UNIVERSIDAD POLITÉCNICA DE MADRID
ESCUELA TÉCNICA SUPERIOR DE INGENIEROS
DE CAMINOS, CANALES Y PUERTOS

PROGRAMA DE DOCTORADO EN SISTEMAS DE INGENIERÍA CIVIL

APPLICATION OF THE REAL OPTIONS APPROACH TO THE APPRAISAL OF MOTORWAY CONCESSIONS. THE ABANDONMENT OPTION.

DOCTORAL THESIS

D. Fernando Cabero Colín

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Master en Gestión de Infraestructuras, Equipamientos y Servicios

Master Universitario en Sistemas de Ingeniería Civil

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Madrid, 2016

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RESUMEN

Las inversiones en proyectos de infraestructuras de transporte, especialmente las concesiones de infraestructuras, están asociadas con un alto grado de incertidumbre y requieren de la aplicación de elevadas cantidades de recursos. La estimación del valor presente de los flujos de caja futuros conlleva descontar esos flujos a una determinada tasa de descuento, que en algunos casos, puede conducir a errores cuando el proyecto lleva asociado cierto grado de flexibilidad.

En estos casos, los métodos de valoración de inversiones basados en la aplicación de la teoría de opciones reales, nos permite estimar el valor del proyecto en un entorno de incertidumbre, añadiendo el valor de la flexibilidad administrativa, operativa y de gestión a los métodos de valoraciones tradicionales. En la presente tesis doctoral se aplica la teoría de opciones reales al caso concreto de la opción de abandono de un proyecto de concesión de infraestructuras de transporte. Para ello, se ha considerado el tráfico como activo subyacente para llevar a cabo la analogía con las opciones financieras.

ABSTRACT

Investments in transport infrastructure projects, and specifically in toll motorway concessions, are associated with a high degree of uncertainty and require a large amount of resources. The estimate of the net present value of the project involves discounting future revenue at a given discount rate, which can lead to mistaken results when the project implies a certain degree of flexibility.

In such cases, methods for the valuation of the investments based on the real options theory allow to estimate projects in an uncertain environment, adding the value of the administrative, operative and managerial flexibility to the strictly financial valuation of the traditional methods. In this dissertation, the options theory has been applied to the specific case of the abandonment option in a toll motorway concession project. For this purpose, the traffic of the motorway has been considered as the underlying asset to carry out a valuation based on the analogy with the financial options.

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1. INTRODUCTION.

Infrastructure services are very important for countries to improve their economy's productivity, growth and competitiveness. Infrastructure financing has important implications for macroeconomic stability. As a countercyclical tool, infrastructure investment can generate employment and consumer demand in the short term, as well as in the long term. This kind of infrastructure is considered as intermediate input in the goods production chain that affects the profitability of production, and any reduction in those input costs may lead to higher levels of income, not only for companies but for users as well.

Infrastructure services may raise the productivity of other factors since its availability leads to higher returns obtainable for other capital and labor. The existence of infrastructure in a given location may attract a flow of additional resources ("crowding-in" private investment); this can lead to reduced factor costs and transaction costs in that area. The positive impact of infrastructures needs efficient allocation of resources; this reduces the potential for investment in infrastructure to take resources away from other more productive investment ("crowding-out" effect). It should be kept in mind that infrastructures by themselves do not produce economic or regional growth, therefore a complement by other resources and productive capacity are needed.

Traditionally, governments have been in charge of infrastructure implementation in developed countries. Nowadays, budgetary constraints constitute a significant impediment to traditional ways of infrastructure development and new formulas are needed to carry out such huge investments. Given the scarcity of public funds, most governments around the world have chosen to transfer the provision of infrastructure services to the private sector. Therefore, private companies are playing an important role because they have more professional knowledge in management, financing, operating procedures and also in technology.

Recognizing infrastructure's importance and lack of funding, most developing countries have turned to the private sector to finance and operate infrastructure services, seeking investment and know-how to accelerate improvements in service levels and quality. Nevertheless, Spain has been a country with a long tradition in infrastructure

development throughout concession¹ agreements. As evidence of this, the investment in toll motorways has been growing since 1967 (Figure 1.a.). There were 3,307 kilometres of motorways in Spain at the end of 2014 in regime of concession, all open to traffic, whose ownership was held by thirty-two concessionaire companies.

Figure 1.a.: Overall Toll Motorways Length Evolution in Spain.

Source: Ministry of Public Works, Spain.

There have been several periods of investment activity, since 1975 to 1980 (in this period all existing concessions were under construction); since 1982 to 1984 (in this period Eurovías and Aumar ended their construction, and the main activity was due to Aucalsa motorway), since 1989 to 1993 (Audasa and Aucalsa)² and Acesa were under construction; and those concessions granted by the Government of Catalonia); since 1996 to 1999 (the following investments were made during this period, such as: Audasa, Aucat, Ausol, Autoestradas, Ausur and Túneles de Artxanda), and since 2000 to 2011 the radial motorways (Henarsa – R2, Accesos de Madrid – R3 and R5; and Madrid Sur – R4) were built and other motorways such as Acega, Aulesa, Castellana de Autopistas and Eje Aeropuerto motorway. Between 2005 and 2007, Madrid – Levante motorway, Madrid – Toledo motorway, Ciralsa, Aucosta and AP-1 motorway extension took place).

¹ PPP agreement under which a Public Contracting Authority grants a specific long term right to a private (or semi-public) company to finance, construct, maintain and operate an infrastructure. The private partner has the responsibility for all operations and investments, while asset ownership remains with the public authority. The counterpart for the private partner as a result of this agreement is the right to obtain revenues from the infrastructure operation, either from the users in the form of a toll or from the Public Authority in the form of payments calculated on the basis of the traffic observed on the motorway.

² These two motorways belonged to the public entity Enausa.

Figure 1.b.: Yearly Investment in Toll Motorways.

Source: Ministry of Public Works.

Private participation is often preceded by sector restructuring and by new laws and regulations in order to protect investors from government actuation, the users from monopolistic positions (created by the entrance of a private operator) and to ensure a competition process between operators.

When a private company decides to invest in a new project, the main goal is to create value for its shareholders. Therefore, it is necessary to understand the available tools we have in order to measure that value³, which comes from the physical aspects of the asset as well as the non-physical aspects of the asset, and has the capabilities of generating extrinsic monetary or intrinsic strategic value. This is because there is an opportunity cost to invest in the project.

The decision to invest in infrastructure projects is a strategic decision that involves high levels of uncertainty, and requires a high paid-in capital by shareholders, and a high degree of irreversibility. According to the traditional point of view, the investment decision-making process depends on the financial analysis to determine the acceptance or the order of preference between several projects. The quality of investment decision-making is affected by a large number of factors, while the most important includes the choice of the criteria for the evaluation and selection of investment projects.

³ Single time-value discounted number that is representative of all future net profitability and is created for an investor if the investor earns more than the investment cost.

The Net Present Value (NPV) methodology, based on a discounted cash flow (DCF) series, is based on a fixed assumptions related to the project payoff and assumes the investment does not take into account the managerial flexibility that exists so that management can alter the course of an investment over time when certain aspects of the project's uncertainty become known. Because in real projects, incomes are neither well-known nor fixed, traditional valuation methodology does not fit very well with the reality in which the company acts.

Starting from the assumption according to which the business purpose is to maximize the value of shareholders' assets⁴, it can be assumed that in the absence of certainty, the investor who has to choose between several options, will select the one in which the most likely outcome is the best, discarding those in which less attractive or adverse results are more likely. However, by making this selection, the investor runs the risk that the less likely event may happen. This does not mean that the chosen decision has been incorrect, but it would mean that the risk involved in the decision has been materialized.

Only the use of traditional methods of investment valuation based on discounted cash flows are inappropriate in valuing certain strategic projects involving managerial flexibility. Therefore, some authors (Myers S. , 1984) and (Kester, 1984) suggested that investment decision analysis shall be extended to methods that take into account such flexibility embedded in real projects, i.e. real option valuation techniques. In this way, the use of traditional NPV of expected cash flows combined with methods that take into account managerial flexibility can grant extra value to the project. Thus, projects with a negative NPV would be acceptable if the value added by real options turns them into a positive.

1.1. SCOPE AND APPLIED METHODOLOGY.

The scope of this dissertation is to develop and further knowledge in the field of managing uncertainty in motorway concessions by applying the real options theory as an analogy of the financial options theory. The goal of this study is to assess how abandonment decisions are influenced by the future development of events in motorway

⁴ Select those projects that have greater Net Present Value.

concessions. This dissertation therefore develops an innovative methodology to assess the abandonment option for this kind of project. As an extension of research by (Lara Galera A. , 2006), this study considers a new and more accurate abandonment criterion to be adapted to the applicable legal framework.

There is extensive literature on the application of the real options theory and the abandonment option is becoming increasingly more important. Most authors have studied this option using binomial decision tree analysis (Mun, 2002), (Fortunato, Brandão, Rozenbaum, & Peixoto, 2008), (Cruz Rambaud & Sánchez Pérez, 2016) and (Vintila, 2007), considering the abandonment criterion for when the present value of future cash flows is less than the asset's salvage value. This dissertation employs a Monte Carlo simulation approach, considering a new abandonment criterion that is much more accurate when dealing with concession projects. Furthermore, since the abandonment option affects lenders and concessionaires differently, this study considers cases in which the abandonment option is more valuable to either the lenders or the concessionaires. While other authors assume that traffic follows a Geometric Brownian Motion (Lara Galera & Sánchez Soliño, 2010), this study verifies this claim by analysing the traffic time data series of Spanish toll motorways and Automatic Traffic Recorders (ATR) for first-generation motorways.

Since the most commonly used valuation method for motorway projects is based on discounted cash flows (Cheah & Garvin, 2009), this dissertation compares traditional appraisal models and their shortcomings when faced with conditions of uncertainty with models that take into account the managerial flexibility implicitly involved in real projects.

Several concessionaires in Spain are currently undergoing liquidation or entering arrangements with creditors. This study explores the main potential sources of uncertainty affecting the feasibility of these projects. As it is impossible to assess and quantify uncertainty through traditional valuation approaches, other valuation methods are required, such as the real options approach.

Five hundred and forty-five (545) kilometres out of the total three thousand three hundred and seven (3,307) kilometres of motorway concessions in Spain are experiencing

financial problems, involving nine (9) concessionaires entering into arrangements with creditors or undergoing liquidation. The Public Administration is responsible for paying the Public Administration's Patrimonial Liability (RPA) to concessionaires undergoing liquidation. An important component of this study is to further knowledge and highlight the importance of the value of the RPA and its impacts on the General State Budget. Furthermore, this dissertation has linked the RPA value to the salvage value of motorway concession assets, making it necessary to study considerations of the RPA concept with respect to the abandonment option's value. Therefore, this research raises concerns about the definition of RPA and its development over time, as well as the corresponding valuation criterion.

This research is based on the following:

- Since no traffic characterizations have been conducted for Spain's toll motorway network, historical annual traffic data was analysed over a twenty-year (20) period in order to confirm that traffic time series can be modelled as a Geometric Brownian Motion (GBM).
- The abandonment criterion was defined by applying the real options approach and including the value of the RPA in the abandonment options, taking into account its similarity to financial options. We should keep in mind that the abandonment option is included in concession agreements.
- A Monte Carlo simulation was conducted in order to apply the abandonment criterion to a real concession project, studying how the abandonment decision is influenced by different variables that affect the project's development, including initial traffic volume, volatility, the percentage of debt, fines, and expropriation overruns.

The methodology in this dissertation is based on the real options theory. A mathematical simulation model was developed using an Excel spreadsheet. This model allows us to determine financial projections based on profit and loss and cash flows using a Monte Carlo simulation. However, the criteria that is normally used to make abandonment decisions is not applicable to motorway concessions since they are

considered to be a public service; it is therefore necessary to develop a criterion that can be applied to the relevant legal framework.

The abandonment option is considered to be a sort of insurance policy permitting the recovery of the initial investment if a company or project performs below expectations (Berger, Ofek, & Swary, 1996) and involves an irreversible commitment. The option therefore possesses value, and information about the exit value of a company's assets can theoretically affect the option's market value. The option to abandon a project prior to its completion is very valuable to the project's sponsors and managers, since it allows them to recover the project's market value under unfavourable conditions. The project's total value is therefore determined by the sum of cash flows and the value of the abandonment option.

This dissertation is organised as follows:

- Section 1: An introduction to transportation infrastructure concession projects in Spain and the current legal framework.
- Section 2: An overview of PPP projects and the need for the private sector's involvement in infrastructure project development.
- Section 3: An explanation and exploration of traditional investment valuation techniques and decision-making processes based on deterministic discounted cash flow models.
- Sections 4: Innovative analysis of real options-based valuation techniques. An introduction to financial options and their similarity to real options.
- Section 5: A review of the stochastic processes used in options valuations and a traffic characterization that verifies whether traffic time series can be modelled as a Geometric Brownian Motion over long periods of time.
- Section 6: This section discusses the most common method for calculating the value of real options involving multiple sources of uncertainty, such as the Monte Carlo simulation.
- Section 7: This section examines abandonment criteria by applying real options valuations and considering the abandonment value. It describes when a

concession contract may be prematurely terminated and deals specifically with the Public Administration's Patrimonial Liability involved in this type of contract.

- Section 8: Case Study.
- Section 9: Conclusions and future lines of research.

2. TRANSPORTATION INFRASTRUCTURE PROJECTS AND CONCESSION CONTRACTS.

Because of budgetary constraints suffered by governments, most of them have resorted to a new ways of infrastructure development where the private sector appears in scene to play an important role. The private partner gets exclusive rights from the government to operate, maintain and sometimes even to carry out investments in a public infrastructure for a given period of time. Revenues may come from the user fee charged to users of the facility, but also from the granting authority based on quality standards.

In comparison with traditional methods of infrastructure financing (Figure 2.a.) from the General-State-Budget⁵, the need of new mechanisms of infrastructure development arises. On the one hand, this new way of infrastructure financing allows governments to develop an infrastructure policy that contributes to sustainable economic development and global competitiveness of a country. On the other hand it can contribute to reduce deficit and public debt restrictions laid down in the “Stability and Growth Pact”.

Figure 2.a.: Contrasting Public Sector Payment Profiles of Conventional Procurement and PPP Procurement Models.

Source: www.parliament.uk

⁵ The General-State-Budget is a financial document which balances the Government's revenues and Government's expenses in the fiscal year.

Infrastructure investment projects involve a large amount of resources and have a great impact in government expenditure. If the project is undertaken by the government, it has to be accounted as government expenditure according to ESA 2010 rules, during the period in which the infrastructure is built, independently of whether the payments to the private sector by the government is made during the same period of time or not, independently of the number of years over which government will have to reimburse the debt (if any) raised in order to finance the asset and independently of the length of the economic life of the asset upon which the value of the asset will be amortised.

Under a Public-Private Partnership⁶ (PPP) scheme, the economic owner of the asset will depend on which bears the majority of the risks and which unit is expected to receive a majority of the rewards of the assets. One important advantage PPP's have for governments, is that the investment can be removed from the government's balance sheet, i.e. with no impact on deficit and public debt, if there is a well balance in risk allocation. This balance is judged by analyzing in detail the allocation of the construction risk and the market risk (i.e. availability and demand) between the Authority and the PPP Company:

- **Construction risk:** It includes costs overruns, the possibility of additional costs resulting from late delivery, not meeting specifications or building codes, and environmental and other risks requiring payments to third parties.
- **Availability risk:** It includes the possibility of additional costs such as maintenance and financing, and the incurrence of penalties because the volume or quality of the services does not meet the standards specified in the contract.
- **Demand risk:** It includes the possibility that demand for the services is higher or lower than expected.
- **Residual Value and Obsolescence risk:** It include the risk that the asset will be less than its expected value at the end of the contract and the degree to which the government has an option to acquire the assets.

⁶ Medium to long term contracts (20 – 30 years) between the public and private sectors whereby some of the service obligations of the public sector are provided by the private sector, with clear agreement on shared objectives for delivery of public infrastructure or public services.

The risk and rewards are on the side of the concessionaire if the construction risk and either the demand or the availability risks have been effectively transferred. This means that the private party can have the responsibility over the finance, design, construction and maintenance of the project. One key feature of these contracts is that the private party should bear a significant amount of risk. The question now is how much risk is considered as significant to transfer to the private party. In this regard, one could contend that a significant amount of a specific risk is considered when if it occurs, the impact over the economic and financial balance can cause the concessionaire default.

The most common PPP scheme carried out worldwide and specifically in Spain is the concession contract. A concession gives to the concessionaire the long term right to use all utility assets conferred on the concessionaire, including responsibility for operations and some investments. There are four main features that become the concession agreement as a particular kind of contract which are:

- The infrastructure can be operated by the private partner or the concessionaire. In this regard, the delivery of the service shall be in accordance with performance standards, allowing the private party to apply and make use of its know-how to meet the requirements.
- The private partner performs the contract under its own risk and fortune.
- The economic and financial balance of the contract if an excessive amount of risk beard by the concessionaire is materialized.
- Financial diversification. Fact which cannot be able in traditional infrastructure contracts on which the public administration pays to the contractor.

A concession is a specific term in civil law countries but, in common law countries, the term used to describe this kind of contracts is called BOT projects. A Build Operate Transfer (BOT) project (Figure 2.b.) is typically used to develop a discrete asset rather than a whole network and is generally entirely new or greenfield in nature (although refurbishment may be involved). In a BOT Project the private company generally obtains its revenues through a fee charged to the utility/ government rather than tariffs charged to users. In common law countries a number of projects are called concessions, such as toll road projects, which are new build and have a number of similarities to BOTs.

Figure 2.b.: Types of PPP Agreements.

Source: World Bank

2.1. THE PRIVATE SECTOR AS A PROJECT SPONSOR.

Unlike traditional infrastructure procurement process in which the Government finances the facility and the private party was only in charge of the construction process, this new formula transfers the responsibility to the private sector for mobilizing funds for infrastructure investment. This implies that the private party shall identify investors and develop the finance structure for the project.

Under a PPP scheme, projects are financed by creating a leveraged firm (Mirzadeh & Birgisson, 2015) which is called the Special Purpose Vehicle (SPV) and it is in charge of raising funds through a combination of equity provided by the project company's shareholders, and third-party debt provided by banks, bonds or other financial instruments. In this regard, some authors have proposed an approach to determine the optimal debt ratio in PPP projects (Chen, Mao, & Hu, 2015). Therefore, the finance structure is the combination of equity and debt, and contractual agreements between the equity holders and lenders.

Figure 2.1.a.: Typical Structure of a PPP Contract.

Source: Author.

As we can see in (Figure 2.1.a.), the PPP agreement is carried out between the Government and the SPV. This is also complemented by a direct agreement between contracting authority and lenders; although often this relationship is limited to the provisions in favor of the lenders included in the PPP agreement, such as step-in rights or senior debt repayment guarantees.

The initial equity investors, who develop the PPP proposal, are typically called project shareholders. These are normally composed by project developers, engineering or construction companies, infrastructure management companies, and private equity funds. PPP project lenders in developing countries may include commercial banks, multilateral and bilateral development banks and finance institutions, and institutional investors such as pension funds. The proportion in which each party is engaged in the contract depends not only on the project, but also in the risks associated with it. Normally, infrastructure projects involve a large proportion of debt, with ranges between 70 to 90 percent of total finance (Yescombe, 2013). This low percentage of equity let shareholders to undertake much more projects because they have more funds to allocate in other projects.

The equity investment is “first in, last out” (Farquharson, Torres de Mästle, Yescombe, & Encinas, 2011) which means that in principle, equity investors bear any loss suffered by

the project, and lenders begin to suffer only if the equity investment is lost. This implies that equity investment has a higher risk than debt, and because of risk and return go hand in hand; equity investors will expect higher returns for that risk. Since equity is therefore more expensive than debt, the more debt a project can rise, the lower its overall funding costs will be. But project promoters are demanded to provide a minimum amount of funds by lenders in order to justify its compromise with the project.

In order to finance long-term infrastructure projects, the project finance tool which is based on lending against the cash flows generated by the project alone is the most effective alternative to conventional direct financing. This means that sponsors will only earn a return, and lenders are repaid, from the revenues generated by the project on its own. The sponsors do not guarantee the project as a whole, and the lenders therefore rely on the cash flow of the project alone to service the debt (repay the principal plus the interests). Project finance shall not be considered as an alternative way to finance projects which cannot be financed on a conventional basis. In order to carry out a project finance, it is necessary to undertake a comprehensive due diligence of the project, which mean higher transaction costs than the conventional financing. A detailed assessment of a project's construction, operating and revenue risks and their allocation between invertors and agents is necessary (Yescombe, 2002).

In order to provide a proper allocation of risks it is important to define contractual arrangements between each party involved, assigning each major risk to the party that is best able to appraise and control that risk. The risks associated with a project are so large that it would not be efficient for a single party to bear them alone. Risk sharing is advantageous when economic, technical, environmental, or regulatory risks are of such magnitude that it would be impossible for a single party to undertake them alone.

The concept of Project Finance is not the same as financing projects, because projects can be financed in many different ways such as projects funded by large firms raising corporate loans against their balance sheet, projects financed by the public sector's issuance of debt or financing from multilateral agencies. Under the Project Finance

scheme, financing is referred to the raising of funds on a non-recourse⁷ or limited-recourse basis to finance an investment project in which the providers of the funds look primarily to the cash flow from the project as the source of funds to service their loans and provide the return of and a return on their equity invested in the project. Debt and equity used to finance the project are paid back from the cash flow generated by the project. This SPV is ring fenced from the rest of the project sponsor's business and prohibited from entering into any business outside the project. There is therefore a clear management focus on cash flows over the entire life of the project.

As we can see financing is not a risk-free process. Risks associated with raising funds are primarily related to the availability of funding, cost of funding, the cost and time associated with arranging funding and the risk that the project will not be able to satisfy debt service obligations. Lenders will have their own requirements for the project, the security rights they will seek and any undertakings required from the grantor and shareholders. But depending on the nature of the funder and the degree in which each party is involved in the project risks have different shape.

- Equity is composed by funds invested in the Specific Purpose Vehicle Company which comprises its share capital and other shareholder funds. Equity holds the lowest priority of the financing structure. As we can see, equity holders are bearing the highest risk and according to the relation between risk and returns, they will expect to receive the highest returns.
- Debt or Senior Debt can be obtained from many sources, such as commercial lenders, export credit agencies, multilateral organizations, bondholders (such as institutional investors) and sometimes the host country government. Senior debt has the highest priority in the repayment order (i.e. senior debt must be serviced before any other payments are made). PPP generally involves the construction of high value, long life assets with stable revenues, and therefore seeks long-term, fixed interest debt.
- Between Equity and Senior Debt, there are mezzanine contributions which have

⁷ The project debt is considered as non-recourse finance to project's sponsors, because loans, securities and other borrowings are designed to be serviced exclusively out of project cash flow.

lower priority than senior debt but higher priority than equity. Examples of mezzanine contributions are subordinated loans⁸ and preference shares⁹. Mezzanine contributors are compensated for the added risk they take either by receiving higher interest rates on loans than the senior debt contributors or by participating in the project profits or the capital gains achieved by project equity.

Project finance is therefore often a more efficient way for lenders and investors to finance major infrastructure investments by the private sector as well as increase the availability of financing. The project finance structure is designed to allocate financial returns and risks more efficiently than a conventional financing structure.

2.1.1. ON RANKING OF CLAIMS.

According to the Law 22/2003, of July 9th (Spanish Law on Bankruptcy), credits are classified, for the purposes of the bankruptcy proceedings, as preferential, ordinary, and subordinated. Preferential claims shall also be classified as claims with special preference, if they are secured on certain properties, goods or rights, and general preference claims, if they affect all the assets of the debtor. No privilege or preference shall be allowed in the bankruptcy proceedings.

- **Article 90:** Claims with special preference.
 - **Article 90.1.:** Claims secured with a voluntary or legal mortgage, either on moveable or immovable assets, or lien on mortgaged or pledged assets.
 - **Article 90.6.:** Claims guaranteed with a pledge constituted in a public document, on the pledge goods or rights that are in the possession of the creditor or a third party. The pledge to guarantee future claims shall only provide special preference to claims arising prior to the declaration opening the bankruptcy proceedings, as well as claims arising after it, when by virtue of Article 68, their reinstatement is effected, or when the pledge is registered on a public register prior to the declaration opening the bankruptcy proceedings.

⁸ Involve a lender agreeing not to be paid until more “senior” lenders to the same borrower have been paid, whether in relation to specific project revenues or in the event of insolvency.

⁹ Equity shares, but with priority over other “common” shares when it comes to distributions.

- **Article 91:** Claims with general preference. These claims are very common when the situation of bankruptcy arises in concession contracts.
 - **Article 91.2.:** The relevant amount for tax and Social Security withholdings owed by the insolvent debtor in fulfillment of a legal obligation.
 - **Article 91.4.:** Tax claims and other Public Law, as Social Security claims that do not enjoy special preference pursuant to Paragraph 1 of Article 90, nor the general preference of Subparagraph 2 of this Article; such preference may be exercised for all the Public Revenue claims and for all the Social Security claims, respectively, for up to fifty per cent (50%) of their amount.
 - **Article 91.7.:** The claims held by the creditor that has applied for the bankruptcy to be declared and that are not subordinated, up to the fifty per cent (50%) of their amount.

After deduction from the aggregate assets of the goods and assets required settling the claims against such assets and against the assets not standing as collateral in favor of special preference claims, or to the remainder thereof once these claims are paid, payment of those enjoying general preference shall be honored.

- Ordinary claims: Are not classified as privilege claims nor subordinated claims. The payment of ordinary claims shall be performed against the aggregate that remain once the claims against the estate and the preferential ones have been paid.
- **Article 92:** The following among others are subordinated claims:
 - **Article 92.1.:** Claims that having been lodged late, are included in the list of creditors by the bankruptcy practitioners or that, not having been duly lodged, or having been lodged late, are included on that list by subsequent notifications, or by the Court when resolving the motion to challenge it.
 - **Article 92.2.:** Claims that, under a contractual agreement, are subordinated in nature with regard to all the other claims against the debtor.
 - The payment of the subordinated debt claims shall not be performed until the ordinary claims have been fully settled.

3. INVESTMENT VALUATION THROUGH THE TRADITIONAL APPROACH.

Transportation infrastructure projects are considered as highly leveraged investments and project lenders have only the guarantees provided by the project itself. There are many financial variables to consider in this financial engineering structure, but by far, the most important one is the percentage of external funds. Whilst sponsors are interested in great leverage levels in order to get a higher profitability of their capital invested; lenders will seek lower leverage levels and guarantees to recover their funds before the end of the project.

When investors invest on a specific company or project, they expect to receive a return on their investment. Therefore, the goal of management teams of every company is to create value for the shareholders using the best available techniques when analyzing all possible investment in order to get the higher return. Because the pursued aim of each company is to create value¹⁰ for its stakeholders, when the management allocates funds to each potential project, they expect to receive a cash inflow stream over the life of the project, greater than the amount invested. Therefore, the project appraisal decision-making process is the one which requires a comparison between the amount of cash, put into an investment with the amount of cash returned.

Traditionally, there are three main approaches to valuation (Mun, 2002), which are called:

- **The market approach:** It looks at comparable assets in the marketplace and their corresponding prices and assumes that market forces will tend to move the market price to an equilibrium level. It is also assumed that the market

¹⁰ Single time-value discounted number that is representative of all future net profitability and is created for an investor if the investor earns more than the investment cost. It comes from the physical aspects of the asset as well as the non-physical aspects of the asset, and has the capabilities of generating extrinsic monetary or intrinsic strategic value. This is because there is an opportunity cost to invest in the project. The opportunity cost is the cost that is incurred if the investor puts cash into a project, so that the cash is not available for investing in other projects anymore.

price is also the fair value of the asset, after adjusting for transaction costs and risk differentials.

