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VALUATION METHODOLOGY

for contingent liabilities in infrastructure projects:

THE COLOMBIAN CASE

General Directorate of Public Credit and National Treasury

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Edition
November, 2020

ISBN (English Version): 978-958-59015-8-2
ISBN (Versión Español): 978-958-59015-7-5
eISBN: 978-958-59015-6-8

GRUPO BANCO MUNDIAL

U.S. DEPARTMENT OF THE TREASURY

Schweizerische Eidgenossenschaft
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Chapter 1

Presentation

In 2011 the General Directorate of Public Credit and National Treasury (DGCPTN, for its Spanish initials) published the document called "Methodology for valuing and monitoring risks in state contracts". This document stipulates the methodologies currently approved by DGCPTN to value risks in government contracts, in compliance with Article 44 of Decree 423 of 2001[1]. These methodologies have made possible the valuation of contingent liabilities for projects currently under execution, which in turn is used to define the required contributions to the Contingency Fund for State Entities (FCEE, for its Spanish initials), providing liquid reserves in the event of materialization of risks which are the Nation's or the Public Contracting Entity's obligation.

With this background and in compliance with Article 46 of Decree 423 of 2001[2], the following document is an updated valuation methodology, incorporating lessons learned from the projects under execution. This new methodology improves the statistical approach and models, allowing a more precise measurement of risks assumed by Public Entities in infrastructure contracts and in turn providing the necessary resources in the State Entities Contingency Fund prior to the materialization of the risks.

[1] Article 44 - "Contingency assessment methodologies. The General Directorate of Public Credit and National Treasury of the Ministry of Finance and Public Credit shall adopt, through general administrative acts, the methodologies applicable to state contracts to determine the value of the contingent obligations stipulated therein" (Compiled Decree 1068 of 2015).

[2] Article 46 - "Evolution of methodologies. The General Directorate of Public Credit and National Treasury of the Ministry of Finance and Public Credit shall permanently evaluate the methodologies for the assessment of the contingent obligations of the State entities, with a view to keeping them in line with the real needs of public procurement. In any case, the evolution of the methodologies must be oriented respecting the purpose and objectives of the State's contractual risk policy system" (Compiled by Decree 1068 of 2015).

This document contains the guidelines required to evaluate the contingent liabilities in the framework of the different contractual schemes for private participation in infrastructure, which are in force in Colombia (e.g. Public-Private Partnerships, Concessions, among others), where the State assumes a portion of the risks. The objective of quantifying the risks and their respective contribution plan to the FCEE is part of a fiscally responsible planning process and helps the government avoid volatility in its annual fiscal obligations that could occur if appropriate analysis of potential contingent obligations in the infrastructure contracts is not done by the different State Entities.

In this sense, this manual provides an update of the guidelines "Methodology for valuing and monitoring risks in state contracts", published by the Ministry of Finance and Public Credit in 2011. The methodological scheme proposed in this new methodology aims to identify the main characteristics of risks in state contracts, account for the context around the risks, and the valuation of the risks. This last step shall be carried out in the project structuring stage and in the respective periodic follow-up, because the risk behavior is dynamic during the term of the contracts.

In regards to public policy, this document shall serve as the primary guidelines that State entities must consider in dealing with risk management and contingent liabilities. This is done with the objective of ensuring planning and budget control strategies for contingent obligations assumed in state infrastructure contracts. In summary, this methodological guide seeks to characterize the risks contemplated in the framework of the execution of contracts, to define the necessary tools for their assessment, and in those cases where it is appropriate, to calculate a contribution plan to the FCEE.

Chapter 2

Scope of application

In the Colombian case, risk management is an integral part of good public procurement practices and is framed by guidelines of discipline and fiscal prudence.

First, Law 448 of 1998[3] and it regulation Decree 423 of 2001[4] define that: *"contingent obligations are those by virtue of which any of the entities indicated in Article 8 of this Decree, contractually stipulate in favor of the contractor, the payment of a sum of money, determined or determinable from identified factors, in case of the occurrence of a future and uncertain event"*.

Secondly, Law 1150 of 2007[5] states *"THE DISTRIBUTION OF RISKS IN STATE CONTRACTS. The tender documents or their equivalents must include the estimation, classification and assignment of the foreseeable risks involved in the contracting. In public tenders, the specifications of the state entities shall indicate the moment when, prior to the presentation of the tenders, the bidders and the entity shall review the allocation of risks in order to establish their definitive distribution"*. In this sense, by virtue of the obligation assumed, the fiscal risk to which the Nation and/or the contracting entity is exposed in infrastructure projects are a function of both the risk profile (probability) and the magnitude of the impact (loss, cost overrun, etc.).

[3] COLOMBIA. CONGRESS OF THE REPUBLIC. Law 448 (July 21, 1998). Through which measures are adopted in relation to the management of contingent obligations of state entities and other provisions on public debt. Article 6.

[4] COLOMBIA. PRESIDENT OF THE REPUBLIC. Decree 423 (March 14, 2001). By which Laws 448 of 1998 and 185 of 1995 are partially regulated. Article 6.

[5] COLOMBIA. CONGRESS OF THE REPUBLIC. Law 1150 (July 16, 2007). By means of which measures for efficiency and transparency are introduced in Law 80 of 1993 and other general provisions on contracting with Public Resources are issued. Article 4.

A third key legal foundation within Colombian law to ensure fiscal responsibility is, through Law 448 of 1998[6], the creation of the State Entity Contingency Fund or FCEE. The FCEE was established to *"meet the contingent obligations of the State Entities as determined by the Government"*. Likewise, Article 44 of Decree 423 of 2001 states: *"Contingency valuation methodologies. The DGCPTN of the Ministry of Finance and Public Credit shall adopt, through general administrative acts, the methodologies applicable to State contracts to determine the value of the contingent obligations stipulated therein and the increase or decrease of the contributions that may be necessary, in accordance with budgetary provisions"*. Thus, by legal mandate, the DGCPTN is responsible for defining the methodologies applicable to the valuation of contingent liabilities that result in the schedule of contributions to the FCEE, in those cases where it applies.

In accordance with the above, the scope of application of this document corresponds to all those entities governed by Law 448 of 1998 and Decree 423 of 2001, and amendments. Notwithstanding the above, this document stipulates the general guidelines for risk management, in order for State entities to have reference tools for the quantification of contingent obligations and the adequate management of the risks that State entities assume within the framework of infrastructure contracts.

[6] COLOMBIA. CONGRESS OF THE REPUBLIC. Law 448 (July 21, 1998). Through which measures are adopted in relation to the management of contingent obligations of state entities and other provisions on public debt. Article 2.

Chapter 3
Introduction

The dynamic analysis of project risks, both during project structuring and in its execution over time, results in a permanent improvement in the decision-making process and contractual management capacity. One result over time is that better technical analysis of the information on the risks allows systematic improvement in the State Entities' ability to assess their contingent obligations adequately and systematically.

In order to foresee and take action on the fiscal impact of contingent liabilities, it is necessary to develop risk models analyzing the volatility and differences from expectation of the variables under study and thus consider whether there may be a negative or positive impact on the project's baseline projections. Some examples of such variables may be: future income or the budget of the project.

Although the examples used to illustrate the methodology are for road projects, these methodologies are for general application for modelling the main risks in infrastructure projects[7], in accordance with the scope of application of Law 448 of 1998, Law 1508 of 2012, Decree 423 of 2001 and their respective modifications.

Therefore, the methodologies presented concentrate on the general mathematical procedures used for risk assessment. The specific parameters depend on the type of project being analyzed. Thus, these sectoral parameters will be available for consultation on the web page of the Public-Private Partnerships (PPPs)[8] Subdirectorate of the DGCPTN and will be an integral part of the methodology adopted by the DGCPTN.

[7] As long as they resemble what is described in this document.

[8] Currently the URL of the page is: https://www.minhacienda.gov.co/webcenter/portal/EntidadesFinancieras/pages_asociacionespblicoprivadasapps/documentosdeinters

In order to have an adequate understanding of the methodology, it is recommended that the users of the methodology have an intermediate knowledge of statistics, as well as knowledge of the context of the project and the sector in which it is developed. Rigor in the application of the methodology is fundamental so that the results reflect consistent relationships between variables and their risk scenarios.

The methodology is presented as follows. Chapter 4 describes the classification process and the fundamental elements of risks in infrastructure projects. Chapters 5 and 6 describe in detail the steps for the quantitative assessment of the two main types of risk: risks associated with the pre-operational stage and with the operational stage of a project. Chapter 7 aims to present a practical example of the use of valuation models for each type of risk and for each case that has been presented throughout the document. Chapter 8 contains a glossary of terms that may be useful in understanding and applying the context of contingent liability valuation models. Finally, Chapter 9 includes the bibliography and academic support used to develop and adapt the mathematical models to the Colombian case.

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Chapter 4
Risk characterization

The identification of risk factors for infrastructure projects should start during the structuring stage. Thus, it is essential to determine from the outset, the risks to be assessed that may arise both in the pre-operational stage and in the operational stage of the project.

In this sense, the State entity must carry out two previous steps before the qualitative rating of probability and impact. Firstly, when structuring and monitoring the project, it must identify the risk factors in the contract between the state entity and the private sector. Secondly, it must assign each of these risk factors or contingent liabilities, between the parties. The allocation must be made to one of the contracting parties[9]: a state entity (public), a concessionaire (private) or may be shared between the two parties, according to the contractual risk policy guidelines.

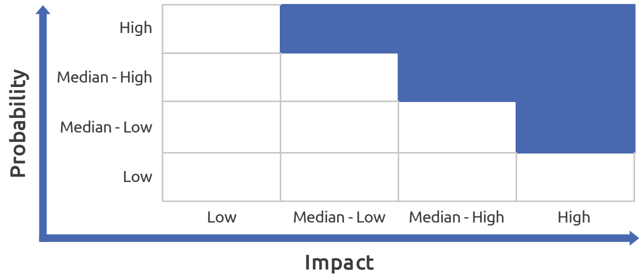
4.1 Valuation risk area

After the identification and allocation of project risks, the probability and impact of each risk must be defined. In this sense, the state entity assigns a qualitative rating according to the probability of occurrence and the impact that the materialization of such risk could generate on the project. The purpose of this is to define whether or not the risks are required to be subject to valuation[10] as denoted by the area shaded in blue in the figure.

[9] For the allocation of each of the risks, state entities shall consider the applicable regulations in force, including, but not limited to, Law 1508 of 2012, Law 448 of 1998, its subsequent amendments and regulatory decrees.

[10] In accordance with Article 45 of Decree 423 of 2001. COLOMBIA. PRESIDENT OF THE REPUBLIC. Decree 423 (March 14, 2001). By which Laws 448 of 1998 and 185 of 1995 are partially regulated. Article 45.

Figure 1. Risk area



Source: Own elaboration DGCPTN

For the risks assigned to the state entity or shared by it, which are classified within the risk area, the contracting entity must: i) submit the quantitative assessment of it, using the methodologies approved by the DGCPTN[11], and ii) propose a Contribution Plan for the FCEE with its respective disbursement schedule, when the regulations in force so stipulate.

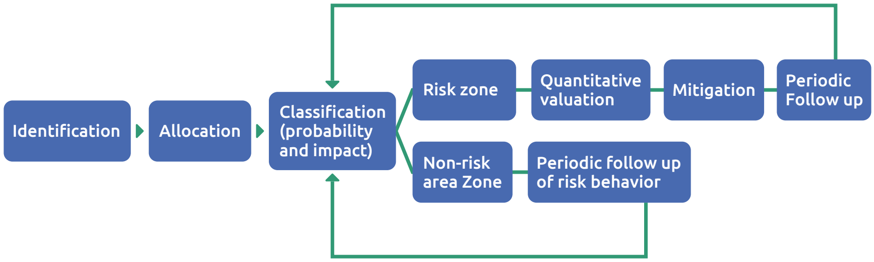
It should be noted that the qualitative assessment (probability and impact) of the risks is carried out with the objective of identifying which of these must be valued, but in no case should be considered a limitation of the assumption of risk by any of the parties to the contract (private or public).

Finally, the periodic monitoring determined by the Applicable Law becomes one of the fundamental pillars for the mitigation of the risks assumed by state entities. Thus, it is very important to establish that this procedure will be carried out throughout the life of the contract, since risks are dynamic, and their probability and impact may vary according to the execution of the project.

In conclusion, it is important that the contracting entities take responsibility for the management of the information, to guarantee the correct application of the methodologies described and to strengthen the inputs used for the statistical development of the models.

[11] If there is no methodology applicable to the risk being evaluated, in accordance with Article 51 of Decree 423 of 2001, the contracting state entity must propose a methodology in accordance with the risk of the respective project.

Figure 2. Risk management



Source: Own elaboration DGCPTN

4.2 Types of risks

The risks of a contract can occur in two stages associated with infrastructure projects: the pre-operational stage (pre-construction and construction), and the operational stage (operation and maintenance). In most cases, the risks associated with the pre-operational stage of the project take the form of cost overruns, which are not usually time dependent as a variable. For example, the risk that the value of the land to be acquired will exceed the initial estimates does not generally depend on the period of acquisition[12] but on the characteristics of the land.

On the other hand, risks in the operational stage of the project generally depend on the fulfillment of long-term variable forecasts, so their valuation is generally dependent on time. An example of this is the volume of traffic that circulates along a road corridor in the period stipulated in the contract.

Accordingly, in general, the risks associated with the pre-operational stage can be classified into cost overruns (which are not time-dependent) and those of the operational stage, such as revenue risks (which do depend on time)[13]. Figure 3 illustrates this categorization.

[12] Apart from adjustments for inflation and other potential adjustments for demand.

[13] This does not mean that there cannot be revenue risks in the pre-operational phase or cost risks in the operational stage.

Figure 3. Risk classification by stage

		Time dependency	
		No	**Yes**
Stage of the project	**Pre-Operational Stage**	Cross section (cost overrun)	
	Operational Stage		Time series (Income)

Source: Own elaboration DGCPTN

4.3 Risk measure

When the risk factor is not time-dependent, the associated random variable used to quantify is of the cross-sectional type. For example, if there are different categories of homogeneous properties to be acquired (e.g. commercial, residential, etc.) and $Quantity_i$ and $Price_i$ represent, respectively within category i, the number of property units and their promised price do not depend on time. Therefore, the base cost of acquiring the project land can be written as:

$$Costs = \sum_{i=1}^{n} Price_i * Quantity_i$$

The scenario at risk is calculated as a percentile of the cost distribution given by the above equation. This percentile should represent the expected loss (i.e. unusually high or low costs), to capture the occurrence of an unlikely but large and significant impacting risk event.

In the example above, the risk scenario consists of incurring higher costs than projected, so the risk percentile should be close to 1. Now, if for simplicity it is assumed that there is no correlation between prices and quantities, and if P_α denotes the α percentile of the distribution, then the following equation represents the risk scenario assessed with a percentile 95 and 95% confidence level:

$$Risk(Costs) = P_{0.95}(Costs) = P_{0.95}\left(\sum_{i=1}^{n} Price_i * Quantity_i\right)$$

On the other hand, if the revenue depends on the period or the time, then the associated random variable is defined as time series. For example, in road projects, the expected revenue in period t, from the collection of a toll that has n different vehicle categories, is given by the equation:

$$Income(t) = \sum_{i=1}^{n} Price_i(t) * Quantity_i(t)$$

The terms $Price_i$ (t) and $Quantity_i$ (t) correspond, respectively, to the rate charged to category i and the number of vehicles that paid the toll, both measured in period t. The risk scenario in this case is that future income will be lower than initially projected, so a scenario at risk that is below the baseline of demand initially contemplated must be chosen. The following equation illustrates this definition taking as a risk scenario the percentile 5 of the probability distribution with a confidence level of 95%.

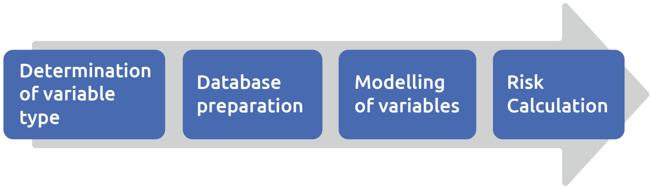
$$Risk(Income_t) = P_{0.05}(Income_t) = P_{0.05}\left(\sum_{i=1}^{n} Price(t)_i * Quantity(t)_i\right)$$

In summary, and regardless of the type of variable used to assess the risk, the methodology seeks to identify the distribution of probability of the risk variable, in order to subsequently quantify the amount to which the State Entity is exposed as a result of the project risks assumed within the framework of the contract.

4.4 Methodological outline

For the calculation of the potential exposure, the methodology assumes a series of sequential steps, regardless of whether the variable is cross-sectional or time series. This procedure is different depending on the information available, but in general it can be summarized in the following figure.

Figure 4. General risk assessment procedure



Source: Own elaboration DGCPTN

Determination of variable type: From the first step, a random variable is obtained, which can be cross-sectional or time series and which allows the capture in monetary terms of the risk events defined for the project. Throughout this chapter, examples of these risk variables are shown, such as the value of the land required to carry out the works or the volume of traffic that circulates along a road corridor during a given period. In the first case, the land cost overrun is directly related to the project's construction cost, while in the second example the concessionaire's income is a function of the observed traffic.

Database preparation: Includes a survey and preparation of the relevant information to model the risk variable found in the previous step. For example, if the project consists of building an additional roadway in an existing corridor, it is useful to know the historical traffic volume of the original roadway to model the traffic variable of the new roadway. The type of information depends on the risk to be assessed, so the specifics will be addressed in more detail in the following chapters.

Modeling the variables: Each risk has specific factors that must be captured in the modelling. For example, sometimes the income or cost risk scenarios depend on two or more variables[14], so the methodology must specify the treatment of each.

[14] For example, when there is uncertainty in both prices and quantities, which were variably needed for the calculation of the risk measure (previous section).

Valuation of the risk: Once the income or costs have been expressed in terms of the respective variable(s) and, therefore, the probability distribution has been defined, the risk is calculated as a sufficiently stressed percentile of that distribution, which will be addressed in more detail in the following sections.

4.5 Risks associated with the pre-operational stage

The risks that traditionally arise during the pre-operational stage of projects (pre-construction and construction), and which materialization determines the amount of the cost overrun, are classified into four fundamental groups, without prejudice to the fact that there may be more: property, environmental, utilities and geological. This section describes the fundamental aspects of each, and Chapter 5 presents the assessment methodology for this type of risk.

4.5.1 Property land risk

Property land risk in infrastructure projects refers to the unexpected effects during the management and/or acquisition of the land required for the development of the project. In general, and in accordance with the regulations in force, the risk associated with the management of the land, which has implications on the terms of the contract, is assigned completely to the private party.

However, the risk related to cost overruns in land acquisition reflected in the cost of the project is usually shared or assigned to the public party. Historically, this has been one of the most common and onerous risks for the State.

This risk is modelled as a cross-sectional variable, as once the effect of inflation on land prices is corrected, the extra cost of a property depends more on its location, attributes and potential use, than on the period in which it is purchased.

4.5.2 Environmental risk

The environmental risk includes unexpected environmental requirements during the management and/or obtaining of the environmental licenses or permits for the execution of the project. As with the previous risk, the management of these permits is usually assigned to the private sector and the cost overruns derived from the procedures and others are usually shared with the public or assigned to the public. Within this risk, additional works requested by the environmental authorities as a result of the procedures in question are also included.

All the effects described above are summarized in cost overruns that are like cross-sectional variables, and therefore have the same treatment as property land risk.

4.5.3 Utility relocation risk

This risk refers to all interference, transfers, protections, or treatment to be made to the utilities within the project corridor. As with environmental and property land risk, such treatment is reflected in a risk of cost overrun with respect to the budget initially contemplated. It also has the treatment of cross-sectional variables.

In previously developed projects, the risk of utility relocation in infrastructure projects was included within the construction risk, which is assigned in its entirety to the private sector. However, taking into account its complexity and implications in the execution of the projects, in some cases and according to the regulations of the case, the risk of cost overruns in utility interference can be retained by the public or shared with the private.

4.5.4 Geological risk

The geological risk is the possibility that changes in the geological conditions of the project will make it difficult, prevent, modify or delay the construction of the project works, including those that could be catalogued as complex: for example, tunnels, viaducts, critical points, among others. Considering the complexity and uncertainty of this risk, the cost overruns are usually shared between the public and the private sector. For the assessment of this risk, a cross-sectional variable is also considered.

4.5.5 Other risks

Within infrastructure projects, other risks may arise which, although not described above, have similar characteristics. In this sense, any risk identified in the contracts and related to cost overruns and, in addition, not dependent on time, will have the same treatment as the risks described in the previous paragraphs.

4.6 Risks associated with the operational stage

The nature of the risks in the operational stage of the project differs from those in the pre-operational stage, as the activities are different. In this sense, it is rare that during this stage the risks of the previous section still materialize, although they may occur in some cases.

Most risks at this stage typically stem from lower than estimated income. That is, the concessionaire receives less income than expected in the structuring stage. This may occur due to factors such as a decrease in demand (traffic), the non-installation of toll booths (in the case of road infrastructure), the lack of an increase in the fees for services that generate income and the imposition of new benefits granted to certain groups with respect to the use of the service charged (e.g. differential tariffs), among others.

4.6.1 Demand risk

Demand risk occurs when the project's actual income is lower than expected because the amounts associated with the income generator is lower than projected. For example, the risk that the number of vehicles passing through a corridor during the life of the contract will be lower than projected. This risk is associated with time series variables.

4.6.2 Risk of differential tariffs

This risk is defined as the possibility of establishing preferential tariffs or benefits for certain users of the infrastructure and that, as a consequence, the income expected by the concessionaire will be reduced. For example, if a group of users is granted a preferential tariff that is lower than the one established for the services in the contract or when a differential tariff is imposed depending on the time of use of the service, then the real income of the project would decrease for each individual in this group who uses the infrastructure. Modelling is discussed in the chapter on assessing risks associated with the operational stage.

4.6.3 Risk of impossibility of collection

Some infrastructure projects provide for the installation of collection or payment mechanisms for the return of the investment. Tolls in road corridors are one example. In this way, the risk of "impossibility of collection" consists of not installing or operating such mechanisms of the project.

The origin of this risk is usually found in the non-conformity of some users or communities directly affected by the collection of the tariff, who mobilize to delay or prevent the installation of the collection mechanisms. This same risk also includes the impossibility of collecting higher tariffs in existing mechanisms. The impact on expected income materializes throughout the life of the contract and therefore risks are assessed using time series.

4.6.4 Risk of relocation of collection mechanisms

In line with the above, the risk of relocation is related to the change of the initial location of a collection mechanism (e.g. toll), due to community disconformities or for any other reason. This risk consists of the possibility of receiving less income if the new location reduces demand and therefore the income associated.

For example, in the case of a toll, the risk of relocation would be associated with the difference between the projected demand at the contractually agreed location and the demand at the new location. This difference must be compensated to the concessionaire on the contractually agreed terms.

4.6.5 Other revenue-related risks

During project implementation, other risks may arise which, although not described above, are also related to income. In this sense, and if they comply with the characteristics of a time series variable, their treatment will be similar.

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Chapter 5

Valuation of risks associated with the pre-operational stage

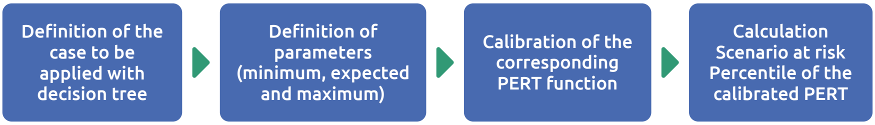
This section describes the methodology for assessing the risks associated with the pre-operational stage of infrastructure projects. It should be noted that the examples used correspond to road infrastructure projects; however, the methodology is general and applies to other sectors where the characteristics of the risk variables may be similar.

A desirable condition for the application of the risk assessment methodology to yield robust results is to have consolidated and reliable information regarding the execution of completed projects. However, in some infrastructure projects that are developed in sectors where traditionally no large investment projects have been developed, it may be difficult to have consolidated historical information in the first years of project execution.

Therefore, this section recognizes that two types of situations may exist: 1. When historical information is available and 2. When no historical information is available to model variables related to project cost overruns. Regarding this last point, the contracting entities are responsible for: i) the preliminary preparation of the available information, and ii) carrying out a due diligence of the information that allows the preparation of complete and good quality databases.

In general terms, the evaluation of risks associated with the pre-operational stage will follow the steps below:

Figure 5. Steps for the application of the risk methodology associated with the pre- operational stage



Source: Own elaboration DGCPTN

5.1 PERT distribution

As explained in previous sections, the cross-sectional variables are characterized by their lack of dependence on time. In this sense, and taking into account the relevant literature and evidence, variables of this type, related to cost overruns in infrastructure projects, are often analyzed using a PERT[15] distribution.

