up effect

The case study in first glance does not appear to be affected by this phenomenon as seen the figure 3.

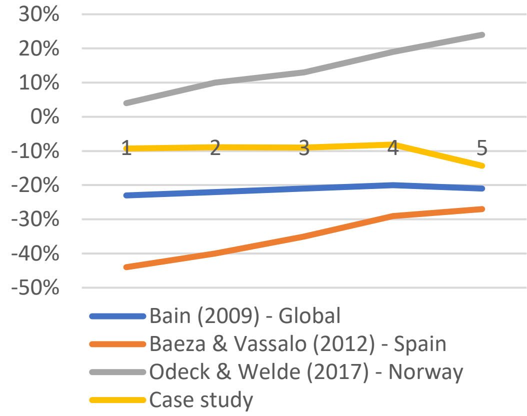


*Figure 4 - Ramp up effect comparison*

As seen the figure above this case study's behavior is the same as Bain's study. However, it was not discarded the idea of ramp up, as it was hypothesized that the traffic forecast annual growth already included the ramp up effect. Table 2 shows the average annual growth of both actual traffic and forecasts.

| Operation year | Actual traffic annual groth | traffic forescats annual growth |
|---|---|---|
| year 2 | 6.83% | 5.11% |
| year 3 | 3.92% | 4.47% |
| year 4 | 3.62% | 4.59% |
| year 5 | 1.18% | 3.27% |
| average (13 years) | 3.89% | 4.36% |

*Table 2 - annual traffic growth*

This hypothesis seems to be correct as the traffic forecasts predict higher growth rates for the first years. The consequence of these higher growth rates is that deviation will not tend to improve over time, even though the forecast is mirroring the actual traffic behavior.

## 5.4. Deviation by concession generation

On this analyzes it was found that the overall average deviation was smaller than on the previous generation with the first-generation presenting an average deviation of -46%, the second-generation reduced this number to -29% and last generation saw its average deviation landing on -4%. This reveal in theory that the public sector is gaining experience in these PPP projects. However, looking at figure 5 that show the different generations deviation's temporal evolution it clear that these average deviations don't tell the whole story.

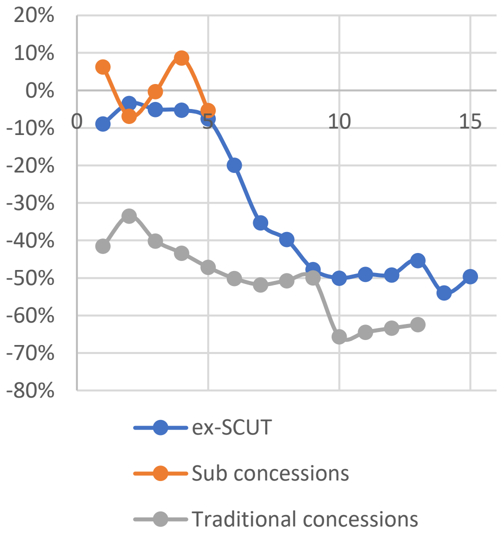


*Figure 5 - Deviation evolution*

As seen in the figure above, in the ex-SCUT concessions there is an abrupt drop in the average deviation. This was the consequence of the introduction of tolls in 2010. This political decision lead to a staggering 40% drop in traffic in these concessions. However, this number may be deceiving as in the same period Portugal was submerged in a financial crisis that lasted from 2010 to 2014. This means that both effects overlap and they're both significant contributors to the overall forecast inaccuracy presented in this case study.

### 5.5. GDP and Traffic growth

Before making this analysis was expected that the actual traffic growth would be positively influenced by the GDP growth. As the GDP is of the main economic indicators, the hypothesis was if the economy grows then traffic will grow too.

Figure 6 shows this correlation, note that of the 15 years analyzed the growth signal was the same in both variables in 13 years.

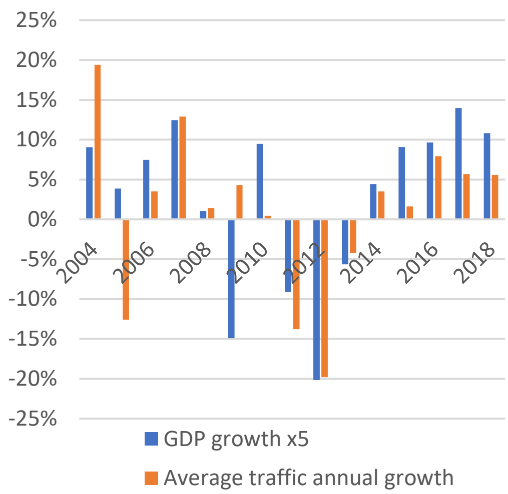


*Figure 6 - GDP growth and traffic growth*

Perhaps more interesting is table 3 that groups both GDP, actual and forecasted traffic annual growth.