- **The income approach:** It looks at the future potential profit or potential free cash flow generated by the asset and attempts to quantify and discount these net free cash flows to a present value. The cost of implementation, acquisition, and development of the asset, i.e. the initial investment; is then deducted from this present value of cash flows to generate a net present value.
- **The cost approach:** It looks at the cost a company would incur if it were to reproduce the asset's future profitability potential, including the cost of its strategic intangibles if the asset were to be created from zero.

Other methodologies used in valuations tend to quantify the economic viability and economic gains assets bring to the company.

Investment decisions are very important in every company because new investment projects actually affect future economic results and company's revenues. Therefore, enterprise's value and its competitive position depend on the projects in which the company invests directly. On the other hand, successfulness or unsuccessfulness of projects depends on the quality of the process of preparing, evaluating and selecting these projects. The quality of investment decisions are affected by a large number of factors, while the most important includes the choice of the criteria for the evaluation and selection of investment projects.

The traditional valuation methodology based on a DCF series, is based on a fixed assumptions related to the project payoff (a deterministic approach). A deterministic DCF model assumes that all future outcomes are fixed and does not take into account the value of flexibility. Therefore, the model does not take into account all possible future fluctuations in business conditions that may change the value of the investment. Because business environment is very variable, and if management has the flexibility to make appropriate changes when conditions differ, then there is indeed value in flexibility, a value that is underestimated using a DCF model. This inherent bias leads to rejection of highly promising projects because of their uncertainty.

Methods based on discounted cash flows assume that the investment is an all-or-nothing strategy and do not account for managerial flexibility that exists such that management can change the course of an investment over time when certain aspects of the project's uncertainty become known.

There are several potential issues in using a traditional DCF calculation on strategic decisions. These problems include undervaluing an asset that currently produces little or not enough cash flow, the non-constant nature of the weighted average cost of capital discount rate through time, the estimation of an asset's economic life, forecast errors in creating the future cash flows, and insufficient tests for plausibility of the final results.

3.1. PROJECT CASH FLOWS.

Project cash flows represent both the benefits and costs of the project along its life cycle. These cash flows should be estimated for the entire project life cycle, including the construction and operation phases. There are basically two cash flow streams:

- Investment Cost.
- Net revenues in the operation phase.

The first cash flow stream typically is comprised of development phase costs and production phase capital costs. The latter, in the case of a product development project, for example, may include building a manufacturing plant and product launch costs. The second stream, commonly referred to as project payoff, is a net cash flow, which is the difference between the revenues and the costs associated with those revenues in the production phase of the project. These cash flows can be considered as contingent and create asymmetric payoffs which cannot be valued by classical valuation methods (Huang & Pi, 2014) because they usually depend on economic, performance or demographic variables.

After accounting for depreciation, taxes, working capital, and so forth, these cash flows are referred to as "free cash flows". The critical point of project valuation lies in estimating these two cash flow streams over the entire project life cycle and discounting

them back to today's value using the appropriate discount rate. The main issue at this point is to select the discount rate.

Within a project finance structure, there are two main stages; the construction period when the project does not generate any cash inflows but only cash outflows; and the operation phase when the project begin to generate cash inflows. During the construction period, the main investments are made and demand of financial resources is at its peak. Once the project is under operation, the main element to assess the concession project is the free cash flow, which is the available amount of money to pay the lenders and shareholders once operational expenses and taxes have been paid. The free cash flow scheme is described below:

- (+) Operational Incomes.
- (-) Operational Expenses.
- **(=) Earnings Before Interests, Taxes, Depreciation and Amortization (EBITDA).**
- (+/-) Other incomes or expenses.
- (-) Amortizations.
- (-) Financial Expenses (Interests and Fees).
- **(=) Earnings Before Taxes (EBT).**
- (-) Corporate Taxes.
- **(=) Earnings After Taxes (EAT).**
- (+/-) Working Capital.
- (+) Amortizations.
- (+/-) Investments.
- **(=) Free Cash Flow (FCF).**

Transportation infrastructure projects are characterized for a great initial investment. Related to that infrastructure, future cash flows are linked to it that are supposed to be necessary to repay all agents involved in the project plus an additional and reasonable profit.

Traffic incomes are often greater than 90% (generally 95% in most cases) of total incomes. Therefore, the importance of accurate traffic estimation is crucial. Future traffic

demand will determine the feasibility of the project and also its bankability. It was mentioned in previous Sections that transportation infrastructure projects are highly leveraged (financial leverage). Initial investment is quite huge unlike the operational expenses. This assumption leads us to consider that motorway projects are not highly leveraged operationally speaking. Because of the initial investment is very high, debt service needs are also very high. Debt repayment (principal + interests) represents the main liability of the concessionaire at the beginning of the operational period.

3.1.1. DISCOUNT RATE.

The discount rate is the rate that is used to convert the future value of the project cash flows to today's value. It is adjusted for the risk perceived to be associated with the project; the higher the risk, the higher the discount rate. The project risk is dictated by the uncertainty of the cash flows and the nature of the project. There are many factors that determine the value of the discount rate for a given cash flow stream:

- Magnitude of risk (cash flow uncertainty).
- The country where the company is investing.
- The division in which the company operates.
- Type of risk (private risk versus market risk).
- The opportunity cost.

When an investment is carried out, the main worries the investors have are the relation between the risk and return of a financial asset. There is a positive relationship between the risk and the expected return of a financial asset which means that the more risk the investor assume, the higher return he will expect.

If there is uncertainty associated with a cash flow stream, the next consideration is whether that stream is influenced by private or market risk. If it is influenced by private risk, the investor will not pay a risk premium because the company should be capable of executing the project with effectiveness and select the proper technology to do it. On the other hand, if a cash flow is subject to market risk, one would account for it by adjusting the discount rate.

If there is no uncertainty associated with a cash flow stream, it means that there is no risk associated with it. Therefore, a risk-free interest rate should be used to discount such cash flows. Risk-free interest rate corresponds to a riskless investment, such as a riskless bond. In dealing with project investments, it is almost impossible to find cash flow streams with absolutely no uncertainty. Therefore, the question of what discount rate is appropriate for a cash flow stream with no uncertainty might be academic or for specific projects in which there are some certain cash flows, and hence they can be discounted at a risk-free rate.

If the uncertainty comes from the investment cost it involves the development cost (Research & Development and Design -> Proposal and Estimation Department and Engineering Department as well) and production phase capital cost, the problem comes from the efficiency of the company which is not subject to market forces. Therefore, the development phase cost is considered to be controlled by private risk but not market risk. The second investment cost, production phase capital, typically includes building a manufacturing plant (construction phase -> the risk of construction), launching a product with a massive marketing campaign, etc. An organization is expected to be able to estimate this cost also with very little uncertainty. This cost is not influenced by the market forces and is subject to private risk only, because it is primarily based on how efficiently the organization can bring this phase of the project to completion. If the uncertainty comes from the operation phase, it is very common that market forces are acting and playing the main important sources of risk. But the company can commit inefficiencies in the operation and maintenance works, so in this case a portion of the uncertainty is related to private risk.

In the real world it may be difficult to completely differentiate the private risk from the market risk. The development and capital costs cannot be estimated with any certainty because of today's fast-changing market forces that are directly influencing these costs irrespective of the private risks. On the other hand, any project investment requires capital, and organizations have to pay a cost to obtain that capital. Therefore, for discounting the cash flows that are subject to private risk, a rate that is either slightly

higher than the risk-free rate or a rate that is c with the organization's weighted average cost of capital shall be used, which represents risk of "business as usual."

If cash flows are directly affected by market risk a proportional risk premium should be added to the risk-free rate. Because investors expect higher returns for taking higher risks, it is only reasonable to discount the market-driven project cash flows at a rate that is defined by the risk level of the project.

$$r_i^* = r_{rf} + rp_i \quad (\text{Equation 3.1.1.1.})$$

Where:

- r_i^* : The risk-adjusted rate of return.
- r_{rf} : The risk-free rate of return.
- rp_i : The risk premium related to the market risk. This represents a compensation for bearing the risk of investing in a particular project.

It is very common to use the cost of capital as the discount rate. Nevertheless, the cost of capital is changing all the time. The cost of capital is basically composed by the cost of debt and the cost of equity, and the bond's yield to maturity is tied up to the market price, and that market price is going to be changing all the time. The cost of debt is basically the bond yield to maturity. The yield to maturity is the annual return that an investor earns on a bond if the investor purchases the bond today and holds it until maturity. It is the yield that equates the present value of the bond's promised payments to its market price.

$$P_0 = \frac{PMT_1}{\left(1+\frac{r_d}{2}\right)} + \dots + \frac{PMT_1}{\left(1+\frac{r_d}{2}\right)^n} + \frac{FV}{\left(1+\frac{r_d}{2}\right)^n} \quad (\text{Equation 3.1.1.2.})$$

Where:

- P_0 : The current market price of the bond.
- PMT_i : The interest payment in period t.
- r_d : The yield to maturity.
- n : The number of periods remaining to maturity.
- FV : The maturity value of the bond.

The cost of equity is usually calculated with the CAPM, and the starting point of the CAPM is the risk-free rate, and the risk-free rate for the yield on 10-year Treasury notes. But, that yield on 10-year Treasury notes is actually changing all the time. Therefore, the cost of equity is changing all the time, and therefore the cost of capital is also going to be changing all the time.

So if we have time changing cost of debt, and cost of equity and therefore, cost of capital, then should we actually use a cost of capital that changes over time, or we can use a constant over time. If we use a different discount rate for each different period, the NPV formula turns into:

$$PV = \frac{CF_1}{(1+r_1)} + \frac{CF_2}{(1+r_1) \cdot (1+r_2)} + \dots + \frac{CF_n}{(1+r_1) \cdot (1+r_2) \cdot \dots \cdot (1+r_n)} \quad (\text{Equation 3.1.1.3.})$$

3.1.1.1. WEIGHTED AVERAGE COST OF CAPITAL (WACC).

In order to maximize capital budget decisions, a model that will determine correctly the market value of a project's levered cash flows is required. A capital budgeting model should account not only for the effects of the investment decision, but also for the effects of the financing decision and the interactions between the two decisions (Miles & Ezzell, 1980).

Capital budgeting decisions relies on the following assumptions:

- Decision making process is based on cash flows instead of on accounting concepts, such as net income.
- The period of time when cash inflows or outflows arrive is very important.
- Cash flows are based on opportunity costs.
- Because of taxes shall be taken into account in any capital budgeting decisions, cash flows are analyzed after taxes.
- Normally, financial costs are often considered in the required rate of return to find the NPV. Therefore, financing costs are ignored in capital budgeting because if we included them in the cash flows, we would be double-counting them.

- Capital budgeting cash flows are not accounting net income. Accounting net income is reduced by noncash charges such as accounting depreciation.

In perfect capital markets all the effects of the financing decision pertain to the tax shield created by debt financing. Thus, as originally shown by (Modigliani & Miller, 1963), the value of a project's levered cash flow stream equals the market value the stream would have if it were unlevered plus the market value of the stream of tax savings on interest payments associated with the debt employed to finance the project. Accordingly, the value of a project's levered cash flows is specified as the sum of these two present values, one representing the effects of the investment decision and the other capturing the effects of the financing decision.

Because of cost of capital represents the cost of financing an organization's activities, whom come from a combination of equity and debt with different costs of capital, a weighted average is required. What it is taken into account is how much of each source of financing the company is actually using. The cost of capital is not really all that much related to cash flows coming out of the company. The cost of capital is really related to risk borne by the investors that provide the capital that corporations need, because it has to do with required returns and required returns always have to do with risk that investors perceived, when they provide the capital that companies need to make investments. There are at least three way of thinking about the cost of capital:

- From the point of view of the investors: Investors are the ones that provide the capital so that the company can invest in new projects. Due to the fact that investors do not provide the capital for free, they are going to require a return. When a return is required, it is function of the risk the investor perceives the he is bearing. That is why there is a positive relation between risk and return. The higher the risk the investor perceives in the capital he invests, the higher the return that he is going to require.
- From the point of view of the company: When the company raises that capital, they need to deliver a return (not necessarily mean paying in cash). The company raises capital and it needs to deliver a return (it does not mean to pay a dividend, but a company can deliver a return in terms of capital gains and

that return is a cost for the company). The weighted average of those costs is the weighted average cost of capital.

- The hurdle rate: The hurdle rate is the minimum required return on the company's investments.

The cost of capital is extremely important for value creation because the return that you get on all the capital invested must beat that cost of capital.

There are many different sources of capital, including issuing equity, debt, and other financial instruments. Each of these sources has a cost and is a component of the cost of capital.

The weighted average cost of capital (WACC) of different cost components of issuing debt, preferred stock, and common equity is reflected in (Equation 3.1.1.1.1.).

$$R_{WACC} = W_d \cdot R_d \cdot (1 - t) + W_e \cdot R_e \quad (\text{Equation 3.1.1.1.1.})$$

Where:

- R_{WACC} : Weighted Average Cost of Capital or the required return on the capital invested.
- W_d : The weight or proportion of debt.

$$W_d = \frac{Debt}{Debt + Equity} \quad (\text{Equation 3.1.1.1.2.})$$

- W_e : The weight or proportion of equity.

$$W_e = \frac{Equity}{Debt + Equity} \quad (\text{Equation 3.1.1.1.3.})$$

- $\sum W_i = 1$
- R_d : The required return on debt. The debt used in the WACC formula is the one that we raise in order to make long-term investments.
- R_e : The required return on equity.

- t^{11} : The effective corporate tax rate.
- $1 - t$: The after-tax cost of debt. After taking into account that when we pay interests on the debt, we get a tax break on that debt. The tax break actually saves taxes that the company has to pay, it reduces the cost of debt, and there is a before tax and an after tax cost of debt.
- $(1 - t) \cdot R_d$: The after-tax cost of debt.

All required returns are related to the risk perceived by investors that provide that particular source of capital. In (Equation 3.1.1.1.), companies will try to find what proportion of debt they need to , and what proportion in equity they need to have in order to minimize that cost of capital.

There are also companies that may actually get financing through debt, equity, convertible debt, preferred stock, or many other possible sources of financing. And each of those sources of financing is going to have a term in the WACC formula. So, the (Equation 3.1.1.1.) can have as little as one term, or as many as substantially different sources of financing a company uses to invest in their operations.

3.2. NET PRESENT VALUE APPROACH.

The Present Value is used to calculate the present day value of any amount of money that is received at a future date. The NPV is the value today of a sum of money due in the future, discounted at the cost of money (Yescombe, 2013). The premise of the equation is that there is a time value of money. There are three variables behind the concept of Time Value of Money (TVM):

- Time: It is worth more 1.00€ today than 1.00€ a year after.
- Inflation: Related to the loss in purchasing power along the time.

¹¹ In just about every tax code in the world, there is an asymmetry because when a company pays interest on the debt, it does that before taxes; but when it pays dividends, it does that after taxes. Therefore, when the company pays one euro of interest, that actually reduces the profit and that means that the company pays less taxes. However, when the company pays one euro of dividends, it does it after taxes which means that it is actually a net euro. It is called the tax shelter.

- Risk: The promise to get a certain amount of money in the future implicitly involves a risk because the pay-out may not take place or the amount may be less than expected.

This assumption relies on the concept that receiving something today is worth more than receiving the same amount of money in the future.

$$PV = \frac{CF_1}{(1+r)} + \dots + \frac{CF_n}{(1+r)^n} = \sum_{i=1}^n \frac{CF_i}{(1+r)^i} \quad (\text{Equation 3.2.1.})$$

Where:

- PV : Present Value of the project.
- CF_i : After-Tax Cash Flow for the period i .
- r : Discount rate. It is considered as a constant for all the investment period.
- n : Investment Time Period.

The purpose of the Net Present Value is to represent the value of a stream of payments in a single number, recognizing the fact that the same nominal payment, made at different times, will have different worth. The NPV of a stream of payments is defined to be the sum of the discounted values of the individual terms in the stream, where each term is discounted to a common reference date.

The Net Present Value (NPV) of an investment is a measure of how much value is created today by undertaking an investment. NPV gives us the profitability earned by an investment measured in current currency units. It is also proven that on perfectly competitive markets¹², is the optimal investment criteria. Analytically, it is calculated by adding up all future net cash flows discounted at a rate of return adjusted by the risk, and subtracting the initial investment as it is shown in (Equation 3.2.2.). The NPV is the unique consistent selecting criteria with the scope of maximizing the company's value. However,

¹² A purely competitive market exists when the following conditions occur:

- Low entry and exit barriers - there are no restraints on firms entering or exiting the market.
- Homogeneity of products - buyers can purchase the good from any seller and receive the same good.
- Perfect knowledge about product quality, price, and cost.
- No single buyer or seller is large enough to influence the market price.

(Myers S. , 1984), (Brennan & Schwartz, 1985), (Kester, 1984), (McDonald & Siegel, 1986), (Pindyck R. , 1991) and (Trigeorgis L. , 1993) all pointed out that NPV approach does not take into account the value of flexibility of real asset investments.

$$NPV = -I + \frac{CF_1}{(1+r)} + \dots + \frac{CF_n}{(1+r)^n} = -I + \sum_{i=1}^n \frac{CF_i}{(1+r)^i} \quad (\text{Equation 3.2.2.})$$

Where:

- NPV : Net Present Value of the project.
- I : Capital invested.
- CF_i : After-Tax Cash Flow for the period i.
- r : Discount rate. It is considered as a constant for all the investment period.
- n : Investment Time Period.

If we consider a different discount rate for each period, the (Equation 3.2.2.) can be written as follows:

$$NPV = -I + \sum_{i=1}^n \frac{CF_i}{\prod_{j=1}^i (1+r_j)^i} \quad (\text{Equation 3.2.3.})$$

Where:

- r_j : Discount rate for the period j.

It is important to keep in mind that there is not a unique discount rate for the calculation of the NPV; different discount rates may be applied depending on the agent or the purpose. The choice of selecting one discount rate or another is critical to determine the present value of a project's cash flows and hence the value of the project as an investment. Therefore, the higher the discount rate, the lower the Net Present Value.

Therefore, there are two main principles behind the DCF calculation:

- The time value of money.
- A premium for the particular risks involved in the investment.

Since a project's NPV represents its value in terms of cash today, we can assume that all positive NPV project should be accepted, maximizing the value of the firm. So, if we are analyzing various projects, the more interesting one, considering only the NPV decision-making process, will be the project with the highest Net Present Value.

The Net Present Value is the difference between how much the operating assets are worth and how much they cost (NPV = present value of assets – required capital expenditure).

$$NPV = \sum PV \text{ of Benefits} - Investment \text{ Cost} \quad (\text{Equation 3.2.4.})$$

However, in many instances, investors tend to discount both benefits and investment costs at a single identical market risk-adjusted discount rate, usually the WACC. This, of course, is flawed. The benefits should be discounted at a market risk-adjusted discount rate like the WACC, but the investment cost should be discounted at a reinvestment rate similar to the risk-free rate. Cash flows that have market risks should be discounted at the market risk-adjusted rate, while cash flows that have private risks should be discounted at the risk-free rate (Mun, 2002). This is because the market will only compensate the firm for taking on the market risks but not private risks. It is usually assumed that the benefits are subject to market risks (because benefit free cash flows depend on market demand, market prices, and other exogenous market factors), while investment costs depend on internal private risks (such as the firm's ability to complete building a project on time or the costs and inefficiencies incurred beyond what is projected).

$$NPV = \sum_{t=1}^T \frac{FCF_t}{(1+WACC)^t} - \sum_{t=1}^T \frac{Investment \text{ Cost}_t}{(1+r_f)^t} \quad (\text{Equation 3.2.5.})$$

Where:

- r_f : Risk-free discount rate.
- $WACC$: Weighted Average Cost of Capital.
- FCF_t : Free Cash Flow.

Therefore, when NPV is positive, the company will increase its own value by making the investment. In contrast, when NPV is negative, the company is better off not making the investment.

Nevertheless, there several aspects an investor should take into consideration prior to using DCF methods, as it is shown in (Table 3.2.a.) (Mun, 2002).

Table 3.2.a.: Disadvantages of Discounted Cash Flow methods vs. Realities in Concession Projects.

DCF Assumptions	Realities
Decisions are made at the beginning of the project and cash flow streams are fixed for the future.	Uncertainty and variability in future costs and revenues. Not all decisions are made today and some may be adapted according to future events.
Single-Static Decision Making Process.	Multiple-Dinamic Decision Making process where management has the flexibility to adapt given a change in the business environment.
Projects are considered as small companies and they are interchangeable with whole firms.	With the inclusion of network effects, diversification, interdependencies, and synergy, firms are portfolios of projects and their resulting cash flows.
Once launched, the project is passively managed.	Projects are usually actively managed through project life cycle, decision options, budget constraints, and so forth.
Future free cash flow streams are highly predictable and deterministic.	Cash flows are usually stochastic and risky in nature. Uncertain Environment.
Project discount rate used is the opportunity cost of capital, which is proportional to non-diversifiable risk.	There are multiple sources of business risks with different characteristics, and some are diversifiable across projects or time.
All risks are completely accounted for by the discount rate.	Firm and project risk can change during the course of a project.
Many factors can affect the outcome of the project and value to investors is reflected in the DCF model through the NPV or IRR.	Because of project complexity and so-called externalities, it may be difficult or impossible to quantify all factors in terms of incremental cash flows. Distributed, unplanned outcomes can be significant and strategically important.

Source: Author based on (Mun, 2002).

3.3. THE CAPITAL ASSET PRICING MODEL (CAPM).

In contrast with the calculation of the cost of debt which is observable and objective, (whether I have a bond trading in the market or whether I am borrowing money from a bank, in both cases, the cost of debt is both observable and objective); the cost of equity needs to be estimated, and it will depend on both the model used and the parameters that the analyst introduce in the model, which make the cost of equity as subjective. As far as the cost of debt is concerned, I observe that number and it becomes objective, but as far as the cost of equity is concerned, I do not observe that number, I must estimate it and therefore it becomes subjective. Therefore, there is an asymmetry between the cost of equity and the cost of debt.

There are many models proposed to estimate the cost of equity, such as the arithmetic average historical return, the Multibeta CAPM, the dividend discount model, the investor expectations or the regulator decisions; but the most widely used is the Capital Asset Pricing Model (CAPM).

The Capital Asset Pricing Model (CAPM) developed in the early 60's by (Sharpe, 1964), (Treynor, 1965), (Lintner, 1965) and (Mossin, 1966), is currently used in a huge range of applications such as estimating the cost of capital for firms and evaluating the performance of managed portfolios and it is based on the idea that not all risks should affect asset prices. It offers predictions about how to measure risk and the relation between expected return and risk. The CAPM is the model that we use to estimate the cost of equity, which is one of the components of the cost of capital.

The first challenge we are facing up when we use the CAPM is to estimate the beta. The challenge is not as greater when we analyze traded companies as when we asses non-traded companies or projects. Estimating the beta in these cases requires the use of proxies for the beta by using the information on the project or company combined with a beta of a publicly traded company. This is the method used in this thesis to determine the beta for motorway concessions.

The beta of a project is affected by the systematic components of business risk and by financial risk. Both of these factors affect the uncertainty of the cash flows of the project.

The business risk of the project is the risk related to the uncertainty of revenues (associated with operating earnings), referred to as sales risk (affected by the elasticity of the demand, the cyclicity of the revenues and the structure of the industry), and to operating risk (affected by both fixed and variable costs), which is the risk related to the company's operating cost structure. The greater the fixed operating costs, relative to variable operating cost; the greater the uncertainty of income and cash flows from operations. Financial risk is the uncertainty of net income and net cash flows attributed to the use of financing that has a fixed cost, such as debt and other financial instruments. The greater the use of fixed-financing sources of capital; the greater the financial risk.

Another way to estimate the beta is by using a comparable company or project with similar risk profile. This way requires some adjustments in order to take into account different degrees of debt. This requires a process of un-levering (in order to remove the effects of financial leverage) and re-levering (to account for the financial structure of our project or company) the beta. The unlevered beta is also referred to as the asset beta because it reflects the business risk of the assets.

The CAPM model states that under some simplifying assumptions, the rate of return on any asset may be expected to be equal to the rate of return on a riskless asset plus a premium that is proportional to the asset's risk relative to the market. The following assumptions are made by the CAPM in order to ignore many of the complexities of financial markets:

- Investors are risk-averse (investors expect to be compensated for bearing risk), utility-maximizing, rational individuals.
- Markets are frictionless, including no transaction costs and no taxes.
- Investors plan for the same single holding period.
- Investors have homogeneous expectations. All investors analyze the same data.
- All investments are infinitely divisible. Any investor decides how much to invest in a certain asset.
- Investors are price takers. There are too many investors operating in the market and any of them is large enough to influence prices.

The CAPM gives us an appropriate expected rate of return (cost of capital) of a project taking into account its relevant risks. It is important to take into account that this rate of return is not promised because the model does not include a default premium. The model states that an investment's cost of capital is lower when it offers better diversification benefits for an investor who holds the overall market portfolio. Market beta is its measure of risk contribution. Therefore, projects contributing more risk, i.e. market beta, require a higher expected rate of return.

A portfolio is a clustered set of financial assets which performance and risk depend on their inherent characteristics.

$$E(\tilde{r}_p) = \sum_{i=1}^n w_i \cdot E(\tilde{r}_i) \quad (\text{Equation 3.3.1.})$$

Where:

- $E(\tilde{r}_p)$: Expected rate of return on the portfolio.
- $E(\tilde{r}_i)$: Expected rate of return on the asset i.
- w_i : Asset's weight on the portfolio.

Variance of the portfolio can be calculated through the (Equation 3.3.2.).

$$\sigma_p^2 = \sum_{i=1}^n w_i \cdot w_j \cdot \sigma_{ij} \quad (\text{Equation 3.3.2.})$$

$$\sigma_{ij} = \sigma_i \cdot \sigma_j \cdot \rho_{ij} \quad (\text{Equation 3.3.3.})$$

Where:

- σ_i : Standard deviation of the asset i.
- σ_{ij} : Covariance between assets i and j.
- ρ_{ij} : Correlation coefficient between assets i and j.

Because of the variance is the most common probability-weighted measure of dispersion, we may say that high-variance assets are riskier than lower-variance assets. Variance is a measure of uncertainty, but it is incomplete. We have to worry about a time dimension, in other words, how much things can change in the decision period.

According to the CAPM, any asset has a value which depends on both its expected return and its market risk. The main result of the model, considering a balanced competitive market is described in (Equation 3.3.4.).

$$E(r_i) = r_{rf} + \beta_i \cdot (E(r_m) - r_{rf}) \quad (\text{Equation 3.3.4.})$$

Where:

- $E(r_i)$: Expected rate of return on the asset i.
- r_{rf} : The risk-free rate of return.
- $E(r_m)$: Expected rate of return on the overall market.
- β_i : Firm's or Project's beta with respect to the market. The company or project might magnify¹³, or mitigate¹⁴, the market's fluctuation.
- $(E(r_m) - r_{rf})$: The expected market risk premium or the equity risk premium. It gives us an idea of how much more return have investors required from investing in equity than from investing in debt.
- $\beta_i \cdot (E(r_m) - r_{rf})$: The Risk Premium. If I am going to bear some risk, I want some extra compensation.

So, the CAPM is basically a model that tells us how we actually calculate the risk premium for a specific company.