The PERT function is a case of the $Beta\ (\alpha, \beta)$ function, and is designed to predict results in situations where information is limited. Thus, the PERT distribution is commonly used when it is required to model any variable and at least certain values or estimates are available for the project[16], such as: V_{Min}, V_{MP} and V_{Max} (minimum, expected or most probable and maximum value)[17].

Thus, the methodology for assessing the risks associated with the pre-operational stage of the projects and related to cross-sectional variables will take as its main inputs the three (3) parameters mentioned above (V_{Min}, V_{MP} and V_{Max}). This above regardless of the level of uncertainty or information available.

[15] Garvey, Book & Covert, Probability Methods for Cost Uncertainty Analysis, CRC Press, 2nd edition, 2016. Erkoyuncu et al, Uncertainty driven service cost estimation support at the bidding stage, International Journal of Production Research, Vol. 51, 2013.

[16] Garvey, Book & Covert, Probability Methods for Cost Uncertainty Analysis, CRC Press, 2nd edition, 2016. Erkoyuncu et al, Uncertainty driven service cost estimation support at the bidding stage, International Journal of Production Research, Vol. 51, 2013.

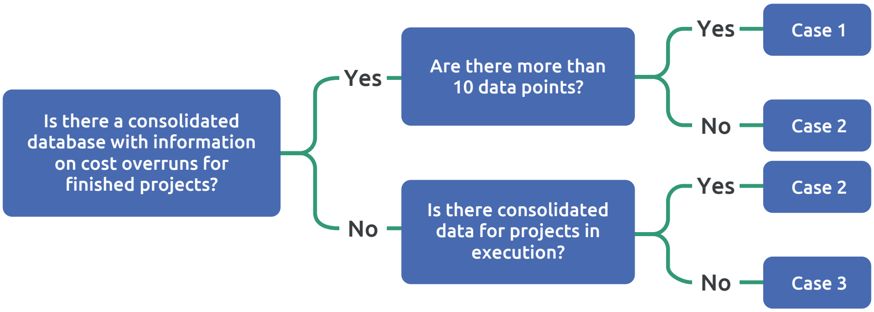
[17] The PERT function has fourth parameter which defines the curvature of the distribution function. The typical value in these types of projects is 4, which produces a form like the normal distribution.

The following subsections explain in detail how to estimate these inputs, according to the information available. In Section 5.3 of the methodology, the calibration of the PERT function is explained in detail, as a distribution to calculate cost overruns.

5.2 Cases for the application of the risk assessment methodology associated with the pre-operational stage

As indicated above, this methodology recognizes that the level of information available may vary from one project to another or from one sector to another. Therefore, the following chart indicates the procedure to be followed, according to the level of information available.

Figure 6. Case definition - Decision tree



Source: Own elaboration DGCPTN

5.2.1 Case 1 - Consolidated historical information for completed projects[18]

It is desirable that state entities who carry out projects under the fashion of private participation schemes such as: concessions or Public Private Partnerships, have a consolidated database, which allows us to know the behavior of the risks in the projects already completed.

[18] Consolidated historical information is considered to be available when there are at least 10 projects with similar characteristics to the project being evaluated (for example, 10 projects completed with property, environmental or network information). For all the purposes of this methodology, it is understood that the category of "finished projects" will include those for which the assessed risk has completely ceased (e.g. acquisition of all the land required by the project).

The above is relevant since, through this information, it is possible to identify historical patterns that allow for the analysis of the behavior of the projects that are subject to evaluation (projects in progress).

Given this, the state entities from the beginning of the execution of the project must collect relevant information regarding the project specific risks. This is done to demonstrate the behavior of cost overruns. For example, in the case of land purchase, it is desirable to have a database on the property lands already acquired, where the initial value of the property (the different commercial appraisals carried out) and the value actually paid can be traced.

For the purposes of this methodology, this case will be used only if the state entity demonstrates that it has a unified database[19] for completed projects, where each piece of data is verified. Otherwise, case 2 of subsection 5.2.2, or case 3 of subsection 5.2.3.

If the database complies with the parameters defined by the DGCPTN, the minimum, expected, and maximum values will be determined as follows for each of the risks where cost overruns may occur:

i) **Minimum value:** shall be determined by the minimum value, in terms of cost overrun percentage of the historical database[20]. In the case where the database has negative cost overruns, i.e. savings, the value is assumed to be 0.

ii) **Expected value:** shall be determined as follows, as the case may be:

» If there is an updated budget of the same project that can induce a percentage of cost overrun[21] to be used in the valuation, lower than the

[19] On the page of the PPPs Subdirectorate, there will be a database template, where state entities must consolidate the information they have and send it at defined intervals to the DGCPTN.

[20] In case of having a sufficiently robust database (minimum information for 10 projects), the DGCPTN will establish in its website the criteria to be taken into account to choose the necessary inputs for the assessment (e.g. type of property, area, etc.).

[21] For all purposes of this methodology, whenever "cost overruns" are mentioned, they refer to percentages or positive values. In no case will negative percentages be taken into account in the calculations. If they exist, it will be assumed that the value is 0.

average percentage of cost overrun for projects with information, the expected value will be:

$$V_{MP} = (30\%^{22}\left(\frac{C_I - C_E}{C_E}\right)^{23} + 70\%(V_P)) * (1 + DP)$$

» If there is an updated budget for the same project that can induce a higher percentage of cost overrun to be used in the valuation than the average percentage of cost overrun for projects with information, the expected value will be:

$$V_{MP} = (70\%^{24}\left(\frac{C_I - C_E}{C_E}\right)^{25} + 30\%(V_P)) * (1 + DP)$$

» If there is no updated budget for the project, the expected value will be:

$$V_{MP} = (V_p) * (1 + DO)$$

iii) **Maximum value:** shall be determined as follows:

$$V_{Max} = \left[max\left(V_P; \left(\frac{C_I - C_E}{C_E}\right)\right)\right] * \left[1 + 3 * (max(DP; DO))\right]$$

Where,

V_{MP}: corresponds to the most probable value to be used in the PERT distribution.

V_P: is the historical average cost overrun for a particular risk, in percentage terms.

[22] If deemed necessary, this value may be modified by the DGCPTN of the Ministry of Finance and Public Credit, and will be published on the web page of the PPPs Subdirectorate.

[23] $\left(\frac{C_I - C_E}{C_E}\right)$ corresponds to the forecast cost overrun for the project, expressed as a percentage.

[24] If deemed necessary, this value may be modified by the DGCPTN of the Ministry of Finance and Public Credit and will be published on the page of the PPPs Subdirectorate.

[25] $\left(\frac{C_I - C_E}{C_E}\right)$ corresponds to the forecast cost overrun for the project, expressed as a percentage.

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C_I: is the estimated and updated budget of the activity that gives rise to the risk (e.g. updated cost of land purchase), once the project is underway. This value will be change according to the updates provided by the entity, which have a direct correlation with the level of information available.

C_E: is the estimated cost of the activity giving rise to the risk (e.g. cost of purchasing land) in the structuring stage (value of the contractually agreed sub-account or base cost).

DP: corresponds to the standard deviation of the last two changes in the updated budgets from one period to another, of the risk being assessed[26]. For the purposes of calculating the variations, the following equation will be considered $\frac{C_t - C_{t-1}}{C_{t-1}}$, where t is the most recent period.

DO: is the average of standard deviations of the last two variations of the updated budgets from one period to another (DP), of the risk being evaluated, for all historical projects[27].

It is necessary to clarify that the maximum value is defined in this way in order to have data that represents the reality of the execution of the same project and takes into account the behavior of historical information reported by other projects, when required. In this sense, if the variations in the updated budgets from one period to another are very high, this will be reflected in the maximum value. If, on the other hand, these have been low, the average variations for other project budgets will allow a conservative estimate.

Likewise, and taking into account the relevance that the estimation of the average and maximum value has within the final result, it is not convenient to assume a fixed maximum for all projects, given that, if their particularities are not taken into account, the risk could be overestimated and result in estimates of the scenario at risk that are not in line with the reality of the project.

[26] Usually the contracting entity estimates the value of the activity giving rise to the risk at different points in time, based on available information. To have at least 2 variations, information must be available for 3 periods (the example in section 7 specifies this calculation).

In the case where there are insufficient estimates, the value that DP will take is DO. If $DP = DO = 0$, the DGCPTN will define the initial criteria for calculating this parameter, based on other projects in the same or different sectors. The above shall apply only during the time when there are no estimates for DP or DO, given that the project is in its initial stage.

[27] The practical example shows in detail the procedure to be followed.

5.2.2 Case 2 - Consolidated information for ongoing projects

In most cases, state entities do not have a database of risks for historical projects that have been completed. In these cases, information on the risks of projects underway should be used, as this is the most up-to-date information available[28]. However, such information may present a degree of uncertainty that must be considered, given that the projects have not yet been completed, or the risk assessed has not yet ceased. In order to incorporate the degree of uncertainty into the estimates, it is necessary to give equal weight to both the information on the project and the information available for the other projects under implementation.

In this regard, the minimum and maximum expected value shall be determined as described in this subsection.

It should be noted that, for practical purposes, the notation will be the same as in the previous subsection and therefore the definitions of the variables are maintained, unless otherwise specified.

For the purposes of the application of Case 2 - Consolidated information for projects in execution, the following variables will maintain their notation, however, they will have the definition specified below.

V_P: is the average cost overrun[29] of projects under implementation for a particular risk, in percentage terms.

DO: is the average of standard deviations of the last two variations of the updated budgets from one period to another (DP for its initials in Spanish), of the risk being evaluated, for all the projects in execution[30].

i) **Minimum value:** shall be determined by the minimum value of cost overrun for a particular risk in the database of projects under implementation. In

[28] In sectors other than roads, where the same risks of cost overruns are present, information from road projects may be used, until information from the specific project is available.

[29] For all purposes of this methodology, whenever "cost overruns" are mentioned, they refer to percentages or positive values. In no case will negative percentages be considered in the calculations. If they exist, it will be assumed that the value is 0.

[30] The practical example shows in detail the procedure to be followed.

the case where some projects have negative cost overruns (i.e. savings), the cost overrun will be assumed to be 0%.

ii) **Expected value:** shall be determined as follows, as the case may be:

» If there is a cost overrun forecast for the project, greater than the average cost overrun of projects under implementation, the expected value will be:

$$V_{MP} = \left(\frac{C_I - C_E}{C_E}\right) * (1 + DP)$$

» If there is a cost overrun forecast for the project, but it is less than the average cost overrun for projects under implementation, the expected value will be:

$$V_{MP} = \left(\frac{\frac{C_I - C_E}{C_E} + V_P}{2}\right) * (1 + DP^{31})$$

» If there is no cost overrun forecast for the project being evaluated, the expected value will be[32]:

$$V_{MP} = V_p * (1 + DO)$$

iii) **Maximum value:** shall be determined as follows:

$$V_{Max} = \left[max\left(V_P; \left(\frac{C_I - C_E}{C_E}\right)\right)\right] * \left[1 + 3 * \left(max(DP; DO)\right)\right]$$

[31] If there are insufficient estimates, the value that DP will take is DO. In the case where DP = DO = 0, DGCPTN will define the initial criteria for the calculation of this parameter, based on other projects in the same or different sectors. The above will apply only during the time in which there are no estimates for DP or DO, given that the project is in its initial stage.

[32] This case applies to projects that are being structured, or that do not yet have information available at the execution stage.

5.2.3 Case 3 - Complete lack of information

The last case uses a panel of experts to define the parameters V_{Min}, V_{MP} and V_{Max}. This case will only apply when at least two of the following assumptions are met:

a. The sector in which the concession or PPP project will be developed, or the specific risk to be assessed, is completely new in this contracting method.

b. There is no information, in any sector, on the particular risk to be assessed.

c. It is not possible to collect information for completed projects or for projects under execution that is comparable in terms of risks, whether for other projects or other contracting modalities[33].

When the above occurs, a panel of experts may be utilized, as long as it is done strictly following the procedure of the proposed methodology in force by the National Planning Department and the updates made by the DGCPTN.

It should be noted that the risk assessment should consider the specific project factors, so the panel of experts should be done per project and per risk, independently. The objective is to focus on the particularities of each project, and to determine with greater certainty the possible cost overruns that may occur. In accordance with the above, extrapolations of the cost overrun of the panel of experts to other projects will not be admissible.

The expert panel information is applicable until Case 2 - Consolidated information for ongoing projects, or Case 1 - Consolidated historical information for completed projects, as described above, can be applied.

5.3 Calibration of the PERT function

As mentioned above, the PERT function is a particular case of the $Beta$ (α, β) function, and it is commonly used when a variable is required and certain

[33] In this case, a comparable project is understood as a project that, although it does not have the same characteristics, has specific risks in common (e.g. property risk in roads and property risk in public buildings; property risk in public works and property risk in PPPs).

values or point estimates are available for the project[34], as are the V_{Min}, V_{MP} and V_{Max} values (minimum, most probable and maximum values).

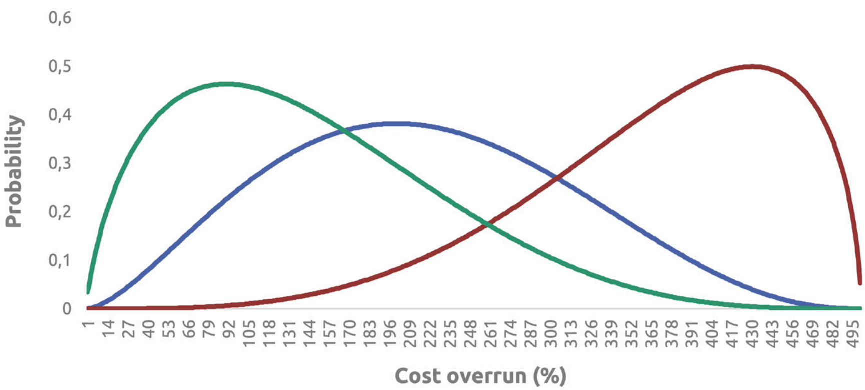
Now, once the values of V_{Min}, V_{MP} and V_{Max} of those dealt with in the previous subsections, the parameters α and β, of the Beta function will be calculated as follows:

$$\alpha = \left(4\frac{(V_{MP} - V_{Min})}{(V_{Max} - V_{Min})}\right) + 1$$

$$\beta = \left(4\frac{(V_{Max} - V_{MP})}{(V_{Max} - V_{Min})}\right) + 1$$

It should be noted that the PERT distribution tends to give greater weighting to the expected value (V_{MP}), so the associated probability distribution will depend largely on this value. The following graph illustrates this behavior with calibrated PERT functions with a common minimum and maximum value equal to V_{Min} = 0% and V_{Max} = 500%, but different V_{MP}. In the following graph, the maximum point of each curve corresponds to the most probable estimated value.

Figure 7. Calibrated PERT function with different V_{MP}



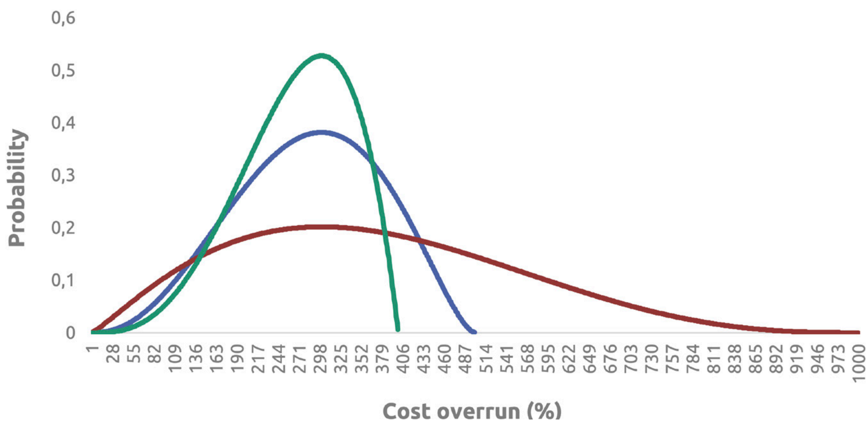
Source: Own elaboration DGCPTN

[34] Garvey, Book & Covert, Probability Methods for Cost Uncertainty Analysis, CRC Press, 2nd edition, 2016. Erkoyuncu et al, Uncertainty driven service cost estimation support at the bidding stage, International Journal of Production Research, Vol. 51, 2013.

Note that the function tends to have a bias towards the most probable value (V_{MP}).

However, the main function of the estimated maximum value V_{Max} is to define the dispersion of the associated probability distribution. This makes sense as the same probability (i.e. 100%) is distributed over a wider range. Figure 8. PERT function calibrated with different V_{Max}, illustrates what is described in this paragraph.

Figure 8. Calibrated PERT function with different V_{Max}



Source: Own elaboration DGCPTN

The graphs above represent the probability distribution functions for a Beta PERT function, with different maximum values. On this probability distribution function, it is possible to calculate the percentage cost overrun associated with a percentile reflecting a risk scenario.

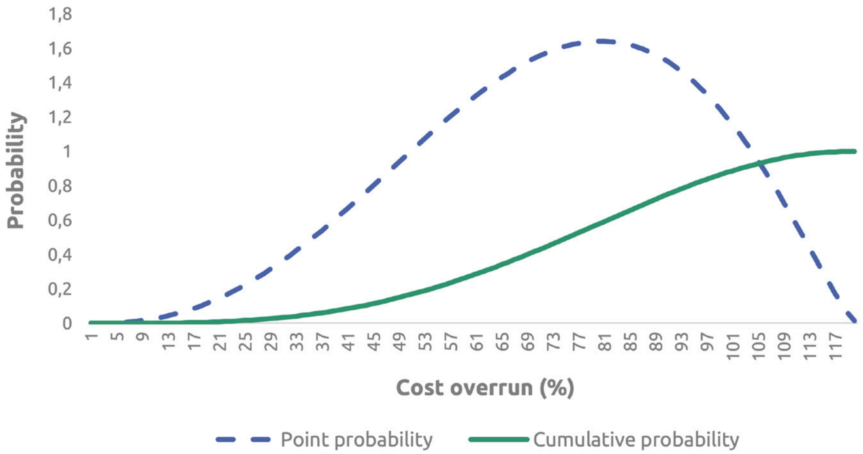
The following table shows a fragment of values generated for a PERT with values of 0%, 80% and 120% as the minimum, most probable and maximum, respectively.

Table 1. PERT probability distribution function[35]

Cost overrun	0%	1%	2%	3%	...	...	117%	118%	119%
Point probability	0.0%	0.0%	0.0%	0.0%	...	...	0.14%	0.08%	0.03%
Cumulative probability	0.0%	0.0%	0.0%	0.0%	...	...	99.81%	99.99%	100%

The number of datapoints generated from the function must be equivalent to the maximum value, so that a sufficient level of granularity is reached to determine the cost overrun associated with the risk percentile. The following graph shows the PERT function corresponding to the previous table.

Figure 9. PERT probability distribution function



Source: Own elaboration DGCPTN

Note that the distribution function (dashed line) can be greater than 1 when the cost overrun is close to its most probable V_{MP} value (in this case equal to 80%). However, the cumulative probability (i.e. the area under the curve given a cost overrun value) is always less than 1 (green line), as it represents a probability.

[35] A complete example of the table is shown in section 7.

5.4 Risk Valuation

With the PERT distribution function generated in the previous step, the percentage cost overrun value is calculated as a percentage of this distribution. The percentile to be used for the purposes of this assessment will depend on the level of risk or project progress, with the aim of capturing the possible associated uncertainty.

The following table shows the percentile to be used according to the level of project progress or risk assessed:

Table 2. Percentages associated with project risk progress[36]

% Risk Progress/ project	0% - 30%	31% - 60%	61%-90%	91%-100%
Percentile	95%	80%	70%	60%

In any case, the progress of the activities associated with the assessed risk should be used as a reference, (e.g. number of plots acquired / number of total plots). If the percentage of risk progress is not available, the percentage of project progress will be used.

Following the example of the previous table, if PERT (V_{Min}, V_{MP}, V_{Max}) is set to PERT with the indicated parameters (0%, 80% and 120%), and a percentage progress of 10%, then the percentile 95 of the distribution will correspond to a cost overrun that is in the range of 106% to 107%, as illustrated in the following table.

Table 3. percentile 95 estimate

Cost overrun	0%	1%	...	106%	107%	...	118%	119%
Probability of point	0.0%	0.0%	...	85.7%	79.6%	...	8.5%	3.5%
Probability accumulated	0.0%	0.0%	...	94.3%	95.1%	...	99.9%	100%

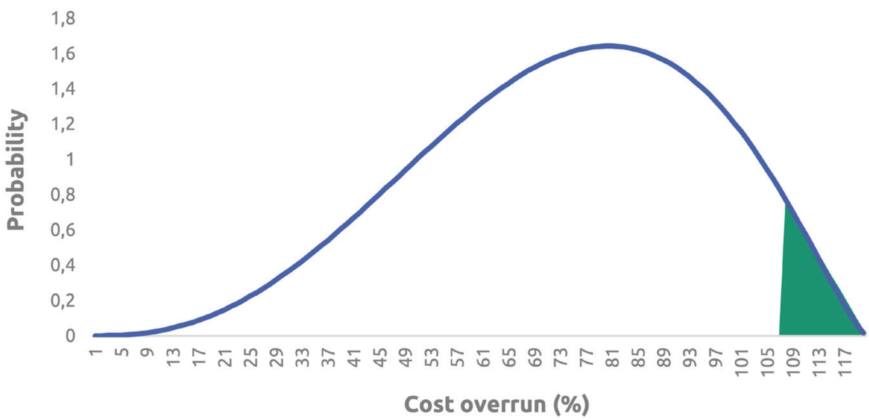
[36] The percentages in this table will apply until the DGCPTN determines otherwise. Also, to the extent that information is collected from the projects, these percentages shall be assessed according with the historical information of materialization of the risks reflecting that a higher or lower percentile must be assumed. The above is directly related to the risk scenario.

The value of the cost overrun of the risk scenario will be given by the data closest to the point where the percentile in the cumulative probability is located. In this case, where the values closest to 95% are 94.3% and 95.1%, the values will be averaged to obtain the percentage of cost overrun. In the table above, this calculation corresponds to:

$$Cost\ overrun\ (\%) = \frac{106\% + 107\%}{2} = 106.5\%$$

Finally, in monetary terms, the value of the total cost overrun is calculated by multiplying the percentage cost overrun by the initial estimated value (in this case under structuring) or the initial cost of the activity associated with the risk, previously used (C_E). For example, if C_E = \$1,200 million, the cost overrun risk valuation equals \$1,200 × 106.5% = \$1,278 million. The following figure illustrates the procedure described.

Figure 10. 95 percentile distribution



Source: Own elaboration DGCPTN

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Chapter 6

Risk valuation associated with the operational stage

This section describes the methodology for assessing the risks associated with the operational stage of infrastructure projects. As in the previous chapter, the examples used correspond to road infrastructure projects; however, the methodology is general and applies to other sectors where the characteristics of the risk variables may be similar.

For the application of this methodology, it is particularly important to have reliable and sufficient data. Given that projection models are based on historical information, the better the data series, the better the predictive results of the model will be. However, in new infrastructure projects *(green field)*, it is normal not to have enough information about the sector in the first years of project execution.

Therefore, as in the case of risk assessment in pre-operational stage, this methodology recognizes that sometimes there is no historical information available to model the random variables. However, it is the responsibility of the contracting entities: i) to prepare the available information, and ii) to carry out due diligence and work to collect information that allows the development of complete and quality databases.

In general terms, the methodology of risk assessment associated with the operational stage consists of the application of an econometric model, with the aim of obtaining long-term demand projections, based on i) existing information, and ii) a risk scenario determined from the results produced by the model.

Likewise, the alternative case is considered that it may not be possible to develop an econometric model, due to not having enough information. Therefore, a projected risk scenario will be considered, based on information available from other initiatives in the sector, from the particular project or from the specific risk. The following sections will explain in detail the procedure to be followed in each case.

6.1 Demand risk

6.1.1 Case 1. Available and adequate historical information

This section presents the application of the methodology to a road project where historical information is available: monthly historical series for traffic (i.e. the project demand variable) in the same project corridor. Historical information is understood to be available and adequate when there is a minimum of five consecutive years (60 months) of information counted backwards from the month prior to the month of assessment, for each category that is expected to be forecasted[37].

Although the toll vehicle categories (e.g. category I or II) constitute separate series that differ, for the examples that will be mentioned throughout the document, it is assumed that the demand variable is only ordinary motor vehicle traffic for a category. It is important to clarify that the application of the methodology in a real project must contemplate the modeling of all the categories that the toll or corridor has and for which there is disaggregated information. The steps to be considered in the assessment are described below.

6.1.1.1 Data preparation and identification of explanatory variables

In order to apply this methodology, it is essential to review and clean up the available data. The aim is to avoid atypical data that appears to be erroneous or cannot be explained[38], and which may affect the results.