| Annual growth | | | |
|---|---|---|---|
| Year | GDP | Traffic forecast | Actual traffic |
| 2007 | 2.51% | 4.85% | 12.91% |
| 2008 | 0.32% | 4.36% | 1.41% |
| 2009 | -3.12% | 3.97% | 4.29% |
| 2010 | 1.74% | 3.83% | 0.44% |
| 2011 | -1.70% | 3.47% | -13.79% |
| 2012 | -4.06% | 3.04% | -19.81% |
| 2013 | -0.92% | 4.03% | -4.18% |
| 2014 | 0.79% | 3.17% | 3.52% |
| 2015 | 1.79% | 3.45% | 1.61% |
| 2016 | 2.02% | 1.95% | 7.91% |
| 2017 | 3.51% | 2.03% | 5.67% |
| 2018 | 2.44% | 1.99% | 5.58% |
| Average | 0.44% | 3.34% | 0.46% |

*Table 3 - Annual growth comparison*

This table revealed the last contributor to the overall traffic inaccuracy of the case study, more specifically why the deviations tend to get worse with the years. Its easy to see that if the forecasted traffic annual growth is to optimistic it is unlikely that the actual traffic will ever meet the forecast, thus, worsening the inaccuracy year over year.

## 6. Conclusions

In general, the primary objective proposed for this dissertation was fulfilled. Although it was not possible to analyze all road concessions operating in Portugal, the case study is quite representative.

The main objective was to quantify traffic deviations and analyze their temporal trends.

Overall, forecasts were moderately optimistic, with an average overestimation of traffic at around 22.7%. This number places this case study within the overall study average (Bain, 2009), which has an average overestimation of 21.4%.

On the other hand, the accuracy of the estimates has deteriorated over time. This time increment of the estimation error is explained by 3 main factors.

Firstly, due to the fact that SCUT concessions make up 50% of the case study, the introduction of tolls on these concessions had a major impact on the traffic level and consequently on the average error of the case study. This decision to introduce tolls led to a drop in traffic at SCUT concessions of around 40%, raising the deviation from -19% in 2010 to -47% in 2012.

The second factor contributing to the traffic breakdown was the 2010-2014 financial crisis. It should be noted that the crisis partially overlaps the introduction of tolls on SCUT so that in these concessions it was impossible to determine the impacts of these events independently. However, as a result of the analysis of paragraph 5.6.1, traffic growth has been concluded in the medium term closely following GDP growth. As one of the direct effects of a financial crisis is the contraction of GDP, the fall in traffic levels would be inevitable. However, due to the overlap above, it was not possible to accurately quantify the direct impacts of the traffic crisis.

The last factor contributing to the increase in the forecast inaccuracy was excessive optimism about the forecasted annual traffic growth. In the period analysed, the estimated average traffic growth was around 3.3%, well above GDP and real traffic growth, which was 0.5%.

This last point exposed the existence of a mechanism for opportunistic behaviour that had not been considered before. Initially, in the literature review it was stated that, depending on the openness to renegotiation shown by the public partner, the private partner could have the incentive to deliberately inflate estimates to increase the chances of winning the public tender and subsequently renegotiate the contract with an improvement of the conditions for the private partner. In this case estimates are inflated from the outset and as such will be relatively straightforward for the public partner, through the forecasts that himself created in the cost-benefit analysis, to detect such optimism in the estimates. However, in light of this analysis, it has been found that this optimism may be concealed over a longer time horizon. That is, in the early years the forecasts may be lower and as such closer to the forecasts produced by the public partner. This can even convey a sense of trust and responsibility from the public partner to the private partner. This will affect cases where the grantor commits to contractually maintain the concessionaire's internal rate of return (IRR) within a given agreed range. Thus, excessively optimistic annual growth in traffic estimates will not be matched by actual traffic growth and will eventually lower the IRR below the contractually anticipated minimum value, leading to a REF request or eventual renegotiation. This overgrowth will be more difficult to identify the longer the time period considered by the estimates. In short, as traffic estimates rely heavily on socio-economic cycles and factors that are impossible to predict in the medium and long term, and at the same time, the contract expects compliance with the base case conditions. It would be advisable to set periodic reviews of assumptions of the base case. In this way, the public partner would be better protected by any opportunistic behaviour of the private partner.

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