The risk-free rate represents the interest an investor would expect from an absolutely risk-free investment over a specified period of time. Everybody uses government bonds, but the question is what the maturity of those government bonds is. However, it is also common to use a risk-free interest rate which has the same or almost the same maturity as the project's lifetime. As can be seen in (Figure 3.3.a.) 46% of the people use the ten year bond. Nevertheless, because of motorways concession projects have more than twenty (20) years of operation, it is necessary to use the thirty-year treasury bond.

¹³ More return investors are going to require.

¹⁴ Less return investors are going to require.

Figure 3.3.a.: What is the Appropriate Period for the Risk-Free Rate?

Source: IESE Business School.

The market risk premium is a concept which in turn depends on three concepts (Fernández, 2004):

- The incremental return of a diversified portfolio over the risk-free rate required by an investor. This concept is called required market risk premium and depends on the investor.
- The historical differential return of the stock market over treasury bonds. This concept is called historical market risk premium. This is the same for all investors.
- The expected differential return of the stock market over treasury bonds. This concept is called expected market risk premium and depends on the investor.

Beta coefficient may be calculated as follows:

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2} = \frac{\sigma_i \cdot \sigma_m \cdot \rho_{im}}{\sigma_m^2} = \frac{\sigma_i}{\sigma_m} \cdot \rho_{im} \quad (\text{Equation 3.3.5.})$$

Where:

- σ_i : The risk of my investment.
- σ_m : Market's risk.
- σ_{im} : The covariance between a firm's stock prices and the market portfolio.

- ρ_{im} : Correlation coefficient between asset i and the market. It can also be expressed as β_{im} .

As we can see, systematic risk or market risk is measured by a stock's beta (β_i). Systematic risk is risk that cannot be diversified and is inherent in the market. It is non-diversifiable because it includes risks factors that are inherent to the market and affect the market as a whole. On the other side of the coin, there is the non-systematic risk; which is a risk that is limited to a particular asset or sector. Nevertheless, (Smith & Nau, 1995) suggest a separation between the private risk of a project, not correlated with the market; and market risk, for which the market is complete. These authors consider that market risk (so called systematic risk) can be perfectly diversified throughout a portfolio traded in the market. On the other hand, private risk (so called non-systematic risk) which comes from the project's uncertainty cannot be diversified. If we consider an investor owning a diversified portfolio of investments including the project, and the project does not represent a great percentage of his wealth, then we can assume that the investor is private risk neutral. This assumption comes from the fact that the market will compensate the investor for the systematic risk he is bearing. Since its non-systematic risk can be diversified within the portfolio.

In financial assets, we can obtain beta through a calculation of the covariance between a firm's stock prices and the market portfolio, divided by the variance of the market portfolio. Beta is then a sensitivity factor measuring the co-movements of a firm's equity prices with respect to the market. Depending on the time frame used for the calculation, beta may fluctuate wildly. We can use as many years as possible in order to capture whether the company magnified some mitigates of the market's fluctuation. The company might have changed a lot over time, and if it had happened, and you go back many years, you are picking up information that is no longer relevant. So, if you go many years back (for example twenty years or more), you run the risk of picking up a lot of information in that beta, that is no longer relevant when you start looking ahead. On the other hand, you can just go a little bit back (for example one year or even two), the problem here is that the company might have done spectacularly well or spectacularly awful. So, taking into account those reasons, an appropriate period to estimate beta is

between five and ten years, but it also depends on the company and the market where the company operates.

Beta is a relevant measure of an asset's risk only when an asset is held within a widely-diversified portfolio. And in that case, one way to think of an asset's beta is as the contribution of the asset to the volatility of the whole portfolio. In general, beta is the reaction of a stock to fluctuations in the market. A beta of one indicates average risk, or return fluctuations similar to those of the market; a beta higher than one indicates higher risk or larger return fluctuations than the market; and a beta lower than one means lower risk or smaller return fluctuations than the market.

Two main conclusions can be inferred from (Equation 3.3.4.):

- The higher the volatility between the asset in relation to market's volatility, the higher the beta (β_i) will be.
- The higher the correlation between the asset and the market, the higher the beta (β_i) will be.

Moreover, the following conclusions can be inferred from (Equation 3.3.5.):

- The higher the volatility σ_i , the higher the beta (β_i).
- The less the market's volatility (σ_m), the higher the beta (β_i).
- The higher the correlation between the asset and the market, the higher the beta (β_i).
- If $\sigma_i = 0 \rightarrow \beta_i = 0 \rightarrow E(k_i) = k_{rf}$
- If $\rho_{im} = 0 \rightarrow \beta_i = 0 \rightarrow E(k_i) = k_{rf}$

The correlation coefficient (ρ_{im}) may have a range of values clustered between -1 and 1. If there is no correlation between the variables, then $\rho_{im} = 0$. Considering this point of view, β_i could be negative.

The correlation coefficient is a magnitude that measures the sign and the strength of the relationship between two variables. When two variables tend to move in the same direction, this coefficient is positive; and when they tend to move in opposite directions, this coefficient is negative. A $\rho_{im} = -1$ means a perfect negative relationship; and when

$\rho_{im} = 1$, a perfect positive relationship. The closer the relationship between two variables is to -1 or to 1 , the stronger the linear relationship between them would be. On the other hand, the more their correlation departs from -1 or 1 and the closer it gets to 0 , the weaker the linear relationship between them would be. And if their correlation is 0 , there would simply be no linear relationship between them. If I have two assets with a correlation of -1 , I could always combine them in a very specific way so that I could eliminate completely the volatility of the portfolio (Figure 3.3.b.), but if the correlation is 1 , there are no correlation gains from combining them (Figure 3.3.c.). This is because if I combine two assets that move in the same direction in a fully synchronized way, my portfolio will move in that way.

Figure 3.3.b.: Eliminating Volatility by Combining Assets.

Source: Author.

Figure 3.3.c.: No Correlation Gains by Combining Assets.

Source: Author.

We can conclude that the lower the correlation between two assets, the more diversification benefits we get from combining them. The closer we get to a correlation of 1 , the lower the diversification benefits; and the closer we get to a correlation of -1 , the

higher the diversification benefits. If we combine two assets with a correlation equal to 1, the volatility of the portfolio will simply be equal to the weighted average of the volatilities of the two assets in the portfolio. But if the correlation is lower than 1, the volatility of the portfolio is lower than the weighted average of the volatility of the two assets in the portfolio. Therefore, the lower the correlation between two assets, the higher the returns we can get from a desired level of risk. What they want is the best balance between returns and risks; they want the highest possible return at every level of risk.

If the investors' main goal is to risk reduction, the lower the correlation between two assets, the more they will gain by combining them. But investors are not also interested in minimizing risks, but also maximizing their returns.

By calling r_i the return of the asset i , the CAPM can be written like in the (Equation 3.3.6.).

$$E(r_i) = r_{rf} + \beta_i \cdot (E(r_m) - r_{rf}) + \varepsilon_i \quad (\text{Equation 3.3.6.})$$

What CAPM states is that $E(\varepsilon_i) = 0$ and $Cov(\varepsilon_i, r_m) = 0$. It follows that:

$$\sigma_i^2 = \beta_i^2 \cdot \sigma_m^2 + var(\varepsilon_i) \quad (\text{Equation 3.3.7.})$$

Where:

- $\beta_i^2 \cdot \sigma_m^2$: Systematic Risk that cannot be diversified.
- $var(\varepsilon_i)$: Idiosyncratic Risk. It can be diversified through the creation of an efficient portfolio.

There shall be a linear relationship between the expected return of the asset and its marginal contribution to the portfolio's risk if the selected portfolio is efficient. Similarly, if there is no linear relation, the portfolio is not efficient (Brealey, Myers, & Allen, 2010).

3.4. PAY-BACK PERIOD.

In capital budgeting, the payback period determines the point at which the cash flows generated by the investment are equal to the cash invested in the project. It is simply the

amount of time it takes to recoup the initial cost of a project from the project's after-tax net cash flows.

All positive earnings after this point are revenues for the investor. The payback period is the oldest of the decision-making criteria. It calculates the return per year from the start of the project until the accumulated returns are equal to the cost of the investment, at which time the investment is said to have been paid back. The period of time taken to achieve this payback is called payback period. Therefore, many companies use the payback period as a measure of the attractiveness of capital investments

The payback period is an important calculation not only for projecting cash flows, interest payments or other value used for the investment, but also for the influence of the project on the entire corporation's asset management and profitability.

$$\text{Payback Period} = \frac{I}{CF_i} \quad (\text{Equation 3.4.1.})$$

Where:

- I : Capital invested.
- CF_i : Net Cash Flow for the period i.

(Equation 3.4.1.) can be written in terms of the IRR (Equation 3.4.2.):

$$\text{Payback Period} = \frac{1 - (1 + IRR)^{-n}}{IRR} \quad (\text{Equation 3.4.2.})$$

Where:

- IRR : Internal Rate of Return of the project.
- n : Investment Time Period.

The calculation shown in (Equation 3.4.1.) assumes that the initial investment is all made at once. But for very large investments, the future value of all amortization payments might be taken and used that as the initial investment.

The payback method is considered a tool with important limitations because it does not take into account the time value of money, risk, financing neither the opportunity cost of the investment. While the value of money can be rectified by applying the

weighted average cost of capital discount, it is agreed that this tool for investment decisions should not be used in isolation. Another deficiency of this method is that it does not take into account cash flows after the project's payback period. As a solution to the "time value of money" deficiency it has been suggested that the simple payback method could be modified by looking at a discounted payback period, thereby searching the payback period when the accumulated present value of the cash flows covers the initial investment.

The use of the discounted payback method could be conceived as a variation of the Net Present Value method. An investment with a payback period shorted than the economic life of the project will always have a positive Net Present Value, if the same discount rate is used for calculations (Stefan, 2000). If a lower risk-free discount rate is used when discounting the discounted payback method cash flows, the acceptable payback period must be shorter than the economic life.

The main criterion to select an investment project when payback method is used is to choose the one which has less payback period.

Under the payback period sets the hurdle rate (threshold barrier) for project acceptance. The payback method indicates how quickly the cost of an investment is recovered but does not measure its profitability, which is very important to capital expenditure decisions, and it is neither inclusive nor sensitive enough to be used as a company's general measure of investment worth.

When applying the payback period approach for project evaluation, there are three steps that should be followed for this technique:

- Forecast expected cash flows in timing and amount.
- Calculate how long it will take to recoup initial investment from net cash flows.
- Apply the appropriate decision rule:
 - For independent projects:

Accept projects with Payback Period < Maximum allowable period¹⁵

- For mutually exclusive projects:

Select the project with the shortest Payback Period < Maximum allowable period.

Independent projects are those projects whose cash flows are independent of each other. Mutually exclusive projects compete directly with each other.

When applying the Payback Period in project evaluation, we have to be aware of the following potential problems the model has:

- The payback period ignores the fact that cash flows are occurring after we have recoup the initial investment. So this leads to a natural bias against projects with longer developmental lives.
- This technique fails to explicitly account for the time value of money.

3.5. INTERNAL RATE OF RETURN (IRR).

The Internal Rate of Return (IRR) is closely related to the Net Present Value (NPV). It is the discount rate of return which cancels out the NPV. It measures the return on the investment over its entire life. The IRR method indicates that an investment should be carried out if that rate of discount which would make the present value of all revenues less all costs equal to zero is higher than an appropriate interest rate.

$$0 = -I + \sum_{i=1}^n \frac{CF_i}{(1+IRR)^i} \quad (\text{Equation 3.5.1.})$$

Where:

- IRR : Internal Rate of Return of the project.
- I : Capital invested.
- CF_i : After-Tax Cash Flow for the period i .
- n : Investment Time Period.

¹⁵ Taking into account the experience the manager has or an external benchmark.

IRR acts as an indicator of the project's profitability for shareholders. Therefore, the higher the IRR, the higher the profitability. Because of that, IRR is widely used for evaluation of future cash flow streams. IRR is a single rate, which makes it intuitive to understand.

The Internal Rate of Return is the mean annual compound return a company gets from a project, considering all the cash put into it, and obtained from it, over time. The IRR is the rate of return that makes the present value of future after-tax cash flows equal to the initial investment.

If we are evaluating projects taking only the IRR criteria, the decision rule with independent project is quite simple. We simply compare the Internal Rate of Return for the project with the appropriate discount rate, given the project's risk, opportunity cost and expectations about the inflation, that is, the time value of money ("r") (See Figure 3.5.a.).

- If $IRR > r$, then accept the project.
- If $IRR < r$, then reject the project.

Figure 3.5.a.: Decision Rule through the IRR Analysis.

Source: Author.

But when analyzing mutually exclusive projects, the decision rule tells us to accept the project with the highest Internal Rate of Return, provided it exceed the minimum benchmark. When we use the IRR criteria only to evaluate mutually exclusive projects, it has the following shortcomings:

- Some projects simply do not have a positive discount rate that when applied to a project's cash flows yield an NPV equal to zero. For example, considering a project involving borrowing. There is a cash inflow up front in return of a series of promise cash outflows.

Figure 3.5.b.: Some Projects do not have an IRR.

Source: Author.

- Other projects might have more than one IRR. For example, in the mining industry where you might have clean-up costs at the end of the project. In these cases, it is necessary to calculate the Net Present Value of the project.

Figure 3.5.c.: Some Projects have Multiple IRR.

Source: Author.

- And finally, considering the projects plotted in (Figure 3.5.d.) there could be a conflict with the IRR evaluation. Project A dominates in terms of Internal Rate of Return because its IRR is far to the right from the IRR of Project B. But at very

low discount rates, Project B dominates Project A in terms of NPV. In these cases, it is necessary to evaluate the project through both NPV and IRR.

Figure 3.5.d.: Conflicting Rankings for Mutually Exclusive Projects.

Source: Author.

In those cases where there is a conflict between both criteria, it is necessary to resort to the NPV and choose that project based on the NPV. In the NPV approach, we are considering the same discount rate (r) for different projects. Nevertheless, in the IRR approach, there are different discount rates equal to the IRR for each project. When we are assuming the required rate of return is (r), we are assuming an opportunity cost of (r) percent (we can find another projects that yield a (r) percent return or pay back the sources of capital that cost (r) percent). The fact that I get from a project a certain IRR, it does not mean that I can reinvest those future cash flows at that rate.

Because the NPV criterion uses the most realistic discount rate, the NPV should be used for assessing mutually exclusive projects. This is because the NPV shows the amount of gain, or wealth increase, as a currency amount.

3.6. PROFITABILITY INDEX.

The profitability index (PI) is the present value of future cash flows divided by the initial outlay (Equation 3.6.1.). The profitability index can also be called “benefit-cost ratio”.

$$PI = \frac{\text{Present value of Future Cash Flows}}{\text{Initial Outlay}} = 1 + \frac{NPV}{\text{Initial Outlay}} \quad (\text{Equation 3.6.1.})$$

The profitability index can be considered as the ratio of the present value of future cash flows to the initial outlay (investment). The NPV is the difference between the present value of future cash flows and the initial investment. Whenever the NPV is greater than zero (invest in the project), the profitability index is greater than one and vice versa.

Therefore, we can state that the investment decision criterion is to invest if profitability index is greater than one (1), and do not invest if the profitability index is lower than one (1).

The profitability index shows the value an investor is receiving in exchange for one unit of currency invested.

4. INVESTMENT VALUATION THROUGH REAL OPTIONS THEORY APPLICATION.

Only the use of traditional methods of investment valuation based on discounted cash flows are inappropriate in valuing certain strategic projects involving managerial flexibility. When the DCF method is used to value a project, the real options attached in it are implicitly ignored. It means that DCF methods do not reflect the value of management (Brealey, Myers, & Allen, 2010).

The aim of assessing investment projects is the maximization of the enterprise value. When analyzing an investment, the following items are typically taken into consideration:

- All cash flows the project will generate are taken into account.
- All future cash flows are discounted to the current date at the opportunity cost of capital¹⁶, which will be established by the market.
- The more profitability project for shareholders will be chosen.

As we saw in Section 3, when we value an investment project, it is necessary to calculate the cash flows the project will generate and then determine their current value using the Net Present Value approach. Taking into account this procedure, a project will be carried out when all future net cash flows discounted at a rate of return adjusted by the risk are higher than the cost of carry out the project is suitable for promotion. However, this methodology was developed to value risk-free bonds and its use has become widespread in projects valuation. Similarly, a project will be carried out when de IRR is equal or greater that the company's cost of capital. The cost of capital is the rate of return required by the suppliers of capital (bondholders and owners) as a compensation for their contribution of capital. It is also considered as the opportunity cost of funds for the suppliers of capital.

Nevertheless, in order to apply classic theories of investment valuation, the following assumptions shall be met:

¹⁶ The opportunity cost of capital is considered the expected return that is not collected when a company invests in a project rather than in financial securities such as bonds. A company's "weighted average cost of capital" (WACC) often is taken as a convenient approximation for the opportunity cost of capital.

- There are not any significant cost of capital in the sense of that company has access to that capital at that cost.
- Capital rationing does not exist. If a project meets acceptance criteria, the capital will be able to finance the project at the cost of capital rate.
- All projects have the same degree of risk; consequently the acceptance or rejection of a project does not affect the cost of capital.
- There is only one significant rate of return.

Classical valuation methods of projects have the disadvantage of undervalue projects in which operational flexibility exists. This makes it impossible to value how management decisions affect under future evolution of the events. That's why a methodology based on real options theory may produce a change in investment valuation perspective, from an aversion to risk framework to a profit gains in a high-risk environment. The assumption of risk neutrality (or aversion to risk) and market completeness are very important to implement the real options approach. Nevertheless, investors are constantly facing up to incomplete markets and un-diversifiable risks. Therefore, the decision to invest will depend on investors' attitude towards risk.

4.1. CONTINGENT DECISIONS.

An option is a kind of financial derivative. A derivative is a financial instrument or a security whose price is dependent upon or derived from one or more underlying assets (i.e. it is contingent on other). The payoff of the option is contingent on an event taking place, so options are referred to as contingent claims. A contingent claim is a derivative contract with a payoff dependent on the occurrence of a future event. The derivative itself is a contract between two or more parties. Its value is determined by fluctuations in the underlying asset. The most common underlying assets include stocks, bonds, commodities, currencies, interest rates and market indexes. A very simple derivative is a forward contract, i.e. an agreement between two parties in which the buyer agrees to buy from the seller, an underlying asset at a future date at a fixed price at the beginning. In this type of agreement, both parties specify the terms and conditions, such as when

and where delivery will take place and the identity of the underlying asset. Therefore, this contract is said to be customized.

Most projects involve contingent decisions, where management can change the course of the project by deciding whether to do certain actions, such as deciding the right time to do the investment, expand the project, or abandon the project among others. There is great strategic value imbedded in these decisions, which can be taken advantage only if management recognizes it and is willing to exercise them.

To capture the true value of a project in its assessment phase, the value of such decisions must be quantified. Otherwise, a project of great future strategic value may be rejected because it cannot compete with other projects in a portfolio based on its short-term value only.

4.2. OPTION PRICING.

An option is a contract between two parties, which provides the holder, with the right (but not the obligation) to buy (sell) a specified quantity of an underlying asset at a fixed price (strike price or exercise price) at or before the expiration date of the option. Simultaneously, the seller is implicitly obliged to sell (buy) such asset under the conditions agreed upon in the contract. Since it is a right but not an obligation, the holder can choose not to exercise the right and allow the option to expire. This is what distinguishes options from forwards and futures, where the holder has the obligation to buy or sell the underlying asset. Whereas there are not any costs to enter into a forward or future contract, there is a cost to obtaining the option which is called as premium.

A beneficial asymmetry is generated by the fact that since the owner has the right, but not the obligation to exercise the option, it will only be exercised in case the oscillation in the underlying asset price is favorable to its holder.

The underlying asset can be a financial asset (shares) or a real asset (gold, coffee, petroleum, etc.). Depending on the period of time when the option is exercised, we can find three types of options:

- **European Options:** European options cannot be exercised before the expiration date of the option contract.
- **American Options:** The option can be exercised at any time prior to its expiration date.
- **Exotic Options:** The option can be exercised on certain days prior to its expiration date.

European options are generally easier to analyze than American options, and some properties the American options have are often deducted from their European counterpart.

For a European option it will be the expectation value of the payoff at expiry discounted to the date the valuation is done for (given the interest rate, the price and the volatility of the underlying asset). Because an American option can be exercised at any time in the future prior to its expiration date, its value cannot ever be less than the payoff. An American option is more valuable than a European option because of the holder has an extra right embedded to exercise the option early if the conditions are favorable to him. But if the holder keeps the American option until expiration, its value is at least the same as a European option.

The valuation of American options is not easy because the asset price at which early exercise is optimal is not known in advance and has to be found in a simulation process. In this case, the Black-Scholes formula has to be solved with a moving boundary condition.

There are several methods to value American options, but among the most commonly used are the numerical procedures such as finite difference methods (Brennan & Schwartz, 1977), or the binomial tree (Cox, Ross, & Rubinstein, 1979). Because of its intuitive character and great flexibility, the binomial tree model explained in Chapter 7.3. is very used. On the other hand, as the tree is getting bigger and more precise, the method converge to the Black-Scholes' theoretical value of the option. However, (Figlewski & Gao, 1999) have demonstrated that the efficiency and precision of this model can be upgraded by modifying those regions where discretization produces the higher

valuation errors, to be more precise, where the value of the option is non-linear (as happens around the exercise price at expiration date).

For American options a solution of the Black-Scholes formula in general cannot be found analytically. The reason is that the point at which early exercise of the option at any time prior to its expiration date is optimal is not known in advance.

There are two kinds of options:

- **Call Options**: Call options are contracts that give the owner the right to buy the underlying asset in the future at an agreed price (strike price) at any time prior to the expiration date of the option. Calls have an expiration date and, depending on the terms of the contract, the underlying asset can be bought any time prior to the expiration date or on the expiration date. The buyer pays a price for this right. At expiration:
 - If the value of the underlying asset (S) > Strike Price (K), the buyer makes the difference: $S - K$.
 - If the value of the underlying asset (S) < Strike Price (K), the buyer does not exercise the option.

More generally:

- The value of a call increases as the value of the underlying asset increases.
- The value of a call decreases as the value of the underlying asset decreases.

$$C_T = \max(S_T - K, 0) \quad \text{(Equation 4.2.1.)}$$

Where:

- C_T : Call option value at the expiration date.
- T : The expiration date.
- S_T : The underlying asset price.
- K : The exercise price.

The expression shown in (Equation 4.2.1.) reflects the payoff to the holder of a long position in the European Call option. A European Call Option gives the holder the right (but not the obligation) to buy from the writer a certain asset for a prescribed price (exercise price or strike price) at a fixed time (expiration date) in the future. In the other side of the coin is the holder of a short position in the European Call whose payoff is shown in (Equation 4.2.2.).

$$-max(S_T - K, 0) = min(K - S_T, 0) \quad (\text{Equation 4.2.2.})$$

(Figure 4.2.a) shows how the call option value changes according to the price of the underlying asset at the expiration date. Plotting S_T on x-axis and C_T on the y-axis gives the payoff diagram.

- **Put Options:** Put options give the buyer of the option the right to sell the underlying asset at a fixed price at any time prior to the expiration date of the option. The buyer pays a price for this right. At expiration:
 - If the value of the underlying asset (S) < Strike Price (K), the buyer makes the difference: $K-S$.
 - If the value of the underlying asset (S) > Strike Price (K), the buyer does not exercise the option.

More generally:

- The value of a put decreases as the value of the underlying asset increases.
- The value of a put increases as the value of the underlying asset decreases.

$$P_T = max(K - S_T, 0) \quad (\text{Equation 4.2.3.})$$

Where:

- P_T : Put option value at the expiration date.
- T : The expiration date.
- S_T : The underlying asset price.
- K : The exercise price.

(Figure 4.2.b) shows how the value of the put option changes in relation to the underlying asset price at the expiration date.

The expression shown in (Equation 4.2.3.) reflects the payoff to the holder of a long position in the European Put option. A European Put Option gives the holder the right (but not the obligation) to sell to the writer a certain asset for a prescribed price (exercise price or strike price) at a fixed time in the future. On the contrary, there is the holder of a short position in the European Put whose payoff is shown in (Equation 4.2.4.).

$$-max(K - S_T, 0) = min(S_T - K, 0) \quad \text{(Equation 4.2.4.)}$$

A short selling means that we sell an asset that we do not own, with the intention of buying it back later. A short selling position over an asset requires first to borrowing it from someone who owns it, and gives it back later. Because we are assuming that there are not any transaction costs, the short seller is free to choose when to buy back and return the asset.

On the one hand, call options can be associated with an investment opportunity, on the other hand, put options may be viewed as an insurance policy because the holder of the option, who also owns the stock, can limit his losses. Thus, in case the stock value drops, the holder can exercise the option and sell the stock at a minimum price that has previously been predetermined as being suitable.

Regarding to the elements contained in the options contract, we can find the following:

- **The buyer (holder):** It is the agent who acquires the right to buy or sell through the acquisition the call or put option. The holder might make any of the following actions since he possess the option:
 - Not doing anything and the option will expire at its expiration date.
 - Exercise the option which means buy or sell the underlying asset.
 - Buy or sell the option.

- **The seller (writer):** The writer is the seller of the contract. When the writer of the contract sells it to the buyer, he collects a payment from the buyer and that's commonly referred to as the premium.
- **Underlying Asset:** Options are a form of derivative assets; which basically means they derive their value from an underlying asset. In an options contract the underlying asset is the asset which is specified in the transaction the holder has the right to carry out.
- **Exercise Price or Strike Price (K):** The strike price is the price at which the specified transaction is to be carried out at should the holder choose to exercise his option. Strike price is the term most commonly used, but it can also be known as the exercise price.
- **Expiration Date or Maturity:** The date on which the contract will expire. If the expiration date passes and the holder has not chosen to exercise their option, then the contract expires worthless.
- **Premium:** The price paid to acquire the option. There are two components to the options premium and they are intrinsic value and time value.

$$\text{Option Premium} = \text{Intrinsic Value} + \text{Time Value} \quad (\text{Equation 4.2.5.})$$

The intrinsic value is determined by the difference between the current trading price and the strike price. Only “In-the-money” options have intrinsic value and can be computed for by taking the difference between the current trading price and the strike price. On the contrary, “Out-of-the-money” options have no intrinsic value.

When we are dealing with real options, the intrinsic value is the difference between the underlying asset's price and the strike price.

$$\text{Intrinsic Value (Call)} = \text{Underlying Price} - \text{Strike Price} \quad (\text{Equation 4.2.6.})$$

$$\text{Intrinsic Value (Put)} = \text{Strike Price} - \text{Underlying Price} \quad (\text{Equation 4.2.7.})$$

By definition, the only options that have intrinsic value are those that are In-the-money. For calls, In-the-money refers to options where the strike price is less than the current underlying price. A put option is In-the-money if its strike price is greater than the current underlying price.

In-the-money (Call) $\rightarrow$ Strike Price $<$ Underlying Price (Equation 4.2.8.)

At-the-money (Call) $\rightarrow$ Strike Price $=$ Underlying Price (Equation 4.2.9.)

Out-of the-money (Call) $\rightarrow$ Strike Price $>$ Underlying Price (Equation 4.2.10.)

For calls, the payoff is $(S_T - K)$, if the option is “In the money” at maturity, but of course it is not the profit because the investor had had to pay the premium to acquire the option. (Figure 4.2.c.) shows how a mismatch between the exercise price and the equilibrium point is, due to the premium.

In-the-money (Put) $\rightarrow$ Strike Price $>$ Underlying Price (Equation 4.2.11.)

At-the-money (Put) $\rightarrow$ Strike Price $=$ Underlying Price (Equation 4.2.12.)