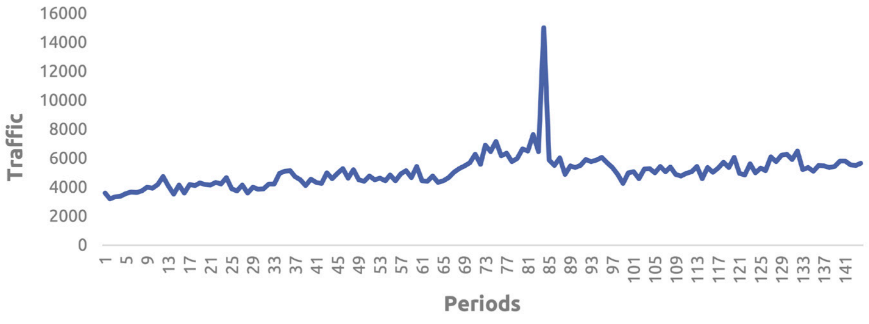
[37] In any case, if data are available for more than 60 months, the full historical path available should be used.

[38] Explained changes are understood as those related to a specific event in the context of the project.

Likewise, in addition to the dependent variable (traffic demand), it is necessary to find some variables that can explain the behavior of traffic, and to ensure the database is adequate and reliable.

i) **Identification of the dependent variable to model:** The dependent variable is one that corresponds to the project's demand. In this case, the measure of demand corresponds to the number of vehicles of a certain category that transit monthly through a given toll, although the demand variable may also refer, in other cases, to the number of passengers using a type of transport system or the number of tons (or any other measure) of cargo that transits through a rail or river corridor. For this example (roads), as far as possible, the traffic series is expected to have a regular behavior over time. However, given the characteristics of the roads in the country and localized situations which can vary over time, it is normal that in some months there are atypical rises or falls that cannot always be explained with the available information, but are (often) related to events or situations in the area or specific context of the project. An example of this case is shown in figure 11.

Figure 11. Original traffic demand series



Source: Own elaboration DGCPTN

When the above occurs, and possible outliers are identified, it is recommended that this information be confirmed and analyzed using a statistical method to detect outliers.

For the purposes of this methodology, the method of detecting outliers to be used will be that of determining the Z-score. In general terms, this method consists on identifying which values of the series are outside the confidence interval, assuming that the data behave as a normal distribution. In this sense, the calculation of the Z-score is done in the following way:

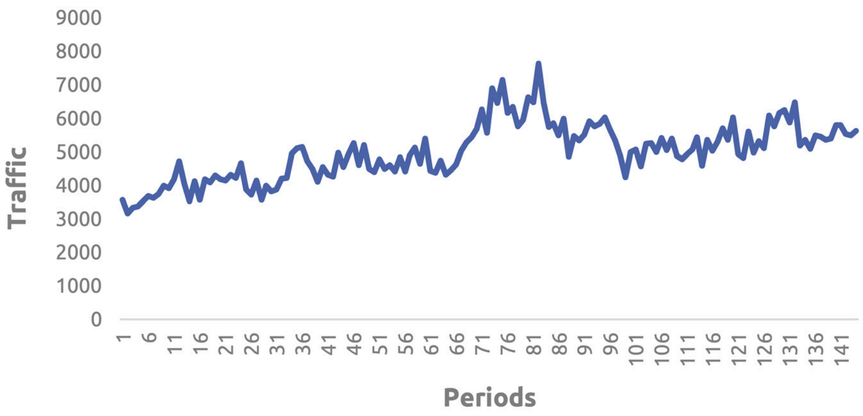
$$Z = (x - \mu)/\sigma$$

Where x is the data for a specific month, μ and σ are the mean and standard deviation of the series, respectively.

However, according to the theoretical evidence, a data is considered outlier if $Z > 3$ or $Z < -3$.

In accordance with the above, in the case that these outliers cannot be explained by a specific event, it is advisable to replace it with a data equivalent to the average growth occurred for the same period in previous years. This will allow us to have a model that adequately represents the normal behavior of the data series, without the estimated parameters suffering distortions due to anomalous data. An example of this result is shown in figure 12. Traffic demand series - extrapolating outliers.

Figure 12. Traffic demand series - extrapolating outliers



Source: Own elaboration DGCPTN

If, on the other hand, the traffic series presents considerable highs or lows, which can be explained by a specific event[39] (which may have generated an atypical behavior of the series), it is advisable to keep all the data, and include within the model a dummy variable (which takes the values of 0 or 1) that captures this effect (this case is shown in section 7 of this document). Depending on the way they are incorporated into the model, this type of dichotomous variable allows: i) marking specific events that have an unusual rise or fall associated with a specific moment or a limited period of time (more or less extensive); ii) including in the model a significant variation of the average volume of historical demand or iii) considering a significant alteration of the general growth trend of the series, in case this type of variation is observed from a moment in time and the independent variables are unable to explain it adequately.

ii) **Identification of model-independent variables[40]:** Bearing in mind that the implementation of an econometric model is proposed, it is necessary to identify the possible variables that explain the behavior of the demand variable. The objective of these variables is to strengthen the model, in order to estimate the future demand trend of the project (i.e. the base case of demand). In principle, at least one of the independent variables should be macroeconomic or financial with future projections available for consultation by the contracting entities. In this sense, and in the case of traffic demand, there is empirical evidence that proves that the real monthly GDP[41] is one such variable that is highly correlated to traffic behavior on the country's roads[42].

[39] Such as landslides, opening of a new roadway, or any other particular factor associated with the context of the project.

[40] All independent variables shall be in the same time frame and in the same unit of measurement. That is, since real GDP will be used, the tariffs and other explanatory variables that apply must be on the same terms. For ease of calculation, the GDP series will be worked out in millions.

[41] In some cases, it may be appropriate to stress this variable, in order to capture possible deviations in the estimates of the macroeconomic or financial variable. In any case, this will be defined by the DGCPTN.

[42] For the other sectors that have infrastructure projects, the macroeconomic variable that will be used will be published on the website of the Subdirectorate of PPPs of the Ministry of Finance and Public Credit. In any case, the contracting entity may propose the explanatory variables that it considers relevant, provided that, these variables are. shown to improve the model estimate, in terms of the significance of the estimators (statistical p or t value) and the adjusted R2.

It is important to mention that, the use of other explanatory variables, based on the particularities of the project, such as the tariff level or behavior of the price of oil, could be relevant to explain the demand of certain series. However, it is fundamental, as mentioned above, to have historical information and projected information to include these variables in the analysis. For the above, it is relevant that the historical information and the projections of the variables to be included come from trustworthy, well known, and reliable sources. From this input comes the success in the results of the methodology.

In the particular case of the tariffs charged to use the project (where historical and future information must be available), it is to be expected that there is an inverse relationship between traffic and tariff. However, due to the particularities of some projects, it is likely that this relationship is not always observed or relevant. For this reason, in any case, a model should be run considering the tariffs, as long as the inclusion of the tariffs is negatively correlated[43].

Also, in some cases, and given that not all months have the same number of working days, the incorporation of the ratio of working days to total days of the month could improve the econometric model, and should therefore be included as long as the results are in line with expectations.

In other cases, variables that do not have the expected sign or are not significant should be omitted and the model should be run with the macroeconomic variable chosen. It should be clarified that, for the application of the model, all the variables must be in the same terms and with the same periodicity. That is, in the case of using the monthly macroeconomic variable real GDP, the tariffs and other explanatory variables must be in real terms and with monthly periodicity.

Finally, in the case of having a variable that is considered relevant, and with adequate and sufficient information, it can be included as an explanatory variable within the model, as long as the regression demonstrates

[43] By the law of supply and demand, it is to be expected that if the price of a good or service increases, the demand for it will decrease. This applies in all cases, except for differential tariffs, where the rate will not necessarily be related to demand.

meaningful correlation, in terms of significance[44], expected sign[45], and fit[46] of the model.

6.1.1.2 Smoothing and transformation of the series

Bearing in mind that we will be working with monthly data, and that each month has a different number of days, it is advisable to use the series in terms of average daily traffic (TPD for its Spanish initials). That is, it is recommended to divide the traffic, by the number of days of each month.

However, the demand series could present a volatile behavior that makes it difficult to interpret and adjust an econometric model. In this sense, it is important to smooth the data, in order to reduce volatility induced errors. However, while it is important to smooth the data, smoothing for more than three periods forward and backward could mean a loss of important information for the model estimate.

Therefore, and for the purposes of this methodology, the moving average will be calculated as follows:

If Y'_t corresponds to the value of the monthly series, in terms of TPD, of the demand variable in period t, then the smoothed series Yt is obtained according to the following equation:

$$Y_t = \frac{1}{2}\left[\frac{1}{4}(Y'_{t-2} + Y'_{t-1} + Y'_t + Y'_{t+1}) + \frac{1}{4}(Y'_{t-1} + Y'_t + Y'_{t+1} + Y'_{t+2})\right]$$

Note that after smoothing the series, the first two values and the last two of the original series are lost. Figure 13 shows an example.

[44] It is desirable that the variables are significant (p value) at 80% or 90% minimum. However, in no case will a variable be accepted with a significance level of less than 50%.

[45] By including some variables, one would intuitively expect them to show some specific sign. For example, it is to be expected that, if there is an increase in tariffs, the demand for vehicles travelling on that route will decrease if there are other travel options. Therefore, if some explanatory variable is included in the model, it must have the expected sign, or else it should not be considered.

[46] One model is better than another, when the adjusted R2 is higher. However, the significance of the variables and their expected sign will be more relevant than the model fit, when choosing the final variables to be counted on.

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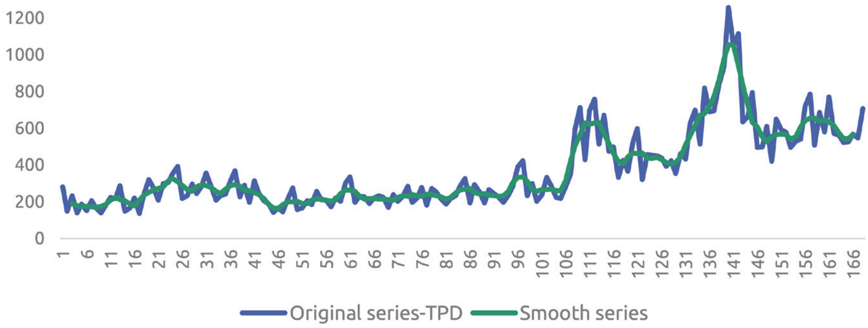
Figure 13. Original series vs. smoothed series



Source: DGCPTN's own preparation

Note that with the smoothed series the values of periods 1 and 2, and 167 and 168 of the original series are lost[47].

6.1.1.3 Econometric model and baseline projection of future demand

The projection of the future baseline is made by means of an econometric model whose independent variables are the variables identified in section 6.1.1.1, and the dependent one is the project's demand variable. All the variables of the series will be worked considering their inter-annual differences (i.e., t - 12) to avoid the problem of spurious regressions[48]. Likewise, and in accordance with greater theoretical rigor, we will work with a log-log model in differences, to make the necessary projections.

This functional form, log-log in differences, recognizes several factors that are explained below: first, that traffic cannot grow indefinitely as a linear function of GDP and other explanatory variables, but that each corridor presents natural limits to the possible number of vehicles which can transit through that place.

[47] It is assumed that for the purposes of the graphic example the number of available historical data is 168.

[48] Regression that yields very high and apparently significant estimators, but that does not really explain the behavior of the dependent variable, given that its estimators are biased and incorrect.

Secondly, it solves the problem, already mentioned, of a possible spurious regression that projects based on the trend and not on real traffic data. Finally, according to theoretical and empirical evidence (see, for example, Oum, 1989), the functional form of log-log models in differences, generates better results than lin-log (linear - logarithm), or lin - lin (linear) models.

Accordingly, the purposes of this subsection are: i) to forecast the baseline of future traffic, and ii) to find a distribution of the prediction error that will be used in the following steps to calculate a scenario at risk.

In this order, the econometric model will be defined as follows:

» **Dependent variable:** the difference of the natural logarithm of the smoothed historical traffic series between periods t and t -12 ($\ln(Y_t)$ - $\ln(Y_{t\text{-}12})$) will be the dependent variable of the linear regression.

» **Independent Variables:** In principle, the explanatory variables[49], will be:

GDP: differences in the natural logarithm of GDP, ($\ln(GDP_t)$- $\ln(GDP_{t\text{-}12})$),

Tariffs: differences in the natural logarithm of tariffs ($\ln(tariffs_t)$- $\ln(tariffs_{t\text{-}12})$), and

Working days / Total days: differences in the natural logarithm of the proportion of working days to total days in the month

$$(\ln(\frac{working\ days_t}{total\ days_t}) - (\ln(\frac{working\ days_{t\text{-}12}}{total\ days_{t\text{-}12}})).$$

Thus, the econometric model that reflects these considerations is described by the following equation:

[49] All models should be estimated considering at least these variables. If the tariffs do not show the expected (negative) sign, regardless of their degree of significance, they must be omitted. Exceptionally, in the case of differential tariffs, which are described below, the sign does not constitute a factor for eliminating the variable, only the significance will be taken into account, in order to eliminate or maintain the variable. If the proportion of working days is not significant, it will be eliminated, regardless of its sign. All debugging on the model must be done variable by variable. In no case will it be allowed to eliminate all the variables at the same time.

$$\hat{Y}_t = \ln(Y_t) - \ln(Y_{t\text{-}12})$$

$$= \beta_0 + \beta_1 * (\ln(GDP_t) - \ln(GDP_{t\text{-}12})) + \beta_2 * (\ln(tariffs_t) - \ln(tariffs_{t\text{-}12}))$$

$$+ \beta_3 * (\ln(\frac{working\ days_t}{total\ days_t}) - (\ln(\frac{working\ days_{t\text{-}12}}{total\ days_{t\text{-}12}})) + \varepsilon_t$$

And if a *dummy* variable has been defined, D_i , to consider an event that occurred in month i, it will enter the model with value $D_i = 1$ for month i and $D_j = 0$ for the remaining months j. Therefore, in the equation of the previous model, it should be added as inter-annual difference ($D_i - D_{i\text{-}12}$) multiplied by a parameter β_4.

Accordingly, the results of the regression may yield some scenarios such as those indicated in the following tables.

Table 4. Possible sign of the parameters

Explanatory variable - sign	Positive	Negative
β_1 - *GDP*	Expected	Not expected
β_2 - *Tariff*	Not expected	Expected
β_3 - *working days ratio*	The sign is not relevant	The sign is not relevant

Table 5. Possible significance of parameters

Explanatory variable - Significance	P Value < 0.5	P Value > 0.5
β_1 - *GDP*	Desirable	Not Desirable
β_2 - *Tariff*		
β_3 - *working days ratio*		

The significance of the parameters will be determined by the statistical t or by the P value of the regression. In this sense, it is desirable that the estimators are significant at 80% or higher. However, considering some limitations that could present the assessed series, it is possible that the significance in some cases is lower than the desired percentage without this implying that the model is not adequate. In any case, the minimum accepted significance cannot be less than 50%.

Based on the above, the way in which the baseline of each of the demand series will be projected will be defined. This, with the objective of having adequate projections and explanatory variables, that are really in line with the behavior of the demand variable.

In the event that the macroeconomic or financial explanatory variable (in this case the GDP), results with the expected sign, and with a goodness of fit or significance equal to or greater than 50%, the estimated model will be used to make the baseline projections, because it allows the best available prediction. In the case that said variable does not have the expected sign (positive) or does not have a degree of significance of at least 50%, it will be accepted that the GDP explanatory variable is not an adequate explanatory variable to use for the regression, for which reason the average of the last 12 months of the demand variable should be used for the baseline projection. That is, it is assumed that the projection will be the average of the last 12 data of the smoothed series Y_t.

In the case of the Tariff as an explanatory variable, it will be included in the model, if and only if the results of the regression show that the variable has the expected sign (negative), regardless of its degree of significance. In this sense, if after estimating the regression, the tariff does not show the expected sign, the model should be re-estimated omitting this variable[50].

Finally, the ratio of working days' variables and the other explanatory variables that are decided to be included will be used only in the case that their inclusion is shown to improve the model versus their non-inclusion[51]. To verify this, the two econometric models should be carried out and presented, and the R^2 result of each one and the respective statistical t of the estimators should be analyzed.

As an illustrative example, Table 6 shows the results of an econometric model and the projection of the future baseline, for any series [52].

[50] In the case of differential tariffs which will be explained later, the sign of the rate will not be relevant. That is, it will only be eliminated if its significance is not greater than 50%.

[51] The model is considered to have improved if the adjusted R_2 increases and the estimators are significant by at least 50%.

[52] A step-by-step example is found in section 7 of this document.

Table 6. Econometric model results

Variable	Coefficient	Significance P
β_0 - *Constant*	-0,0698[53]	0,19
β_1 - *GDP*	4,0963	0,00
β_2 - *Tariff*	1,4998	0,10
β_3 - *Working days ratio*	0,3321	0,37

The results of this example show that the tariff does not have the expected sign (negative). Therefore, following what is indicated in this subsection, the model must be re-estimated, without taking it into account[54], as shown in Table 7.

Table 7. Results of the econometric model re-estimation

Variable	Coefficient	Significance P
β_0 - *Constante*	-0,0536	0,32
β_1 - *PIB*	3,8138	0,00
β_3 - *Proporción días hábiles*	0,3591	0,35

Re-estimating the model, the results show that the variables GDP and the ratio of working days meet the criteria described in Table 4. Parameter sign and Table 5. Significance of the parameters. Therefore, the methodology application continues only with these two explanatory variables.

It is important to remember that since the model is log-log in differences, a transformation must be made to estimate demand in levels (without adjustments) and to continue with the projection in terms of TPD. For this, the formula to be used to project the demand baseline in this example, in levels (without adjustments), is[55]:

[53] In all cases, a maximum of 4 decimals is suggested.

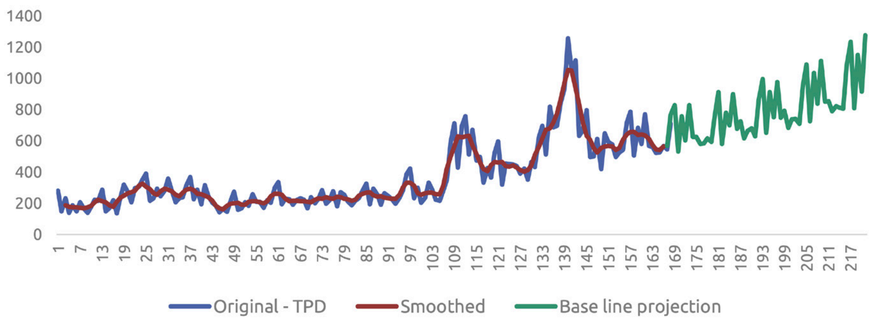
[54] If the project contemplates a substantial tariffs increase at any point in time, for the purposes of projecting the demand baseline, such increases will not be considered, since they will be considered when calculating revenues.

[55] It should be clarified that if there are more explanatory variables, they should be included in the corresponding formula.

$$\hat{Y}_t = e^{(\beta_0 + \beta_1 * (\ln(GDP_t) - \ln(GDP_{t-12})) + \beta_2 * (\ln(\frac{working\ days_t}{total\ days_t}) - (\ln(\frac{working\ days_{t-12}}{total\ days_{t-12}}))))} * Y_{t-12}$$

In this sense, the demand baseline is projected, as reflected in figure 14.

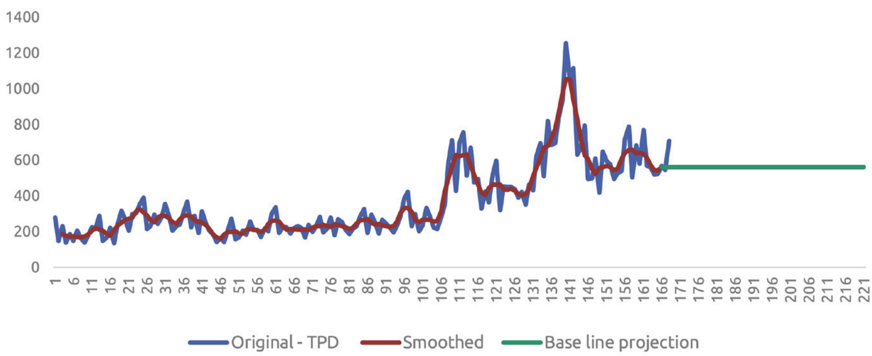
Figure 14. Demand baseline (monthly)



Source: Own elaboration DGCPTN

As mentioned above, in the exceptional cases in which the GDP or the macroeconomic or financial variable used does not result in the expected sign, the econometric model will not be used, and instead the demand will be projected based on the average of the last 12 data of the smoothed series Y_t. In exceptional cases, the DGCPTN could define another criterion to make the projection in these cases. This is shown in figure 15.

Figure 15. Demand baseline with average for the last 12 months

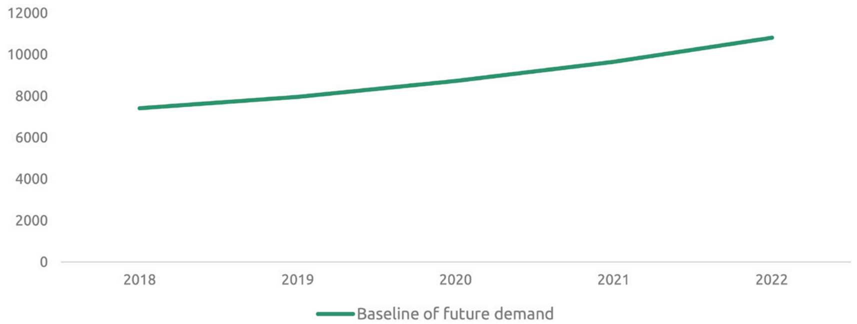


Source: Own elaboration DGCPTN

6.1.1.4 Transformation of the series into annual data

After having the traffic projection in monthly terms and with the objective of calculating annual projections[56], the series will be transformed into annual traffic data . An example of the transformation of figure 14 will be like figure 16. In the case of figure 15, the projection will remain constant, but in this case, in annual terms.

Figure 16. Baseline of future annual demand



Source: Own elaboration DGCPTN

6.1.1.5 Risk adjustment I: Estimation error

The objective of Risk Adjustment I is to choose a scenario at risk after estimating the future demand. This is based on the premise that, for the calculation of the contingent liability, a scenario below the baseline scenario should be used so that the traffic forecast is appropriately conservative.

In this sense, Risk Adjustment I translates into a downward displacement of the base demand projection ($\hat{Y}_t$) estimated in sections 6.1.1.3, by a percentage equivalent to one percentile[57] of the absolute error of prediction of the econometric model estimate calculated in section 6.1.1.3.

[56] The annual projection will be the sum of the 12-month traffic. It is important to say that at this point the demand continues in terms of daily traffic, so an additional transformation will be made later. In section 7 of this document, there is an example with the practical step-by-step.

[57] The value of the percentile to be used will be defined on the website of the PPPs Subdirectorate of the Ministry of Finance and Public Credit.

The equations for this procedure are shown below. As an illustration, the percentile 95 adjustment of the errors of the econometric model is made:

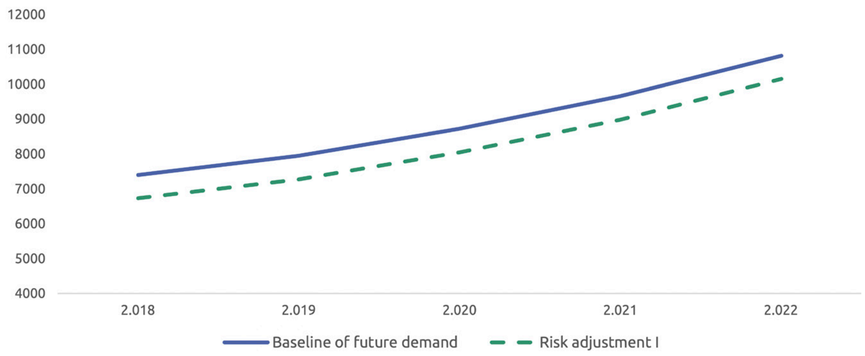
$$|\varepsilon_t| = |Y_t - \hat{Y}_t|$$

That is, for t = 1,...,T the series of absolute errors is calculated and $|\varepsilon_t| = \{|\varepsilon_1|, |\varepsilon_2|, \dots, |\varepsilon_T|\}$ the new projection path is obtained, which includes the effect of the Risk Adjustment I:

$$Y_t^{[1]} = \hat{Y}_t - P_{95}(|\varepsilon_t|)$$

Where $P_{95}(|\varepsilon_t|)$ denotes the percentile 95 of the absolute error and $Y_t^{[1]}$ denotes the traffic after the first risk adjustment has been applied. Figure 17 illustrates what is described in this subsection:

Figure 17. Risk Adjustment I



Source: Own elaboration DGCPTN

Note that the first year (2018) corresponds to the last actual data available (smoothed). In this sense, it is to be expected that the Risk Adjustment I, is a parallel line lower than the demand baseline estimated in the previous subsections.