Out-the-money (Put) $\rightarrow$ Strike Price $<$ Underlying Price (Equation 4.2.13.)

For puts, the situation is the opposite as in calls, the payoff is $(K - S_T)$, if the option is “In the money” at maturity, but of course it is not the profit because the investor had had to pay the premium to acquire the option. (Figure 4.2.f.) shows how a mismatch between the exercise price and the equilibrium point is, due to the premium.

The time value of an option decreases as its expiration date approaches and becomes worthless after that date. This phenomenon is known as “time decay”. The time value represents the amount of time that the option position has to become more profitable due to a favorable move in the underlying price. In general, investors are willing to pay a higher premium for more time (assuming the different options have the same exercise price), since time increases the likelihood that the position can become profitable. The time value depends on the five following aspects:

- The remaining time until expiration. The greater the time until option’s expiration (keeping all other factors as constant), the greater the premium. This is because there is more time to increase its value.
- The volatility of the underlying asset. It indicates the variability in the underlying asset’s profitability. Ceteris Paribus conditions, the premium increase with the volatility.

- The relation between the exercise price and the market price. An option with a great intrinsic value need a greater investment and limits the advantage gained with the contract and, therefore, time value is not as significant in the premium anymore.
- Risk-free interest rate in the short term. Options investment has to compete with other kind of investments. It is normally to use the short term public debt as the interest rate. Because of the exercise price's NPV depends on the interest rate, the value of the option also depends on it.
- The supply and demand of the option.

Figure 4.2.a.: Premium paid by the buyer in the options contract.

Source: Author.

In (Table 4.2.a.), it can be seen how the value of an European and American call or put option vary when an increase in any of the factors involved in the contract occur under *ceteris paribus* conditions.

Table 4.2.a.: Effects on the Price of European and American CALL and PUT Options, When an Increase in any of the Factors Involved in the Contract Occur.

Factor	European CALL Option	European PUT Option	American CALL Option	American PUT Option
Volatility	Increase	Increase	Increase	Increase
Asset Price	Increase	Decrease	Increase	Decrease
Exercise Price	Decrease	Increase	Decrease	Increase
Expiration Date	Increase ¹⁷	Increase ¹⁸	Increase	Increase

^{17, 13} In contrast which what happens with American Call and Put Options where an increase on the expiration date turns the option more valuable, European Call and Put options do not necessarily behave the same way.

Factor	European CALL Option	European PUT Option	American CALL Option	American PUT Option
Risk-free Interest Rate	Increase	Decrease	Increase	Decrease
Dividends	Decrease	Increase	Decrease	Increase

Source: Author.

Regarding the (Equation 4.2.1.), the value of the Call Option at maturity will be the difference between the Asset Price (S_T) and the Strike Price (K); ($S_T - K$). Therefore, as the Asset Price increases, the Call Option becomes more valuable and less valuable as the Strike Price increases.

For Put Options, the situation is the opposite. Taking into account the (Equation 4.2.3.), as the Asset Price increases, the Put Option becomes less valuable and more valuable as the Strike Price increases.

Regarding the time to maturity (expiration date), both American Call and Put options become less valuable as the time to maturity approaches because the owner will have less opportunities that things turn favorable. In general, the more time to the expiration date of the option, the greater the time value of it because the price of the underlying asset has more time to change its value, and therefore the likelihood of the option to be “in the money” is larger.

As far as the volatility is concerned, it represents how uncertain is the movement of the underlying asset. As volatility increases, the chance that the underlying asset will do very well or the opposite increases. The volatility is highly related to the risk of the investment, and risky investments are often related to the possibility of obtaining higher returns. Because the owner of an option, only pays at the beginning the premium of the option and has the possibility to exercise the option if things go well, and not to exercise the options if things turn unfavorable. Similarly with Puts if the price decreases, the owner has limited upside risk in the event of the price increases. In option pricing models, the volatility for call options and put options with the same strike price and expiration date is the same.

Regarding to the Risk-free interest rate, as interest rate in the economy increases, the expected return required by investors from the stock tends to increase. In addition, the present value of any future cash flow received by the holder of the option decreases. The combined impact of these two effects is to increase the value of call options and decrease the value of put options (Hull J. , 2006).

The last but not least, dividends have the effect of reducing stock price when they are given to investors. Therefore, the value of a call option (Figure 4.2.b.) the day after dividends are given will decrease; but the value of a put option will be increased.

Options are traded both on exchanges markets and in the over-the-counter markets. If the option is listed on an organized market, exercise prices are prefixed and depend on the standardized quotes that are already established by the stock exchange. But if the option belongs to an over-the-counter (OTC) market, exercise prices are free and fixed between the parties involved in the contract. The over-the-counter market is an important alternative to exchanges and, measured in terms of the total volume of trading, has become much larger than the exchange-traded market.

A key advantage of the OTC markets is that the terms of a contract do not have to be those specified by a stock exchange market (Hull J. , 2006). Therefore, market participants are free to negotiate any deal between them. A disadvantage is that there is usually some credit risk in OTC trades. Credit risk has become a characteristic of OTC markets, because there is always the likelihood, remote or not, that a default from one party involved in the contract may occur.

Figure 4.2.b.: Value of a Call Option.

Source: Author.

Figure 4.2.c.: Profit to Calls Buyer (Long Call).

Source: Author.

If the option is “in the money” at maturity, the holder will exercise the option and therefore, the seller has the obligation to sell the underlying asset. (Figure 4.2.d.) shows the profit and losses of the seller.

Figure 4.2.d.: Profit and Losses to Calls Seller (Short Call).

Source: Author.

It may be observed that a call option only has value when the underlying asset price is higher than the exercise price. Both European and American call options can never be worth more than the underlying asset. Therefore, the present value of the underlying asset represents the upper boundary to the option price.

$$C_E \leq S_0 \text{ and } C_A \leq S_0 \quad (\text{Equation 4.2.14.})$$

Where:

- C_E : Value of European call option to buy one unit of the underlying asset.
- C_A : Value of American call option to buy one unit of the underlying asset.
- S_0 : The Present Value of the underlying asset.

If these relationships were not true, an arbitrageur¹⁹ could easily make a riskless profit by buying the underlying asset and selling the call option.

On the other hand are the put options. The circumstances where these kinds of options turn profitable are the opposite of those in which the call is profitable.

Figure 4.2.e.: Value of a Put Option.

Source: Author.

¹⁹ Arbitrage occurs when equivalent assets or combination of assets sell for two different prices. This situation creates an opportunity to profit at no risk with any commitment of money.

Figure 4.2.f.: Profit and Losses to Puts Buyer (Long Put).

Source: Author.

Figure 4.2.g.: Profit and Losses to Puts Seller (Short Put).

Source: Author.

In this case, the put option only has value when the underlying asset price is lower than the exercise price.

For American put options, the strike price represents the upper boundary of the value of the American put option.

$$P_A \leq K \quad (\text{Equation 4.2.15.})$$

Where:

- P_A : Value of American put option to sell one unit of the underlying asset.
- K : The Strike Price of the Option.

For European put options, it is known that at the expiration date the option will not be worth more than the strike price K . Therefore, it cannot be worth more than the present value of the strike price.

$$P_E \leq K \cdot e^{-r \cdot T} \quad \text{(Equation 4.2.16.)}$$

Where:

- P_E : Value of European put option to sell one unit of the underlying asset.
- K : The Strike Price of the Option.
- r : The continuously compounded risk-free rate of interest.
- T : Time to expiration of the Option.

If this relationship were not true, an arbitrageur could make a riskless profit by writing the option and investing the proceeds of the sale at the risk-free interest rate.

We have seen the upper limits both European and American calls and puts can reach without bringing the arbitrageurs the opportunity to make profits. Now, we are going to face with lower limits that these kinds of options can reach.

Considering the following portfolios:

Portfolio A: One European call option plus a zero-coupon bond that provides payoff K at time T .

Portfolio B: One share of the stock.

In portfolio A, the zero-coupon bond will be worth K at time T . If $(S_T > K)$, the investor will exercise the option at maturity and portfolio A is worth $[(S_T - K) + K = S_T]$. If $(S_T < K)$, the investor will not exercise the option because it is worthless and then portfolio A is worth K (the payoff provided by the zero-coupon bond). Therefore, at maturity, portfolio A is worth: $\max(S_T, K)$.

²⁰ If an investment grows according to a continuously compounded interest rate (r), then its value increases by a factor $e^{r \cdot T}$ over a time length (t).

In portfolio B, the rationale is easier. It will be worth S_T at time T . We can derive from last explanation that in absence of arbitrage, portfolio A worth more or equal to portfolio B (Equation 4.2.17.). The zero-coupon bond is worth $K \cdot e^{-r \cdot T}$ today.

$$C_E + K \cdot e^{-r \cdot T} \geq S_0 \quad (\text{Equation 4.2.17.})$$

$$C_E \geq S_0 - K \cdot e^{-r \cdot T} \quad (\text{Equation 4.2.18.})$$

Where:

- S_0 : The Current price of the stock.
- C_E : Value of European call option to buy one share.
- K : The Strike Price of the Option.
- r : The continuously compounded risk-free rate of interest.
- T : Time to expiration of the Option.

$$C_E \geq \max(S_0 - K \cdot e^{-r \cdot T}, 0) \quad (\text{Equation 4.2.19.})$$

Considering the following portfolios:

Portfolio A: One European put option plus one share.

Portfolio B: A zero-coupon bond that provides payoff K at time T .

In portfolio A, if $(S_T < K)$, the investor will exercise the option at maturity and portfolio A is worth $[(K - S_T) + S_T = K]$. If $(S_T > K)$, the investor will not exercise the option because it is worthless and then portfolio A is worth S_T (the price of the share at time T). Therefore, at maturity, portfolio A is worth: $\max(S_T, K)$.

In portfolio B, the rationale is easier. It will be worth K at time T (the payoff provided by the zero-coupon bond). We can derive from last explanation that in absence of arbitrage, portfolio A worth more or equal to portfolio B (Equation 4.2.20.). The zero-coupon bond is worth $K \cdot e^{-r \cdot T}$ today.

$$P_E + S_0 \geq K \cdot e^{-r \cdot T} \quad (\text{Equation 4.2.20.})$$

$$P_E \geq K \cdot e^{-r \cdot T} - S_0 \quad (\text{Equation 4.2.21.})$$

$$P_E \geq \max(K \cdot e^{-r \cdot T} - S_0, 0) \quad (\text{Equation 4.2.22.})$$

Where:

- S_0 : The Current price of the stock.
- P_E : Value of European put option to sell one share.
- K : The Strike Price of the Option.
- r : The continuously compounded risk-free rate of interest.
- T : Time to expiration of the Option.

4.3. PARAMETERS USED IN OPTIONS PRICING (THE GREEKS).

Because of sometimes options are tailor made in order to satisfy the needs of each different client and we cannot resort to standardized products traded in the market, it is difficult to hedge their exposure to risk. To solve this problem, we have to our disposal the “Greek letters”, or the “Greeks”. In option contracts, the Greeks are a series of handy variables that help explain the various factors that affect in the movement of options prices. Each Greek letter measures a different dimension to the risk in an option position and the aim of a trader is to manage the Greeks so that all risks are acceptable.

- **Delta (δ) – The hedge ratio:** Delta measures how much an option price is expected to change per unitary currency unit in the price of the underlying asset. As expiration approaches, the delta for In-the-money puts will approach -1 and delta for out-of-the-money puts will approach 0. That’s because if puts are held until expiration, the owner will both exercise the option and sell stock, or the put will expire worthless. For example, a Delta equals to 0.50 € means that the option’s price will theoretically move 0.50 € for every 1 € move in the price of the underlying asset or stock.
 - **Call Options:**
 - Have a positive Delta that can range from zero to 1.
 - At-the-money options usually have a Delta near 0.50.
 - The Delta will increase (and approach to 1) as the option gets deeper in the money.
 - The Delta of In-the-money call options will get closer to 1 as expiration approaches.

- The Delta of out-of-the-money call options will get closer to zero as expiration approaches.
- For a European call option over a stock which no pays dividends:

From the Black-Scholes formula, the Delta of a Call Option can be expressed according to (Equation 4.3.1.).

$$\Delta(\text{call}) = N(d_1) \quad (\text{Equation 4.3.1.})$$

Where:

- d_1 : $d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right) \cdot t}{\sigma \cdot \sqrt{t}}$.
- $N(x)$: The cumulative probability function for a variable with a standard normal distribution $N(0,1)$.
- (Equation 4.4.1.) is used for a long position (position to buy) in one call option. If we would like the equation for short positions (position to sell), we only have to change the right side of the equation for $-N(d_1)$.
 - Put Options:
 - Have a negative Delta that can range from zero to -1.
 - At-the-money options usually have a Delta near -0.50.
 - The Delta will decrease (and approach -1) as the option gets deeper in the money.
 - The Delta of In-the-money put options will get closer to -1 as expiration approaches.
 - The Delta of out-of-the-money put options will get closer to zero as expiration approaches.

For a European call option over a stock which no pays dividends:
From the Black-Scholes formula, the Delta of a Put Option can be expressed according to (Equation 4.3.2.).

$$\Delta(\text{put}) = N(d_1) - 1 \quad (\text{Equation 4.3.2.})$$

- Delta is negative, which means that a long position in a put option should be hedged with a long position in the underlying stock, and a short position in a put option should be hedged with a short position in the underlying stock.

If the premium of a call option (is the same with a put option) can be expressed as a function like:

$$C = f(S, E, r, t, \sigma) \quad (\text{Equation 4.3.3.})$$

Then δ can be analytically expressed as:

$$\delta_c = \frac{\partial C}{\partial S} > 0 \quad (\text{Equation 4.3.4.})$$

For a put option:

$$\delta_p = \frac{\partial P}{\partial S} < 0 \quad (\text{Equation 4.3.5.})$$

Where:

- C : The price of a call option.
- P : The price of a put option.
- S : The price of the underlying asset.
- E : The exercise price.
- r : Rate of return.
- t : Time until the expiration date.
- σ : Volatility.

Figure 4.3.a.: Variation of Delta with stock price for a Call Option.

Source: (Hull J. , 2006).

Figure 4.3.b.: Variation of Delta with stock price for a Put Option.

Source: (Hull J. , 2006).

(Figure 4.3.c.) shows how delta varies with the time to maturity for In-the-money, at-the-money and out-of-the-money call options.

Figure 4.3.c.: Variation of Delta with time to maturity for a Call Option.

Source: (Hull J. , 2006).

- **Gamma (Γ) – The rate of change of Delta:** Gamma measures the rate of change in an option's Delta per unitary currency unit change in the price of the underlying stock. Since a Delta is only good for a given moment in time, Gamma tells how much the option's Delta should change as the price of the underlying stock or index increases or decreases.

For a European Call or Put option on a non-dividend-paying stock, the Gamma can be expressed according to Black-Scholes-Merton formula as:

$$\Gamma = \frac{N'(d_1)}{S_0 \cdot \sigma \cdot \sqrt{T}} \quad (\text{Equation 4.3.6.})$$

Where:

- S_0 : The stock price at time $t=0$.
- d_1 : $d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2}) \cdot t}{\sigma \cdot \sqrt{t}}$.
- $N'(x)$: $N'(x) = \frac{1}{\sqrt{2\pi}} \cdot e^{-x^2/2}$, is the probability density function for a standard normal distribution.
- σ : Volatility.
- T : Time to expiration (years).

Figure 4.3.d.: Variation of Gamma with the Stock price.

Source: (Hull J. , 2006).

Figure 4.3.e.: Variation of Gamma with Time to maturity.

Source: (Hull J. , 2006).

For an at-the-money option, gamma decreases as the time to maturity increases. Short-life at-the-money options have very high gammas, which mean that the value of the option holder's position is highly sensitive to jumps in the stock price.

- **Theta (θ) – Time Decay:** Theta measures the change in the price of an option for a one-day decrease in its time to expiration. Since options lose value as expiration date approaches, Theta estimates how much value the option will lose, each day, *ceteris paribus* conditions.

For a European Call option on a non-dividend-paying stock, theta can be expressed according to Black-Scholes-Merton formula as:

$$\theta(call) = -\frac{S_0 \cdot N'(d_1) \cdot \sigma}{2\sqrt{T}} - r \cdot K \cdot e^{-r \cdot T} \cdot N(d_2) \quad (\text{Equation 4.3.7.})$$

Where:

- S_0 : The stock price at time $t=0$.
- d_1 : $d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2}) \cdot t}{\sigma \cdot \sqrt{t}}$.
- d_2 : $d_2 = d_1 - \sigma \cdot \sqrt{t}$.
- $N'(x)$: $N'(x) = \frac{1}{\sqrt{2\pi}} \cdot e^{-x^2/2}$, is the probability density function for a standard normal distribution.
- r : Risk-less interest rate corresponding to the life of the Option.
- K : The Strike Price of the Option.
- σ : Volatility.
- T : Time to expiration (years).
- $N(x)$: The cumulative probability function for a variable with a standard normal distribution $N(0,1)$.

For a European Put option on a non-dividend-paying stock, theta can be expressed according to Black-Scholes-Merton formula as:

$$\theta(put) = -\frac{S_0 \cdot N'(d_1) \cdot \sigma}{2\sqrt{T}} + r \cdot K \cdot e^{-r \cdot T} \cdot N(-d_2) \quad (\text{Equation 4.3.8.})$$

Where:

- $N(-d_2) = 1 - N(d_2)$.
- d_2 : $d_2 = d_1 - \sigma \cdot \sqrt{t}$.

Figure 4.3.f.: Time-Value Erosion.

Source: Schwab Center for Financial Research.

- **Rho (ρ) – Sensitivity to interest rates:** Rho measures the expected change in an option's price per 1% change in interest rates. It tells how much the price of an option should rise or fall if the risk-free interest rate increases or decreases.
 - As interest rate increase, the value of call options will generally increase.
 - As interest rate increase, the value of put options will generally decrease.
 - For these reasons, call options have positive Rho and put options have negative Rho.
 - Rho is not a huge factor in the price of an option, but should be considered if prevailing interest rates are expected to change.

For a European Call option on a non-dividend-paying stock, rho can be expressed according to Black-Scholes-Merton formula as:

$$\rho(call) = K \cdot T \cdot e^{-r \cdot T} \cdot N(d_2) \quad (\text{Equation 4.3.10.})$$

Where:

- S_0 : The stock price at time $t=0$.
- d_1 : $d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2}) \cdot t}{\sigma \cdot \sqrt{t}}$.
- d_2 : $d_2 = d_1 - \sigma \cdot \sqrt{t}$.
- $N'(x)$: $N'(x) = \frac{1}{\sqrt{2\pi}} \cdot e^{-x^2/2}$, is the probability density function for a standard normal distribution.

- r : Risk-less interest rate corresponding to the life of the Option.
- K : The Strike Price of the Option.
- σ : Volatility.
- T : Time to expiration (years).

$$\rho(\text{put}) = -K \cdot T \cdot e^{-r \cdot T} \cdot N(-d_2) \quad (\text{Equation 4.3.11.})$$

- **Vega or Kappa (K):** Vega measures the rate of in an option's price per 1% change in the implied volatility of the underlying stock. While Vega is not a real Greek letter, it is intended to tell you how much an option's price should move when the volatility of the underlying security or index increases or decreases.
 - Vega measures how the implied volatility of a stock affects the price of the options of that stock.
 - Volatility is one of the most important factors that affect the value of options.
 - Neglecting Vega can cause an overpay when buying options. All other factors being equal, when determining strategy, consider buying options when Vega is below normal levels and selling options when Vega is above normal levels.
 - A drop in Vega will typically cause both calls and puts to lose value.
 - An increase in Vega will typically cause both calls and puts to gain value.

For a European Call or Put option on a non-dividend-paying stock, vega (or Kappa) can be expressed according to Black-Scholes-Merton formula as:

$$K = S_0 \cdot \sqrt{T} \cdot N'(d_1) \quad (\text{Equation 4.3.12.})$$

Where:

- S_0 : The stock price at time $t=0$.
- d_1 : $d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2}) \cdot t}{\sigma \cdot \sqrt{t}}$.
- $N'(x)$: $N'(x) = \frac{1}{\sqrt{2\pi}} \cdot e^{-x^2/2}$, is the probability density function for a standard normal distribution.

- r : Risk-less interest rate corresponding to the life of the Option.
- K : The Strike Price of the Option.
- σ : Volatility.
- T : Time to expiration (years).

Figure 4.3.g.: Variation of Vega with the Stock price for an Option.

Source: (Hull J. , 2006).

4.4. FINANCIAL OPTIONS VALUATION.

4.4.1. THE BLACK & SCHOLES' MODEL.

This model relies on the assumption that any derivative asset that depends on the price of a stock which pays no dividends (a stock listed in a stock exchange market, or the present value of future cash flows of a project), shall comply with the partial differential equation of Black-Scholes, because we have created a portfolio consisting of the option and the asset.

We have to take into account that there is no arbitrage opportunity. This assumption is based on the fact that it is not possible to make a risk-free profit that gives a greater return than that provided by the interest from a bank deposit.

As any financial model, Black-Scholes option-pricing model is dependent on a set of assumptions. Some of them are employed in financial models such as (Sharpe, 1964), (Lintner, 1965) and (Mossin, 1966) Capital Asset Pricing Model (CAPM). The following assumptions should be fulfilled for the Black-Scholes model to be valid:

- Security markets are frictionless. There are no transaction costs, taxes and restrictions on security trading. Moreover, all securities are perfectly divisible and short selling allowed.
- There are no additional payments from the underlying asset (such as dividends) during the life of the option. Most companies pay dividends to their shareholders, so this assumption represents a limitation to the model considering that higher dividend yields involve lower call premiums.
- European exercise terms are used. European exercise term point out that the option can only be exercised on the expiration date. On the other hand, American exercise term allow the holder of the option to exercise his right at any time during the life of the option, making American options more valuable due to their greater flexibility.
- There are no riskless arbitrage opportunities. Therefore, there is never an opportunity to make a risk-free profit that gives a greater return than that provided by the interest from a riskless investment such as a bank deposit.
- Investors can borrow and lend at the same risk-free interest rate, which is constant during the life of the option. This risk-free interest rate is subject to changes; thereby this assumption is not real.
- Trading in asset market is continuous through time.
- Markets are efficient. This assumption suggests that people cannot consistently predict the direction of the market or an individual stock. The market operates continuously with share prices following a continuous Itô process.
- Price of the underlying asset has a lognormal distribution and evolves according to a Geometric Brownian Motion with continuous simple paths (there are no jumps in the process).
- Investors prefer more to less and agree on the function of underlying asset's variance σ^2 . This variance is considered to be constant.

The value of both call and put options in the Black-Scholes model can be written as follows:

$$C = S \cdot N(d_1) - K \cdot e^{-r \cdot t} \cdot N(d_2) \quad (\text{Equation 4.4.1.1.})$$

$$P = -S \cdot N(-d_1) + K \cdot e^{-r \cdot t} \cdot N(-d_2) \quad (\text{Equation 4.4.1.2.})$$

Where:

- C : The value of the call option.
- S : The Current Value of the underlying asset.
- K : The Strike Price of the Option.
- $N(x)$: The cumulative probability function for a variable with a standard normal distribution $N(0,1)$.
- t : Life to expiration of the Option.
- r : Risk-less interest rate corresponding to the life of the Option.
- d_1 : $d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2}) \cdot t}{\sigma \cdot \sqrt{t}}$.
- d_2 : $d_2 = d_1 - \sigma \cdot \sqrt{t}$.
- σ^2 : Variance in the Ln(value) of the underlying asset.

The element $e^{-r \cdot t}$ in (Equation 4.4.1.1.) is the present value factor and reflects the fact that the exercise price on the call option does not have to be paid until the expiration date. $N(d_1)$ and $N(d_2)$ elements are probabilities, estimated by using a cumulative standardized normal distribution and the values d_1 and d_2 obtained for an option.

In addition, it should be noted that the price of an option does not depend on the expected return of the underlying asset, aggregate supply of assets and risk preferences of investors, as neither of these variables appear in (Equation 4.4.1.1.), (Equation 4.4.1.2.), d_1 and d_2 . It is also necessary to emphasize that the preceding formulas are derived for European options only as American options can be exercised before the expiration date of the option.

(Merton, Theory of rational option pricing, 1973) showed that, if there is no additional payments during the lifetime of the option such as dividends in common stock case, then it is not rational for an investor to exercise an American option before the maturity day. Therefore, the (Black & Scholes, 1973) analysis can also be applied to evaluate American options on non-dividend paying common stocks. Moreover, (Merton, Theory of rational option pricing, 1973) modifies the (Equation 4.4.1.1.) and (Equation 4.4.1.2.) to account

for both American and European style options and stochastic interest rate. Finally, (Merton, 1976) and (Cox & Ross, 1976) modified the model for the underlying asset's price movements.

Black-Scholes-Merton equilibrium option-pricing model is a convenient and straightforward way for computing prices of European call and put options. However, the model has limitations because of the unrealistic assumptions described above. (Haug & Talleb, 2009) argued that violation of the assumptions associated with continuous trading, dynamic hedging and lognormal distribution of underlying assets' price exposes the model to risks of tail events. Events, which are considered to be highly improbable and do not have dear consequences.

4.4.2. PUT-CALL PARITY.

Before describing this important property of options, it is necessary to do the following assumptions:

- There are no arbitrage opportunities, i.e. no party can get a riskless profit.
- Borrowing and lending are possible at the risk-free interest rate $r_f > 0$ which is constant over time and is compounded continuously.
- There are no transaction costs, and no dividends are paid on stocks.

Considering the following portfolios:

Portfolio A: One European call option plus a zero-coupon bond that provides payoff K at time T .

Portfolio B: One European put option plus one share of the stock.

In portfolio A, the zero-coupon bond will be worth K at time T . If $(S_T > K)$, the investor will exercise the option at maturity and portfolio A is worth S_T , as it was explained in Section 4.2.. If $(S_T < K)$, the investor will not exercise the option because it is worthless and then portfolio A is worth K (the payoff provided by the zero-coupon bond). Therefore, at maturity, portfolio A is worth: $\max(S_T, K)$.

In portfolio B, if ($S_T < K$), the investor will exercise the option at maturity and portfolio B is worth K , as it was explained in Section 4.2.. But, if ($S_T > K$) then the option is worthless and portfolio B is worth S_T (the price of the share of the stock).

Table 4.4.2.a. summarizes the values of both portfolios at time T .

Table 4.4.2.a.: Values of Portfolios A and B at Maturity.

		$S_T < K$	$S_T > K$
Portfolio A	Call Option	$S_T - K$	0
	Zero-Coupon Bond	K	K
	Total Price	S_T	K
Portfolio B	Put Option	0	$K - S_T$
	Share of the Stock	S_T	S_T
	Total Price	S_T	K

Source: Author based on (Brealey, Myers, & Allen, 2010).

As it can be seen, the value of both portfolios at maturity is the same because both options are European and can only be held until the expiration date of the option. Therefore, they also have the same present value.

$$\text{Present Value Portfolio A: } C_E + K \cdot e^{-r \cdot T} \quad (\text{Equation 4.4.2.1.})$$

$$\text{Present Value Portfolio B: } P_E + S_0 \quad (\text{Equation 4.4.2.2.})$$

$$C_E + K \cdot e^{-r \cdot T} = P_E + S_0 \quad (\text{Equation 4.4.2.3.})$$

Where:

- C_E : European call option.
- P_E : European put option.
- S_0 : The price of the share of the stock at time $T = 0$.

The main conclusion obtained from (Table 4.4.2.a.) which is expressed in (Equation 4.4.2.3.) is the Put-Call parity, only applicable to European options.

The Put-Call parity states that for European Options, which asset does not pay dividends:

- The sale of a call option is equal to purchase a put option with the same exercise price and expiration, its corresponding underlying asset and borrow money for an amount equal to the actualized strike price. At the end of this process, the final result is null.
- The purchase of a put option is equal to buy a call option with the same exercise price and period of time, to sale the underlying asset and give money for an amount such that, at the expiration date, the sum of the principal and the obtained interests are equal to the strike price.

4.5. REAL OPTIONS THEORY.

Management decisions bring with them important consequences that can lead to failure as well as business success. But what is clear is that those management's decisions actually involve a great disbursement of funds from the firm. Therefore, it is very important to have adequate resources to assess the options every company has when they face capital investment decisions. In a strict sense, the real options approach is the extension of the theory of financial options to the valuation of options on real assets or projects. This approach is particularly appropriate in the context of strategic decision-making process and in the evaluation of investment opportunities under conditions of uncertainty²¹. It can be used as a tool that managers can apply in order to make strategic decisions in a capital investment environment. The real options approach can be viewed as an alternative calculation approach and provides additional calculation tool (Santos, Soares, Mendes, & Ferreira, 2014).

²¹ Islamic Financing is particularly sensitive to uncertainty. The existence of uncertainty in a contract, which is called *Gharar*, is prohibited and must be eliminated. In Islamic Finance, *Gharar* is known as a term describing risky or hazardous sales or transactions, where details concerning the operation are unknown or uncertain. *Gharar* is generally prohibited under Islam, which explicitly forbids trades that are considered to have excessive risk due to uncertainty. Accordingly, undertaking transactions with insufficient knowledge of the market or product and thereby incurring an excessive risk or interest is also forbidden. Therefore, the real options approach could be applied in this field and help this problem.

The DCF approach assumes a single decision pathway with fixed incomes and outcomes, and all decisions are made at the beginning. Therefore, once the analysis has been made, if the evolution of the environment that affects the project or the firm takes an unexpected twist, it is very difficult to vary the path that managers had adopted at the beginning. That is why we say that traditional assessment methods do not have to take into account managerial flexibility. On the other hand, the real options approach need to assume a multiple dynamic series of decisions, where management has the flexibility to adapt given a change in the business environment. Therefore, the total value of the project is given by the sum of the static value, and the value of the flexibility. Nevertheless, if the value of the real option is negligible, the use of traditional approaches is enough (Horn, Kjærland, Molnár, & Steen, 2015). This method is very worthy because management may adapt their decisions according to the evolution of uncertain events. Sometimes they will exercise the options, while on other occasions they will not, depending on new information. In that regard, (Mun, 2002) considers that the real options approach involves a learning model because as time goes by and new information becomes available (Lee, Lee, Kim, & Kim, 2013), uncertainty level decreases.

Traditional assessment methods take into account if benefits obtained by the investment are higher or lower than the associated costs of undertake it. However, the real options analysis considers all possible paths the management can follow prior to execute the investment and it is very useful under conditions of uncertainty.

(Dixit & Pindyck, 1994) stated that the option *“gives us the right (which we need not to exercise) to make an investment expenditure (the exercise price of the option) and receive a project (a share of stock) the value of which fluctuates stochastically”*. This statement gives us the importance of taking into account the presence of real options in project evaluation. But in order to apply the real options approach in project evaluation, we have to analyze previously if the underlying asset follows a stochastic process.

The analogy between financial and real options is imperfect, making the use of financial option valuation models problematic for real options (Bowman & Moskowitz, 2001). Exchange-traded options often have explicit features that strategic options do not have. These differences determine whether option valuation models are useful for

managerial decision-making process. By applying the real options theory to the decision-making process in projects, the most important assumption is related to the distribution of the underlying asset or stock price. In the Black-Scholes formula (Equation 4.4.1.1.) and (Equation 4.4.1.2.), the stock price is assumed to follow a lognormal distribution, with a constant level of volatility.

The real options approach takes into account more than one decision paths in project evaluation as a consequence of high uncertainty embedded in projects. This methodology takes the advantage of managerial flexibility in adopting the optimal strategy as new information becomes available, allowing the management to rectify their strategy under conditions of uncertainty. As information becomes available and uncertainty becomes resolved, management can choose the best strategies to implement. The real options approach is particularly appropriate when:

- Because of real options are used to assess contingent assets, this methodology is appropriate when the decision-making process depends on the evolution of future events over time. For example, when the decision to invest can be postponed, looking forward the evolution of the market.
- When disbursements can be made in phases. This may happen in R&D projects.
- When volatility affects project's cash flows. If there is no volatility, the only use of traditional approaches is perfectly valid. It is important to take into account that the greater the volatility, the larger the penalization we are introducing to the project if we only use traditional valuation methods. For example; we have the opportunity to invest, i.e. a call option to invest in the project, and it is a project with high volatility. Considering the (Equation 4.2.1.), if present value of the future cash flows is less than the investment, we are not going on because of the value of the option is equal to zero. But, because the volatility is high, the present value of the future cash flows could be greater than the investment; and the project turns into feasible. (Figure 4.5.b.) shows the effect of volatility (uncertainty) in the value of the project (Amram & Kulatilaka, 2000).

Figure 4.5.a.: When Does Real Options Provide Value?

Managerial Flexibility	High	Medium Option Value	High Option Value
	Low	No Option Value	Small Option Value
		Low	High
		Uncertainty	

Source: (Kodukula & Paupudesu, 2006).

Real options are natural consequences of circumstances created by real-world situations that provide the characteristics of irreversibility, uncertainty and possibilities of postponement. These characteristics make it possible to establish an analogy between an investment opportunity (real option) and a financial option (Table 4.5.a.). The exercise of the option (the investment) is irreversible, but the firm always has the possibility of preserving the value of its option (postponing the investment) until the market conditions are more favorable. Once this analogy has been established, it is possible to calculate the value of a real option using the same methods employed for determining the value of a financial option.

Table 4.5.a.: Analogy between Financial Options and Real Options.

<u>Real Option</u>	<u>Variable</u>	<u>Financial Option</u>
Present value of the future cash flows the real asset will generate.	S	Present value of the future cash flows the financial asset will generate.
Project investment cost / The abandonment value of the investment.	K	Option exercise price.
Time to expiration of the investment/abandonment opportunity.	t	Time to expiration of the option.
Underlying asset's operative risk: Volatility of the present value of future cash flows.	σ^2	Variance of the financial asset returns.

<u>Real Option</u>	<u>Variable</u>	<u>Financial Option</u>
Risk-free interest rate.	r_f	Risk-free interest rate.
Foregone cash flows for not undertaken the investment right now.	D	Underlying asset's dividend.

Source: Author based on (Rakić & Radenović, 2014).

An investment project has many similarities with an option to buy stock on the financial markets. Both imply a right, but not an obligation, to acquire an asset by paying a specific amount of money at a certain moment in the future, or before a certain moment in the future. The right to buy a stock is known as a call option; when the stock is actually acquired, it is said that the option is exercised. Similarly, the decision to invest (to buy an existing asset or to build a new one) can be treated as the exercise of a call option. Investment or expansion decisions are affected by both economic and technical uncertainty and therefore, by using the real options approach, management team will adapt the decision-making process to the real situation endowing the project with a high level of flexibility. Economic uncertainty is caused by factors that are external to the project and is generally represented by stochastic oscillations. Technical uncertainty is caused by internal factors, such as uncertainty regarding the production size and the project's performance as a result of the technologies employed. The managerial flexibilities that are built into projects give managers the freedom to make decisions such as to invest, to expand, temporarily shut down or abandon a given project.

Because of the decision-making process through conventional techniques; such as the NPV and the IRR explained in Sections 3.2. and 3.5.; does not take into account the managerial flexibility explained in last paragraph, a given project may perhaps be under-assessed and this may lead to irreversible decision-making errors. That's why consider managerial flexibility throughout the real options approach can maximize the investment opportunity value of the project. In addition, the real options approach can be applied as a way to mitigate risks and to increase the value of the project (Rakić & Radenović, 2014).

Figure 4.5.b.: The Value of Uncertainty.

Source: (Amram & Kulatilaka, 2000).

From a traditional point of view, the higher the level of uncertainty, the lower the value of a project. Under the real options approach, a higher level of uncertainty can mean a higher value of the project if managers identify and use their options to meet the future and sometimes unexpected evolution of events with flexibility. Options that are inherent to investments allow managers to reduce the exposure to bad results and increase the ability to exploit good results, as and when they occur, thereby increase the value of the investment project.

Real options can be used to design and manage strategic investments in an active way. An option provides the opportunity of taking a decision after watching how events develop. On the exercise date, if everything has happened as expected, one kind of decision will be taken, but if an unforeseen, or unlikely event has taken place, another decision can be taken. This means that the return obtained is not strictly linear, as it depends on the decision that is adopted. Non-linear returns can be a tool to reduce the exposure to uncertainty, and this is extremely useful for managers.

For each company, the decision-making process is usually developed in uncertain environments. Those decisions normally involve high costs, but they may also create high value to the shareholders. When a company faces up to investment projects, it is necessary to prioritize and study the feasibility of each project. That evaluation is carried out by the management of the company which has to deal with the dynamic nature of the marketplace that involves high degrees of flexibility. The analysis of real options adds value to the project thanks to the flexibility, which it is no possible to capture with

classical methods because they only deal with expected cash flows discounted at a constant rate, since they consider the risk to be constant throughout the entire life of the project. Because of these methods normally use intuitive discount rates; they are unsuitable for quantitative analyses. Therefore, because of there is a strong tendency to overvalue risk aversion, these methods tend to underestimate all projects.

4.6. HOW CAN REAL OPTIONS HELP TO MANAGEMENT THE DECISION-MAKING PROCESS.

Real options is a systematic approach and integrated solution using financial theory, economic analysis, management science, decision science, statistics and econometric modeling in applying options theory in valuing real physical assets in a dynamic and uncertain business environment where decision-making processes are flexible to determine strategic capital investment, valuing investment opportunities and project capital expenditures.

The value of capital investment depends upon the stream of future cash flows that a certain project can generate, but in most cases, those cash flows are uncertain.

Investment decisions normally involves choices about a variety of control opportunities such as when to invest (McDonald & Siegel, 1986), (Majd & Pindyck, 1987), (Lee, 1988) and (Pindyck R. , 1988); how to modify operating plans during a project's life (Stulz, 1982), (Johnson, 1987), (Kensinger, 1988) and (Triantis & Hodder, 1990) as well as whether to abandon a project or an investment in midstream (Robichek & Van Horne, 1967), (Bonini, 1977), (Kensinger, 1980) and (Myers & Majd, 1990).

As (Mun, 2002) estates, real options are important for the following decision-making processes:

- Identifying different corporate investment decision pathways or projects that management can deal with given a highly uncertain business conditions.
- Valuing each strategic decision pathway and what it represents in terms of financial viability and feasibility.

- Prioritizing these pathways or projects based on a series of qualitative or quantitative metrics.
- Optimizing the value of strategic investment decisions by assessing different decision paths under certain conditions or using a different sequence of pathways to lead to the optimal strategy.
- Timing the effective execution of an investment and finding the optimal trigger value and cost or revenue drivers.
- Managing existing or developing new optionalities and strategic decision pathways for future opportunities.

“Real options are useful for identifying, understanding, valuing, prioritizing, selecting, timing, optimizing and managing strategic business and capital allocation decisions” (Mun, 2002). Real projects have strategic options embedded with a very significant intrinsic value. Nevertheless, this intrinsic value is really worthy if management both identifies the options (Bérard & Perez, 2014) and decides to execute the strategies. We can assume that companies will tend to optimize the expenses and create value for the firm. Therefore, the real options theory relies on the principle that management is logical and competent, and that it acts in the best interests of the company and its shareholders through the maximization of wealth and minimization of risk and losses.

Whereas the DCF method is a deterministic model, the real options approach takes into account the change in the underlying asset value due to uncertainty over the life of a project. In any project, a range of possible outcomes over the life of a project may occur, as the uncertainty increases as a function of time. As a result, the range of asset values would take the shape of a curve, called the "cone of uncertainty" (Kodukula & Paupudesu, 2006) (Figure 4.6.a.). The cone of uncertainty reflects that uncertainty increases over time. Risk may or may not increase over time, whilst uncertainty does.

Figure 4.6.a.: The Cone of Uncertainty.

Source: (Kodukula & Paupudesu, 2006).

The real options approach accounts for this whole range of uncertainty using stochastic processes and calculates a "composite" options value for a project, considering only those outcomes that are favorable (i.e., exercising the option) and ignoring those that are not (letting the options expire). This assumes that the decision makers will always take the value-maximizing decision at each decision point in the project life cycle. The DCF method accounts for the downside of a project by using a risk-adjusted discount rate. On the other hand, the real options approach captures the value of the project for its upside potential by accounting for proper managerial decisions that would presumably be taken to limit the downside risk.

We have to take into consideration that the real options approach is a complementary tool used in project valuation. Therefore, when projects have very high Net Present Value, the information added by real options is negligible because the projects are already attractive for investment and the additional value that may be provided would not change the decision. Similarly, on projects with very low Net Present Values, the additional value provided by real options would not be relevant, since the investment decision would still be a "no go." As illustrated in (Figure 4.6.b.), real options offer the greatest value on projects with an Net Present Value close to zero (either positive or negative) and high certainty.

Figure 4.6.b.: Benefits of Real Options Analysis Relative to Net Present Value.

Source: (Kodukula & Paupudesu, 2006).

4.7. REAL OPTIONS IN MOTORWAY CONCESSION CONTRACTS.

In the field of transportation infrastructure, investment projects have some specific features, different to other types of investment. Generally speaking, infrastructure transportation projects have a high degree of uncertainty, they require an important amount of resources and are, to a large extent, irreversible. These features are clear in motorway concessions, where there is a wide potential for the application of the real options approach.

Real options arise in a natural way from the interpretation of the clauses established in the actual contracts of motorway concessions. After all, the real options approach contributes a valuation tool, and the terms of the options are embedded in the contracts that regulate rights and obligations for both contracting parties.

In the case of motorways, some of the existing or possible real options in the projects are as follows:

- Minimum traffic guarantees (traffic floors) or maximum traffic limitations (traffic caps).
- Public subsidies when traffic is lower than expected.
- Investment in new motorway stretches.
- Early abandonment of the concession.
- Anticipated reversion of the concession.

- Public participation loans.
- Extension of the concession period.

These mechanisms reduce cash-flow volatility, add flexibility to the project and allow a better management of the concession based on the occurrence of future events. Some of these mechanisms have been used one way or another in toll motorway programs in different countries. In Spain, for example, public participation loans have been granted in numerous motorway projects since 1996 (Vassallo & Sánchez Soliño, 2007).

The possible exercise of this series of rights represents an added value for the project which is not captured by the traditional procedures of valuation. So, the lack of an appropriate quantitative tool has prevented the effectiveness of these mechanisms from reaching their maximum potential. The habitual practice of calculating the net present value (NPV) of the project by means of the discount of cash flows, leads to erroneous results when the project incorporates certain flexibility. The main limitation of the NPV is that it assumes a static view of the investment project, without considering the value of possible decisions which may be made in the future and, subsequently, does not fully take into account changes in the variables that affect the project. On the other hand, the use of a decision tree technique, in combination with the NPV method, has an important drawback: the results depend on the discount rate used in the analysis, but, at the same time, the relevant discount rate depends on the options that are present in the project.

With respect to these limitations, some authors, such as (Myers S. , 1984) and (Kester, 1984), have suggested that investment analysis should benefit from the use of options valuation techniques, to take into account the true investment opportunities and eliminate the distance between financial theory and strategic planning. In other words, the NPV of projects, obtained through the traditional method, should be supplemented with the value of options that stem from strategic flexibility. In order to value these options in investment projects, the financial options theory can be used, when taking into consideration the following premises.

Samuelson's theorem (Samuelson, 1965) proved that the rate of return on any security follows a random walk, as long as investors have complete information about those cash

flows. This means that all the information about the expected future cash flows is already backed into the current stock price. The extension of these concepts for real assets markets would make it possible to consider an investment project as an asset with a value that follows a stochastic process similar to that of a financial asset.

(Copeland & Antikarov, 2001) have applied Samuelson's theorem to investment projects, and have concluded that, regardless of the pattern of cash flows that the project is expected to generate in the future, the variations of its present value will also follow a random walk. As a result, all the uncertainty sources of the project can be combined into one (the present value of the project), whose parameters can be estimated using a Monte Carlo simulation.

However, when the variable that generates uncertainty (in our case, the traffic on a motorway) itself follows a random walk, we can calculate the value of the derivative assets (the options) starting directly from the process followed by that variable, which is considered the underlying asset determining the value of the options. This procedure notably simplifies the calculation method.

Therefore, an essential assumption in the theoretical model adopted by analogy with the financial options theory is that traffic growth follows a random walk. This is equivalent to assuming that variations of traffic on a motorway can be modeled as a Geometric Brownian Motion (GBM):

$$\theta_t - \theta_{t-1} = \mu \cdot \theta_{t-1} \cdot \Delta t + \sigma \cdot \theta_{t-1} \cdot \Delta z \quad (\text{Equation 4.7.1.})$$

Or:

$$\frac{\theta_t - \theta_{t-1}}{\theta_{t-1}} = \mu \cdot \Delta t + \sigma \cdot \Delta z \quad (\text{Equation 4.7.2.})$$

Where:

- θ_t : Traffic Volume.
- μ : Traffic Growth Rate.
- σ : Traffic Volatility.

- Δz : Wiener process ($\Delta z = \xi_t \cdot \sqrt{\Delta t}$, where ξ_t is a normally distributed variable with zero mean and unit standard deviation (Dixit & Pindyck, 1994).

The (Equation 4.7.1.) could be expressed as follows:

$$d\theta = \mu \cdot \theta dt + \sigma \cdot \theta dz \quad (\text{Equation 4.7.3.})$$

Where:

- θ_t : Traffic Volume.
- μ : Traffic Growth Rate.
- σ : Traffic Volatility.
- dt : Differential Period of Time.
- dz : Increment of a Wiener process.

Starting from (Equation 4.7.3.), and applying Itô's lemma, we can find the process followed by the natural logarithm of θ (Itô, 1951):

$$d(\ln(\theta)) = \mu' \cdot dt + \sigma \cdot dz \quad (\text{Equation 4.7.4.})$$

Where is the natural logarithm of traffic and $\mu' = \mu - \frac{\sigma^2}{2}$.

On the right hand of (Equation 4.7.4.), the parameter is a constant drift term or growth parameter. It means that the logarithm of traffic has a growth of per unit of time. The assumption of a GBM (non-stationarity hypothesis) is frequently made for economic and financial variables. For stock prices, for example, this hypothesis is generally accepted, and it has been used for the development of the theory of option valuation, since the initial works carried out by (Black & Scholes, 1973) and (Merton, 1973). A GBM has also been applied for certain real variables. In the field of road traffic, this assumption has been made by (Zhao, Sundarajan, & Tsen, 2004) to analyze the decision-making process in motorway development, and by other authors (Rose, 1998; Irwin, 2003, 2007; Huang & Chou, 2006; Wei-hua & Da-Shuang, 2006; Lara Galera, 2006 and Lara Galera & Sánchez Soliño, 2010).

However, the GBM hypothesis is not always evident. (Pindyck & Rubinfeld, 1998), for example, have analyzed whether commodity prices follow this process. They found that, for very long time series (more than 100 years), detrended prices of crude oil and copper do not follow a random walk, but a mean-reverting process.

Given the relevance of this question for the application of the real options approach, (Cabero Colín, Sánchez Soliño, & Lara Galera, 2013) have performed a test for the hypothesis of a GBM for the evolution of traffic volume on motorways by use the series available for Spanish motorways, which, in most cases, cover a thirty-year period.

4.7.1. VALUATION OF NON-FINANCIAL UNDERLYING ASSETS.

Existing models used to value financial options are still valid when underlying assets are not financial, such as traffic, wind, sun radiation and so on. Nevertheless, it is necessary to make some adjustments before applying the models in order to be valid.

Consider an underlying asset (X) with financial characteristics, and this asset does not give any dividend, its returns follow a Geometric Brownian Motion such that:

$$dX = \mu' \cdot X \cdot dt + \sigma' \cdot X \cdot dz_t \rightarrow \frac{dX}{X} = \mu' \cdot dt + \sigma' \cdot dz_t \quad (\text{Equation 4.7.1.1.})$$

Where:

- X : The return of the underlying asset.
- μ' : Expected modification rate of the variable X per unit of time. This is the drift rate or the growth rate of the expected returns of the asset.
- σ' : The volatility measure.
- dz : A Wiener process $dz = \xi \cdot \sqrt{dt}$. And $\xi \in N(0,1)$.

In this kind of assets, the expected total capital gain μ , shall be correlated with the asset's risk, which is represented by the volatility.

Consider two assets f_1 and f_2 , whose value is a derivative of the underlying asset X and the time t , both of them follow a Geometric Brownian Motion described in (Equation 4.7.1.2.) and (Equation 4.7.1.3.). Therefore, $f_1 = f_1(X, t)$ and $f_2 = f_2(X, t)$.

$$df_1 = \mu_1 \cdot f_1 \cdot dt + \sigma_1 \cdot f_1 \cdot dz_t \quad (\text{Equation 4.7.1.2.})$$

$$df_2 = \mu_2 \cdot f_2 \cdot dt + \sigma_2 \cdot f_2 \cdot dz_t \quad (\text{Equation 4.7.1.3.})$$

If we build a portfolio consisted on $(\sigma_2 \cdot f_2)$ units of the first asset, and $-(\sigma_1 \cdot f_1)$ units of the second, we end up with a risk-less portfolio.

$$\pi = (\sigma_2 \cdot f_2) \cdot f_1 - (\sigma_1 \cdot f_1) \cdot f_2 \quad (\text{Equation 4.7.1.4.})$$

By differentiating the (Equation 4.7.1.4.): $d\pi = [(\sigma_2 \cdot f_2) \cdot f_1 - (\sigma_1 \cdot f_1) \cdot f_2] \cdot dt$, and substituting in (Equation 4.7.1.2.) and (Equation 4.7.1.3.):

$$d\pi = [\mu_1 \cdot (\sigma_2 \cdot f_2) \cdot f_1 - \mu_2 \cdot (\sigma_1 \cdot f_1) \cdot f_2] \cdot dt \quad (\text{Equation 4.7.1.5.})$$

Because π is a risk-less portfolio, its profitability in the time interval dt shall be equals to the risk-free rate of return. Therefore, (Equation 4.7.1.5.) turns into:

$$d\pi = r_f \cdot \pi \cdot dt = r_f \cdot [(\sigma_2 \cdot f_2) \cdot f_1 - (\sigma_1 \cdot f_1) \cdot f_2] \cdot dt \quad (\text{Equation 4.7.1.6.})$$

Where:

- r_f : The risk-free rate of return.

In order to both (Equation 4.7.1.5.) and (Equation 4.7.1.6.) have the same value, they shall comply with the following parity:

$$\mu_1 \cdot \sigma_2 - \mu_2 \cdot \sigma_1 = r_f \cdot (\sigma_2 - \sigma_1) \quad (\text{Equation 4.7.1.7.})$$

or:

$$\frac{\mu_1 - r_f}{\sigma_1} = \frac{\mu_2 - r_f}{\sigma_2} = \lambda \quad (\text{Equation 4.7.1.8.})$$

λ is known as the market price of the asset's (X) risk value. λ will also comply that for any derivative asset regardless of its nature, which value depends on X and the time t [$f_i = f_i(X, t)$].

$$\lambda = \frac{\mu_i - r_f}{\sigma_i} \rightarrow \mu_i - r_f = \lambda \cdot \sigma_i \quad (\text{Equation 4.7.1.9.})$$

The market price of X links the return with the derivative assets' risk which depends on X . The term $(\mu_i - r_f)$ can be interpreted as the expected surplus of return that is above the risk-free rate of return and shall be equal to $(\lambda \cdot \sigma_i)$.

Considering a derivative asset of X and t , such that: $f = f(X, t)$. If we differentiate it, we will have:

$$df = \frac{\partial f}{\partial t} \cdot dt + \frac{\partial f}{\partial X} \cdot dX + \frac{1}{2} \cdot \frac{\partial^2 f}{\partial X^2} \cdot (dX)^2 + \dots \quad (\text{Equation 4.7.1.10.})$$

If we suppose that the asset $f = f(X, t)$ follows a Geometric Brownian Motion, then it satisfies that:

$$df = \mu \cdot f \cdot dt + \sigma \cdot f \cdot dz_t \quad (\text{Equation 4.7.1.11.})$$

Following the (Equation 4.7.1.1.) and differentiating it, then we have:

$$\begin{aligned} (dX)^2 &= \mu^2 \cdot X^2 \cdot (dt)^2 + \sigma^2 \cdot X^2 \cdot (dz_t)^2 + 2 \cdot \mu \cdot \sigma \cdot X^2 \cdot dt \cdot dz_t = \\ &= \mu^2 \cdot X^2 \cdot dt \end{aligned} \quad (\text{Equation 4.7.1.12.})$$

By substituting (Equation 4.7.1.1.), (Equation 4.7.1.9.) and (Equation 4.7.1.12.) into (Equation 4.7.1.8.), then we have:

$$\mu \cdot f = \mu' \cdot X \cdot \frac{\partial f}{\partial X} + \frac{\partial f}{\partial t} + \frac{1}{2} \cdot \frac{\partial^2 f}{\partial X^2} \cdot \mu'^2 \cdot X^2 \quad (\text{Equation 4.7.1.13.})$$

$$\sigma \cdot f = \sigma' \cdot X \cdot \frac{\partial f}{\partial X} \quad (\text{Equation 4.7.1.14.})$$

By substituting (Equation 4.7.1.13.) and (Equation 4.7.1.14.) into (Equation 4.7.1.6.), then we have:

$$\frac{\partial f}{\partial t} + X \cdot \frac{\partial f}{\partial X} \cdot (\mu' - \lambda \cdot \sigma') + \frac{1}{2} \cdot \frac{\partial^2 f}{\partial X^2} \cdot \mu'^2 \cdot X^2 = r_f \cdot f \quad (\text{Equation 4.7.1.15.})$$

If we compare the (Equation 4.7.1.15.) with the Black-Scholes for an action which does not pay dividends, they both are similar. It satisfies that $(\mu' - \lambda \cdot \sigma') = r_f$. In the case that the asset pays a dividend (δ), the term $(\mu' - \lambda \cdot \sigma')$ shall be equal to $(r_f - \delta)$ in order to get the (Equation 4.7.1.15.) and the Black-Scholes to be the same.

When we deal with real assets, the (Equation 4.7.1.7.) does not necessary be satisfied, because the growth rate μ and the volatility σ do not necessarily have to be correlated

$$\mu' - \lambda \cdot \sigma' \neq r_f \quad (\text{Equation 4.7.1.16.})$$

Nevertheless, the (Equation 4.7.1.15.) can also be valid. If we consider the non-financial asset (X) pays a fictitious dividend equals to (δ) with satisfies:

$$\mu' - \lambda \cdot \sigma' = r_f - \delta \quad (\text{Equation 4.7.1.17.})$$

In general, every asset with depends on a non-financial asset (X) can be valued by adjusting the expected growth rate (μ), to $(\mu - \lambda \cdot \sigma)$, and then we can operate under a risk neutrality environment. The main issues comes from how to determine the market value of the asset (X). When there is historical information about the asset, the best and easiest way to determine the value of λ , is to resort to the Capital Asset Pricing Model:

As stated in (Equation 3.3.4.):

$$\begin{aligned} E(r_i) &= r_{rf} + \beta_i \cdot (E(r_m) - r_{rf}) \rightarrow \\ \rightarrow \mu &= r_f + \beta_i \cdot (r_m - r_f) \end{aligned} \quad (\text{Equation 4.7.1.18.})$$

$$\begin{aligned} \mu - r_f &= \beta_i \cdot (r_m - r_f) \rightarrow \lambda \cdot \sigma = \beta_i \cdot (r_m - r_f) \rightarrow \\ \rightarrow \lambda &= \frac{\beta_i \cdot (r_m - r_f)}{\sigma} \end{aligned} \quad (\text{Equation 4.7.1.19.})$$

Where:

- μ : Expected modification rate of the variable X per unit of time. This is the drift rate or the growth rate of the expected returns of the asset.
- r_m : The expected rate of return of the market.
- σ : The volatility measure of the asset.
- σ_m : Market's risk.
- β_i : Firm's or Project's beta with respect to the market. The company or project might magnify, or mitigate, the market's fluctuation. So everything else equal, the more that a company or project

magnifies the market fluctuation, the more return investors are going to require; and the more the company or project mitigate the market fluctuation, the less return that investors are going to require.