On the other hand, when the baseline $\hat{Y}_t$ comes from the average of the last 12 months of the Y_t, series, no risk adjustment I is made, as the series itself reflects a risk scenario where there is neither growth nor decline from current levels. In other words, $Y_t^{[1]} = \hat{Y}_t$.

BACK TO CONTENT

6.1.1.6 Risk adjustment II: projected structural changes[58]

The construction of some projects in Colombia involves new technical specifications, which result in savings in transportation costs or travel times and in turn attract considerable increases in demand. Such increases can be called "structural changes"[59] that could not be captured by an econometric model that only uses historical information. Therefore, the objective of Risk Adjustment II is to consider such increases, limiting them based on available historical information on structural changes shown in previous projects and years. This adjustment is then overlaid the demand projection from Risk Adjustment I.

The *"structural change"*, in general terms, can be defined as the modification of the historical pattern of demand, permanent in time, due to a change in the technical conditions of the road or the project. For example, for road projects, a structural change may result from the provision of an additional lane that reduces travel times and therefore encourages traffic demand along the corridor.

Within a single project, several structural changes can be estimated as different functional units, milestones or lanes come into operation. These changes are reflected in the most up-to-date traffic study, where the context and characteristics of the project were considered[60].

However, it is possible that the real impact of the structural change will be lower than that estimated in the traffic study and therefore that the real future demand will be lower than the projection estimated in the structuring stage[61]. To incorporate this future and uncertain fact in the traffic projection of the project, it is deemed pertinent to apply a conservative scenario of structural changes, based on what has been historically observed by category.

[58] The Glossary of Terms defines what is meant by structural change. This definition can only be applied in the context of this methodology and will not support other types of interpretations.

[59] Structural change shall be understood strictly as defined in the Glossary of Terms and shall be applied only for the purposes of this methodology. For this reason, this definition should not be used in other contexts.

[60] For other sectors, this example will resemble permanent changes over time as a result of variations in the technical conditions of the project.

[61] In some projects, a negative structural change may be expected, i.e. the traffic will decrease rather than increase. In the PPPs Subdirectorate web page, you will find the value that is will give to this parameter and the same procedure described in this section should be followed, considering that the maximum value between M_s and the teat value defined for these cases should be considered.

The following procedure will be followed to develop this subsection:

Assume that there is a single positive w structural change in the period $T+k+1$. In this sense, two inputs are required: i) the most updated traffic study where a percentage of structural change is incorporated which will be calculated as M_S and ii) a parameter θ defined as the structural changes historically observed in different corridors[62]. With these inputs, the following procedure will be followed:

1. **Structural change in the traffic study:** determine the percentage increase of the structural change. If $S_t = \{ S_T, S_{T+1}, \ldots \}$ denotes the series of the most up-to-date traffic study, then the structural change assumes that S_t has a higher jump than the average trend between the periods S_{T+k} and S_{T+k+1}. According to this, and after subtracting the trend, the percentage of structural change is defined as:

$$M_S = \frac{S_{T+k+1} - S_{T+k}}{S_{T+k}}$$

2. **Limit to the impact of structural change on the $Y_t^{[1]}$ series:** the M_s change is compared with the percentage θ, and the minimum[63] is chosen between these two values. With the above, the $Y_t^{[1]}$ moves parallel upwards in a magnitude equal to the minimum between M_S and θ,starting from the period $T + k + 1$. Accordingly, after applying Risk Adjustment II, the estimated value of traffic in the series is written as:

$$Y_t^{[2]} = \begin{Bmatrix} Y_t^{[1]} & \text{Si: } t \leq T + k \\ Y_t^{[1]} * (1 + \min(M_S; \theta)) & \text{Si: } t > T + k \end{Bmatrix}$$

In other words, for the periods prior to the structural change, the series obtained $Y_t^{[1]}$after Risk Adjustment I remains unchanged, however after

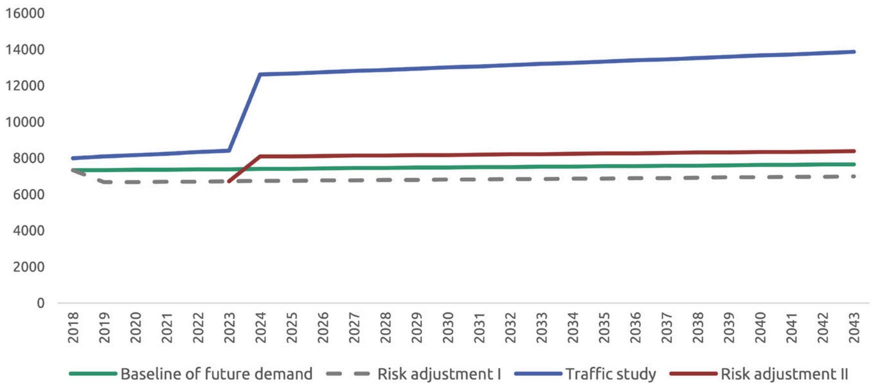
[62] This factor is calculated based on the structural changes observed in existing corridors. It can be consulted on the web page of the PPPs Subdirectorate of the Ministry of Finance and Public Credit. For other sectors, where something similar is expected to occur, the DGCPTN of the Ministry of Finance and Public Credit will define the value that will be granted to said parameter.

[63] If a negative structural change is expected, select the maximum value between the two indicated values (M_S and Theta), and move the Y_t line [1] downwards.

the structural change w projected for the $T+k+1$, period, the line is moved upwards by an amount equivalent to $(\min(M_s;\theta))$.

As an illustration, Figure 18 shows the result of a practical exercise, assuming that M_s = 50% and θ = 20%.

Figure 18. Risk Adjustment II



Source: Own elaboration DGCPTN

It is noted that the traffic projection contained in the traffic study (blue line) does not necessarily match the baseline of future demand $\hat{Y}_t$, (green line). This can occur, because in some cases the input of the traffic study comes from specific analyses of the project and the second from an econometric model based on historical information.

When the updated demand study (traffic for this example) estimates more than one structural change in the life of the contract, the same procedure described above with $Y_t^{[2]}$ playing the role from $Y_t^{[1]}$ and applying the procedure described in section 6.1.1.6. This yields as a result $Y_t^{[3]}$ which constitutes the demand risk scenario for the project.

6.1.1.7 Project income estimate and contingent calculation

Once this is obtained, for the calculation of the contingent liability, it is necessary to estimate the income of the project. In this sense, the series of traffic resulting from the application of Risk Adjustment II, at original levels, must be multiplied by the tariffs expected to be charged in the project. The result of this will be an amount in revenues that must be compared with the contractually agreed revenues. This difference will be the contingent value to be provisioned for the risk of traffic demand in the project.

6.1.2 Case 2. Insufficient historical information

When there is not a minimum of 60 months (5 years) of consecutive historical information for the demand variable, it is not possible to create an econometric model in terms of Y_t and the explanatory variables. In this case, the series of the initial demand study (structuring) E_t is considered as the projection of the demand baseline, from which Risk Adjustment I: Estimation error and Risk Adjustment II: Projected structural changes are made. The above, considering that said projections were those initially contemplated to agree on the conditions for entering the contract. In this sense, it is adequate to start from this base to make the respective risk scenarios.

$$\hat{Y}_t = E_t$$

It is important to mention that Case 2. Insufficient historical information will only apply until the 5 years of information are available required to apply Case 1. Available and adequate historical information. Once there is sufficient historical information, the contracting entity must apply the methodology described in section 6.1.1

6.1.2.1 Risk adjustment I: Estimation error

The main objective of this adjustment is to define a scenario at risk, based on the demand study carried out when structuring the project.

In order to establish the risk scenario, the use of two inputs has been established, according to the procedure that will be mentioned later.

The first of these corresponds to a q[64] percentage value which is calculated by the DGCPTN of the Ministry of Finance and Public Credit, based on the

[64] This parameter shall be regularly updated according to the information available in each sector.

traffic deviations observed in the projects under implementation[65]. The aim of this parameter is to correct possible deviations that may occur in the demand baseline in the structuring of projects, due to an over-estimation of the initial assumptions. The second corresponds to the pessimistic scenario of the updated traffic study S_t^- [66], that is to say, demand projections that reflect the more conservative context of the project:

Based on the two inputs mentioned above, the following procedure is performed:

1. The risk scenario shall be defined as the minimum between the pessimistic scenario of the updated traffic study S_t^- and the result of the baseline (i.e. E_t) after adjusted by q

$$Y_t^{[1]} = \min\left(S_t^-;\ \hat{Y}_t - q \cdot E_t\right) = \min(S_t^-; E_t - q \cdot E_t)$$

2. In the case where the result of the above equation is that the risk scenario is constituted by, $\hat{Y}_t - q \cdot E_t$, what will happen is a parallel downward displacement of the $\hat{Y}_t$ baseline equal to q. On the contrary, if as a result of the above equation, it is evident that the risk scenario will be described by the variable S_t^-, this path will be the main input to continue with the valuation.

In order to preserve the notation introduced in the previous section, the series $Y_t^{[1]}$ resulting from Risk Adjustment I is denoted, regardless that the procedure differs from the steps to be followed when a historical series Y_t is available. This notation also facilitates the description of the second risk adjustment.

[65] This parameter will be defined in the web page of the PPPs Subdirectorate of the Ministry of Finance and Public Credit, and will be calculated taking into account the average or a sufficiently conservative percentile of the traffic deviations observed between the initial demand study (structuring) and the actual traffic of the projects with information. It should be clarified that in cases where partial information exists (for example, from a toll of the same project), the DGCPTN may define the value of q parameter in function of this information, based on general criteria, considering the particularity of the project.

[66] Generally, in infrastructure projects, there is a model for the projection of demand and initial income with which the project was structured, which for these purposes will be called a "structuring traffic study". Subsequently, there may be as many updates as required, to collect new demand projections. For these purposes, the updating of the most recent projections at the time the assessment is carried out will be called an "updated traffic study". In some cases, it is likely that the updated traffic study will be the structuring traffic study.

6.1.2.2 Risk adjustment II: structural change

For this case Risk Adjustment II aims to recognize that there may be a change in the behavior of the demand series, derived from changes in the conditions of the road or the project. Based on the structuring traffic study, this change in behavior was already contemplated in the initial demand estimate. However, this adjustment aims to capture the possible over-estimation of the structural change initially contemplated, and therefore limits the percentage applied to the series.

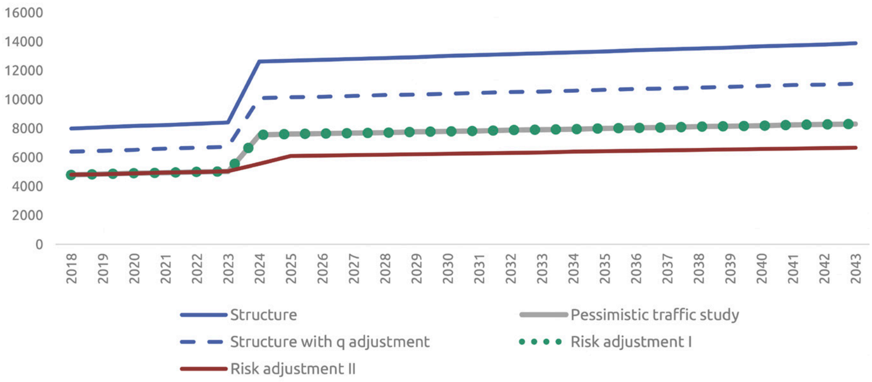
However, if the M_S, structural change, defined in this case for the structuring traffic study, is less than or equal to the parameter θ, defined by DGCPTN, no adjustment will be applied after Risk Adjustment I. The above is because this indicates that the structural change estimated in the structuring stage is lower than that observed in other projects and defined by the parameter θ. If, on the other hand, M_S is higher than the θ parameter, the future baseline will be adjusted so that it reflects a structural change of magnitude θ and not in M_S.

So, if the structural change occurs in the T+k period, and θ is lower than M_S, the magnitude of the adjustment corresponds to $Y_{t-1}^{[1]} * (1+\theta)$ in the T+k. period. For subsequent periods, it will be defined as $Y_{t-1}^{[1]} * (1+z)$ where z is the natural growth of traffic. Otherwise, no adjustment will be made.

$$Y_t^{[2]} = \begin{Bmatrix} Y_t^{[1]} & \text{Si: } t < T+k \\ Y_{t-1}^{[1]} * (1+\theta) & \text{Si: } t = T+k \\ Y_{t-1}^{[1]} * (1+z) & \text{Si: } t > T+k \end{Bmatrix}$$

Assuming again, that M_S = 50% and θ = 20%, the final risk scenario is a $Y_t^{[2]}$ series that has incorporated the risk adjustments for each future structural change estimated in the term of the contract, as shown in figure 19. Insufficient historical information.

Figure 19. Insufficient historical information



Source: Own elaboration DGCPTN

In figure 19, the pessimistic scenario of the updated traffic study is less than displacing the structuring traffic series downwards ($\hat{Y}_t - q \cdot E_t$). Therefore, the series of the first risk adjustment coincides with the pessimistic scenario of the updated traffic study (grey line), and the $Y_t^{[2]}$ series is calculated from, $Y_t^{[1]}$, by making a growth of magnitude θ and not M_s.

6.2 Differential tariffs risk

The differential tariffs risk, as explained in section 4.6.2, is the risk that certain users of the infrastructure may be granted preferential tariffs.

This risk comprises two factors (the volume of preferential traffic and the rate charged). For example, in road infrastructure projects, the risk scenario is that the volume of traffic benefiting from the preferential rate is higher than estimated in the structuring stage and/or that the preferential rate is lower than the one contractually agreed. This would lead to the estimated revenues of the project decreasing as more users make use of the benefit.

Likewise, it is important to mention that, according to the historical information available for Colombian road corridors, there is no strong evidence that allows us to conclude that the volume of special category traffic correlates with the respective discount. For this reason, and for simplicity in the modeling, it is assumed that these two risk factors, Q_t quantities and P_t prices are independent.

6.2.1 Calculation of quantities Q_t

The Q_t quantities will then be modelled to obtain the corresponding risk assessment. As in the case of demand risk, the method considers two cases according to the quality and sufficiency of the available historical information[67].

6.2.1.1 Case 1: Available and adequate historical information for differential categories.

6.2.1.1.1 Demand baseline projection for differential tariffs

When historical differential tariff information exists for a project (e.g. "Special Category" traffic figures for the tolls that make up the series), the methodology described in section 6.1.1 is applied, in particular the first three subsections: 6.1.1.1, 6.1.1.2, 6.1.1.3[68] with the monthly historical series of the special traffic that will be equivalent to what was mentioned in the previous subsections as Y'_t.

For the exceptional case mentioned in section 6.1.1.3, in which the regression coefficient of the macroeconomic or financial variable does not result in the expected sign or does not have a degree of significance greater than 50%, the baseline of future demand should be projected based on the maximum traffic of the last 12 months.

This process results in a base line $\hat{Y}_t$ for the traffic of this user category with which it is possible to make the respective risk adjustments. This is explained by the fact that differential rate risk materializes when the volume of special category traffic is high, so for this section the baseline corresponds to the maximum value instead of the average.

After the procedure indicated in this sub-section has been followed, one then follows what is described in section 6.1.1.4.

[67] The decision criterion for considering that the available historical information is adequate is the same as that for demand risk: consecutive observations for at least 60 months (5 years). In the event of more than 60 months, all available information will be used.

[68] In the case of differential tariffs, it is likely that one of the explanatory variables is the number of project quotas. For the case of the independent Rate variable, if this variable is significant it will be included in the model, regardless of its sign, otherwise it will be omitted.

6.2.1.1.2 Risk adjustment I: Estimation error for differential categories

As in section 6.1.1.5 , the adjustment depends on whether the $\hat{Y}_t$ baseline comes from a regression or the maximum available in the last 12 months.

In the first case, it is possible to compute the series of errors in absolute value $|\varepsilon_t| = \{|\varepsilon_1|, |\varepsilon_2|, \dots, |\varepsilon_T|\}$ of the regression and then define the risk adjustment as a vertical parallel shift equal to the percentile 95 of those errors, or to the percentile defined by DGCPTN:

$$Y_t^{[1]} = \hat{Y}_t + P_{95}(|\varepsilon_t|)$$

As mentioned in the previous subsection, the risk scenario in differential tariffs consists of high levels of special category traffic, so the percentile 95 of the absolute error is added on top rather than subtracted[69].

Otherwise, when the baseline $\hat{Y}_t$ comes from the maximum of the last 12 months of the historical series, no Risk I Adjustment is made due to estimation error, as this projection, in itself, already captures the risk scenario of the project experiencing a high volume of special category traffic. Therefore, it turns out that $Y_t^{[1]} = \hat{Y}_t$.

6.2.1.1.3 Risk Adjustment II: changes in the behavior of the differential tariffs series

In the case of differential tariffs, it may not be a structural change itself, but a change in the behavior of the series[70]. This may occur (in the case of roads) because the number of vehicles with benefits increased substantially with respect to what was historically observed.

In this case, and taking into account that there may be information during the execution of the project that is not reflected either in the initial structuring model or in the updated traffic study, Risk Adjustment II will be applied as long as there is formal information (resolution or letter from the interested

[69] In some cases, there may be an administrative act that limits the number of differential tariffs (quotas or maximum passes). In these cases, if the projected demand is higher than this limit, the limit imposed by administrative act must be considered, in order not to overestimate the risk.

[70] The Glossary of Terms defines this expression.

parties) indicating that the number of beneficiaries or the frequency with which they obtain the benefit may change with respect to what has been historically observed.

For example, if the formal information available to S_t, for simplicity, contemplates a change in the behavior of the series of 20% of the effective traffic from the T+k period, then the minimum upward adjustment of special category traffic should be 20% from the T+k period. If, on the other hand, there is information that the beneficiaries will decrease, no risk adjustment will be made until the effects of this decrease are evident. The above, in order to maintain a conservative scenario.

6.2.1.2 Case 2. Insufficient and/or inadequate historical information for differential tariffs

Similarly, to case 6.1.2, which is based on insufficient information on full tariff traffic, in this case the demand baseline is defined as the demand projection for differential categories that was considered in the traffic study of the structuring stage E_t. The required risk adjustments are made on this baseline.

In the case in which the structuring model has not contemplated differential tariffs, the traffic of the full category will be taken as the baseline, multiplied by the r percentage, defined in the web page of the PPPs Subdirectorate of the Ministry of Finance[71], as shown below.

$$\widehat{Y_t} = (\mathrm{r} * E_t)$$

6.2.1.2.1 Risk adjustment I: Estimation error for differential categories

Similarly, to what happens in section 6.1.2.1, in order to determine the Risk Adjustment I for an event in which there is not available adequate information, the two inputs defined as i) q' which corresponds to the deviations observed between the differential traffic contemplated initially in the structure, and the differential traffic actually observed from existing projects, and ii) S_t^+ which

[71] This parameter will be defined in the web page of the Subdirectorate of PPPs of the Ministry of Finance and Public Credit, and is calculated taking into account the average percentage of differential traffic vs. full traffic, in the corridors that have information. In the event that full historical traffic information is available but not differential traffic, the historical traffic path should be used, and multiplied by the parameter r to find the differential traffic path, and follow the steps of the case with information.

refers to the optimistic scenario of the updated traffic study for differential traffic. In the case where no differential traffic was contemplated, the optimistic scenario of full traffic will be taken, multiplied by the parameter r.

From the above, the following procedure will be followed:

1. The risk scenario is defined as the maximum between the optimistic scenario of the updated S_t^+ traffic study and the baseline (i.e. E_t) after the q' adjustment is applied.

$$Y_t^{[1]} = \max\left(S_t^+;\ E_t + q' \cdot E_t\right)$$

2. If the result of the above equation is that the risk is constituted by $E_t + q' \cdot E_t$, then there will be a parallel shift up of the $\hat{Y}_t$ baseline (that is to say, E_t) on a scale equal to q'[72]. On the contrary, if as a result of the above equation it is evident that the risk scenario will be described by the optimistic scenario of the traffic study S_t^+ this path will be the main input to continue with the assessment.

It should be made clear that this procedure will only apply to traffic with differential tariffs.

6.2.1.2.2 Risk Adjustment II: changes in the behavior of the differential tariffs series

In this case, and only if there is formal information about a change in the series behavior, the procedure described in section 6.2.1.1.3 shall be followed. Otherwise, the procedure described in this subsection will not be performed and therefore there will be no Risk Adjustment II.

6.2.2 Definition of tariffs P

Unlike the volume of traffic along a road corridor in a special category, the amount of discount granted to stakeholders is not time-dependent. There-

[72] This parameter will be defined by the DGCPTN of the Ministry of Finance and Public Credit, and will be updated periodically.

fore, the differential rate is also not time-dependent[73] and the risk scenario is defined based on a single differential rate shock.

6.2.2.1 Case 1. Available project information

It is understood that information is available when the project already has a formally established tariff, which provides an additional or different benefit to that contemplated in the contract. In this case, the differential tariff P_E, is equivalent to the tariff granted in accordance with the resolution or the act in firm that grants the additional benefit or that modifies the tariff that had been established in the contract initially.

Note that in this case there is no greater uncertainty regarding the discount value, since the terms of the contract, the resolution or the final act already establish it. In this sense, the tariff to be compensated (P_C), would be determined for the difference between the contractually established tariff (P_T) and the new special tariff granted (P_E).

$$P_C = P_T - P_E$$

6.2.2.2 Case 2. Insufficient project information

In some cases, even when there is no firm administrative act, it is likely that there is a formal proposal by the stakeholders requesting the creation of a differential tariff or the modification of the existing preferential tariff. In this case, the risk scenario is that the proposed tariff will be applied on those terms, since the demands of those groups are already revealed there.

If there is no information regarding applications or firm acts that can determine the differential tariff to be applied in the project, the risk scenario will be determined as follows:

1. The DGCPTN shall publish a table of discounts[74] between the full and differential tariffs by category, based on historical information of actual discounts applied. The percentage values in this table correspond to the

[73] Only normal CPI indexing should be considered.

[74] Information available on the website of the PPPs Subdirectorate of the Ministry of Finance and Public Credit.

average or a risk percentage of the projects considered with information, classified by category.

2. To define the shock applied to the full tariff, the contracting entity shall, for each category, calculate the product $d{\cdot}P_T$. The risk scenario is then defined as the minimum between $d{\cdot}P_T$ and P_E:

$$P = min(d \cdot P_T;\ P_E)$$

Where, P is the differential tariff that will be taken into account for the calculation of the assessment; P_T, is the full tariff to which a discount will be applied; d corresponds to the discount by category, according to the table published by DGCPTN, and P_E is the rate contemplated in the structuring for the differential category. If no differential tariff has been contemplated, P_E will be equal to $d{\cdot}P_T$.

For example, if the full and special tariffs for category II of the project were \$15,000 and \$12,000, respectively, d = 0.4, then the tariff P corresponding to the risk scenario is calculated as: P = min ((0.4 ∗ 15,000); 12,000) = min (6,000; 12,000) = \$6,000.

6.2.3 Income estimates and calculation of differential tariff contingent

Similar to how the estimate was made in section 6.1.1.7, when obtaining the results of the demand calculation Q_t and tariffs P, the calculation of the income from differential tariffs must be carried out and compared with the conditions that have been contractually agreed. The above, to complete the valuation of the contingent treated during the 6.2.

6.3 Risk of Impossibility to Collect

As mentioned in previous sections, the risk of inability to collect is associated with the inability to install or operate the tollbooths or the collection mechanism of the project, and with the inability to increase the tariffs in these mechanisms. In these cases, the assessment logic follows the same patterns as in section 6.2 Risk of Differential tariffs, with respect to the respective risk adjustments.

However, the prolonged materialization of this type of risk could lead the contracting entity not to continue with the project, or to take contractual management measures to mitigate the risk. For this reason, in the structuring stage the period of these valuations will be limited, in the time indicated in the web page of the PPPs Subdirectorate of the Ministry of Finance and Public Credit[75]. However, in the execution stage, this risk must be evaluated for the entire life of the project, unless the context of the project shows, without any room for subjectivity, that the risk will be active for a period of time less than the term of the contract.

6.4 Risk of Relocation of Collection Mechanisms

In this case, the risk is given by the difference in demand that may occur between one location and another. Therefore, to make this assessment, it is necessary to have demand information from both the original and the new location. In case these insufficiencies are available, the procedures mentioned in section 6.1 and 6.2 will be applied, according to the following assumptions:

1. For the original location, the Risk Adjustment I scenario will be assumed, which contemplates an increase in historical traffic. What is contemplated in the 6.2.

2. For the new location, the Risk Adjustment I scenario will be assumed, which contemplates a decrease in historical traffic. That is, what is contemplated in the 6.1.

6.5 Other Risks Related to Not Obtaining Income

In the event that the project contemplates risks different from those described above, and which are related to the non-obtainment of income, the same methodology described in the previous sections will be applied as the assumptions and the nature of the risk allow.

[75] It should be noted that, if the contracting authority considers that there is a longer time period for the estimation of risk, because of the context of the project, the contracting authority may include it. However, valuations will not be allowed with a time shorter than that mentioned in the web page of the PPP´s Subdirectorate of the Ministry of Finance and Public Credit.

6.6 Other Risks

In the event that, during the execution of the infrastructure project, risks are identified that are not explicitly found in this methodology, but that are similar in behavior and structure to what is expressed above, the methodology described in this document will be used.

In those cases, in which partial use of the methodology is required, the methodology will be presented for approval by the DGCPTN, in accordance with the regulations in force (Decree 1068 of 2015).

6.7 Calculation of the State Entity Contingency Fund Contribution Plan

In accordance with the regulations in force, if it is required to set up a plan for contributions to the FCEE, such calculation will be based on the assessments calculated on the basis of this document and the specific terms of each project must be adjusted in accordance with the contractual terms under which the compensation will be made.

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Chapter 7

Practical Examples

The main objective of the following is to describe in detail the procedure for applying the methodology. To facilitate the example, certain aspects have been simplified.

7.1 Practical example of risks associated with the pre-operational stage

i) Definition and calculation of initial parameters

***CE* =** is the estimated initial cost of the activity that gives rise to the risk in the structuring phase (e.g. cost of land purchase - value of the sub-account if applicable).

***CI* =** is the estimated and updated budget of the activity that gives rise to the risk (e.g. updated cost of land purchase), once the project is underway.

V_p **=** average percentage of cost overrun on historical or ongoing projects, as appropriate.

***DP* =** corresponds to the standard deviation of the last two variations of the updated budgets from one period to another of the risk and project being evaluated.

***DO* =** is the average standard deviation of the last two variations of the updated budgets (DP) reported by the entity, for all historical or ongoing projects, as applicable.

In cases where a negative cost overrun is present, it will be assumed to be 0%.

DP and DO are calculated as follows:

Property Land Risk - Budget without Savings								
Project	Sub-account Value	Month of Reference	jun-16	dec-16	jul-17	oct-17	apr-18	dec-18
P1	53.741	dic-12	79.938	-	53.741	53.741	53.741	53.741
P2	85.117	dic-12	124.348	134.048	123.917	122.238	130.199	130.199
P3	175.608	dic-12	315.895	275.757	299.861	299.861	325.327	325.327
P4	26.195	dic-12	88.849	84.716	84.715	84.715	84.716	103.461
P5	23.135	dic-12	40.764	42.937	46.358	46.358	54.982	54.982
P6	59.900	dic-12	121.991	109.718	59.900	59.900	59.900	70.433
P7	54.772	dic-12	72.880	66.024	71.952	71.952	71.952	84.905
P8	38.601	dic-12	68.485	49.281	38.601	38.601	38.601	43.417
P9	28.325	dic-12	50.305	50.032	28.325	28.631	35.371	28.325
P10	12.556	dic-13	-	-	12.556	12.556	12.556	12.556
P11	700	dic-13	-	3.161	4.534	4.534	3.114	2.751
P12	228.411	dic-13	-	228.411	237.031	237.031	357.340	236.520
P13	120.716	dic-13	-	-	120.716	120.716	120.716	120.716
P14	124.908	dic-13	-	126.979	124.908	124.908	124.908	124.908
P15	70.914	dic-13	-	-	144.587	144.587	123.439	123.544
P16	29.356	dic-12	-	129.499	126.321	126.321	113.902	122.623
P17	122.791	dic-13	-	-	191.554	191.554	203.634	203.634
P18	9.137	dic-12	-	-	10.704	10.704	10.084	14.352
P19	62.532	dic-13	-	-	85.262	85.262	120.792	112.861
P20	57.028	dic-15	-	-	-	-	-	131.000

Projects Samples	9	12	19	19	19	20
% Cost overrun	76,65%	48,63%	40,54%	40,44%	54,08%	51,70%

Property Land Risk – Deviations Report								
Project	Sub-account Value	jun 2016	dec 2016	jul 2017	oct 2017	apr 2018	dec 2018	Standard deviation of deviations in reports (DP)
P1	53.741				0,0%	0,0%	0,0%	0,0%
P2	85.117		7,8%	-7,6%	-1,4%	6,5%	0,0%	4,61%
P3	175.608		-12,7%	8,7%	0,0%	8,5%	0,0%	6,0%
P4	26.195		-4,7%	0,0%	0,0%	0,0%	22,1%	15,6%
P5	23.135		5,3%	8,0%	0,0%	18,6%	0,0%	13,2%
P6	59.900		-10,1%	-45,4%	0,0%	0,0%	17,6%	12,4%
P7	54.772		-9,4%	9,0%	0,0%	0,0%	18,0%	12,7%
P8	38.601		-28,0%	-21,7%	0,0%	0,0%	12,5%	8,8%
P9	28.325		-0,5%	-43,4%	1,1%	23,5%	-19,9%	30,7%
P10	12.556				0,0%	0,0%	0,0%	0,0%
P11	700			43,5%	0,0%	-31,3%	-11,6%	13,9%
P12	228.411			3,8%	0,0%	50,8%	-33,8%	59,8%
P13	120.716				0,0%	0,0%	0,0%	0,0%
P14	124.908			-1,6%	0,0%	0,0%	0,0%	0,0%
P15	70.914				0,0%	-14,6%	0,1%	10,4%
P16	29.356			-2,5%	0,0%	-9,8%	7,7%	12,4%
P17	122.791				0,0%	6,3%	0,0%	4,5%
P18	9.137				0,0%	-5,8%	42,3%	34,0%
P19	62.532				0,0%	41,7%	-6,6%	34,1%
P20	57.028							

Average of Deviations	14,4%

CASE 1. Consolidated historical information for completed projects.

This case will apply only if the entity has a database of completed projects, and with the characteristics set out in the page of the PPPs Subdirectorate of the Ministry of Finance and Public Credit.

Historical Information – Property Land Risk	
Minimum cost overrun	0%
Average cost overrun (V_P)	60%

For example, to calculate ***DP*** for project 2, the following steps must be completed

1. Calculate the changes in estimates over time.

$$December\ 2016 = (134.048.354.535 - 124.347.857.240) / (124.347.857.240) = 7.8\%$$

$$July\ 2017 = (123.917.219.134 - 134.048.354.535) / (134.048.354.535) = -7.6\%$$

$$October\ 2017 = (122.237.929.333 - 123.917.219.134) / (123.917.219.134) = -1.4\%$$

$$April\ 2018 = (130.199.049.424 - 122.237.929.333) / (122.237.929.333) = 6.5\%$$

$$December\ 2018 = (130.199.049.424 - 130.199.049.424) / (130.199.049.424) = 0.0\%$$

2. DP shall correspond to the standard deviation of the last 2 periods calculated above

$$DP = STDEV\ (6.5\%; 0.0\%) = 4.6\%$$

DO will be the average DP calculated for projects with information (14.4%).

» Cost overrun information for the project to be evaluated

Project Information	
Sector	Transport
Risk	Land Purchase
Status	Construction stage
Initial sub-account value (C_E)	5.000
Value of risk-related activities in progress (updated) (C_I)	8.500
Expected cost overrun for the project (C_I - C_E) / C_E	70%[76]
Deviation of budget update (DP)	4.6%
Average Deviation for Budget Updates (DO)	14.4%
Percentage of property execution (properties acquired/ total properties)	66%

For this case, the minimum, most probable and maximum value are defined by:

$$V_{min} = \textit{minimum percentage of the historical database}$$

$$V_{MP} = (70\% \left(\frac{C_I - C_E}{C_E}\right) + 30\%(V_P)) * (1+DP)$$

$$V_{Max} = Max\,(V_P; \left(\frac{C_I - C_E}{C_E}\right)) * (1 + 3 * (\max\,(DP; DO)))$$

When replacing the values

$$\mathbf{V_{min} = 0\%}$$

$$V_{MP} = (70\% * 70\% + 30\% * 60\%) * (1 + 4.6\%)$$

$$\mathbf{V_{MP} = 70.08\%}$$

$$V_{Max} = Max\,(60\%; 70\%) * (1 + 3 * (\max\,(4.6\%; 14.4\%)))$$

$$\mathbf{V_{Max} = 100.2\%}$$

[76] Since the percentage of project cost overrun is higher than the average percentage of cost overrun of completed projects, the weighting of the Most Probable Value is 70%-30% giving the highest percentage to the highest cost overrun. Otherwise, the weighting would be reversed.

» No cost overrun information for the project

Project Information	
Sector	Transport
Risk	Land Purchase
Status	Construction stage
Initial sub-account value (C_E)	5.000
Value of risk-related activities in progress (updated) (C_I)	Not applicable
Expected cost overrun for the project (C_I - C_E) / C_E	Not applicable
Deviation of budget update (DP)	Not applicable
Average Deviation for Budget Updates (DO)	14.4%
Percentage of property execution (properties acquired / total properties)	0%

For this case the minimum, most probable and maximum values are defined by:

$$V_{min} = \textit{minimum percentage of the historical database}$$

$$V_{MP} = V_P * (1 + DO)$$

$$V_{Max} = Max\,(V_P; \left(\frac{C_I - C_E}{C_E}\right)) * (1 + 3 * (\max\,(DP; DO)))$$

When replacing the values

$$\mathbf{V_{min} = 0\%}$$

$$V_{MP} = 60\% \, * (1+14.4\%)$$

$$\mathbf{V_{MP} = 68.6\%}$$

$$V_{Max} = Max\,(60\%; 0\%) * (1 + 3 * (\max\,(0\%; 14.4\%)))$$

$$\mathbf{V_{Max} = 85.9\%}$$

CASE 2. Consolidated information for projects in execution

» **Project cost overrun greater than the average cost overrun of projects in execution.**

Project Information	
Sector	Transport
Risk	Land Purchase
Status	Construction Stage
Initial sub-account value (C_E)	5.000
Value of risk-related activities in progress (updated) (C_I)	8.500
Expected cost overrun for the project (C_I - C_E) / C_E	70%
Average cost overrun of projects in execution (V_p)	60%
Deviation of budget update (DP)	4.6%
Average Deviation for Budget Updates (DO)	14.4%
Percentage of property execution (properties acquired/ total properties)	66%

For this case the minimum, most probable and maximum values are defined by:

$$V_{min} = minimum\ percentage\ of\ the\ database\ of\ projects\ in\ execution$$

$$V_{MP} = \left(\frac{C_I - C_E}{C_E}\right) * (1 + DP)$$

$$V_{Max} = Max\,(V_P; \left(\frac{C_I - C_E}{C_E}\right)) * (1 + 3 * (\max\,(DP; DO)))$$

$$\mathbf{V_{min} = 0\%}$$

$$V_{MP} = (70\%) * (1+4.6\%)$$

$$\mathbf{V_{MP} = 73.2\%}$$

$$V_{Max} = Max\,(60\%; 70\%) * (1 + 3 * (\max\,(4.6\%; 14.4\%)))$$

$$\mathbf{V_{Max} = 100.2\%}$$

» Lower than average cost overrun of projects in execution

Project Information	
Sector	Transport
Risk	Land Purchase
Status	Construction stage
Initial sub-account value (C_E)	5.000
Value of updated risk-related activities in execution (C_I)	6.500
Expected cost overrun for the project (C_I - C_E) / C_E	30%
Average cost overrun of projects under implementation (V_P)	60%
Deviation of budget update (DP)	4.6%
Average deviation from budget updates (DO)	14.4%
Percentage of property execution (properties acquired/ total properties)	66%

For this case the minimum, most probable and maximum values are defined by:

$$V_{min} = \textit{minimum percentage of the database of projects in execution}$$

$$V_{MP} = \left(\frac{\frac{C_I - C_E}{C_E} + V_P}{2}\right) * (1+DP)$$

$$V_{Max} = Max\,(V_P; \left(\frac{C_I - C_E}{C_E}\right)) * (1 + 3 * (\max\,(DP; DO)))$$

When replacing the values

$$\boldsymbol{V_{min} = 0\%}$$

$$V_{MP} = \frac{30\% + 60\%}{2} * (1+4.6\%)$$

$$\boldsymbol{V_{MP} = 47.1\%}$$

$$V_{Max} = Max\,(60\%;\,30\%) * (1 + 3 * (\max\,(4.6\%;\,14.4\%)))$$

$$\boldsymbol{V_{Max} = 85.9\%}$$

» **No forecast for the project**

Project Information	
Sector	Transport
Risk	Land Purchase
Status	Construction stage
Initial sub-account value (C_E)	5.000
Value of updated risk-related activities in execution (C_I)	Not applicable
Expected cost overrun for the project (C_I - C_E) / C_E	Not applicable
Average cost overrun of projects under implementation (V_P)	Not applicable
Deviation of budget update (DP)	Not applicable
Average deviation from budget updates (DO)	14.4%
Percentage of property execution (properties acquired/ total properties)	0%

For this case the minimum, most probable and maximum values are defined by:

$$V_{min} = minimum\ percentage\ of\ the\ database\ of\ projects\ in\ execution$$

$$V_{MP} = V_P * (1 + DO)$$

$$V_{Max} = Max\,(V_P;\left(\frac{C_I - C_E}{C_E}\right)) * (1 + 3 * (\max\,(DP;\,DO)))$$

When replacing the values

$$\boldsymbol{V_{min} = 0\%}$$

$$V_{MP} = 60\% * (1+14.4\%)$$

$$\boldsymbol{V_{MP} = 68.6\%}$$

$$V_{Max} = Max\,(60\%;\,0\%) * (1 + 3 * (\max\,(0\%;\,14.4\%)))$$

$$\boldsymbol{V_{Max} = 85.9\%}$$

CASE 3. Complete lack of information

This last case involves the application of a panel of experts to define the parameters V_{Min}, V_{MP} and V_{Max}. This case will only apply when at least two of the following conditions are met:

a. The sector in which the concession or PPP project will be developed, or the specific risk to be assessed, is completely new in this contracting modality.

b. There is no information, in any sector, on the particular risk to be valued.

c. There is no possibility of collecting historical information or information on ongoing projects for other projects or other forms of contracting that is comparable to the risks.

When the above occurs, a panel of experts may be done as long as it strictly follows the procedure of the proposed methodology in force by the National Planning Department and updates made by DGCPTN.

ii) Calibration of the PERT function

Irrespective of the case, the procedure for PERT calibration shall be carried out in the same way.

For the purposes of this example, it will be assumed that the V_{Min}, V_{MP} and V_{Max} results are as follows:

Project Information	
Sector	Transport
Risk	Land Purchase
Status	Construction stage
Percentage of property execution (properties acquired/ total properties)	66.6%
V_{Min}	0.0%
V_{MP}	73.5%
V_{Max}	101.5%

Based on the above, parameters α and β must be defined, they are defined as follows:

$$\alpha = \left(\frac{4(V_{MP} - V_{Min})}{(V_{Max} - V_{Min})}\right) + 1$$

$$\beta = \left(\frac{4(V_{Max} - V_{MP})}{(V_{Max} - V_{Min})}\right) + 1$$

When replacing the values

$$\alpha = \left(\frac{4(73.5\% - 0\%)}{(101.5\% - 0\%)}\right) + 1$$

$$\boldsymbol{\alpha = 389.7\%}$$

$$\beta = \left(\frac{4(101.5\% - 73.5\%)}{(101.5\% - 0\%)}\right) + 1$$

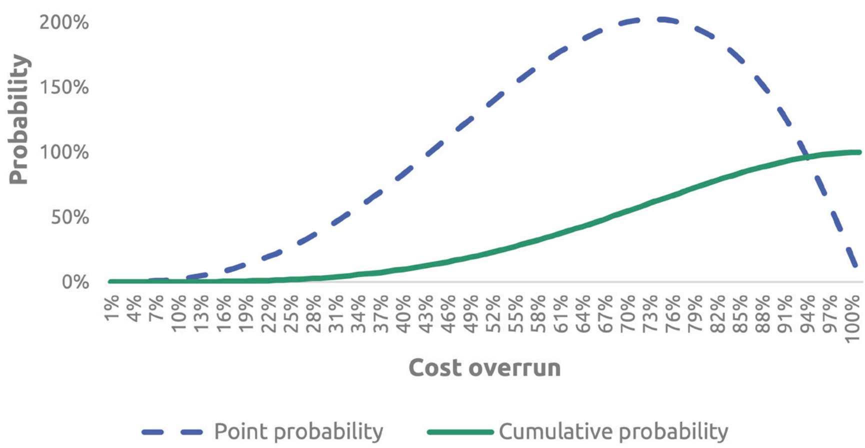
$$\boldsymbol{\beta = 210.3\%}$$

Once the previous parameters have been defined, the point and cumulative probability of the Beta function should be estimated, using the BETA.DIST formula (in Excel) and the values, in percentage terms, of cost overrun, alpha, beta, minimum and maximum found previously.

X	f(x)	F (X)	X	f(x)	F (X)
Cost overrun	Point probability	Cumulative probability	Cost overrun	Point probability	Cumulative probability
1%	0,0000325	0,00%	27%	0,3277260	2,46%
2%	0,0002396	0,00%	28%	0,3587513	2,80%
3%	0,0007671	0,00%	29%	0,3911844	3,18%
4%	0,0017454	0,00%	30%	0,4249928	3,58%
5%	0,0032939	0,00%	31%	0,4601391	4,03%
6%	0,0055222	0,01%	32%	0,4965814	4,50%
7%	0,0085312	0,02%	33%	0,5342731	5,02%
8%	0,0124142	0,03%	34%	0,5731631	5,57%
9%	0,0172567	0,04%	35%	0,6131957	6,17%
10%	0,0231371	0,06%	36%	0,6543110	6,80%
11%	0,0301273	0,09%	37%	0,6964444	7,47%
12%	0,0382922	0,12%	38%	0,7395273	8,19%
13%	0,0476907	0,16%	39%	0,7834865	8,95%
14%	0,0583754	0,22%	40%	0,8282449	9,76%
15%	0,0703926	0,28%	41%	0,8737209	10,61%
16%	0,0837830	0,36%	42%	0,9198290	11,51%
17%	0,0985814	0,45%	43%	0,9664797	12,45%
18%	0,1148170	0,56%	44%	1,0135793	13,44%
19%	0,1325133	0,68%	45%	1,0610303	14,48%
20%	0,1516884	0,82%	46%	1,1087313	15,56%
21%	0,1723550	0,98%	47%	1,1565770	16,70%
22%	0,1945204	1,17%	48%	1,2044584	17,88%
23%	0,2181868	1,37%	49%	1,2522627	19,10%
24%	0,2433512	1,60%	50%	1,2998738	20,38%
25%	0,2700054	1,86%	51%	1,3471715	21,70%
26%	0,2981364	2,14%	52%	1,3940326	23,07%

X	f(x)	F (X)	X	f(x)	F (X)
Cost overrun	Point probability	Cumulative probability	Cost overrun	Point probability	Cumulative probability
53%	1,4403301	24,49%	79%	1,9622065	72,65%
54%	1,4859339	25,96%	80%	1,9354993	74,60%
55%	1,5307104	27,46%	81%	1,9037386	76,52%
56%	1,5745229	29,02%	82%	1,8667605	78,41%
57%	1,6172317	30,61%	83%	1,8244054	80,25%
58%	1,6586939	32,25%	84%	1,7765186	82,05%
59%	1,6987637	33,93%	85%	1,7229518	83,80%
60%	1,7372924	35,65%	86%	1,6635643	85,50%
61%	1,7741287	37,40%	87%	1,5982249	87,13%
62%	1,8091185	39,19%	88%	1,5268141	88,69%
63%	1,8421053	41,02%	89%	1,4492266	90,18%
64%	1,8729301	42,88%	90%	1,3653751	91,59%
65%	1,9014317	44,77%	91%	1,2751945	92,91%
66%	1,9274466	46,68%	92%	1,1786481	94,14%
67%	1,9508095	48,62%	93%	1,0757364	95,27%
68%	1,9713532	50,58%	94%	0,9665085	96,29%
69%	1,9889088	52,56%	95%	0,8510801	97,20%
70%	2,0033059	54,56%	96%	0,7296616	97,99%
71%	2,0143729	56,57%	97%	0,6026051	98,65%
72%	2,0219371	58,59%	98%	0,4704903	99,19%
73%	2,0258249	60,61%	99%	0,3343064	99,59%
74%	2,0258625	62,64%	100%	0,1959252	99,86%
75%	2,0218754	64,66%	101%	0,0600267	99,99%
76%	2,0136895	66,68%	102%		
77%	2,0011310	68,69%			
78%	1,9840272	70,68%			

Figure 20. Point and cumulative probability



Source: Own elaboration DGCPTN

Given that the percentage of risk or project progress can give an estimate of the level of associated uncertainty, to define the risk scenario a percentile (of the cumulative probability) should be chosen according to the level of uncertainty of the project, according to the following table:

% Risk Advance / project	0% - 30%	31% - 60%	61%-90%	91%-100%
Percentile	95%	80%	70%	60%

For this example, the advance of risk is 66.6%, so the risk percentile will be 70%.

Then, from the point and cumulative probability table it is necessary to look for the cumulative probability closest to 70%.

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X	f(x)	F (X)
Cost overrun	Probability Point	Cumulative probability
53%	1,4403301	24,49%
54%	1,4859339	25,96%
55%	1,5307104	27,46%
56%	1,5745229	29,02%
57%	1,6172317	30,61%
58%	1,6586939	32,25%
59%	1,6987637	33,93%
60%	1,7372924	35,65%
61%	1,7741287	37,40%
62%	1,8091185	39,19%
63%	1,8421053	41,02%
64%	1,8729301	42,88%
65%	1,9014317	44,77%
66%	1,9274466	46,68%
67%	1,9508095	48,62%
68%	1,9713532	50,58%
69%	1,9889088	52,56%
70%	2,0033059	54,56%
71%	2,0143729	56,57%
72%	2,0219371	58,59%
73%	2,0258249	60,61%
74%	2,0258625	62,64%
75%	2,0218754	64,66%
76%	2,0136895	66,68%
77%	2,0011310	68,69%
78%	1,9840272	70,68%

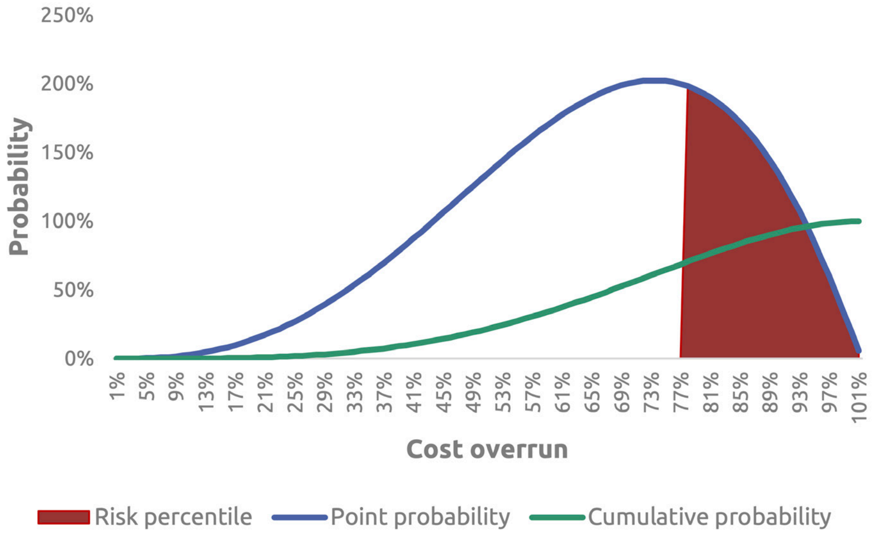
X	f(x)	F (X)
Cost overrun	Probability Point	Cumulative probability
79%	1,9622065	72,65%
80%	1,9354993	74,60%
81%	1,9037386	76,52%
82%	1,8667605	78,41%
83%	1,8244054	80,25%
84%	1,7765186	82,05%
85%	1,7229518	83,80%
86%	1,6635643	85,50%
87%	1,5982249	87,13%
88%	1,5268141	88,69%
89%	1,4492266	90,18%
90%	1,3653751	91,59%
91%	1,2751945	92,91%
92%	1,1786481	94,14%
93%	1,0757364	95,27%
94%	0,9665085	96,29%
95%	0,8510801	97,20%
96%	0,7296616	97,99%
97%	0,6026051	98,65%
98%	0,4704903	99,19%
99%	0,3343064	99,59%
100%	0,1959252	99,86%
101%	0,0600267	99,99%
102%		

Cumulative probability closer to the 70% risk percentile.