- r_f : The risk-free rate of return.

5. STOCHASTIC PROCESSES USED IN OPTIONS VALUATION.

In the study of random variables, when we include the presence of the deterministic variable, such as time, it is considered that the random variable depends on time. In other words, the random variable will depend on both the probabilistic phenomenon and time. In consequence, any function that is established in terms of the random variable, such as the distribution function or the density function, they will be also time dependent.

Since traffic is a variable that depends on time, this can be studied throughout stochastic processes. A certain variable follows a stochastic process when it changes in value over time, randomly. The theory of stochastic processes focuses on the study and modelling of systems that evolve along time, or space, according to non-deterministic laws, i.e. of randomness.

5.1. TYPE OF STOCHASTIC PROCESSES.

A stochastic process is a process in which a certain value changes over time in an uncertain way, i.e., we only know the distribution of the possible values of the process at any time point.

Stochastic processes can be classified as discrete or continuous in time and in space.

- **Discrete time:** It is the one in which the variable can change its value in specific moments of time.
- **Continuous-time:** It is the one in which the variable can change its value at any moment in time.
- **Discrete variable:** It is the one in which the variable can only take certain discrete values.
- **Continuous variable:** It is the one in which the variable can only take any real value.

A stochastic process is comprised by a set of random variables of the form $\{X_t: t \in T\}$, parametrized by a set " T ", called parametric space, whose values belong to a set " S ", called space statements. To the set $T \subset \mathbb{R}$ of sub-indices is called parametric set and it

can be continuous and numerable. It is called space statements "S", to the set of possible values that the random variable $\{X_t\}_{t \in \mathbb{R}}$ can take. It can take as parametric space the discrete set $T = \{0, 1, 2, \dots\}$, or the continuous set $T = [0, \infty)$. The former is known as a discrete time process and it will be written $\{X_n: n = 0, 1, \dots\} \rightarrow \{X_n: n \in \mathbb{N}\}$. Whereas the latter is known as a continuous time process, such that $\{X_t: t \geq 0\} \rightarrow \{X_t: t \in \mathbb{R}^+\}$.

A discrete-time stochastic process is one where the value of the variable can change only at certain fixed points in time and it can be expressed as $\{X_0 = x_0, X_1 = x_1, X_2 = x_2, \dots, X_{n-1} = x_{n-1}, X_n = x_n\}$. Discrete-time stochastic processes are mainly used for the calculation of probabilities of occupation of each state from the probabilities of change of state. Is, at a time $t = n - 1$, we are in the state x_{n-1} , the probability with which we will be in the state x_n at a time $t = n$ is $P = \left(X_n = x_n / X_{n-1} = x_{n-1} \right)$. This probability is called transition rate. And those probabilities that are expressed as $P = (X_n = x_n)$ are called state occupancy likelihood.

Another interesting type of probability is that which considers the likelihood of occupy a certain state at any time n , taking into account that since 0 to $n - 1$ it is known where the process was. This can be written as:

$$P = \left(X_n = x_n / X_0 = x_0, X_1 = x_1, \dots, X_{n-1} = x_{n-1} \right).$$

This probability depends on all over the previous process, while the transition probability depends only on the current state which occupies the process. This fact leads to introduce the following property:

- **Markov Property:** When the conditional probability distribution of future states of the process depends only upon the present state, not on the sequence of events that preceded it. It satisfies the following statement: $P =$

$$\left(X_n = x_n / X_0 = x_0, \dots, X_{n-1} = x_{n-1} \right) = \left(X_n = x_n / X_{n-1} = x_{n-1} \right)$$

Whereas a continuous-time stochastic process is one here changes can occur at any time. In a continuous-variable process, the underlying variable can take any value within a

certain range; whereas in a discrete-variable process, only certain discrete values are possible.

$$\mathbb{P}[a \leq X \leq b] = \int_a^b f(x)dx \quad (\text{Equation 5.1.1.})$$

Where:

- a, b : Constants where the random variable can take any value.
- X : A continuous random variable.
- $f(x)$: The probability density function.

$$\mathbb{P}[X \in S] = 1 \quad (\text{Equation 5.1.2.})$$

Where:

- X : A random variable.
- S : A finite countable set such that $S \subset \mathbb{R}$.

Stochastic processes involve random variables. A random variable “X” is a function that assigns a real value to each outcome in a sample space, called “S”.

A continuous time stochastic process with continuous sample paths which has the Markov property is called a diffusion process. To the simplest and most commonly used diffusion process is called the Brownian motion. In a continuous time stochastic diffusion model, the price behaves like a Brownian motion and it is not likely that the stock moves by a large amount over a short period of time, unless the stock has a very high volatility or something exogenous happens (such as a capital increase, renegotiations, debt restructuring, defaults and so on). But it is also possible for stock prices to suffer jumps, even if the time to maturity is very short. Therefore, there is a non-negligible probability that after a sudden change in the stock price the option will move from out-of-the-money to In-the-money.

From the financial engineering and risk management perspective, jumps allow quantifying and taking into account the risk of strong stock price movements over short time intervals. The stochastic processes with jumps that are most commonly used are the Poisson process and Cox process

5.2. WIENER PROCESS.

When we assess variables over time, they can change their value in an uncertain way, which is also called a stochastic process. As it was mentioned in Section 6.1., stochastic processes can be continuous or discrete in time and also in space. A Wiener process is a kind of Markov stochastic process²², $Z(t)$, in which random variables are normally distributed, i.e., a process with a mean equals to zero (0) and variance equals to one (1). The path followed by the variable in the past is not relevant and does not influence the probability distribution of the price at any particular time in the future. The variances of these normally distributed random variables increase to reflect that it is more uncertain to predict the value of the process after a long period of time. A variable Z follows a Wiener process if it has the two following properties:

- The change ΔZ during a small period of time Δt is:

$$\Delta z = \xi \cdot \sqrt{\Delta t} \quad (\text{Equation 5.2.1.})$$

Where ξ has a standardized normal distribution $N(0,1)$.

- The values of ΔZ for any two different short intervals of time, Δt , are independent.

In the limit $\Delta t \rightarrow 0$, Equation 6.2.1. can be written as:

$$dZ = \xi \cdot \sqrt{dt} \quad (\text{Equation 5.2.2.})$$

It follows from the first property that Δz has a normal distribution with mean equals to zero, standard deviation equals to $\sqrt{\Delta t}$, and variance equals to Δt .

The second property implies that Z follows a Markov process. Considering a change in the value of Z during a long period of time, T , this can be denoted by $Z(T) - Z(0)$. It can be regarded as the sum of the changes in Z in N small time intervals of length Δt , where $N = \frac{T}{\Delta t}$, thus:

²² In a Markov stochastic process, the likelihood of the state at any point in time in the future depends only on its present state, not on any past states. The next value is independent of the path the present value is obtained.

$$Z(T) - Z(0) = \sum_{i=1}^N \xi_i \cdot \sqrt{\Delta t} \quad (\text{Equation 5.2.3.})$$

where the ξ_i ($i = 1, 2, \dots, N$) are distributed $N(0,1)$.

It can be easily stated from the second property of Wiener process that the ξ_i are independent of each other.

The process described above has a drift rate of zero and a variance rate of 1, because of it is normally distributed $N(0,1)$. The drift rate is the mean change per unit of time for a stochastic process. We can also define the variance rate, which is the variance change per unit of time. The drift rate of zero means that the expected value of Z at any future time is equal to its current value. A variance rate equals to one (1) means that the variance of the change in z in a time interval of length T is equal to T .

A generalized Wiener process for a variable x can be described in terms of dz as follows:

$$dx = \alpha \cdot dt + \sigma \cdot dz \quad (\text{Equation 5.2.4.})$$

Where:

- α, σ : Constants. Where α describes the drift of the process, and σ represents the volatility or its variation.
- dz : The Wiener process.

The $\alpha \cdot dt$ term implies that x has an expected drift rate of α per unit of time. The term $\sigma \cdot dz$ can be regarded as adding noise or variability of the path followed by x . The amount of this noise is σ times a Wiener process. Because of a Wiener process has a standard deviation of 1, (Equation 5.2.4.) implies that the process followed by x has a standard deviation of σ .

The differential dz is a random variable with a mean 0 and variance equals to dt . According to the properties of a Wiener process, the values of dz for different times are independent.

5.3. CONTINUOUS DIFFUSION PROCESS.

The process used and developed in this dissertation is the Geometric Brownian Motion. Other stochastic processes such as the mean-reverting process or square root process are described in Annex II.

5.3.1. GEOMETRIC BROWNIAN MOTION (GBM).

Brownian motion is one of the most famous and fundamental continuous time stochastic processes. It is considered both a martingale and a Gaussian process. The formulation of this process was inspired by the physical phenomenon which is the irregular jiggling sort of movement exhibited by a small particle suspended in a fluid (Brown, 1828), named after the botanist Robert Brown who observed and studied it in 1827. A physical explanation of Brownian motion was given by Einstein, who analyzed Brownian motion as the cumulative effect of innumerable collisions of the suspended particle with the molecules of the fluid. The Brownian motion was originally used by L. Bachelier in 1900 in order to model the stock price movements (Klebaner, 1998).

Mathematically Brownian Motion B_t , $0 \leq t \leq T$, is a set of random variables, one of each value of the real variable t in the interval $[0, T]$. This collection has the following properties:

- B_t is continuous in the parameter t , with $B_0 = 0$.
- For each t , B_t is normally distributed with expected value 0 and variance t , and they are independent of each other.
- For each t and s , the random variables $B_{t+s} - B_s$ and B_s are independent. Moreover $B_{t+s} - B_s$ has variance t .

Before explaining how the Geometric Brownian Motion works, it is necessary to introduce some previous concepts. As it was explained in previous Sections, a Markov process is a kind of stochastic process where the path followed by the variable in the past is not relevant and does not influence the probability distribution of the variable at any particular time in the future. Therefore, the history of the process and the way that has

reached the current state is irrelevant. The expected value of a random variable x_t at time t , depends only in the previous value x_{t-1} .

An Arithmetic Brownian Motion (ABM) is a kind of stochastic process defined in terms of a Wiener process such that:

$$x_t - x_{t-1} = \Delta x = \mu \cdot \Delta t + \sigma \cdot \Delta z \quad (\text{Equation 5.3.1.1.})$$

Where:

- μ : Expected modification rate of the variable x per unit of time.
- σ : The volatility.
- Δz : A Wiener process $\Delta z = \xi \cdot \sqrt{\Delta t}$.
- $\sigma \cdot \Delta z$: This term of the equation disrupt the trend followed by $\mu \cdot \Delta t$, σ times the Wiener process Δz .

For a given period of time Δt , the growth in the random variable Δx is distributed according normal distribution with mean $\mu \Delta t$ and variance $\sigma^2 \Delta t$ ($\Delta x \approx N(\mu \Delta t, \sigma^2 \Delta t)$).

Because of Δz is a Wiener process, we know that it follows a normal probability distribution with mean 0 and variance Δt . Then Δx also follows a normal distribution with mean $\mu \Delta t$ and variance $\sigma^2 \Delta t$.

A Geometric Brownian Motion (GBM) is a stochastic process that follows:

$$x_t - x_{t-1} = \Delta x = \mu \cdot x_{t-1} \cdot \Delta t + \sigma \cdot x_{t-1} \cdot \Delta z \quad (\text{Equation 5.3.1.2.})$$

$$\frac{x_t - x_{t-1}}{x_{t-1}} = \mu \cdot \Delta t + \sigma \cdot \Delta z \quad (\text{Equation 5.3.1.3.})$$

Where:

- μ : Expected modification rate of the variable x per unit of time.
- σ : The volatility.
- Δz : A Wiener process $\Delta z = \xi \cdot \sqrt{\Delta t}$.
- $\sigma \cdot \Delta z$: This term of the equation disrupt the trend followed by $\mu \cdot \Delta t$, σ times the Wiener process Δz .

As it can be seen, the increment in the variable x divided by the variable in the last period of time, follows an Arithmetic Brownian Motion. The trajectories of a Wiener process are continuous but not differentiable. Therefore, in order to pass from a discrete time process to a continuous time process, it is necessary to do so by means of a tool called mathematical integral.

We can define a stochastic process whose increments depend on a Wiener process. An Itô process (which will be described in Section 6.5.) or diffusion process, is a Wiener process in which parameters μ and σ are functions of the variable itself and time ($\mu = f(x_t, t)$ and $\sigma = g(x_t, t)$) Equation 5.3.1.4.).

$$x_{t+1} - x_t = \Delta x = f(x_t, t) \cdot \Delta t + g(x_t, t) \cdot \Delta z \quad (\text{Equation 5.3.1.4.})$$

If we force the (Equation 5.3.1.4.) to tend to zero ($\Delta t \rightarrow 0$), it can be written in continuous time as:

$$dx_t = f(x_t, t) \cdot dt + g(x_t, t) \cdot dz \quad (\text{Equation 5.3.1.5.})$$

$$x_t = x_0 + \int_0^t f(x_t, t) \cdot dt + \int_0^t g(x_t, t) \cdot dz \quad (\text{Equation 5.3.1.6.})$$

Because of the process $y_t = \ln(x_t)$ follows an ABM in continuous time:

- $y_t = \ln(x_t) \rightarrow \frac{\partial y_t}{\partial t} = 0 ; \frac{\partial y_t}{\partial x_t} = \frac{1}{x_t} ; \frac{\partial^2 y_t}{\partial x_t^2} = -\frac{1}{x_t^2}$
- Applying the Itô's lemma:

$$\begin{aligned} dy_t &= \left[\mu x_t \frac{1}{x_t} + \frac{1}{2} \sigma^2 x_t^2 \left(-\frac{1}{x_t^2} \right) \right] dt + \frac{1}{x_t} \sigma x_t dz = \\ &= \left[\mu - \frac{1}{2} \sigma^2 \right] dt + \sigma dz \end{aligned} \quad (\text{Equation 5.3.1.7.})$$

As $y_t = \ln(x_t)$, then $x_t = e^{y_t}$. Therefore, x_t follows a log-normal distribution.

A Geometric Brownian Motion can also be described as:

$$dS_t = \mu \cdot S_t \cdot dt + \sigma \cdot S_t \cdot dz_t \quad (\text{Equation 5.3.1.8.})$$

$$\frac{dS_t}{S_t} = \mu \cdot dt + \sigma \cdot dz_t \quad (\text{Equation 5.3.1.9.})$$

Where:

- S_t : The value of the underlying asset at time "t".

The Exponential Brownian Motion can be described as:

$$\frac{dS_t}{S_t} = e^{\mu \cdot dt + \sigma \cdot dz_t} = e^{\mu \cdot dt} \cdot e^{\sigma \cdot dz_t} \quad (\text{Equation 5.3.1.10.})$$

The different paths followed by a Wiener process are continuous but not derivable, so it is necessary to use integration for the conversion from a discrete process to a continuous process, throughout the Itô's Lemma (Itô, 1951).

The process described in (Equation 5.3.1.9.) describes a GBM process, where μ is the drift rate, σ is the volatility and dz_t is the Wiener process.

Such that S_t and dS_t are lognormally distributed.

$$\ln\left(\frac{dS_t}{S_t}\right) \in N(\mu, \sigma) \quad (\text{Equation 5.3.1.11.})$$

If at time $t = 0$, $X(0) = 0$, then the expected value of the process followed by X at any time t is such that:

$$E[X(t)] = X_0 \cdot e^{\mu \cdot t} \quad (\text{Equation 5.3.1.12.})$$

and the variance of the process followed by X at any time t is:

$$V[X(t)] = X_0^2 \cdot e^{2 \cdot \mu \cdot t} \cdot (e^{\sigma^2 \cdot t} - 1) \quad (\text{Equation 5.3.1.13.})$$

In the continuous case where there is a drift parameter μ , the expected value then becomes:

$$E\left[\int_0^\infty X(t) \cdot e^{-r_f \cdot t} \cdot dt\right] = \int_0^\infty X_0 \cdot e^{-(r_f - \mu) \cdot t} \cdot dt = \frac{X_0}{r_f - \mu} \quad (\text{Equation 5.3.1.14.})$$

5.4. ITÔ'S LEMMA.

A further type of stochastic process is the Itô Process. This is a generalized Wiener process in which the parameters α and σ are functions of the value of the underlying variable x and time t .

$$dS = \alpha(x, t)dt + \sigma(x, t)dz \quad (\text{Equation 5.4.1.})$$

Where:

- α : The drift rate.
- σ : The standard deviation or volatility.
- dz : The Wiener process.

Both the expected drift rate and variance rate of an Itô process are liable to change over time. In a small interval between t and $(t + \Delta t)$, the variable changes from x to $(x + \Delta x)$.

$$\Delta x = \alpha(x, t)\Delta t + \sigma(x, t)\Delta z \quad (\text{Equation 5.4.2.})$$

From (Equation 5.4.2.) we can conclude that the drift rate of S is equal to $\alpha(x, t)$; and the variance rate is equal to $\sigma(x, t)^2$.

For a function $f(x, y)$ in which variables x and y satisfy the (Equation 5.4.3.).

$$df = \frac{\partial f}{\partial x} dx + \frac{\partial f}{\partial y} dy \quad (\text{Equation 5.4.3.})$$

However, we can have a function f which depends not only on a real variable t , but also on a stochastic process such as Brownian Motion. Suppose that $f = f(B_t, t)$, where B_t denotes Brownian Motion, the (Equation 5.4.3.) can be written as follows:

$$df = \frac{\partial f}{\partial t} dt + \frac{\partial f}{\partial B_t} dB_t \quad (\text{Equation 5.4.4.})$$

If we expand the function df using Taylor's formula, (Equation 5.4.4.) turns into:

$$df = \frac{\partial f}{\partial t} dt + \frac{\partial f}{\partial B_t} dB_t + \frac{1}{2} \cdot \frac{\partial^2 f}{\partial t^2} (dt)^2 + \frac{\partial^2 f}{\partial t \partial B_t} dt dB_t + \frac{1}{2} \cdot \frac{\partial^2 f}{\partial B_t^2} (dB_t)^2 + \text{higher other terms} \quad (\text{Equation 5.4.5.})$$

We discard all terms involving dt to a power higher than 1. Note that the term $dt dB_t$ has magnitude $(dt)^{3/2}$. This leaves the following expression for df .

$$df = \frac{\partial f}{\partial t} dt + \frac{\partial f}{\partial B_t} dB_t + \frac{1}{2} \cdot \frac{\partial^2 f}{\partial B_t^2} (dB_t)^2 \quad (\text{Equation 5.4.6.})$$

We next use the fact that $[(dB_t)^2 = dt]$ and write:

$$df = \left(\frac{\partial f}{\partial t} + \frac{1}{2} \cdot \frac{\partial^2 f}{\partial B_t^2} \right) dt + \frac{\partial f}{\partial B_t} dB_t \quad (\text{Equation 5.4.7.})$$

(Equation 5.4.7.) is called Itô's Lemma (Itô, 1951), and gives us the correct expression for calculating differentials of composite functions which depend on Brownian Motion.

Going back to the theory of option pricing described in Section 4.2., the value of any derivative asset can be calculated as the price of equilibrium of a contingent asset²³, $Q_i = Q_i(S, t)$ (Lara Galera & Sánchez Soliño, 2010), which depends on time and on one state variable S . Because of S follows a Wiener process as indicated in (Equation 5.3.1.8.). Therefore:

$$dQ_i = \left(\frac{\partial Q_i}{\partial S} \cdot \alpha_S \cdot S + \frac{\partial Q_i}{\partial t} + \frac{1}{2} \cdot \frac{\partial^2 Q_i}{\partial S^2} \cdot \sigma_S^2 \cdot S^2 \right) dt + \left(\frac{\partial Q_i}{\partial S} \cdot \alpha_S \cdot S \right) dz \quad (\text{Equation 5.4.8.})$$

Looking at the (Equation 5.4.8.) we can see that both the asset Q_i and the underlying asset S , share the same source of uncertainty which is dz . Therefore, we can create a riskless portfolio by choosing a certain amount of asset ($+\frac{\partial Q_i}{\partial S}$ units of asset) and a certain amount of derivative asset (-1 unit of derivative asset). We have a short position in one unit of derivative asset and a long position of $\frac{\partial Q_i}{\partial S}$ units of asset. Therefore, our riskless portfolio will be defined as it is shown in (Equation 5.4.9.).

$$\Pi = -Q_i + \frac{\partial Q_i}{\partial S} \cdot S \quad (\text{Equation 5.4.9.})$$

A differential change in the portfolio during a differential period of time will be defined as:

$$d\Pi = -dQ_i + \frac{\partial Q_i}{\partial S} \cdot dS \quad (\text{Equation 5.4.10.})$$

By substituting (Equation 5.3.1.8.) and (Equation 5.4.8.) in (Equation 5.4.10.) we have:

$$d\Pi = \left(-\frac{\partial Q_i}{\partial t} - \frac{1}{2} \cdot \frac{\partial^2 Q_i}{\partial S^2} \cdot \sigma_S^2 \cdot S^2 \right) dt \quad (\text{Equation 5.4.11.})$$

As we can see, (Equation 5.4.11.) does not have any term depending on the stochastic process dz . Therefore, we can assume that Π is a riskless portfolio during a differential

²³ A contingent asset is the one whose existence depends solely upon the occurrence of future events that cannot be controlled by the manager. Due to the uncertainty of future events, these assets are not placed on the balance sheet.

period dt . Moreover, because of there is no arbitrage opportunities, the portfolio will generate a riskless return during that differential period as it is shown in (Equation 5.4.12.).

$$d\Pi = r_f \cdot \Pi dt \quad (\text{Equation 5.4.12.})$$

Where:

- r_f : The risk-free rate of return.
- Π : The riskless portfolio shown in (Equation 5.4.9.).

By substituting (Equation 5.4.9.) and (Equation 5.4.11.) in (Equation 5.4.12.):

$$\left(-\frac{\partial Q_i}{\partial t} - \frac{1}{2} \cdot \frac{\partial^2 Q_i}{\partial S^2} \cdot \sigma_s^2 \cdot S^2\right) dt = r_f \cdot \left(-Q_i + \frac{\partial Q_i}{\partial S} \cdot S\right) dt$$

$$\frac{\partial Q_i}{\partial t} + r_f \cdot \frac{\partial Q_i}{\partial S} \cdot S + \frac{1}{2} \cdot \frac{\partial^2 Q_i}{\partial S^2} \cdot \sigma_s^2 \cdot S^2 = r_f \cdot Q_i \quad (\text{Equation 5.4.13.})$$

From (Equation 5.4.13.) we can conclude the conclusion that the asset Q_i depends on the risk-free rate of return, the volatility of the underlying asset and on the underlying asset itself. Therefore there is no drift neither uncertainty represented by the stochastic process dz .

5.5. THE LOG-NORMAL PROPERTY.

The Black-Scholes method described in Section 4.4.1. assumes that a percentage change in the stock price in a short period of time is normally distributed. By using Itô's Lemma to derive the process followed by $\ln(S)$ when S follows the process described in (Equation 5.3.1.8.). We define $G = \ln(S)$. Since $\frac{\partial G}{\partial S} = \frac{1}{S}$, $\frac{\partial^2 G}{\partial S^2} = -\frac{1}{S^2}$ and $\frac{\partial G}{\partial t} = 0$.

The process followed by G can be described as follows:

$$dG = \left(\mu - \frac{\sigma^2}{2}\right) \cdot dt + \rho \cdot dz \quad (\text{Equation 5.5.1.})$$

Where:

- μ : The expected rate of return.
- σ : The volatility of the underlying asset.

- ρ : The volatility followed by the process $G = Ln(S)$.
- dz : A Wiener process.

(Equation 5.5.1.) states that $G = Ln(S)$ follows a Wiener process with a constant drift rate $\left(\mu - \frac{\sigma^2}{2}\right)$ and variance rate ρ^2 . The change in $Ln(S)$ between time 0 and T is therefore normally distributed, with mean $\left(\mu - \frac{\sigma^2}{2}\right) \cdot T$ and variance $(\rho^2 \cdot T)$. This means that:

$$Ln(S_T) - Ln(S_0) \sim N \left[\left(\mu - \frac{\sigma^2}{2} \right) \cdot T, \rho \cdot \sqrt{T} \right] \quad (\text{Equation 5.5.2.})$$

Where:

- S_T : The value of the underlying asset at time "t=T".
- S_0 : The value of the underlying asset at time "t=0".

so that:

$$Ln \left(\frac{S_T}{S_0} \right) \sim N \left[\left(\mu - \frac{\sigma^2}{2} \right) \cdot T, \rho \cdot \sqrt{T} \right] \quad (\text{Equation 5.5.3.})$$

and

$$Ln(S_T) \sim N \left[Ln(S_0) + \left(\mu - \frac{\sigma^2}{2} \right) \cdot T, \rho \sqrt{T} \right] \quad (\text{Equation 5.5.4.})$$

A variable which has a lognormal distribution can take any value between zero and infinite as it is shown in (Figure 5.5.a.).

Figure 5.5.a.: Lognormal Distribution.

Unlike the Normal distribution, it is skewed so that the mean, median and mode are all different. According to (Equation 5.5.4.) and the properties of the lognormal distribution, the expected value of S_T is given by:

$$E(S_T) = (S_0) \cdot e^{\mu \cdot T} \quad (\text{Equation 5.5.5.})$$

Where:

- S_T : The value of the underlying asset at time "t".
- S_0 : The value of the underlying asset at time "t=0".
- μ : The expected rate of return.
- T : Time in the future.

And the variance is given by:

$$Var(S_t) = S_0^2 \cdot e^{2 \cdot \mu \cdot T} \cdot (e^{\sigma^2 \cdot T} - 1) \quad (\text{Equation 5.5.6.})$$

5.6. DICKEY-FULLER AND AUGMENTED DICKEY-FULLER APPROACHES.

When we analyze time series, it is very important to study the stationarity of data. On the one hand, we can say that a series with trend is "non-stationary" if it has a unit root. Moreover, we can also say that a series without trend is stationary if it does not have unit root.

A stochastic process $\{x_t : t = 1, 2, \dots\}$ is stationary, if for each set of temporary indices $(1 \leq t_1 \leq t_2 \leq \dots \leq t_m)$, the joint distribution $(x_{t_1}, x_{t_2}, \dots, x_{t_m})$ is the same as $(x_{t_1+h}, x_{t_2+h}, \dots, x_{t_m+h})$ for each $h \geq 1$.

A variable is non-stationary if its mean and its variance change over time. Therefore, the introduction of non-stationary variables in the estimation of regressions using ordinary least squares (OLS), leads to erroneous inferences. In this case, if the variables are non-stationary, the future estimate of the relationship between these variables must be based on the co-integration method. Given that the unit root test in time series is a condition on the existence of co-integration, the (Dickey & Fuller, 1979) test is the most widely used for this purpose.

The unit root analysis starts from the following equations:

Model without trend or drift:

$$\Delta Y_t = \beta \cdot Y_{t-1} + \varepsilon_t \quad (\text{Equation 5.6.1.})$$

Model with drift and without trend:

$$\Delta Y_t = \alpha + \beta \cdot Y_{t-1} + \varepsilon_t \quad (\text{Equation 5.6.2.})$$

Model with drift and deterministic trend:

$$\Delta Y_t = \alpha + \beta \cdot Y_{t-1} + ct + \varepsilon_t \quad (\text{Equation 5.6.3.})$$

Where:

- y_t : Random Variable.
- α : Intercept /drift.
- β : Constant Parameter.
- ε_t : White Noise.

A process is stationary if its mean and its variance are constant over time, and if the value of the covariance between two periods only depends on the distance between these two periods and not the moment in which it is measured. If the mean depends on time (non-stationarity in mean), is that the series has a deterministic trend or that the series is stationary around the trend. If the variance depends on time (non-stationarity in the variance) is said that the series has a stochastic trend. Stochastic trends can also be combined with deterministic trends, as in the case of a random walk with drift.

An example of a stationary process is the autoregressive process. Autoregressive processes are those that form a set of processes such that an observation depends on the previous observations. An Autoregressive process of order p , i.e. $AR(p)$, is a stochastic process $(Y_t)_{t \in \mathbb{Z}}$, which follows the following model:

$$Y_t = c + \phi_1 Y_{t-1} + \dots + \phi_p Y_{t-p} + a_t \quad t \in \mathbb{Z} \quad (\text{Equation 5.6.4.})$$

Where:

- Y_t : Random Variable.
- $c, \phi_1, \dots, \phi_p \in \mathbb{R}$: Constants.
- The process a_t is a white noise with variance σ^2 . The term a_t is also called “innovation” because of it represents the new information that appears every moment. If this term did not exist, the series would be deterministic.

- The present value of the series is a linear function of the previous values and the current innovation. Therefore it is said that the process can be expressed as a linear function of all previous innovations.

Nevertheless (Perron, 1989) showed that if there is a break, it leads to a bias that reduces the ability to reject the null hypothesis of a false unit root. To avoid this, (Perron, 1989) proposed to allow, where there is a structural exogenous break; the Augmented Dickey-Fuller (ADF) test.

The analysis of stationarity is used to avoid spurious regression, as a run-up to the analysis of co-integration. In order to perform the unit root (or non-stationarity) test of time series, we start from an autoregressive model $AR(1)$ like the following:

$$y_t = \alpha + \rho \cdot y_{t-1} + \varepsilon_t, \text{ where } |\rho| < 1 \quad (\text{Equation 5.6.5.})$$

Where:

- y_t : Random Variable.
- α : Intercept.
- ρ : Constant Parameter.
- ε_t : White Noise.

Subtracting the term y_{t-1} from both sides of (Equation 5.6.5.), we obtain:

$$y_t - y_{t-1} = \alpha + (\rho - 1) \cdot y_{t-1} + \varepsilon_t \quad (\text{Equation 5.6.6.})$$

In order to make the calculation easier, we can call $\beta = (\rho - 1)$, so (Equation 5.6.6.) can be written as follows:

$$y_t - y_{t-1} = \alpha + \beta \cdot y_{t-1} + \varepsilon_t \quad (\text{Equation 5.6.7.})$$

Then, we could try to estimate the parameter β by using Ordinary Least Squares (OLS), and calculating the t-statistic to test whether β is significantly different from 0. If we cannot reject the hypothesis that $\beta = 0$, then we say that the process has a unit root, and cannot reject that the variable y_t is non-stationary. However, if the true value of ρ is 1 ($\beta = 0$), then the OLS estimator of ρ is biased towards zero (Pindyck & Rubinfeld, 1998). Then the use of OLS could lead us to incorrectly reject the non-stationarity hypothesis.

To solve this problem, (Dickey & Fuller, 1979), (Dickey & Fuller, 1981) used a Monte Carlo simulation to calculate the correct critical values for the distribution of the t-statistic when $\rho = 1$.

Additionally, other authors have obtained these critical values, such as MacKinnon (MacKinnon, 1990), (MacKinnon, 2010).

Table 5.6.a.: MacKinnon's Critical Values.

MACKINNON'S CRITICAL VALUES			
N (Sample Size)	1%	5%	10%
5	-5.6046	-3.6949	-2.9828
10	-4.2971	-3.2127	-2.7477
15	-3.9591	-3.0810	-2.6810
20	-3.8085	-3.0207	-2.6504
25	-3.7241	-2.9862	-2.6326
30	-3.6701	-2.9640	-2.6210
35	-3.6329	-2.9484	-2.6129
40	-3.6056	-2.9369	-2.6069
45	-3.5847	-2.9281	-2.6022
50	-3.7896	-2.9212	-2.5986

Source: (MacKinnon, 1990) and (MacKinnon, 2010).

If the t-statistic obtained in our estimation is greater than the critical value, we cannot reject the null hypothesis, $\beta = 0$, and we cannot reject that the traffic time series is non-stationary.

In this kind of test, we assume that there is no serial correlation in the error term ε_t . However, the process described before could be non-stationary, even when serial correlation exists. So, the same authors (Dickey & Fuller, 1979), (Dickey & Fuller, 1981), proposed an extended method which is known as Augmented Dickey-Fuller test (ADF). In this test, the model is expanded by adding the lagged dependent variable to the right side of the equation. Therefore, (Equation 5.6.1.), (Equation 5.6.2.) and (Equation 5.6.3.) become:

Model without trend nor drift:

$$\Delta Y_t = \beta \cdot Y_{t-1} + \sum_{j=1}^m \lambda_j \cdot \Delta y_{t-1} + \varepsilon_t \quad (\text{Equation 5.6.8.})$$

Model with drift and without trend:

$$\Delta Y_t = \alpha + \beta \cdot Y_{t-1} + \sum_{j=1}^m \lambda_j \cdot \Delta y_{t-1} + \varepsilon_t \quad (\text{Equation 5.6.9.})$$

Model with drift and deterministic trend:

$$\Delta Y_t = \alpha + \beta \cdot Y_{t-1} + ct + \sum_{j=1}^m \lambda_j \cdot \Delta y_{t-1} + \varepsilon_t \quad (\text{Equation 5.6.10.})$$

Where:

- y_t : Random Variable.
- α : Intercept /drift.
- β : Constant Parameter.
- ε_t : White Noise.
- Where λ_j represents the m parameters obtained in the regression analysis between the dependent variable Δy_t and the same dependent variable with a lag of j periods.

The more general ADF equation is the (Equation 5.6.10.), which has the following sub-models:

Table 5.6.b.: Variants of the ADF Test with Drift and Deterministic Trend.

Model (1)	$\alpha = 0, \beta = 0, c = 0$	Unit Root, no trend
Model (2)	$\alpha = 0, \beta < 0, c = 0$	Stationarity around zero equilibrium.
Model (3)	$\alpha \neq 0, \beta = 0, c = 0$	Unit Root with drift
Model (4)	$\alpha \neq 0, \beta < 0, c = 0$	Stationarity around constant nonzero equilibrium
Model (5)	$\alpha \neq 0, \beta = 0, c \neq 0$	Unit Root around a deterministic time trend
Model (6)	$\alpha \neq 0, \beta < 0, c \neq 0$	Trend stationary

Source: Author.

Because of the explosivity of the Model (5) and the unlikelihood of the Model (2) when we have a stationary process around the exact zero balance, (Elder & Kennedy, 2001)

propose that these two models can be rejected as eligible. Therefore we can choose between models (1), (3), (4) and (6). By analyzing these four models we can conclude that Models (1) and (4) do not generate a trend in the variable, whereas Models (3) and (6) do. Because traffic time series show a trend over time, we can reject Models (1) and (4). Nevertheless, as it can be seen in traffic graphs, the traffic evolution over time does not always grow as the years go by. Whereas Model (6) refers to a deterministic trend ($c \neq 0$) and it is trend stationary; Model (3) refers to a stochastic trend. Therefore, Model (3) fits better with the case study.

There have been performed several studies about the behavior of the Dickey-Fuller test when the variable under study is influenced by a jump in their average values (Montañés Bernal, 1997); concluding that from an asymptotic point of view, the Dickey-Fuller tests are not altered by the presence of a change in average levels of the variables.

Therefore Augmented Dickey-Fuller test is conceptually useful as a possible fix for of autocorrelation problems which might appear in the error term for the basic model used in the simple Dickey-Fuller test. For that reason, the Augmented Dickey-Fuller is the one selected to perform the unit root test.

5.6.1. THE APPLICATION OF THE MODEL TO SPANISH MOTORWAY NETWORK. THE FIRST GENERATION SPANISH MOTORWAYS.

Spanish Motorways have been analyzed in order to verify that traffic follows a Geometric Brownian Motion. In the study, the main motorways in Spain, both toll motorways and free ones have been under study. Data have been taken from the concessionaries (in the case of toll motorways) and from the traffic maps published by the Spanish Ministry of Public Works (in case of free motorways).

The Annual Average Daily Traffic (AADT) in each motorway in order to avoid the seasonality problem in traffic volumes have been used for the research.

In order to perform the Augmented Dickey-Fuller test, the following formulas are used:

$$y_t = \ln(\theta_t) \quad \text{(Equation 5.6.1.1.)}$$

$$\Delta y_t = \ln \left(\frac{\theta_t}{\theta_{t-1}} \right) \quad (\text{Equation 5.6.1.2.})$$

Where:

- θ_t : The traffic volume in the year t in terms of AADT.

With these considerations, equations (Equation 5.6.1.1.) and (Equation 5.6.1.2.) take the form:

$$\ln(\theta_t) = \alpha + \rho \cdot \ln(\theta_{t-1}) + \varepsilon_t \quad (\text{Equation 5.6.1.3.})$$

$$\ln(\theta_t) = \alpha + \rho \cdot \ln(\theta_{t-1}) + \sum_{j=1}^m \lambda_j \Delta \ln(\theta_{t-j}) + \varepsilon_t \quad (\text{Equation 5.6.1.4.})$$

By applying a regression analysis, using Ordinary Least Squares (OLS) to obtain the estimation of the parameter β and the t-statistic for that estimation. We have used the software “Eviews 7” in order to perform the analysis.

Out of the twenty seven toll motorways existing in Spain, it has been analyzed only those ones where traffic time series are long enough (around thirty years). The results are shown in (Table 5.6.1.a.).

Table 5.6.1.a.: Results of the Unit Root Test for Toll Motorways’ Traffic Time Series.

Motorway	Augmented Dickey-Fuller test Statistic		Critical Value	Durbin-Watson Test (**)		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
MONTMELÓ - LA JONQUERA (A-7)	-1.743995	0.4019 (higher than a significance level of 5%)	-2.938987	1.809364	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($d_u < d < 4-d_u$). Therefore, there is no auto-correlation.
BARCELONA - TARRAGONA (A-7)	-2.143868	0.2295 (higher than a significance level of 5%)	-2.941145	2.023702	2	
MONTMELÓ - PAPIOL (A-7) (*)	-0.815183	0.7980 (higher than a significance level of 5%)	-2.981038	1.872525	2	
ZARAGOZA - MEDITERRÁNEO (A-2)	-2.116113	0.2397 (higher than a significance level of 5%)	-2.941145	2.396744	0	

Motorway	Augmented Dickey-Fuller test Statistic		Critical Value	Durbin-Watson Test (**)		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
VILLALBA - ADANERO	-1.076521	0.7154 (higher than a significance level of 5%)	-2.938987	2.033510	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
SEVILLA CÁDIZ	-0.903439	0.7766 (higher than a significance level of 5%)	-2.938987	1.821353	1	
TARRAGONA - VALENCIA	-1.802892	0.3737 (higher than a significance level of 5%)	-2.938987	1.736541	1	
VALENCIA - ALICANTE	-1.703073	0.4215 (higher than a significance level of 5%)	-2.943427	1.804958	1	
FERROL - FRONTERA PORTUGUESA	-1.781624	0.3829 (higher than a significance level of 5%)	-2.951125	1.880777	1	
BILBAO - ZARAGOZA	-1.41716	0.5639 (higher than a significance level of 5%)	-2.948404	1.865817	1	
BURGOS - ARMIÑÓN	-1.894472	0.3310 (higher than a significance level of 5%)	-2.948404	2.009365	1	
LEÓN - CAMPOMANES	-2.481725	0.1301 (higher than a significance level of 5%)	-2.967767	2.012497	2	
Note: The higher the difference between the p-value and 0.05; the higher the likelihood to make a mistake if we reject the null hypothesis.						
(*) Because of the traffic time series present an important break between the years 1985 and 1986, it produces a bias to the rejection of the null hypothesis of existence of unit root. It is not normal a 272.74% traffic growth in one year. Therefore, there has been analyzed a traffic time series for the period from 1986 to 2014 (29 years) for this motorway.						
(**) The Durbin-Watson (D-W) test has been used in order to check if the number of lags adopted by the Augmented Dickey-Fuller test is correct. Durbin-Watson test is fully explained in Section 6.8.						

Source: Author.

The unit root analysis for toll motorways has been performed with those which have a traffic time series of more than thirty years. According to the results obtained by using the “Eviews 7” software, we cannot reject the null hypothesis of unit root. Therefore, we cannot reject the hypothesis that the traffic behaves like a Geometric Brownian Motion

(GBM) in toll motorways. To give more consistency to the study, the correlogram of each motorway has been obtained, which are shown in Annex III. As may be seen, the decrease in all correlograms is low and almost constant, which is a signal of non-stationarity.

For toll-free Spanish motorways, data have been taken from traffic maps published by the Spanish Ministry of Public Works between 2000 and 2014, starting from the vehicles counting devices (stations) installed along the corridors.

Due to the fact that a lot of stations have changed their category (secondary to primary or primary to permanent), and their location as well, it has been necessary a research work for all the stations along the years.

Once all data were collected, a lot of stations did not have complete traffic time series. Because of that, only those stations with complete traffic time series were considered. The following toll-free motorways were analysed:

- A-1 Motorway.
- A-2 Motorway.
- A-3 Motorway.
- A-5 Motorway.
- A-6 Motorway

The results for the A-1 Motorway are shown in (Table 5.6.1.b.). Each station is named after the distance (in Kilometres) to the origin of the road (column Kilometre Point). There have been removed those automatic traffic recorders located at the entrance and at the exit of the city of Burgos due to their great levels of volatility because of internal journeys maybe.

Table 5.6.1.b.: Results of the Unit Root Test for A-1 Motorway Traffic Time Series.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic (*)	Lags	
P.K. 32.00	-1.132236	0.6930 (higher than a significance level of 5%)	-2.941145	2.065974	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
P.K. 98.40	-3.210962	0.0247 (lower than a significance level of 5%)	-2.916566	2.243836	0	ADF t-statistic is lower than 5% Mackinnon critical value. Therefore we reject the null hypothesis of unit root. However, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
P.K. 101.00	-2.331261	0.1703 (higher than a significance level of 5%)	-2.981038	2.301472	0	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
P.K. 108.00	-2.085514	0.2516 (higher than a significance level of 5%)	-2.986225	2.035811	1	
P.K. 135.90	-1.314306	0.6130 (higher than a significance level of 5%)	-2.941145	1.917838	1	
P.K. 199.00	-2.222727	0.2039 (higher than a significance level of 5%)	-2.991878	2.04137	1	
P.K. 205.60	-1.916062	0.3200 (higher than a significance level of 5%)	-2.986225	2.163144	1	
P.K. 230.90	-1.408811	0.5617 (higher than a significance level of 5%)	-2.986225	1.806177	1	
P.K. 235.10	-1.165365	0.6710 (higher than a significance level of 5%)	-2.998064	2.092688	3	
P.K. 277.90	-2.517315	0.1235 (higher than a significance level of 5%)	-2.986225	1.976069	1	

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic (*)	Lags	
P.K. 295.50	-2.820726	0.0648 (higher than a significance level of 5%)	-2.941145	1.973468	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
Note: The higher the difference between the p-value and 0.05; the higher the likelihood to make a mistake if we reject the null hypothesis.						
(*) The Durbin-Watson (D-W) test has been used in order to check if the number of lags adopted by the Augmented Dickey-Fuller test is correct. Durbin-Watson test is fully explained in Section 6.8.						

Source: Author.

In this motorway only in the automatic traffic recorder located at the Kilometre point 98.40 the result of the analysis is that we can reject the null hypothesis of the existence of a unit root. As we can see in (Figure 5.6.1.a.) the traffic time series has a growing trend until the year 2006, when the trend is broken and begins to decrease. This fact can affect the results. Nevertheless, in ten (10) out of eleven (11) of the automatic traffic recorders analysed the hypothesis of existence of unit root cannot be rejected. Therefore, we cannot reject the hypothesis that the traffic behaves like a Geometric Brownian Motion (GBM) in the A-1 motorway.

Figure 5.6.1.a.: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 98.40 on the A-1 Motorway.

Source: Author.

In order to compare the Volatility of Each Automatic Traffic Recorder, the same period of time shall be considered, in most cases values are separated from the mean value (10.93%). The automatic traffic recorder (TGS) located at Kilometre points 230.86 (at this kilometre point, the road N-234 connects with the motorway, so this fact can be affecting to this great value of the volatility) and 277.90; are the furthest away from the mean value. These volatilities are medium to high (17.11% and 16.94% respectively). If we analyse the whole motorway and take the average traffic as the homogeneous one, the volatility drops a little to 9.61% for the A-1 motorway.

Table 5.6.1.c.: Volatility of Each Automatic Traffic Recorder for A-1 Motorway.

	Years	Volatility	GMG	AMG
K.P. 32.00	26	6.17%	2.30%	3.80%
K.P. 98.40	26	10.60%	1.32%	3.43%
K.P. 101.00	26	8.28%	3.70%	4.20%
K.P. 108.00	26	7.93%	2.63%	3.02%
K.P. 135.90	26	11.76%	1.59%	3.21%
K.P. 199.00	26	13.35%	1.16%	1.99%
K.P. 205.60	26	12.44%	1.35%	2.13%
K.P. 230.86	26	17.11%	2.79%	4.44%
K.P. 277.90	26	16.94%	0.12%	1.52%
K.P. 295.50	26	4.68%	0.04%	0.17%
Average		10.93%	1.70%	2.79%

Source: Author.

Figure 5.6.1.b.: Volatility of Each Automatic Traffic Recorder for A-1 Motorway.

Source: Author.

The results for the A-2 Motorway are shown in (Table 5.6.1.d.).

Table 5.6.1.d.: Results of the Unit Root Test for A-2 Motorway Traffic Time Series.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic (*)	Lags	
K.P. 35.90	-0.835017	0.7978 (higher than a significance level of 5%)	-2.938987	2.191302	0	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 47.00	-2.248817	0.1953 (higher than a significance level of 5%)	-2.986225	1.814255	1	
K.P. 116.20	-1.235608	0.6485 (higher than a significance level of 5%)	-2.943427	1.969696	2	
K.P. 148.10	-2.379174	0.1573 (higher than a significance level of 5%)	-2.986225	1.949827	1	
K.P. 190.60	-2.526934	0.1214 (higher than a significance level of 5%)	-2.986225	2.065755	1	
K.P. 229.00	-2.548381	0.1104 (higher than a significance level of 5%)	-2.919952	2.003791	3	

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic (*)	Lags	
K.P. 258.15	-3.268135	0.0272 (lower than a significance level of 5%)	-2.981038	2.115648	0	ADF t-statistic is lower than 5% Mackinnon critical value. Therefore we reject the null hypothesis of unit root. Nevertheless, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 307.20	-1.67621	0.4274 (higher than a significance level of 5%)	-3.020686	2.00928	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 317.20	-1.837439	0.3550 (higher than a significance level of 5%)	-2.981038	2.196182	0	
K.P. 334.70	-2.505004	0.1263 (higher than a significance level of 5%)	-2.986225	2.115778	1	
K.P. 373.85	-3.812154	0.0049 (lower than a significance level of 5%)	-2.916566	1.723164	0	ADF t-statistic is lower than 5% Mackinnon critical value. Therefore we reject the null hypothesis of unit root. Nevertheless, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 402.00	-1.8552145	0.3484 (higher than a significance level of 5%)	-2.981038	1.801574	0	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 501.10	-1.910113	0.3212 (higher than a significance level of 5%)	-3.020686	2.187823	1	
K.P. 563.70	-1.818775	0.3621 (higher than a significance level of 5%)	-3.004861	2.057609	2	
K.P. 608.30	-2.069012	0.2578 (higher than a significance level of 5%)	-2.981038	1.765209	0	

Source: Author.

In this motorway, in the automatic traffic recorders located at the kilometre points 258.15 and 373.85 the result of the analysis is that we can reject the null hypothesis of existence of unit root.

Figure 5.6.1.c.: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 258.15 on the A-2 Motorway.

Source: Author.

Figure 5.6.1.d.: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 373.85 on the A-2 Motorway.

Source: Author.

As we can see in (Figure 5.6.1.c.), there is a growing trend in traffic time series until the year 2006 when the trend is broken and begins to decrease slightly. In addition, traffic time series shown in (Figure 5.6.1.d.) has three (3) breaks on the trend which are affecting the analysis result, the big one in 1976 than in 1985 and finally in 2007. Nevertheless, in two (2) out of sixteen (16) of the automatic traffic recorders analysed the hypothesis of existence of unit root cannot be rejected. Therefore, we cannot reject the hypothesis that the traffic behaves like a Geometric Brownian Motion (GBM) in the A-2 motorway.

Table 5.6.1.e.: Volatility of Each Automatic Traffic Recorder for A-2 Motorway.

	Years	Volatility	GMG	AMG
K.P. 35.90	21	9.06%	2.24%	4.63%
K.P. 47.00	21	9.65%	2.45%	3.48%
K.P. 116.20	21	4.88%	0.60%	1.23%
K.P. 148.10	21	7.43%	1.49%	2.12%
K.P. 190.60	21	7.67%	1.60%	2.26%
K.P. 229.00	21	6.49%	0.39%	1.20%
K.P. 258.15	21	9.55%	0.93%	1.60%
K.P. 307.20	21	18.16%	2.57%	4.22%
K.P. 317.20	21	14.51%	0.03%	0.99%
K.P. 334.70	21	8.81%	1.50%	2.23%
K.P. 373.85	21	6.97%	0.42%	1.33%
K.P. 402.00	21	11.88%	-1.67%	-1.42%
K.P. 501.10	21	18.35%	5.90%	7.77%
K.P. 563.70	21	14.84%	2.76%	4.24%
K.P. 608.30	21	8.62%	2.42%	3.39%
Average		10.46%	1.57%	2.62%

Source: Author.

Figure 5.6.1.e.: Volatility of Each Automatic Traffic Recorder for A-2 Motorway.

Source: Author.

In order to analyse the Volatility of Each Automatic Traffic Recorder, the same homogenizer criterion as the one considered for the A-1 motorway has been conducted. In most cases values do not go so far from the mean value (10.46%) except those located at Kilometre points 307.20 , 317.20 (these automatic traffic recorders are located in the outskirts of the city of Zaragoza), 501.10 and 563.70 (18.16%, 14.51%, 18.35% and 14.84% respectively). If we analyse the whole motorway and take the average traffic as the homogeneous one, the volatility drops to 8.98% for the A-2 motorway.

The results for the A-3 Motorway are shown in (Table 5.6.1.f.).

Table 5.6.1.f.: Results of the Unit Root Test for A-3 Motorway Traffic Time Series.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 18.90	-2.098032	0.2471 (higher than a significance level of 5%)	-3.004861	1.876677	0	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($d_u < d < 4 - d_u$). Therefore, there is no autocorrelation.
K.P. 30.10	-0.833293	0.7926 (higher than a significance level of 5%)	-2.981038	2.013918	0	
K.P. 48.50	-2.836128	0.0703 (higher than a significance level of 5%)	-3.012363	1.894822	2	
K.P. 62.20	-2.265485	0.1899 (higher than a significance level of 5%)	-2.981038	2.2627	0	

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 86.90	-1.893648	0.3299 (higher than a significance level of 5%)	-2.981038	2.056583	0	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 130.10	-2.224104	0.2030 (higher than a significance level of 5%)	-2.981038	1.586362	0	
K.P. 150.80	-1.968231	0.2979 (higher than a significance level of 5%)	-2.986225	1.837224	1	
K.P. 278.80	-1.616294	0.4603 (higher than a significance level of 5%)	-2.981038	2.156305	0	
K.P. 306.30	-2.282159	0.1847 (higher than a significance level of 5%)	-2.981038	2.109786	0	
K.P. 317.80	-1.823013	0.3616 (higher than a significance level of 5%)	-2.981038	2.215629	0	
K.P. 334.30	-1.436045	0.5477 (higher than a significance level of 5%)	-2.991878	1.82302	2	

Source: Author.

In all automatic traffic recorders the result of the analysis is that we can reject the null hypothesis of existence of unit root. Therefore, we cannot reject the hypothesis that the traffic behaves like a Geometric Brownian Motion (GBM) in the A-2 motorway.

Table 5.6.1.g.: Volatility of Each Automatic Traffic Recorder for A-3 Motorway.

	Years	Volatility	GMG	AMG
K.P. 18.90	23	13.13%	3.18%	4.06%
K.P. 30.10	23	6.63%	3.22%	4.04%
K.P. 48.50	23	9.16%	3.65%	4.25%
K.P. 62.20	23	12.17%	3.74%	5.20%
K.P. 86.90	23	12.75%	2.98%	4.33%
K.P. 130.10	23	13.07%	3.61%	5.16%
K.P. 150.80	23	12.45%	2.57%	3.81%

	Years	Volatility	GMG	AMG
K.P. 278.80	23	9.58%	1.45%	2.18%
K.P. 306.30	23	15.89%	2.01%	3.69%
K.P. 317.80	23	18.57%	3.05%	5.42%
K.P. 334.30	23	7.78%	1.79%	2.42%
Average		11.93%	2.84%	4.05%

Source: Author.

Figure 5.6.1.f.: Volatility of Each Automatic Traffic Recorder for A-3 Motorway.

Source: Author.

In order to analyse the Volatility of Each Automatic Traffic Recorder, the same homogenizer criterion as the one considered for the previous motorways has been conducted. Analysing the Volatility of Each Automatic Traffic Recorder, in most cases values do not go so far from the mean value (11.93%) except those located at kilometre points 30.10, 306.30, 317.80 and 334.30 (6.63%, 15.89%, 18.57 and 7.78%). If we analyse the whole motorway and take the average traffic as the homogeneous one, the volatility drops to 6.26% for the A-3 motorway.

The results for the A-4 Motorway are shown in (Table 5.6.1.h.).