The value of the cost overrun of the risk scenario will be given by the data closest to the point where the percentile is in the cumulative probability. In the cases where the values are equidistant to the percentile sought, the values will be averaged to obtain the percentage of cost overrun.

For this example, the percentage of project cost overrun is 78%.

Figure 21. 70% risk percentage and 78% cost overrun



Source: Own elaboration DGCPTN

iii) Contingent value

Finally, in monetary terms, the value of the total cost overrun is calculated by multiplying the percentage cost overrun by the estimated value or initial cost of the risk-related activity, used previously (C_E).

If the initial value is 5,000, the contingent value will be 5.000 x 78% = 3.900

7.2 Practical example of risks associated with the operational stage

CASE 1. Demand risk: available and adequate historical information

Project Information	
Sector	Transport
Number of toll booths	1
Available and adequate historical information	Yes
Number of categories per toll	2
Duration	5 years

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1. Data preparation and identification of explanatory variables

» Historical demand Series

Year	Month	CAT I	CAT II
2005	January	73.523	3.567
2005	February	46.741	3.170
2005	March	56.362	3.336
2005	April	42.453	3.380
2005	May	47.173	3.531
2005	June	48.333	3.672
2005	July	59.892	3.616
2005	August	51.445	3.740
2005	September	45.511	3.982
2005	October	49.119	3.907
2005	November	51.281	4.176
2005	December	63.440	4.729
2006	January	76.549	4.046
2006	February	49.854	3.526
2006	March	48.653	4.120
2006	April	59.009	3.568
2006	May	46.153	4.172
2006	June	52.310	4.081
2006	July	62.729	4.293
2006	August	56.537	4.186
2006	September	50.908	4.150
2006	October	54.399	4.306
2006	November	56.215	4.216
2006	December	68.927	4.661
2007	January	84.407	3.876
2007	February	55.557	3.719
2007	March	55.866	4.142
2007	April	60.705	3.567
2007	May	53.312	3.989

Year	Month	CAT I	CAT II
2008	January	84.701	4.728
2008	February	60.931	4.485
2008	March	69.428	4.097
2008	April	54.685	4.553
2008	May	62.414	4.318
2008	June	64.474	4.259
2008	July	66.508	4.970
2008	August	66.238	4.556
2008	September	56.141	4.929
2008	October	63.794	5.261
2008	November	60.030	4.602
2008	December	78.200	5.201
2009	January	92.534	4.484
2009	February	61.401	4.385
2009	March	61.299	4.768
2009	April	71.000	4.491
2009	May	63.037	4.608
2009	June	68.615	4.412
2009	July	72.004	4.830
2009	August	68.398	4.416
2009	September	59.156	4.899
2009	October	66.954	5.116
2009	November	63.867	4.647
2009	December	81.356	5.401
2010	January	94.339	4.434
2010	February	64.473	4.382
2010	March	65.524	4.744
2010	April	65.991	4.320
2010	May	62.947	4.441

2007	June	59.714	3.825
2007	July	64.702	3.882
2007	August	60.209	4.192
2007	September	53.967	4.215
2007	October	57.325	4.945
2007	November	59.033	5.100
2007	December	76.655	5.141

2010	June	64.599	4.630
2010	July	74.377	5.025
2010	August	68.139	5.276
2010	September	61.075	5.440
2010	October	71.022	5.691
2010	November	64.814	6.261
2010	December	93.224	15.859

Year	Month	CAT I	CAT II
2011	January	94.102	6.903
2011	February	61.342	6.442
2011	March	78.667	7.136
2011	April	82.607	6.158
2011	May	66.661	6.329
2011	June	76.486	5.762
2011	July	82.605	5.960
2011	August	76.491	6.622
2011	September	69.051	6.479
2011	October	75.052	7.632
2011	November	82.018	12.420
2011	December	96.820	13.340
2012	January	109.562	5.857
2012	February	78.483	5.497
2012	March	78.083	5.997
2012	April	83.617	4.861
2012	May	74.606	5.469
2012	June	82.408	5.326
2012	July	88.939	5.504
2012	August	82.246	5.909
2012	September	76.336	5.759
2012	October	82.285	5.840
2012	November	79.564	6.036
2012	December	100.019	5.670

Year	Month	CAT I	CAT II
2014	January	121.132	4.871
2014	February	79.581	4.768
2014	March	98.359	4.925
2014	April	101.213	5.069
2014	May	86.029	5.422
2014	June	92.291	4.590
2014	July	93.348	5.357
2014	August	97.733	5.024
2014	September	83.185	5.298
2014	October	96.249	5.702
2014	November	93.970	5.362
2014	December	117.508	6.034
2015	January	77.314	2.118
2015	February	147.539	7.634
2015	March	98.158	5.599
2015	April	100.648	4.974
2015	May	96.938	5.323
2015	June	104.286	5.106
2015	July	105.481	6.091
2015	August	102.374	5.761
2015	September	89.510	6.171
2015	October	103.813	6.244
2015	November	104.818	5.878
2015	December	125.072	6.472

2013	January	127.691	5.334
2013	February	81.524	4.882
2013	March	95.600	4.230
2013	April	71.959	4.986
2013	May	78.878	5.067
2013	June	92.674	4.563
2013	July	91.125	5.231
2013	August	88.930	5.255
2013	September	79.788	4.994
2013	October	90.907	5.404
2013	November	87.550	5.055
2013	December	110.330	5.384

2016	January	135.829	5.190
2016	February	102.051	5.355
2016	March	116.500	5.080
2016	April	91.674	5.496
2016	May	100.760	5.451
2016	June	103.724	5.355
2016	July	118.332	5.402
2016	August	107.973	5.799
2016	September	96.505	5.791
2016	October	105.590	5.534
2016	November	99.325	5.486
2016	December	117.398	5.629

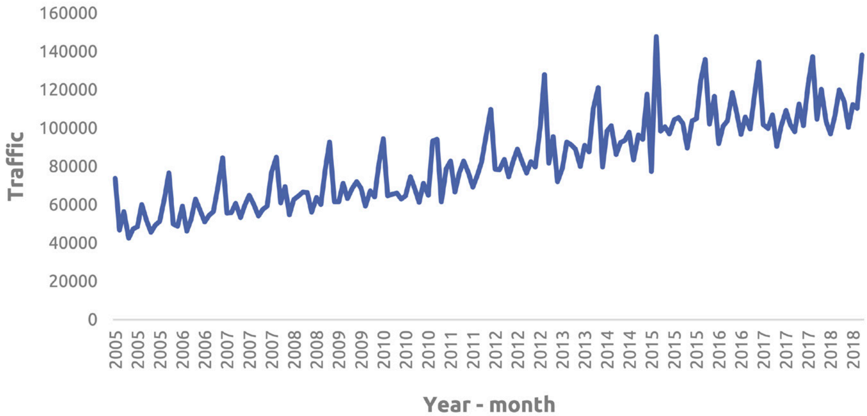
Year	Month	CAT I	CAT II
2017	January	134.236	4.575
2017	February	101.770	4.303
2017	March	99.634	4.943
2017	April	106.709	4.266
2017	May	90.260	4.442
2017	June	100.762	4.552
2017	July	109.210	5.211
2017	August	101.811	4.904
2017	September	98.065	4.794
2017	October	112.496	5.334
2017	November	101.011	4.947
2017	December	123.388	5.152

Year	Month	CAT I	CAT II
2018	January	137.249	4.846
2018	February	104.483	4.710
2018	March	120.059	5.029
2018	April	103.124	5.399
2018	May	96.784	5.143
2018	June	106.277	4.716
2018	July	119.972	5.197
2018	August	113.771	5.386
2018	September	100.322	5.426
2018	October	112.197	5.582
2018	November	110.260	5.745
2018	December	137.972	5.896

Category	μ	σ
CAT I	82.951	22.888
CAT II	5.136	1.464

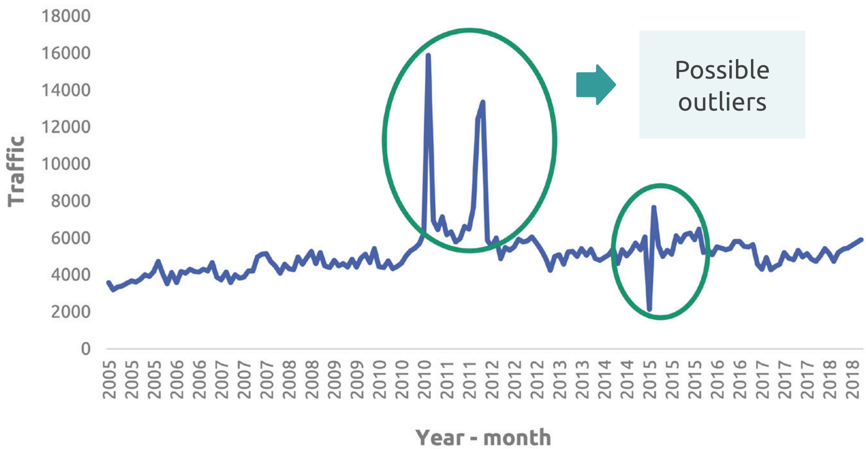
In this step it is necessary verify that there are at least 60 monthly data.

Figure 22. CAT I demand series



Source: Own elaboration DGCPTN

Figure 23. CAT II demand series



Source: Own elaboration DGCPTN

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» Outlier verification

For this step, the Z-Score check should be used to determine whether the apparent outliers are indeed outliers.

Therefore, the following formula will be applied to each data of the series to be evaluated.

$$Z = (x - \mu)/\sigma$$

Possible outliers are shown in category II in december 2010, november and december 2011 and january 2015. However, to decrease the probability of error, the Z-score test is performed for the entire series, as shown below.

Year	Month	CAT II	Z Score
2005	January	3.567	- 1,07
2005	February	3.170	- 1,34
2005	March	3.336	- 1,23
2005	April	3.380	- 1,20
2005	May	3.531	- 1,10
2005	June	3.672	- 1,00
2005	July	3.616	- 1,04
2005	August	3.740	- 0,95
2005	September	3.982	- 0,79
2005	October	3.907	- 0,84
2005	November	4.176	- 0,66
2005	December	4.729	- 0,28
2006	January	4.046	- 0,74
2006	February	3.526	- 1,10

Year	Month	CAT II	Z Score
2008	January	4.728	- 0,28
2008	February	4.485	- 0,44
2008	March	4.097	- 0,71
2008	April	4.553	- 0,40
2008	May	4.318	- 0,56
2008	June	4.259	- 0,60
2008	July	4.970	- 0,11
2008	August	4.556	- 0,40
2008	September	4.929	- 0,14
2008	October	5.261	0,09
2008	November	4.602	- 0,36
2008	December	5.201	0,04
2009	January	4.484	- 0,45
2009	February	4.385	- 0,51

2006	March	4.120	- 0,69
2006	April	3.568	- 1,07
2006	May	4.172	- 0,66
2006	June	4.081	- 0,72
2006	July	4.293	- 0,58
2006	August	4.186	- 0,65
2006	September	4.150	- 0,67
2006	October	4.306	- 0,57
2006	November	4.216	- 0,63
2006	December	4.661	- 0,32
2007	January	3.876	- 0,86
2007	February	3.719	- 0,97
2007	March	4.142	- 0,68
2007	April	3.567	- 1,07
2007	May	3.989	- 0,78
2007	June	3.825	- 0,90
2007	July	3.882	- 0,86
2007	August	4.192	- 0,64
2007	September	4.215	- 0,63
2007	October	4.945	- 0,13
2007	November	5.100	- 0,02
2007	December	5.141	0,00

2009	March	4.768	- 0,25
2009	April	4.491	- 0,44
2009	May	4.608	- 0,36
2009	June	4.412	- 0,49
2009	July	4.830	- 0,21
2009	August	4.416	- 0,49
2009	September	4.899	- 0,16
2009	October	5.116	- 0,01
2009	November	4.647	- 0,33
2009	December	5.401	0,18
2010	January	4.434	- 0,48
2010	February	4.382	- 0,51
2010	March	4.744	- 0,27
2010	April	4.320	- 0,56
2010	May	4.441	- 0,47
2010	June	4.630	- 0,35
2010	July	5.025	- 0,08
2010	August	5.276	0,10
2010	September	5.440	0,21
2010	October	5.691	0,38
2010	November	6.261	0,77
2010	December	15.859	7,32

Year	Month	CAT II	Z Score
2011	January	6.903	1,21
2011	February	6.442	0,89
2011	March	7.136	1,37
2011	April	6.158	0,70
2011	May	6.329	0,81
2011	June	5.762	0,43
2011	July	5.960	0,56
2011	August	6.622	1,01

Year	Month	CAT II	Z Score
2014	January	4.871	- 0,18
2014	February	4.768	- 0,25
2014	March	4.925	- 0,14
2014	April	5.069	- 0,05
2014	May	5.422	0,20
2014	June	4.590	- 0,37
2014	July	5.357	0,15
2014	August	5.024	- 0,08

2011	September	6.479	0,92
2011	October	7.632	1,70
2011	November	12.420	4,97
2011	December	13.340	5,60
2012	January	5.857	0,49
2012	February	5.497	0,25
2012	March	5.997	0,59
2012	April	4.861	- 0,19
2012	May	5.469	0,23
2012	June	5.326	0,13
2012	July	5.504	0,25
2012	August	5.909	0,53
2012	September	5.759	0,43
2012	October	5.840	0,48
2012	November	6.036	0,61
2012	December	5.670	0,36
2013	January	5.334	0,14
2013	February	4.882	- 0,17
2013	March	4.230	- 0,62
2013	April	4.986	- 0,10
2013	May	5.067	- 0,05
2013	June	4.563	- 0,39
2013	July	5.231	0,07
2013	August	5.255	0,08
2013	September	4.994	- 0,10
2013	October	5.404	0,18
2013	November	5.055	- 0,06
2013	December	5.384	0,17

2014	September	5.298	0,11
2014	October	5.702	0,39
2014	November	5.362	0,15
2014	December	6.034	0,61
2015	January	2.118	- 2,06
2015	February	7.634	1,71
2015	March	5.599	0,32
2015	April	4.974	- 0,11
2015	May	5.323	0,13
2015	June	5.106	- 0,02
2015	July	6.091	0,65
2015	August	5.761	0,43
2015	September	6.171	0,71
2015	October	6.244	0,76
2015	November	5.878	0,51
2015	December	6.472	0,91
2016	January	5.190	0,04
2016	February	5.355	0,15
2016	March	5.080	- 0,04
2016	April	5.496	0,25
2016	May	5.451	0,22
2016	June	5.355	0,15
2016	July	5.402	0,18
2016	August	5.799	0,45
2016	September	5.791	0,45
2016	October	5.534	0,27
2016	November	5.486	0,24
2016	December	5.629	0,34

Year	Month	CAT II	Z Score
2017	January	4.575	- 0,38
2017	February	4.303	- 0,57
2017	March	4.943	- 0,13
2017	April	4.266	- 0,59
2017	May	4.442	- 0,47
2017	June	4.552	- 0,40
2017	July	5.211	0,05
2017	August	4.904	- 0,16
2017	September	4.794	- 0,23
2017	October	5.334	0,14
2017	November	4.947	- 0,13
2017	December	5.152	0,01
2018	January	4.846	- 0,20
2018	February	4.710	- 0,29
2018	March	5.029	- 0,07
2018	April	5.399	0,18
2018	May	5.143	0,00
2018	June	4.716	- 0,29
2018	July	5.197	0,04
2018	August	5.386	0,17
2018	September	5.426	0,20
2018	October	5.582	0,30
2018	November	5.745	0,42
2018	December	5.896	0,52

For example, to estimate the Z-score of december 2010, the procedure is as follows

$$Z = (15.859 - 5.136) \ / \ 1.464$$
$$Z = 7{,}32$$

An item of information is an outlier if Z < -3 o Z > 3.

Of the 4 candidates identified graphically as outliers, only 3 of them turn out to be outliers after the application of the Z-score: december 2010, november, and december 2011, as indicated in the tables above.

If outliers are explained by some particular phenomenon on these dates, the data shall be kept intact. Otherwise, the outlier should be extrapolated based on the average growth of that month in previous years.

» **Identification of the model independent variables**

For the purposes of this methodology and the application of the econometric model, at least historical information and (future) projections must be available, with the same timeframe as the demand series (monthly), of the following variables:

1. **Macroeconomic variable:** Monthly real GDP in millions.

2. **Tariffs in Fixed Peso (FX Rate):** (same terms as GDP, the only adjustment over time being inflation).

3. **Ratio of working days to total days in the month.**

4. **Dummy variable for outliers that are easily explained:** (the projection is assumed to be 0 - only included if the series has outliers that can be explained according to the context and development of the historical information of the project).

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2005	January	31	20	42.207	8.400	0,65
2005	February	28	20	42.207	8.400	0,71
2005	March	31	20	42.207	8.400	0,65
2005	April	30	22	42.663	8.400	0,73
2005	May	31	20	42.663	8.400	0,65
2005	June	30	21	42.663	8.400	0,70
2005	July	31	19	42.841	8.400	0,61
2005	August	31	22	42.841	8.400	0,71
2005	September	30	22	42.841	8.400	0,73
2005	October	31	20	43.707	8.400	0,65
2005	November	30	20	43.707	8.400	0,67
2005	December	31	22	43.707	8.400	0,71
2006	January	31	21	44.548	8.600	0,68
2006	February	28	20	44.548	8.600	0,71
2006	March	31	22	44.548	8.600	0,71
2006	April	30	18	45.049	8.600	0,60
2006	May	31	21	45.049	8.600	0,68
2006	June	30	20	45.049	8.600	0,67
2006	July	31	19	46.335	8.600	0,61
2006	August	31	21	46.335	8.600	0,68
2006	September	30	22	46.335	8.600	0,73
2006	October	31	21	47.106	8.600	0,68

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2006	November	30	20	47.106	8.600	0,67
2006	December	31	19	47.106	8.600	0,61
2007	January	31	21	47.636	8.600	0,68
2007	February	28	20	47.636	8.600	0,71
2007	March	31	22	47.636	8.600	0,71
2007	April	30	19	48.295	8.600	0,63
2007	May	31	21	48.295	8.600	0,68
2007	June	30	20	48.295	8.600	0,67
2007	July	31	20	49.524	8.600	0,65
2007	August	31	21	49.524	8.600	0,68
2007	September	30	20	49.524	8.600	0,67
2007	October	31	22	50.119	8.600	0,71
2007	November	30	20	50.119	8.600	0,67
2007	December	31	20	50.119	8.600	0,65
2008	January	31	21	50.468	8.500	0,68
2008	February	29	20	50.468	8.500	0,69
2008	March	31	18	50.468	8.500	0,58
2008	April	30	22	50.298	8.500	0,73
2008	May	31	20	50.298	8.500	0,65
2008	June	30	19	50.298	8.500	0,63
2008	July	31	23	51.081	8.500	0,74
2008	August	31	19	51.081	8.500	0,61
2008	September	30	22	51.081	8.500	0,73
2008	October	31	22	50.098	8.500	0,71
2008	November	30	18	50.098	8.500	0,60
2008	December	31	21	50.098	8.500	0,68
2009	January	31	20	50.557	8.900	0,65
2009	February	28	20	50.557	8.900	0,71
2009	March	31	21	50.557	8.900	0,68

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2009	April	30	20	50.882	8.900	0,67
2009	March	31	21	50.557	8.900	0,68
2009	Abril	30	20	50.882	8.900	0,67
2009	May	31	19	50.882	8.900	0,61
2009	June	30	19	50.882	8.900	0,63
2009	July	31	22	51.243	8.900	0,71
2009	August	31	19	51.243	8.900	0,61
2009	September	30	22	51.243	8.900	0,73
2009	October	31	21	51.697	8.900	0,68
2009	November	30	19	51.697	8.900	0,63
2009	December	31	21	51.697	8.900	0,68
2010	January	31	19	52.271	8.800	0,61
2010	February	28	20	52.271	8.800	0,71
2010	March	31	22	52.271	8.800	0,71
2010	April	30	20	52.899	8.800	0,67
2010	May	31	20	52.899	8.800	0,65
2010	June	30	20	52.899	8.800	0,67
2010	July	31	20	53.453	8.800	0,65
2010	August	31	21	53.453	8.800	0,68
2010	September	30	22	53.453	8.800	0,73
2010	October	31	20	54.641	8.800	0,65
2010	November	30	20	54.641	8.800	0,67
2010	December	31	22	54.641	8.800	0,71
2011	January	31	20	55.600	9.400	0,65
2011	February	28	20	55.600	9.400	0,71
2011	March	31	22	55.600	9.400	0,71
2011	April	30	19	56.867	9.400	0,63
2011	May	31	22	56.867	9.400	0,71
2011	June	30	20	56.867	9.400	0,67

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2011	July	31	19	58.070	9.400	0,61
2011	August	31	22	58.070	9.400	0,71
2011	September	30	22	58.070	9.400	0,73
2011	October	31	20	58.429	9.400	0,65
2011	November	30	20	58.429	9.400	0,67
2011	December	31	21	58.429	9.400	0,68
2012	January	31	21	59.039	9.500	0,68
2012	February	29	21	59.039	9.500	0,72
2012	March	31	22	59.039	9.500	0,71
2012	April	30	19	59.595	9.500	0,63
2012	May	31	21	59.595	9.500	0,68
2012	June	30	19	59.595	9.500	0,63
2012	July	31	20	59.454	9.500	0,65
2012	August	31	21	59.454	9.500	0,68
2012	September	30	20	59.454	9.500	0,67
2012	October	31	22	59.814	9.500	0,71
2012	November	30	20	59.814	9.500	0,67
2012	December	31	20	59.814	9.500	0,65
2013	January	31	21	60.953	9.500	0,68
2013	February	28	20	60.953	9.500	0,71
2013	March	31	18	60.953	9.500	0,58
2013	April	30	22	62.175	9.500	0,73
2013	May	31	21	62.175	9.500	0,68
2013	June	30	18	62.175	9.500	0,60
2013	July	31	22	62.621	9.500	0,71
2013	August	31	20	62.621	9.500	0,65
2013	September	30	21	62.621	9.500	0,70
2013	October	31	22	63.019	9.500	0,71
2013	November	30	20	63.019	9.500	0,67
2013	December	31	21	63.019	9.500	0,68

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2014	January	31	21	64.144	9.400	0,68
2014	February	28	20	64.144	9.400	0,71
2014	March	31	20	64.144	9.400	0,65
2014	April	30	20	64.692	9.400	0,67
2014	May	31	21	64.692	9.400	0,68
2014	June	30	18	64.692	9.400	0,60
2014	July	31	23	65.333	9.400	0,74
2014	August	31	19	65.333	9.400	0,61
2014	September	30	22	65.333	9.400	0,73
2014	October	31	22	66.360	9.400	0,71
2014	November	30	18	66.360	9.400	0,60
2014	December	31	21	66.360	9.400	0,68
2015	January	31	20	66.200	9.300	0,65
2015	February	28	20	66.200	9.300	0,71
2015	March	31	21	66.200	9.300	0,68
2015	April	30	20	66.701	9.300	0,67
2015	May	31	19	66.701	9.300	0,61
2015	June	30	19	66.701	9.300	0,63
2015	July	31	22	67.473	9.300	0,71
2015	August	31	19	67.473	9.300	0,61
2015	September	30	22	67.473	9.300	0,73
2015	October	31	21	67.857	9.300	0,68
2015	November	30	19	67.857	9.300	0,63
2015	December	31	21	67.857	9.300	0,68
2016	January	31	19	68.013	9.600	0,61
2016	February	29	21	68.013	9.600	0,72
2016	March	31	20	68.013	9.600	0,65
2016	April	30	21	68.043	9.600	0,70
2016	May	31	20	68.043	9.600	0,65
2016	June	30	21	68.043	9.600	0,70

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2016	July	31	19	68.600	9.600	0,61
2016	August	31	22	68.600	9.600	0,71
2016	September	30	22	68.600	9.600	0,73
2016	October	31	20	69.173	9.600	0,65
2016	November	30	20	69.173	9.600	0,67
2016	December	31	22	69.173	9.600	0,71
2017	January	31	21	68.560	9.600	0,68
2017	February	28	20	68.560	9.600	0,71
2017	March	31	22	68.560	9.600	0,71
2017	April	30	18	69.239	9.600	0,60
2017	May	31	21	69.239	9.600	0,68
2017	June	30	20	69.239	9.600	0,67
2017	July	31	19	69.688	9.600	0,61
2017	August	31	21	69.688	9.600	0,68
2017	September	30	21	69.688	9.600	0,70
2017	October	31	21	70.043	9.600	0,68
2017	November	30	20	70.043	9.600	0,67
2017	December	31	19	70.043	9.600	0,61
2018	January	31	21	70.348	9.700	0,68
2018	February	28	20	70.348	9.700	0,71
2018	March	31	19	70.348	9.700	0,61
2018	April	30	21	70.883	9.700	0,70
2018	May	31	21	70.883	9.700	0,68
2018	June	30	19	70.883	9.700	0,63
2018	July	31	20	71.467	9.700	0,65
2018	August	31	21	71.467	9.700	0,68
2018	September	30	20	71.467	9.700	0,67
2018	October	31	22	71.962	9.700	0,71
2018	November	30	20	71.962	9.700	0,67
2018	December	31	20	71.962	9.700	0,65

In the case of roads, the macroeconomic variable best related to traffic is GDP. However, in the case of other sectors, one will have to determine the best explanatory variable for that sector or project.

The table above should be made for each of the categories of the collection mechanism. If it is not divided into categories, the application will be made according to the behavior of the demand series.

All variables must have projections until the time the contract is completed. (For this example, 5 years). For the projected tariffs, only inflation should be included, not additional structural changes nor exchange tariffs changes.

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2019	January	31	21	72.362	9.600	0,68
2019	February	28	20	72.362	9.600	0,71
2019	March	31	22	72.362	9.600	0,71
2019	April	30	19	73.357	9.600	0,63
2019	May	31	21	73.357	9.600	0,68
2019	June	30	20	73.357	9.600	0,67
2019	July	31	20	74.594	9.600	0,65
2019	August	31	21	74.594	9.600	0,68
2019	September	30	20	74.594	9.600	0,67
2019	October	31	22	74.594	9.600	0,71
2019	November	30	20	74.594	9.600	0,67
2019	December	31	20	74.594	9.600	0,65

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2020	January	31	21	75.286	9.600	0,68
2020	February	29	20	75.286	9.600	0,69
2020	March	31	18	75.286	9.600	0,58
2020	April	30	22	76.321	9.600	0,73
2020	May	31	20	76.321	9.600	0,65
2020	June	30	19	76.321	9.600	0,63
2020	July	31	23	77.608	9.600	0,74
2020	August	31	19	77.608	9.600	0,61
2020	September	30	22	77.608	9.600	0,73
2020	October	31	22	77.608	9.600	0,71
2020	November	30	18	77.608	9.600	0,60
2020	December	31	21	77.608	9.600	0,68
2021	January	31	20	78.478	9.600	0,65
2021	February	28	20	78.478	9.600	0,71
2021	March	31	21	78.478	9.600	0,68
2021	April	30	20	79.557	9.600	0,67
2021	May	31	19	79.557	9.600	0,61
2021	June	30	19	79.557	9.600	0,63
2021	July	31	22	80.898	9.600	0,71
2021	August	31	19	80.898	9.600	0,61
2021	September	30	22	80.898	9.600	0,73
2021	October	31	21	80.898	9.600	0,68
2021	November	30	19	80.898	9.600	0,63
2021	December	31	21	80.898	9.600	0,68
2022	January	31	19	81.931	9.600	0,61
2022	February	28	20	81.931	9.600	0,71
2022	March	31	22	81.931	9.600	0,71
2022	April	30	20	83.058	9.600	0,67
2022	May	31	20	83.058	9.600	0,65
2022	June	30	20	83.058	9.600	0,67

Year	Month	Days in the Month	Working Days	GDP	Tariffs	Working days ratio
2022	July	31	20	84.458	9.600	0,65
2022	August	31	21	84.458	9.600	0,68
2022	September	30	22	84.458	9.600	0,73
2022	October	31	20	84.458	9.600	0,65
2022	November	30	20	84.458	9.600	0,67
2022	December	31	22	84.458	9.600	0,71
2023	January	31	20	85.454	9.600	0,65
2023	February	28	20	85.454	9.600	0,71
2023	March	31	22	85.454	9.600	0,71
2023	April	30	19	86.629	9.600	0,63
2023	May	31	22	86.629	9.600	0,71
2023	June	30	20	86.629	9.600	0,67
2023	July	31	19	88.089	9.600	0,61
2023	August	31	22	88.089	9.600	0,71
2023	September	30	22	88.089	9.600	0,73
2023	October	31	20	88.089	9.600	0,65
2023	November	30	20	88.089	9.600	0,67
2023	December	31	21	88.089	9.600	0,68

2. Smoothing and transformation of the demand series

$$Y_t = \frac{1}{2}\left[\frac{1}{4}(Y'_{t-2} + Y'_{t-1} + Y'_t + Y'_{t+1}) + \frac{1}{4}(Y'_{t-1} + Y'_t + Y'_{t+1} + Y'_{t+2})\right]$$

The demand series should be converted to daily for the analysis. For this reason, the monthly value must be divided by the number of days in the month. The above, in order to capture the effect on demand, which will vary with the number of days in each month.

For the purposes of this example, the smoothing of the first few years and the last few years is shown for category I. However, the exercise must be performed for all years and categories in the series. As shown in the following table, when the smoothing is done, the first two data of the series are lost as well as the last two.

Year	Month	Days in the Month	CAT I traffic	TPD CAT I	Smoothed series CAT I
2005	January	31	73.523	2.372	
2005	February	28	46.741	1.669	
2005	March	31	56.362	1.818	1.712
2005	April	30	42.453	1.415	1.599
2005	May	31	47.173	1.522	1.606
2005	June	30	48.333	1.611	1.651
2005	July	31	59.892	1.932	1.680
2005	August	31	51.445	1.660	1.677
2005	September	30	45.511	1.517	1.645
2005	October	31	49.119	1.584	1.666
2005	November	30	51.281	1.709	1.833
2005	December	31	63.440	2.046	1.977
2006	January	31	76.549	2.469	1.984
2006	February	28	49.854	1.781	1.956
2006	March	31	48.653	1.569	1.824
2006	April	30	59.009	1.967	1.697
2006	May	31	46.153	1.489	1.749
2006	June	30	52.310	1.744	1.788
2006	July	31	62.729	2.024	1.796
2006	August	31	56.537	1.824	1.823
2006	September	30	50.908	1.697	1.806
2006	October	31	54.399	1.755	1.837

Year	Month	Days in the Month	CAT I traffic	TPD CAT I	Smoothed series CAT I
2006	November	30	56.215	1.874	2.015
2006	December	31	68.927	2.223	2.172
2007	January	31	84.407	2.723	2.192
2007	February	28	55.557	1.984	2.158
2007	March	31	55.866	1.802	2.008
2007	April	30	60.705	2.024	1.883
2007	May	31	53.312	1.720	1.920
2007	June	30	59.714	1.990	1.945
2007	July	31	64.702	2.087	1.945
2007	August	31	60.209	1.942	1.937
2007	September	30	53.967	1.799	1.904
2007	October	31	57.325	1.849	1.956
2007	November	30	59.033	1.968	2.139
2007	December	31	76.655	2.473	2.287

The first value of smoothed Y_t is calculated for category I as follows:

$$Y_t = \frac{1}{2}\left[\frac{1}{4}(2.372 + 1.669 + 1.818 + 1.415) + \frac{1}{4}(1.669 + 1.818 + 1.415 + 1.522)\right]$$

$$Y_{march2005} = 1.712$$

Year	Month	Days in the Month	CAT I traffic	TPD CAT I	Smoothed series CAT I
2014	January	31	121.132	3.907	3.339
2014	February	28	79.581	2.842	3.347
2014	March	31	98.359	3.173	3.183
2014	April	30	101.213	3.374	3.070
2014	May	31	86.029	2.775	3.079
2014	June	30	92.291	3.076	3.031

Year	Month	Days in the Month	CAT I traffic	TPD CAT I	Smoothed series CAT I
2014	July	31	93.348	3.011	3.004
2014	August	31	97.733	3.153	3.007
2014	September	30	83.185	2.773	3.026
2014	October	31	96.249	3.105	3.120
2014	November	30	93.970	3.132	3.165
2014	December	31	117.508	3.791	3.401
2015	January	31	77.314	2.494	3.676
2015	February	28	147.539	5.269	3.626
2015	March	31	98.158	3.166	3.650
2015	April	30	100.648	3.355	3.505
2015	May	31	96.938	3.127	3.311
2015	June	30	104.286	3.476	3.334
2015	July	31	105.481	3.403	3.309
2015	August	31	102.374	3.302	3.275
2015	September	30	89.510	2.984	3.271
2015	October	31	103.813	3.349	3.374
2015	November	30	104.818	3.494	3.640
2015	December	31	125.072	4.035	3.836
2016	January	31	135.829	4.382	3.890
2016	February	29	102.051	3.519	3.801
2016	March	31	116.500	3.758	3.537
2016	April	30	91.674	3.056	3.388
2016	May	31	100.760	3.250	3.388
2016	June	30	103.724	3.457	3.449
2016	July	31	118.332	3.817	3.498
2016	August	31	107.973	3.483	3.487
2016	September	30	96.505	3.217	3.417
2016	October	31	105.590	3.406	3.392
2016	November	30	99.325	3.311	3.569
2016	December	31	117.398	3.787	3.737

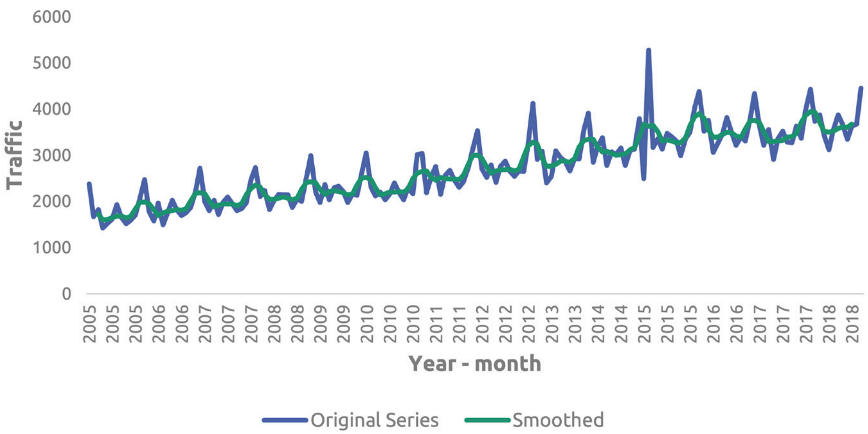
Year	Month	Days in the Month	CAT I traffic	TPD CAT I	Smoothed series CAT I
2017	January	31	134.236	4.330	3.754
2017	February	28	101.770	3.635	3.713
2017	March	31	99.634	3.214	3.507
2017	April	30	106.709	3.557	3.295
2017	May	31	90.260	2.912	3.299
2017	June	30	100.762	3.359	3.303
2017	July	31	109.210	3.523	3.314
2017	August	31	101.811	3.284	3.392
2017	September	30	98.065	3.269	3.407
2017	October	31	112.496	3.629	3.474
2017	November	30	101.011	3.367	3.706
2017	December	31	123.388	3.980	3.864
2018	January	31	137.249	4.427	3.940
2018	February	28	104.483	3.732	3.935
2018	March	31	120.059	3.873	3.704
2018	April	30	103.124	3.437	3.517
2018	May	31	96.784	3.122	3.493
2018	June	30	106.277	3.543	3.522
2018	July	31	119.972	3.870	3.579
2018	August	31	113.771	3.670	3.616
2018	September	30	100.322	3.344	3.602
2018	October	31	112.197	3.619	3.675
2018	November	30	110.260	3.675	
2018	December	31	137.972	4.451	

Similarly,

$$Y_{october2018} = \frac{1}{2}\left[\frac{1}{4}(3.670+3.344+3.619+3.675)+\frac{1}{4}(3.344+3.619+3.675+4.451)\right]$$

$$Y_{october2018} = 3.675$$

Figure 24: Original and Smoothed series CAT I



Source: Own elaboration DGCPTN

3. Econometric model and baseline projection of future demand

$$\hat{Y}_t = \ln(Y_t) - \ln(Y_{t\text{-}12})$$

$$= \beta_0 + \beta_1 * (\text{In}(GDP_t) - \text{In}(GDP_{t\text{-}12}))$$

$$+ \beta_2 * (\text{In}(tariffs_t) - \text{In}(tariffs_{t\text{-}12}))$$

$$+ \beta_3 * (\text{In}(\frac{working\ days_t}{total\ days_t}) - (\text{In}(\frac{working\ days_{t\text{-}12}}{total\ days_{t\text{-}12}})) + \varepsilon_t$$

If a D_i *dummy* variable has been defined, to consider an event that occurred in the month i, it will enter the model with value D_i = 1 for the month i and D_j = 0 for the remaining j months. Therefore, in the equation of the previous model, the inter annual difference $(D_i - D_{i-12})$ should be added, multiplied by a β_4 parameter.

Category I

Regression statistics	Coefficient	Significance P Value
β_0	0.02	0.00
β_1 - *GDP*	0.88	0.00
β_2 - *Tariff*	0.25	0.04
β_3 - *Ratio of working days*	0.01	0.78

Category II

Regression statistics	Coefficient	Significance P Value
β_0	-0.10	0.00
β_1 - *GDP*	2.63	0.00
β_2 - *Tariff*	1.52	0.00
β_3 - *Ratio of working days*	0.08	0.65
β_4 - *Dummy*	0.14	0.13

The model should be re-estimated by eliminating the variables (one by one) that are not significant or do not have the expected sign. The methodological text defines the criteria for considering the significance and expected sign of the variables.

Category I

Regression statistics	Coefficient	Significance P Value
β_0	0.023	0.00
β_1 - *GDP*	0.922	0.00

Category II

Regression statistics	Coefficient	Significance P Value
β_0	-0.088	0.00
β_1 - *GDP*	2.783	0.00
β_4 - *Dummy*	0.192	0.04

The econometric models are done and it is verified that the coefficients are at least 50% significant and have the expected sign.

In case the macroeconomic variable does not have the expected sign or a level of significance of at least 50%, the econometric model will not be used for the projection of the series, but the average demand (smoothed) of the last 12 months will be held constant for purposes of the projection.

» **Baseline projection of future demand Category I.**

Based on the coefficients found in the econometric model, the historical demand line must be estimated, to find the errors in the estimate.

Year	Month	Smoothed series	Baseline (historical trend model)	Estimation error
2005	January			
2005	February			
2005	March	1.712		
2005	April	1.599		
2005	May	1.606		
2005	June	1.651		
2005	July	1.680		
2005	August	1.677		
2005	September	1.645		
2005	October	1.666		
2005	November	1.833		
2005	December	1.977		
2006	January	1.984		
2006	February	1.956		
2006	March	1.824	1.841	17
2006	April	1.697	1.719	23
2006	May	1.749	1.727	22
2006	June	1.788	1.775	13

$$\hat{Y}_t = e^{(\beta_0+\beta_1 * (ln(PIB_t) - ln(PIB_{t-12}))} * Y_{t-12}$$
$$\hat{Y}_t = e^{(0.023 + 0.922 * 0.05)} * 1.712$$
$$\hat{Y}_t = 1.841$$

$$|\varepsilon_t| = |Y_t - \hat{Y}_t|$$
$$|\varepsilon_t| = |1.824 - 1.841|$$
$$|\varepsilon_t| = 17$$

Year	Month	Smoothed series	Baseline (historical trend model)	Estimation error
2006	July	1.796	1.848	52
2006	August	1.823	1.843	20
2006	September	1.806	1.809	3
2006	October	1.837	1.826	12
2006	November	2.015	2.009	6
2006	December	2.172	2.166	6
2007	January	2.192	2.158	34
2007	February	2.158	2.129	30
2007	March	2.008	1.984	23
2007	April	1.883	1.850	33
2007	May	1.920	1.907	12
2007	June	1.945	1.950	5
2007	July	1.945	1.953	8
2007	August	1.937	1.983	46
2007	September	1.904	1.964	60
2007	October	1.956	1.990	34
2007	November	2.139	2.183	44
2007	December	2.287	2.353	66
2008	January	2.352	2.365	12
2008	February	2.305	2.328	23
2008	March	2.134	2.166	32
2008	April	2.050	2.000	51
2008	May	2.044	2.038	6
2008	June	2.072	2.065	7
2008	July	2.093	2.047	47
2008	August	2.064	2.038	26
2008	September	2.035	2.004	31
2008	October	2.065	2.000	65
2008	November	2.252	2.187	66
2008	December	2.408	2.338	70
2009	January	2.422	2.410	12
2009	February	2.400	2.362	38

Year	Month	Smoothed series	Baseline (historical trend model)	Estimation error
2009	March	2.262	2.186	75
2009	April	2.154	2.119	35
2009	May	2.209	2.113	96
2009	June	2.232	2.142	91
2009	July	2.205	2.147	57
2009	August	2.181	2.117	64
2009	September	2.141	2.087	54
2009	October	2.169	2.174	5
2009	November	2.355	2.371	16
2009	December	2.507	2.536	29
2010	January	2.523	2.555	32
2010	February	2.468	2.531	63
2010	March	2.288	2.385	97
2010	April	2.143	2.284	141
2010	May	2.160	2.342	182
2010	June	2.195	2.367	171
2010	July	2.196	2.344	149
2010	August	2.214	2.319	106
2010	September	2.201	2.277	75
2010	October	2.272	2.335	62
2010	November	2.499	2.535	36
2010	December	2.611	2.698	87
2011	January	2.646	2.731	86
2011	February	2.661	2.672	11
2011	March	2.519	2.477	41
2011	April	2.453	2.343	110

It is worth noting that the 0.05 corresponding to the GDP is obtained from the inter-annual difference of the natural logarithms of the GDP. Also, the other explanatory variables are calculated in case they apply.

Year	Month	Smoothed series	Baseline (historical trend model)	Estimation error
2011	May	2.514	2.362	152
2011	June	2.494	2.400	93
2011	July	2.477	2.424	53
2011	August	2.480	2.444	36
2011	September	2.472	2.430	42
2011	October	2.563	2.472	91
2011	November	2.799	2.718	81
2011	December	2.989	2.841	148
2012	January	2.998	2.860	138
2012	February	2.929	2.877	52
2012	March	2.746	2.723	23
2012	April	2.610	2.620	10
2012	May	2.659	2.684	26
2012	June	2.686	2.663	23
2012	July	2.686	2.589	97
2012	August	2.692	2.592	100
2012	September	2.653	2.584	69
2012	October	2.698	2.679	19
2012	November	2.966	2.925	41
2012	December	3.195	3.124	72
2013	January	3.281	3.157	124
2013	February	3.232	3.085	147
2013	March	2.931	2.892	39
2013	April	2.757	2.776	19
2013	May	2.761	2.828	67
2013	June	2.802	2.856	55
2013	July	2.875	2.882	7
2013	August	2.870	2.888	18
2013	September	2.847	2.847	1
2013	October	2.931	2.895	36
2013	November	3.173	3.183	10
2013	December	3.318	3.429	111

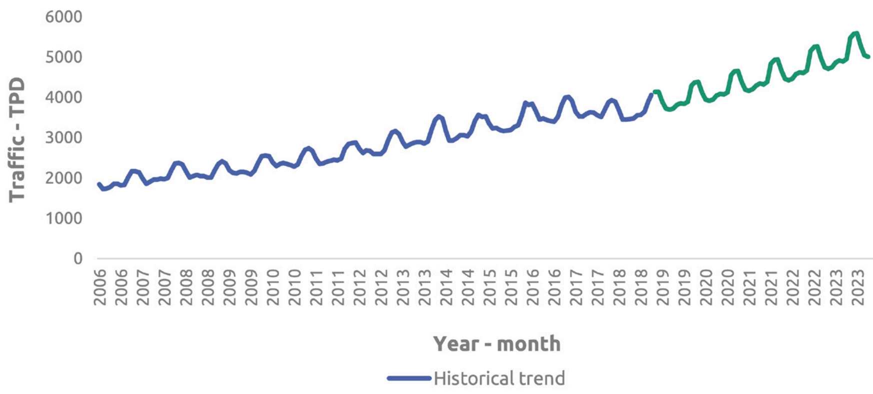
Year	Month	Smoothed series	Baseline (historical trend model)	Estimation error
2014	January	3.339	3.518	179
2014	February	3.347	3.465	117
2014	March	3.183	3.143	40
2014	April	3.070	2.925	146
2014	May	3.079	2.929	150
2014	June	3.031	2.972	59
2014	July	3.004	3.058	54
2014	August	3.007	3.052	45
2014	September	3.026	3.028	3
2014	October	3.120	3.144	24
2014	November	3.165	3.404	239
2014	December	3.401	3.559	158
2015	January	3.676	3.515	160
2015	February	3.626	3.524	101
2015	March	3.650	3.351	299
2015	April	3.505	3.230	275
2015	May	3.311	3.240	71
2015	June	3.334	3.189	144
2015	July	3.309	3.165	145
2015	August	3.275	3.168	107
2015	September	3.271	3.188	83
2015	October	3.374	3.258	116
2015	November	3.640	3.305	335
2015	December	3.836	3.551	285
2016	January	3.890	3.854	36
2016	February	3.801	3.802	1
2016	March	3.537	3.828	290
2016	April	3.388	3.652	263
2016	May	3.388	3.449	61
2016	June	3.449	3.473	24
2016	July	3.498	3.437	61
2016	August	3.487	3.401	86

Year	Month	Smoothed series	Baseline (historical trend model)	Estimation error
2016	September	3.417	3.397	21
2016	October	3.392	3.512	120
2016	November	3.569	3.789	220
2016	December	3.737	3.993	256
2017	January	3.754	4.008	255
2017	February	3.713	3.916	204
2017	March	3.507	3.645	138
2017	April	3.295	3.521	227
2017	May	3.299	3.521	222
2017	June	3.303	3.584	281
2017	July	3.314	3.630	316
2017	August	3.392	3.619	226
2017	September	3.407	3.546	140
2017	October	3.474	3.510	35
2017	November	3.706	3.693	13
2017	December	3.864	3.867	3
2018	January	3.940	3.931	9
2018	February	3.935	3.888	47
2018	March	3.704	3.673	32
2018	April	3.517	3.444	74
2018	May	3.493	3.448	46
2018	June	3.522	3.453	70
2018	July	3.579	3.469	110
2018	August	3.616	3.551	65
2018	September	3.602	3.566	35
2018	October	3.675	3.643	32
2018	November		3.886	
2018	December		4.051	

From the estimation errors, the Percentile 95 of these is calculated.

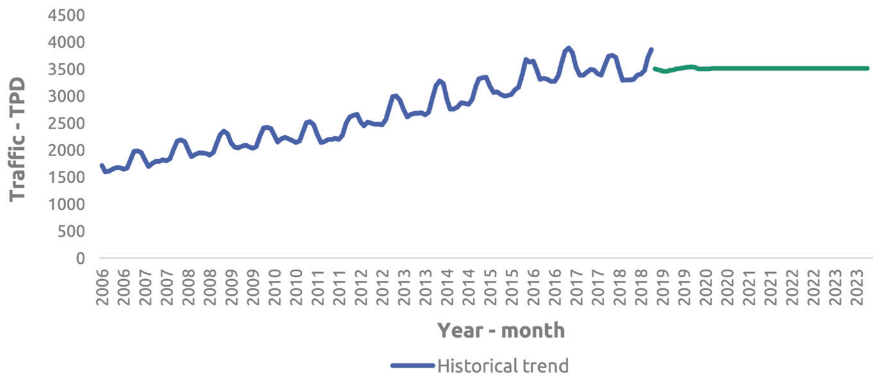
» **Baseline projection of future demand Category I (future trend)**

Figure 25. Baseline demand Category I - Econometric model



Source: Own elaboration DGCPTN

Figure 26. Category I demand baseline (case without GDP)



Source: Own elaboration DGCPTN

The next step is to add the months, to have daily annual data.

Year	Month	Baseline (future trend model)
2018	November	3.886
2018	December	4.051
2019	January	4.136
2019	February	4.131
2019	March	3.888
2019	April	3.713
2019	May	3.688
2019	June	3.718
2019	July	3.808
2019	August	3.848
2019	September	3.832
2019	October	3.885
2019	November	4.283
2019	December	4.372
2020	January	4.382
2020	February	4.125
2020	March	3.939
2020	April	3.912
2020	May	3.944
2020	June	4.039
2020	July	4.082
2020	August	4.065
2020	September	4.121
2020	October	4.544
2020	November	4.638
2020	December	4.649

47.302

50.440

Year	Month	Baseline (future trend model)
2021	January	4.383
2021	February	4.186
2021	March	4.157
2021	April	4.191
2021	May	4.293
2021	June	4.337
2021	July	4.320
2021	August	4.380
2021	September	4.829
2021	October	4.929
2021	November	4.940
2021	December	4.658
2022	January	4.455
2022	February	4.424
2022	March	4.461
2022	April	4.568
2022	May	4.616
2022	June	4.597
2022	July	4.661
2022	August	5.138
2022	September	5.245
2022	October	5.257
2022	November	4.957
2022	December	4.740

53.603

57.120

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Year	Month	Baseline (future trend model)
2023	January	4.704
2023	February	4.743
2023	March	4.857
2023	April	4.908
2023	May	4.888
2023	June	4.956
2023	July	5.464
2023	August	5.577
2023	September	5.590
2023	October	5.271
2023	November	5.040
2023	December	5.002

60.998

4. Risk adjustment I: Estimation error

$$Y_t^{[1]} = \hat{Y}_t - P_{95}(|\varepsilon_t|)$$

With the percentile 95 of errors estimated in step 3, the risk adjustment I is determined.

Year	Future baseline	Adjustment of Risk I
2006	18.563	
2007	24.404	
2008	25.575	
2009	26.765	
2010	28.972	
2011	30.315	
2012	32.919	
2013	35.718	
2014	38.196	
2015	39.683	
2016	43.587	
2017	44.060	
2018	44.004	
2019	47.302	47.043
2020	50.440	50.180
2021	53.603	53.344
2022	57.120	56.861
2023	60.998	60.739

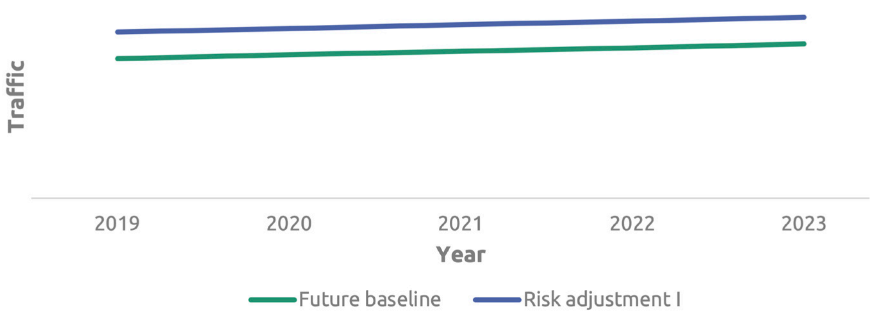
$$P_{95}(|\varepsilon_t|)$$

$$P_{95}(|260|)$$

$$Y_t^{[1]} = 47.302 - 260 = 47.043$$

The Risk adjustment I is a parallel shift downwards of the future baseline.

Figure 27. Risk Adjustment I Category I



Source: Own elaboration DGCPTN

5. Risk adjustment II: Structural change

Structural Change Assumptions	
Category I	86%
Θ	20%
Structural change period	2021

The risk adjustment II, for category I is applied as follows, assuming that there is no trend:

$$M_S = \frac{S_{T+k+1} - S_{T+k}}{S_{T+k}}$$

$$M_S = 86\%$$

$$Y_t^{[2]} = \begin{cases} Y_t^{[1]} & \text{Si: } t \leq T+k \\ Y_t^{[1]} * (1 + \min(M_s; \theta)) & \text{Si: } t > T+k \end{cases}$$

$$Y_{2021}^{[2]} = 53.344 * (1 + 20\%)$$

$$Y_{2021}^{[2]} = 64.013$$

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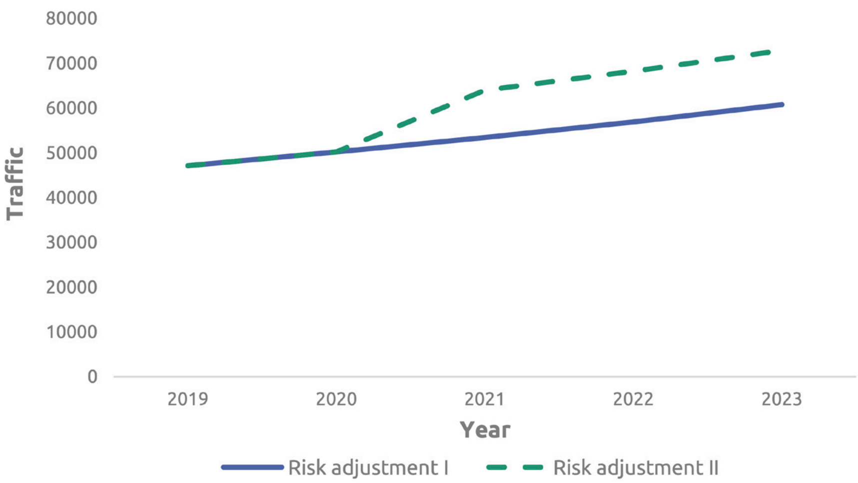
The above applies to all periods from the structural change and after.

Gráfico 28. Ajuste de Riesgo II Categoría I



Fuente: Elaboración propia DGCPTN

Year	Future base line	Risk Adjustment I	Risk Adjustment II
2006	18.563		
2007	24.404		
2008	25.575		
2009	26.765		
2010	28.972		
2011	30.315		
2012	32.919		
2013	35.718		
2014	38.196		
2015	39.683		

Year	Future base line	Risk Adjustment I	Risk Adjustment II
2016	43.587		
2017	44.060		
2018	44.004		
2019	47.302	47.043	47.043
2020	50.440	50.180	50.180
2021	53.603	53.344	64.013
2022	57.120	56.861	68.233
2023	60.998	60.739	72.887

Structural Change

For this example, the Risk Adjustment II, multiplied by 30 (days of the month) to have unadjusted but comparable values, will be the line of the risk scenario that should be multiplied by the respective tariffs to find the project's revenues, and then calculate the contingent value, comparing the initially expected revenues, versus the risk scenario revenues.

CASE 2. Demand risk: Insufficient or inadequate historical information

Project Information	
Sector	Transport
Number of toll booths	1
Available and adequate historical information	No
Number of categories per toll	2
Duration	7 years

In the case of insufficient information, the demand baseline will be determined by the initial demand study (Structuring) E_t.

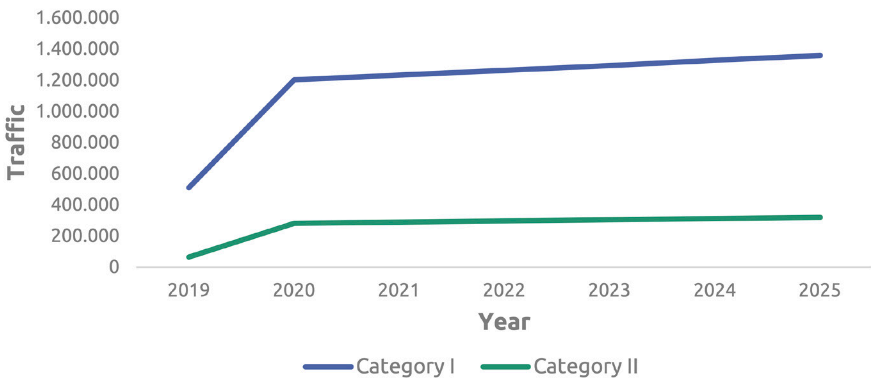
$$\hat{Y}_t = E_t$$

» **Baseline according to structure**

We take as a baseline the unadjusted estimates shown in the structuring of the project (in the case where the structuring study is shown in other terms, it should be in the same terms but otherwise unadjusted). In this case, total projected traffic by category is taken.

Structuring Model	2019	2020	2021	2022	2023	2024	2025
Category I	508.810	1.201.215	1.231.145	1.262.170	1.293.925	1.326.410	1.359.625
Category II	64.970	280.320	287.255	294.555	302.220	309.885	317.550

Figure 29. Structuring baseline



Source: Own elaboration DGCPTN

» Risk adjustment I: Estimation errors

$$Y_t^{[1]} = \min\left(S_t^-;\ \hat{Y}_t - q \cdot E_t\right) = \min(S_t^-; E_t - q \cdot E_t)$$

Assumptions	
q	30%
Toll installation	2019

Updated traffic study (pessimistic scenario)	2019	2020	2021	2022	2023	2024	2025
Category I	279.846	660.668	677.130	694.194	711.659	729.526	747.794
Category II	58.473	252.288	258.530	265.100	271.998	278.897	285.795

Category I

Year	Pessimistic scenario traffic study	Scenario Adjustment structuring
2019	279.846	356.167
2020	660.668	840.851
2021	677.130	861.802
2022	694.194	883.519
2023	711.659	905.748
2024	729.526	928.487
2025	747.794	951.738

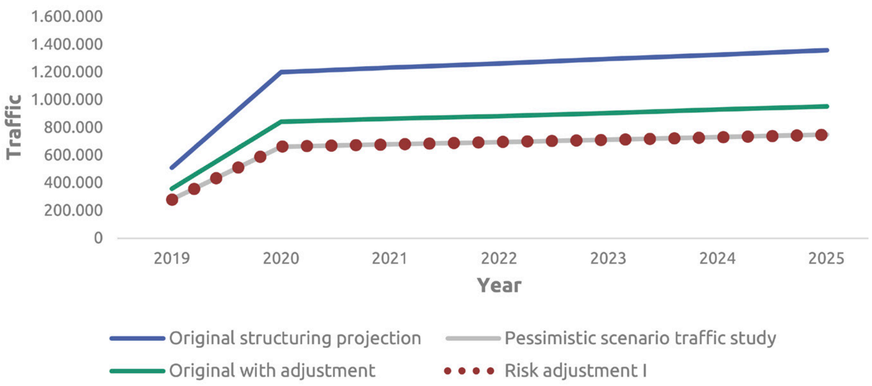
Minimum scenario

Category II

Year	Pessimistic scenario traffic study	Scenario Adjustment structuring
2019	58.473	40.931
2020	252.288	176.602
2021	258.530	180.971
2022	265.100	185.570
2023	271.998	190.399
2024	278.897	195.228
2025	285.795	200.057

Minimum scenario

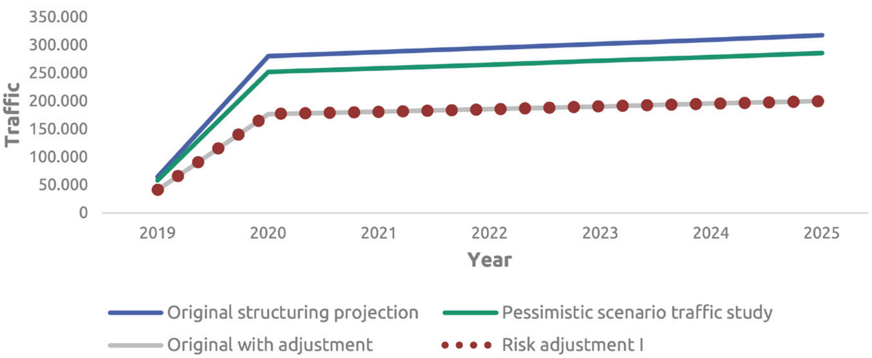
Figure 30. Risk Adjustment I - Category I



Source: Own elaboration DGCPTN

The risk scenario matches with **the traffic study's pessimistic scenario.**

Figure 31. Risk Adjustment I - Category II



Source: Own elaboration DGCPTN

In this case the risk scenario corresponds to **the adjusted structuring scenario.**

» Risk adjustment II: Structural change

Structural Change Assumptions – CAT I	
M_S	136%
θ	20%
Period of structural change	2.020

Since θ is smaller than M_S, θ should be used for risk adjustment II.

$$M_S = \frac{S_{T+k+1} - S_{T+k}}{S_{T+k}}$$

$$M_S = 136\%$$

$$Y_t^{[2]} = \begin{Bmatrix} Y_t^{[1]} & \text{Si: } t < T+k \\ Y_{t-1}^{[1]} * (1+\theta) & \text{Si: } t = T+k \\ Y_{t-1}^{[1]} * (1+z) & \text{Si: } t > T+k \end{Bmatrix}$$

$$Y_{2020}^{[2]} = 279.846 * (1 + 20\%)$$

$$Y_{2020}^{[2]} = 335.815$$

$$Y_{2021}^{[2]} = 335.815 * (1 + 3\%)$$

$$Y_{2021}^{[2]} = 345.890$$

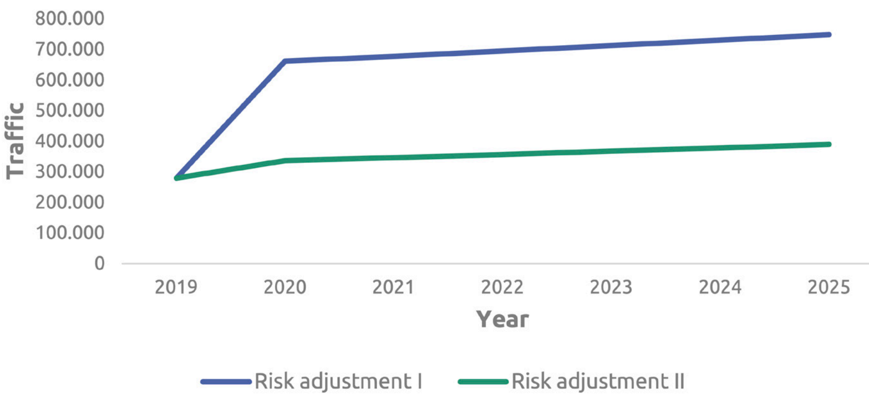
3% represents the growth expected from traffic for the years after the structural change.

Year	Risk Adjustment I	Risk Adjustment II
2019	279.846	279.846
2020	660.668	335.815
2021	677.130	345.890
2022	694.194	356.266
2023	711.659	366.954
2024	729.526	377.963
2025	747.794	389.302

Structural Change

The dotted box above represents the demand risk scenario to be used to calculate the contingency value.

Figure 32. Risk Adjustment II - Category I



Source: Own elaboration DGCPTN

The same procedure must be carried out with the other project categories.

CASE 3. Risk of differential tariffs: Available historical information

Project Information	
Sector	Transport
Number of special category tolls	1
Available and adequate historical information	Yes
Number of special categories per toll	2
Duration	7 years

Steps 1 to 3 are the same as CASE 1, but using the traffic demand for the differential toll.

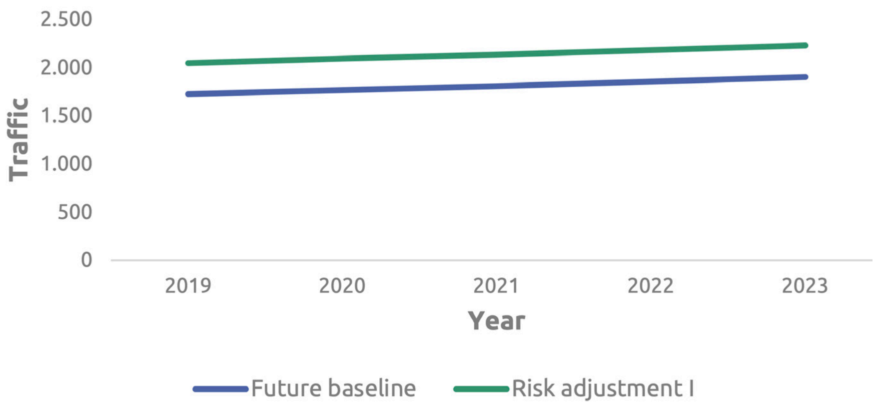
» **Risk adjustment I: Estimation error**

$$Y_t^{[1]} = \hat{Y}_t + P_{95}(|\varepsilon_t|)$$

In this case of the methodology, the Risk Adjustment I will be add the P_{95} of the estimated errors of the model. In other words, a shift upwards rather than downwards of the future demand baseline.

For this example, we assume the following baseline of differential traffic demand, and P_{95} = 326. Then the figure of risk adjustment I will be:

Figure 33. Risk Adjustment I - Differential Traffic



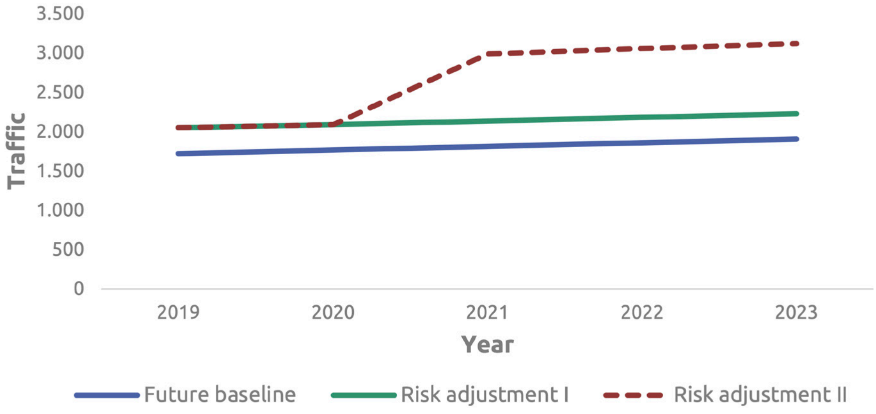
Source: Own elaboration DGCPTN

» **Risk Adjustment II: Change in series behavior**

Assumptions - change in the series behavior	
Increase in beneficiaries	40%
Year of increase	2021

The change in the behavior of the series is about the incorporation of the formal information available with respect to a change in quotas or past experience of the users who have benefited from it. Suppose that for category I, the plan is to increase the number of beneficiaries by 40% in 2021. This means that it is expected that there will be 40% more traffic historically observed since 2021. This percentage is incorporated into the line derived from Risk Adjustment I.

Figure 34. Risk Adjustment II - Differential Traffic



Source: Own elaboration DGCPTN

From Risk Adjustment II, the contingent value is estimated by multiplying this traffic by the tariff to be compensated for each special category car that passes through.

This procedure must be carried out for each special category of the project, and where there is compensation.

CASE 4. Differential Tariff Risk: insufficient and/or inadequate historical information

Project Information	
Sector	Transport
Number of special category tolls	2
Available adequate historical information	No
Number of special categories per toll	1
Duration	7 years

» **Definition of Q (Quantities)**

Toll 1

Structuring Model		
Year	Category I	Category IE
2019	1.165.179	233.036
2020	1.201.215	240.243
2021	1.231.145	246.229
2022	1.262.170	252.434
2023	1.293.925	258.785
2024	1.326.410	265.282
2025	1.359.625	271.925

Toll 2

Structuring Model		
Year	Category I	Category IE
2019	271.910	N/A
2020	280.320	N/A
2021	287.255	N/A
2022	294.555	N/A
2023	302.220	N/A
2024	309.885	N/A
2025	317.550	N/A

» **Baseline according to structuring**

Year	Toll 1	Toll 2
2019	233.036	54.382
2020	240.243	56.064
2021	246.229	57.451
2022	252.434	58.911
2023	258.785	60.444
2024	265.282	61.977
2025	271.925	63.510

→ $271.910 * 20\% = 54.382$

Since the structuring model does not contemplate differential tariffs for toll 2, the baseline is determined by the base demand of that category, multiplied by the r parameter, which for the purposes of this example is 20%.

» Risk adjustment I: Estimation errors

$$Y_t^{[1]} = \max\left(S_t^{+};\ E_t + q' \cdot E_t\right)$$

Assumed errors in estimation	
q'	15%
Year of implementation differential tariffs	2.019

There will be a q' for every project category.

Toll 1
Category IE

Year	Pessimistic scenario traffic study	Scenario Adjustment structuring
2019	279.643	267.991
2020	288.292	276.279
2021	295.475	283.163
2022	302.921	290.299
2023	310.542	297.603
2024	318.338	305.074
2025	326.310	312.714

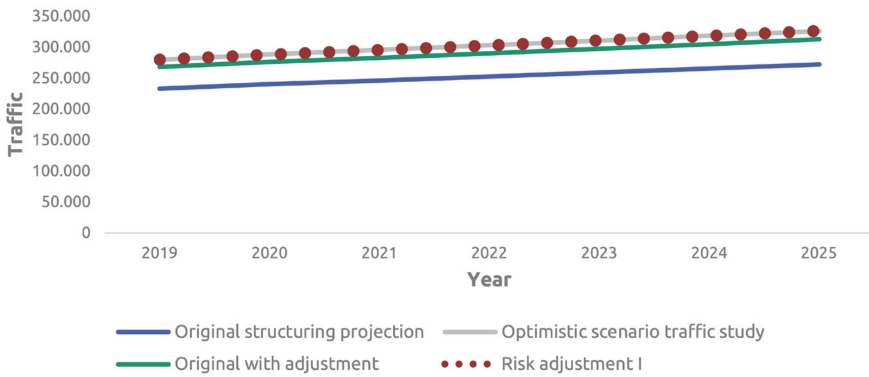
Maximum scenario

Toll 2
Category IE

Year	Pessimistic scenario traffic study	Scenario Adjustment structuring
2019	57.101	62.539
2020	58.867	64.474
2021	60.324	66.069
2022	61.857	67.748
2023	63.466	69.511
2024	65.076	71.274
2025	66.686	73.037

Maximum scenario

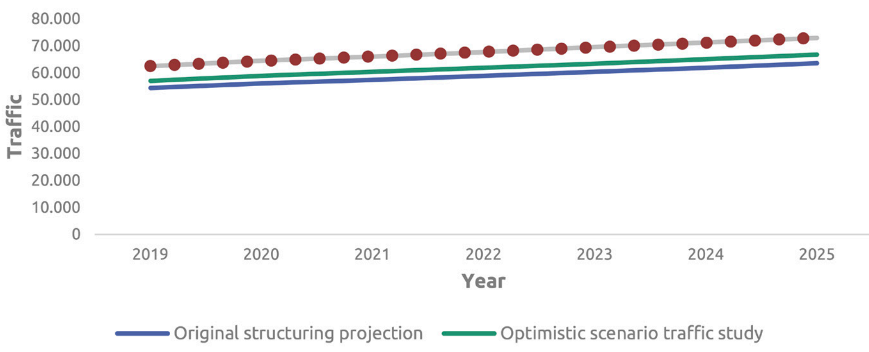
Figure 35: Risk Adjustment I Toll 1



Source: Own elaboration DGCPTN

> The risk scenario is the **optimistic scenario of the traffic study.**

Figure 36: Risk Adjustment I Toll 2



Source: Own elaboration DGCPTN

> For this case, the risk scenario is **the base scenario of structuring with the *q´* adjustment.**

» Risk adjustment II: change in the series behavior

Assumptions - Change in series behavior	
Toll 1	50%
Toll 2	No

Toll 1

Year	Risk adjustment I	Adjustment
2019	279.643	419.464
2020	288.292	432.437
2021	295.475	443.212
2022	302.921	454.381
2023	310.542	465.813
2024	318.338	477.508
2025	326.310	489.465

Toll 2

Year	Risk adjustment I
2019	62.539
2020	64.474
2021	66.069
2022	67.748
2023	69.511
2024	71.274
2025	73.037

As there is no evidence of change in the series' behavior, Risk Adjustment II is not applied.

» Definition of *P* (tariffs)

In case there is formal information, the tariff (P_E) of the resolution or the respective administrative act will be used.

$$P_C = P_T - P_E$$

$P_C \rightarrow$ *Fee to be compensated*

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In case there is no information, the minimum between the structuring tariff and the full tariff with an adjustment defined in the PPP's Subdirectorate page will be used.

$$P = min\ (d * P_T; P_E)$$

$$P_C \rightarrow Differential\ tariff$$

CASE 5. Other Risks: Impossibility to collect - Relocation of collection mechanisms - Risks related to not obtaining income

The application of other risks associated with income is carried out as in the previous cases, considering the particularities of each project and the associated risk scenario.

The infrastructure revolution
in Colombia.
Photo: Courtesy of ANI.

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Chapter 8

Glossary of Terms

- **Change in the series behavior:** For the purposes of this methodology, the change in the series behavior refers to evidence that can be supported, which indicates that the future series will behave in a different way from what has been historically evidenced. This case applies only to differential tariffs.

- **Structural change:** For the purposes of this methodology, a structural change is understood as a change in the level or trend of the traffic series resulting from a specific change impacting the project performance. In this sense, this structural change must coincide with the entry into operation of the work, with the provision of a new lane or with some demonstrable change in the context, as a result of the project. It should be noted that some structural changes may occur at different times or gradually. The DGCPTN may define the criteria on the web page of the PPPs Subdirectorate, regarding what is or is not considered a structural change.

- **Traffic study:** The traffic study refers to the updated demand studies available to the Contracting Entity in the process of contract execution. The updated traffic study submitted should be the one that has more relation with the real demand that may occur in the corridor. In case there is no traffic study after the structuring study, it will be understood that reference is being made to the original structuring traffic study.

- **Historical information:** Historical information is understood to be available when there are 5 consecutive years (or 60 months) of information counted backwards from the month prior to the month of assessment.

- **Structuring traffic study:** Refers to the demand study which the project was structured with.

- **Levels:** It refers to the demand serie in its original terms (without any adjustment).

- **Contingent liability:** Refers to a future and uncertain fact, which represents a conditioned monetary obligation, as determined by Decree 1068 of 2015, or the rule that modifies or replaces it.

- **Cost overruns:** Refers to the difference between the initial budget contemplated in the structuring of the project and its respective updating in time. In the cases in which this updating gives a lower budget than the one initially contemplated, it will be assumed that the value of the cost overrun is 0. In no case can negative values be used for the calculations described in the methodology.

Chapter 9

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