Table 5.6.1.h.: Results of the Unit Root Test for A-4 Motorway Traffic Time Series.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 19.00	-0.872321	0.7861 (higher than a significance level of 5%)	-2.941145	2.074221	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 65.00	-2.150667	0.2279 (higher than a significance level of 5%)	-2.981038	1.995528	0	
K.P. 80.21	-2.362083	0.1619 (higher than a significance level of 5%)	-2.986225	1.975279	1	
K.P. 96.60	-3.740896	0.0060 (lower than a significance level of 5%)	-2.916566	2.02934	0	ADF t-statistic is lower than 5% Mackinnon critical value. Therefore we can reject the null hypothesis of unit root. Nevertheless, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 122.60	-3.133129	0.0299 (lower than a significance level of 5%)	-2.916566	2.202002	0	
K.P. 130.00	-1.861378	0.3439 (higher than a significance level of 5%)	-2.986225	1.82897	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 196.90	-1.852496	0.3479 (higher than a significance level of 5%)	-2.986225	1.868299	1	
K.P. 265.91	-1.650973	0.4478 (higher than a significance level of 5%)	-2.936942	1.5913	0	
K.P. 283.10	-1.918322	0.3188 (higher than a significance level of 5%)	-2.991878	2.075009	2	
K.P. 308.60	-1.159	0.6754 (higher than a significance level of 5%)	-2.986225	2.009996	1	
K.P. 356.67	-2.873329	0.0623 (higher than a significance level of 5%)	-2.981038	2.445671	0	

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 369.80	-2.731602	0.0824 (higher than a significance level of 5%)	-2.981038	1.72336	0	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 408.80	-1.102401	0.6985 (higher than a significance level of 5%)	-2.986225	1.839018	1	
K.P. 427.00	-1.966673	0.2985 (higher than a significance level of 5%)	-2.986225	1.974922	1	
K.P. 435.10	-1.99316	0.2878 (higher than a significance level of 5%)	-2.981038	2.03929	0	
K.P. 456.00	-1.811919	0.3667 (higher than a significance level of 5%)	-2.981038	2.443637	0	
K.P. 505.00	-2.137544	0.2325 (higher than a significance level of 5%)	-2.981038	1.840086	0	
K.P. 525.00	-2.436424	0.1425 (higher than a significance level of 5%)	-2.986225	2.22193	1	
K.P. 531.00	-1.51521	0.5102 (higher than a significance level of 5%)	-2.981038	1.943992	0	
K.P. 667.33	-2.06119	0.2608 (higher than a significance level of 5%)	-2.981038	1.97269	0	

Source: Author.

Figure 5.6.1.g.: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 96.60 on the A-4 Motorway.

Source: Author.

Figure 5.6.1.h.: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 122.60 on the A-4 Motorway.

Source: Author.

In this motorway, in the automatic traffic recorders located at the kilometre points 96.60 and 122.60 the result of the analysis is that we can reject the null hypothesis of existence of unit root. Nevertheless, in two (2) out of twenty (20) of the automatic traffic

recorders analysed the hypothesis of existence of unit root cannot be rejected. Therefore, we cannot reject the hypothesis that the traffic behaves like a Geometric Brownian Motion (GBM) in the A-4 motorway.

We can see in both figures (Figure 5.6.1.g. and Figure 5.6.1.h.) a structural brake in the year 2007 when the trend changes into a decreasing. This fact can affect the results.

Table 5.6.1.i.: Volatility of Each Automatic Traffic Recorder for A-4 Motorway.

	Years	Volatility	GMG	AMG
K.P. 19.00	27	12.78%	3.31%	5.83%
K.P. 65.00	27	10.32%	3.19%	3.72%
K.P. 80.21	27	8.90%	2.42%	2.82%
K.P. 96.60	27	8.99%	1.30%	3.11%
K.P. 122.60	27	11.38%	1.29%	3.30%
K.P. 130.00	27	8.28%	2.96%	3.29%
K.P. 196.90	27	11.84%	2.82%	3.51%
K.P. 265.91	27	8.20%	1.27%	2.30%
K.P. 283.10	27	10.28%	2.54%	3.05%
K.P. 308.60	27	8.17%	1.08%	1.40%
K.P. 356.67	27	8.45%	2.45%	2.81%
K.P. 369.80	27	6.34%	2.41%	2.61%
K.P. 408.80	27	15.11%	0.07%	1.20%
K.P. 427.00	27	9.99%	3.21%	3.72%
K.P. 435.10	27	9.41%	2.46%	2.89%
K.P. 456.00	27	11.66%	2.14%	2.80%
K.P. 505.00	27	10.51%	1.99%	2.53%
K.P. 525.00	27	10.80%	4.59%	5.20%
K.P. 531.00	27	8.37%	3.35%	3.68%
K.P. 667.33	27	9.79%	4.23%	4.73%
Average		9.98%	2.45%	3.23%

Source: Author.

Figure 5.6.1.i.: Volatility of Each Automatic Traffic Recorder for A-4 Motorway.

Source: Author.

In order to analyse the Volatility of Each Automatic Traffic Recorder, the same homogenizer criterion as the one considered for the previous motorways has been conducted. Analysing the Volatility of Each Automatic Traffic Recorder, in most cases values do not go so far from the mean value (9.98%) except the one located at Kilometre point 408.80 (15.11%). This automatic traffic recorder is located at the outskirts of Cordoba so that is why this value is that high. If we analyse the whole motorway and take the average traffic as the homogeneous one, the volatility rises a little to 12.81% for the A-4 motorway.

The results for the A-5 Motorway are shown in (Table 5.6.1.j.).

Table 5.6.1.j.: Results of the Unit Root Test for A-5 Motorway Traffic Time Series.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 37.00	-0.98754	0.7423 (higher than a significance level of 5%)	-2.981038	2.194816	0	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root.
K.P. 62.70	-0.850916	0.7927 (higher than a significance level of 5%)	-2.941145	1.814364	1	Moreover, the D-W statistic belongs to the interval ($d_u < d < 4 - d_u$). Therefore, there is no auto-correlation.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 73.00	-1.502851	0.5157 (higher than a significance level of 5%)	-2.986225	2.124806	1	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.
K.P. 82.00	-1.211148	0.6531 (higher than a significance level of 5%)	-2.986225	1.862161	1	
K.P. 109.60	-2.697502	0.0812 (higher than a significance level of 5%)	-2.91765	1.541001	1	
K.P. 127.00	-0.709198	0.8267 (higher than a significance level of 5%)	-2.986225	2.122725	1	
K.P. 153.00	-1.573393	0.4815 (higher than a significance level of 5%)	-2.981038	2.069519	0	
K.P. 190.10	-0.915264	0.7662 (higher than a significance level of 5%)	-2.986225	1.947295	1	
K.P. 233.10	-2.597122	0.1009 (higher than a significance level of 5%)	-2.926622	1.973836	1	
K.P. 267.00	-0.962069	0.7512 (higher than a significance level of 5%)	-2.981038	1.994591	0	
K.P. 295.00	-0.886296	0.7740 (higher than a significance level of 5%)	-2.998064	1.931931	3	
K.P. 329.20	-3.846643	0.0075 (lower than a significance level of 5%)	-2.986225	1.698194	1	ADF t-statistic is lower than 5% Mackinnon critical value. Therefore we can reject the null hypothesis of unit root. Nevertheless, the D-W statistic belongs to the interval ($du < d < 4-du$). Therefore, there is no auto-correlation.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 346.70	-1.387022	0.5706 (higher than a significance level of 5%)	-2.998064	1.764218	3	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root.
K.P. 377.00	-1.51895	0.5136 (higher than a significance level of 5%)	-2.938987	1.909151	0	Nevertheless, the D-W statistic belongs to the interval ($d_L < d < d_U$). Therefore, the hypothesis of no auto-correlation is non-conclusive.

Source: Author.

In this motorway, in the automatic traffic recorder located at the kilometre point 329.20 the result of the analysis is that we can reject the null hypothesis of existence of unit root. Nevertheless, in one (1) out of fourteen (14) of the automatic traffic recorders analysed the hypothesis of existence of unit root cannot be rejected. Therefore, we cannot reject the hypothesis that the traffic behaves like a Geometric Brownian Motion (GBM) in the A-5 motorway.

Figure 5.6.1.j.: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 329.20 on the A-5 Motorway.

Source: Author.

We can see in both figures (Figure 5.6.1.j.) a small structural brake in the year 2011 when the trend changes into a decreasing. This fact could affect the result.

Table 5.6.1.k.: Volatility of Each Automatic Traffic Recorder for A-5 Motorway.

	Years	Volatility	GMG	AMG
K.P. 37.00	27	13.23%	5.70%	6.65%
K.P. 62.70	27	8.72%	2.35%	3.96%
K.P. 73.00	27	25.23%	20.11%	6.28%
K.P. 82.00	27	6.28%	3.74%	3.93%
K.P. 109.60	27	9.92%	1.00%	2.58%
K.P. 127.00	27	9.54%	3.17%	3.64%
K.P. 153.00	27	6.15%	2.89%	3.07%
K.P. 190.10	27	13.28%	2.17%	3.01%
K.P. 233.10	27	5.85%	1.82%	3.49%
K.P. 267.00	27	7.46%	2.95%	3.22%
K.P. 295.00	27	10.46%	2.62%	3.17%
K.P. 329.20	27	8.14%	4.04%	4.38%
K.P. 346.70	27	8.83%	2.78%	3.16%
K.P. 377.00	27	6.22%	2.55%	4.05%
Average		9.95%	4.14%	3.90%

Source: Author.

Figure 5.6.1.k.: Volatility of Each Automatic Traffic Recorder for A-5 Motorway.

Source: Author.

Analysing the Volatility of Each Automatic Traffic Recorder, in most cases values do not go so far from the mean value (9.95%) except the one located at Kilometre point 73.00 (25.23%). This automatic traffic recorder is located at the outskirts of the city of Mostoles in Madrid region so that is why this value is that high. If we analyse the whole motorway

and take the average traffic as the homogeneous one, the volatility rises a little to 11.99% for the A-5 motorway.

The results for the A-6 Motorway are shown in (Table 5.6.1.I.):

Table 5.6.1.I.: Results of the Unit Root Test for A-6 Motorway Traffic Time Series.

Kilometre Point	Augmented Dickey-Fuller Test		Critical Value	Durbin-Watson Test		Conclusion
	t-Statistic	p-value	5% Value	D-W Statistic	Lags	
K.P. 21.00	-2.401953	0.1468 (higher than a significance level of 5%)	-2.926622	2.001233	2	ADF t-statistic is higher than 5% Mackinnon critical value. Therefore we cannot reject the null hypothesis of unit root. Moreover, the D-W statistic belongs to the interval ($d_u < d < 4-d_u$). Therefore, there is no auto-correlation.
K.P. 112.20	-2.430891	0.1443 (higher than a significance level of 5%)	-2.991878	1.868666	2	
K.P. 131.00	-1.385176	0.5793 (higher than a significance level of 5%)	-2.941145	1.967363	1	
K.P. 138.40	-2.351637	0.1652 (higher than a significance level of 5%)	-2.991878	2.250334	2	
K.P. 156.20	-2.898307	0.0617 (higher than a significance level of 5%)	-3.004861	1.889364	4	
K.P. 173.10	-2.839227	0.0678 (higher than a significance level of 5%)	-2.991878	1.995547	2	
K.P. 217.10	-1.986692	0.2903 (higher than a significance level of 5%)	-2.986225	2.03099	1	
K.P. 226.00	-1.852496	0.3479 (higher than a significance level of 5%)	-2.986225	1.868299	1	
K.P. 255.30	-2.190952	0.2124 (higher than a significance level of 5%)	-2.933158	1.9901	2	
K.P. 262.60	-1.274324	0.6250 (higher than a significance level of 5%)	-2.986225	2.07996	1	

Source: Author.

In this motorway, in all automatic traffic recorders under study, the result of the analysis is that we can reject the null hypothesis of existence of unit root. Therefore, we cannot reject the hypothesis that the traffic behaves like a Geometric Brownian Motion (GBM) in the A-6 motorway.

Table 5.6.1.m.: Volatility of Each Automatic Traffic Recorder for A-6 Motorway.

	Years	Volatility	GMG	AMG
K.P. 21.00	27	8.81%	1.23%	2.67%
K.P. 112.20	27	10.17%	3.87%	4.40%
K.P. 131.00	27	8.54%	2.64%	4.36%
K.P. 138.40	27	10.84%	4.14%	4.75%
K.P. 156.20	27	13.58%	3.43%	4.38%
K.P. 173.10	27	9.35%	4.58%	5.03%
K.P. 217.10	27	12.85%	2.87%	3.72%
K.P. 226.00	27	11.84%	2.82%	3.51%
K.P. 255.30	27	6.47%	1.83%	3.32%
K.P. 262.60	27	11.16%	0.95%	1.56%
Average		10.36%	2.83%	3.77%

Source: Author.

Figure 5.6.1.l.: Volatility of Each Automatic Traffic Recorder for A-6 Motorway.

Source: Author.

Analysing the Volatility of Each Automatic Traffic Recorder, in most cases values do not go so far from the mean value (10.36%) except those located at Kilometre points 156.20, 217.10 and 255.30 (13.58% (This automatic traffic recorder is located at the outskirts of the city of Medina del Campo in the Valladolid province, so that is why this value can be

that high.), 12.85% and 6.47%). If we analyse the whole motorway and take the average traffic as the homogeneous one, the volatility rises a little to 11.34% for the A-6 motorway.

5.7. DURBIN-WATSON AUTOCORRELATION ANALYSIS.

Because of traffic evolution involves time series data, the problem of positive autocorrelation exists in the model. So, in order to verify the existence of autocorrelation in residuals, the (Durbin & Watson, 1951) is used.

$$H_0: \rho = 0$$

$$H_1: \rho > 0$$

Throughout this analysis, we can modify the number of lags used by the Augmented Dickey-Fuller test if there is no absence of autocorrelation.

The test statistic is the following:

$$d = \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2} \quad (\text{Equation 5.7.1.})$$

Where:

- n : Number of observations.
- e_t : The residue for the observation "t". $e_t = y_t - \hat{y}_t$, where y_t and $\hat{y}_t$ are respectively, the observed and predicted values of the response variable for individual i.
- "d" becomes smaller as the serial correlations increase.

In order to establish the limits of the variation of the statistic "d", (Equation 5.7.1.) can be expressed as follows:

$$\begin{aligned} d &= \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2} = \frac{\sum_{t=2}^n (e_t^2 + e_{t-1}^2 - 2e_t e_{t-1})}{\sum_{t=1}^n e_t^2} = \\ &= \frac{\sum_{t=1}^n e_t^2 + \sum_{t=1}^n e_{t-1}^2 - 2 \sum_{t=1}^n e_t e_{t-1}}{\sum_{t=1}^n e_t^2} \end{aligned} \quad (\text{Equation 5.7.2.})$$

In (Equation 5.7.2.), the statistic depends on the first order sampling autocorrelation coefficient for the residues $\hat{\rho}$. When the sample is big enough, it can be considered that $\sum_{t=2}^n e_t^2 \approx \sum_{t=2}^n e_{t-1}^2 \approx \sum_{t=1}^n e_t^2$, then the statistic “d” can be expressed as:

$$d \approx \frac{2\sum_{t=2}^n e_t^2 + 2\sum_{t=2}^n e_t e_{t-1}}{\sum_{t=1}^n e_t^2} \quad (\text{Equation 5.7.3.})$$

The first order empiric correlation coefficient can be calculated as:

$$\hat{\rho} = \frac{\sum_{t=2}^n e_t e_{t-1}}{\sum_{t=1}^n e_t^2} \quad (\text{Equation 5.7.4.})$$

Then, the statistic can be expressed as:

$$d \approx 2 \cdot (1 - \hat{\rho}) \quad (\text{Equation 5.7.5.})$$

Taking into account that the correlation coefficient has the limits $-1 \leq \hat{\rho} \leq 1$, then the variation range of the Durbin-Watson statistic and its sign can be guessed

$$\hat{\rho} = -1 \rightarrow d \approx 4 \quad \text{negative autocorrelation exists}$$

$$\hat{\rho} = 0 \rightarrow d \approx 2 \quad \text{absence of autocorrelation}$$

$$\hat{\rho} = 1 \rightarrow d \approx 0 \quad \text{we can accept that positive correlation exists}$$

Therefore, the statistic will have values between 0 and 4 in such a way that the closer the value of the statistic to zero (to four), the higher the evidence of positive (negative) autocorrelation. If the value of the “d” statistic is equal to two, then the simple correlation will be null, therefore a problem of correlation does not exists.

Figure 5.7.a.: Range of Values for the “d” Statistic.

- $0 < d < d_L$ hypothesis H_0 is rejected, then positive autocorrelation exists.
- $4 - d_L < d < 4$ hypothesis H_0 is rejected, then negative autocorrelation exists.

- $du^{24} < d < 4-du$ hypothesis H_0 is not rejected, there is no correlation in the model.
- $dL < d < du$ the contrast is not conclusive.
- $4-du < d < 4-dL$ the contrast is not conclusive.

²⁴ du is a value obtained in (Savin & White, 1977) tables.

6. REAL OPTIONS CALCULATION METHODOLOGY.

Companies make investments to expand markets and businesses and to make profits for their own business in competitive and uncertain markets. These opportunities, converted into investment projects, are normally assessed by traditional methods of evaluation based on discounted cash flows. These methods show some deficiencies because of they only expect one scene for the model and do not take into account the volatility and uncertainty during the life of the project as well as they are not capable of assessing the inherent managerial flexibility. Therefore, the main problem traditional valuation methods have is that they tend to undervalue investments made under uncertainty and risky environments.

Managerial flexibility provides the option to review the decisions to take the best option as the reality is going on. A better approach to assess the managerial flexibility is often made by decision trees, but this approach has its own problem of assigning the right probabilities for different future scenes (Andalaft-Chacur, Montaz Ali, & González Salazar, 2011).

When assessing investment projects subjected to high volatility and uncertainty, it is necessary to use a method which can integrate the financial and the strategic theories to price appropriately the managerial flexibility existing in investment projects as form of options; this is the real options method (Myers S. , 1977). It applies financial options theory to quantify the value of management flexibility and leverage uncertainty in a changing world. The use of real options helps the management board to quantify the risks and potential rewards associated with making investments in risky environments.

6.1. VOLATILITY.

Volatility is one of the most important factors that affect the value of options. It is one of the variables that influence the time value of an option and indicate the variability in the underlying asset's profitability. Because the value of any option depends on the riskiness of the underlying asset, volatility is an important variable that affects the investment decision making process. It measures how much things can change before an

investment decision must finally be made. That depends both on how uncertain the future value of the assets is, and on how long we can defer a decision.

Many capital budgeting decisions involve projects with uncertain cash flows that have significant managerial flexibilities. In these cases, real options pricing models can support the decision-making, as traditional methods do not capture the value of the options that may be embedded in the project. The estimation of the volatility for the stochastic project value model is the more complex part of this approach, since this parameter determine the degree of uncertainty. The relationship between volatility and real option value is well known (Hull J. , 2006).

In the case of financial options, the determination of the volatility for the stochastic process model of the underlying asset is relatively straightforward, since volatility can be estimated from market or historical data. For commodities, the volatility can be obtained from futures market data (Bøckman, Fleten, Juliussen, Langhammer, & Revdal, 2008).

In order to determine the project volatility, some authors consider that the volatilities of the underlying risky assets and the volatility of the project are the same (Paddock, Siegel, & Smith, 1988) (Trigeorgis L. , 1996). Nevertheless, (Copeland & Antikarov, 2003) demonstrate that the volatility of the underlying asset and that of the project are not the same, as the project volatility is also influenced by the fixed costs that arise from the operational and financial leverage of the project (Tufano, 1998). On the other hand, other authors consider the volatility of the stock market as a proxy for the project volatility (Dixit & Pindyck, 1994).

(Copeland & Antikarov, 2003) presented an approach for valuing real options based on the notion that the present value of the project without options is the best unbiased estimator of the market value of the project. Thus, under this assumption, the project without options serves as the underlying asset in the option valuation model. If changes in the value of the project without options are then assumed to vary over time according to a Geometric Brownian Motion (GBM) stochastic process, which is a commonly used model for asset values, then the project options can be valued with traditional option pricing methods, such as the binomial tree model of (Cox, Ross, & Rubinstein, 1979). The

(Copeland & Antikarov, 2003) approach uses Monte Carlo simulation to estimate the volatility of the GBM process when the underlying asset is the project value without options.

The most widely used method to determine the volatility is to use the instantaneous standard deviation of historic changes in project value (Equation 6.1.1.). Starting with a series of traffic, convert them into relative growths $\left(AADT_i / AADT_{i-1} \right)$. The standard deviation of these natural logarithm growths is the volatility of traffic used in a real options analysis.

$$\sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (\alpha_i - \bar{\alpha})^2} \quad \text{(Equation 6.1.1.)}$$

Where:

- n : Number of historic observations of traffic.
- α_i : $\ln\left(\frac{AADT_i}{AADT_{i-1}}\right)$, ($i = 1, 2, \dots, n$).
- $\bar{\alpha}$: the mean of α_i 's.

If the potential project is identical to others owned and operated by listed companies, it may be possible to estimate σ_V^j from a historical series of unlevered company values (Davis, 1998). If there are options on these listed companies, an implied volatility could also be estimated (Hull J. , 1997).

6.2. MONTE CARLO SIMULATION.

Simulation is any analytical method that is meant to imitate a real-life system, especially when other analyses are too mathematically complex or too difficult to reproduce (Mun, 2002). Therefore, a simulation can be defined as an analogy (Chofaras & Steinmann, 1995). Spreadsheet risk analysis uses both a spreadsheet model and simulation to analyze the effect of varying inputs based on outputs of the modeled system.

A simulation calculates numerous scenarios of a model by repeatedly picking values from the probability distribution for the uncertain variables and using those values for the event. As all those scenarios produce associated results, each scenario can have a forecast. By combining Monte Carlo simulation with Dynamic Stochastic Programming it is possible to develop methods for valuing American options (Grant, Vora, & Weeks, 1997), (Ibáñez & Zapatero, 2004) and (Longstaff & Schwartz, 2001).

Monte Carlo simulation is a forward looking method that in principle seems incompatible with backward induction. The combination of Monte Carlo simulation and dynamic programming allows developing methods to price American options (Ibáñez & Zapatero, 2004).

Monte Carlo simulation provides approximate solutions to a variety of mathematical problems by performing statistical sampling experiments. This process involves performing many simulations using random numbers and probability to get an approximation of the answer to the problem. The defining characteristic of Monte Carlo methods is its use of random numbers in its simulations. In fact, these methods derive their collective name from the fact that Monte Carlo, the capital of Monaco, has many casinos and casino roulette wheels are a good example of a random number generator.

This method is widely used in investment valuation. For each variable used in the investment process, the potential values for them are defined thanks to a likelihood distribution whose choice will depend on the surrounding conditions of the variable. Afterwards, a theoretical population is obtained throughout a sequence of random numbers. Therefore, Monte Carlo simulation consists on generating random numbers and converts them into random variables of the model. The method is applied as following:

- The probability density function $f(x)$ shall be defined and then the cumulative probability function is graphically plotted.

$$y = F(x) = \int_{-\infty}^x f(u)du \quad (\text{Equation 6.2.1.})$$

- Then we have to choose a number between 0 and 1 through any random numbers generating process.

- The random number thus obtained will be represented on the ordinate axis and plot a horizontal line since this point. The interface point between the horizontal line and the curve $F(x)$ represents the first value of the simulation.
- Repeat the same process until the obtained values are enough.

Monte Carlo simulation can be used in different ways, but in the most common approach in project valuation, each project scenarios is created by taking a random value for one of the input parameters of the DCF and solving for the Net Present Value. The following steps are involved in the process:

- Define the probability distribution of each input variable that affects the free cash flows by identifying its average value and standard deviation of the distribution, by using historical data. If there is no history on the data of an input variable to estimate its standard deviation, optimistic and pessimistic estimates which correspond to approximately 1% and 99% probabilities may be provided based on management's judgment.
- Draw one value for each input parameter from within its distribution and estimate the Net Present Value using the DCF method.

Throughout this procedure a series of forecast asset values are created using Geometric Brownian Motion, and discounted back to the present, at the risk-free rate.

6.3. THE BINOMIAL DECISION TREE ANALYSIS.

In order to represent the different possible paths that might be adopted by the stock price over the entire life of an option, a very common analysis has been developed for option pricing. It is called binomial decision tree analysis. Decision trees focus on modelling various kinds of flexibilities during a life span of a project. The rationale of this technique is that the stock price follows a random walk. In each time step, it has a certain probability of moving up by a certain percentage amount and a certain probability of moving down by a certain percentage amount. This model enables professionals to recognize the interdependencies of decisions made at different stages of the project investment (Trigeorgis L. , 1996). The main difference between binomial decision trees

and Monte Carlo simulation in which the Brownian Motion stochastic process can be applied is that the former is a type of discrete simulation whereas the latter is a continuous simulation. Traditionally, discrete models are more popular when valuing real options because of their simplicity (Xue & Zhang, 2014).

There are two ways to solve the binomial decision tree; the first one is by using the risk-neutral probabilities, and the second is the use of market-replicating portfolios. The market-replicating portfolio method is based on the assumption that there are no arbitrage opportunities and there are enough traded assets in the market that can exactly replicate the payoff profile. This procedure can be perfectly applicable to financial options where stocks are freely traded and highly liquid. Nevertheless, in real options where physical assets and projects are involved, it is not as much easier to apply this method, and replicating portfolios are also more difficult to apply.

In real options, instead of using a risky set of cash flows and discounting them at a risk-adjusted discount rate comparable to the DCF models, one can easily risk-adjust the probabilities of specific cash flows occurring at specific times. This is called a risk-neutral probability approach (Mun, 2002). Therefore, using these risk-adjusted probabilities on the cash flows allows us to discount these cash flows at the risk-free rate.

By assuming that the stock price follows a multiplicative binomial process over discrete periods, the rate of return on the stock over each period can have two possible values: $(u - 1)$ with probability (p) , or $(1 - d)$ with probability $(1 - p)$.

$$u = e^{\sigma\sqrt{\Delta t}} \quad (\text{Equation 6.3.1.})$$

$$d = e^{-\sigma\sqrt{\Delta t}} = \frac{1}{u} \quad (\text{Equation 6.3.2.})$$

$$p = \frac{e^{(r_f - \delta) \cdot (\Delta t)} - d}{u - d} \quad (\text{Equation 6.3.3.})$$

Where:

- σ : Volatility of the natural logarithm of the underlying free cash flow returns in percent. This volatility is measured in a yearly basis; multiplying it by the

square root of the time scale, breaks it down into the time-step's equivalent volatility.

- T : Time to maturity in years.
- r_f : The risk-free rate or the rate of return on a riskless asset.
- δ : Continuous dividend outflows in percent.
- $\Delta t = T/n_{steps}$: Time scale between steps.
- p : The risk-neutral probability value.

Regarding the (Equation 5.3.1.8.), there are two clearly separated parts, the deterministic term: $e^{\mu \cdot dt}$ which accounts for the slope or growth rate of the Brownian process. And the stochastic term: $e^{\sigma \cdot dz_t} = e^{\sigma \cdot \xi \cdot \sqrt{dt}}$. This latter term has a volatility component σ , a time component dt , and a simulated component $\xi \in N(0,1)$. As it was mentioned at the beginning of this Section, binomial decision trees are a type of discrete simulations, therefore we no longer need to re-simulate at every time period and the simulated component ξ can be dropped out from the equation. Therefore, the remaining stochastic term is simply $e^{\sigma \cdot \sqrt{dt}}$ which is represented in the up-factor (u).

Thus, if the current stock price is S , the stock price at the end of the period will be either $(u \cdot S)$ or $(d \cdot S)$. We can represent this movement through the following diagram (Figure 6.3.a.).

Figure 6.3.a.: Stock Price Evolution in One Period.

Calling r_f the risk free rate of return, and assuming it as a constant, on the basis of there is no arbitrage conditions, we can state that $u > r_f > d$. We assume that there is no arbitrage conditions in the process because if so, there would be profitable riskless arbitrage opportunities involving only the stock and riskless borrowing and lending.

Let C be the present value of an European call option over a stock with exercise price equals to K . At maturity, the value of the option will be $C = \max[0, S_T - K]$. C_u is its value at the end of the period if the stock price goes up to $u \cdot S$, and C_d its value at the end of the period if the stock price goes down to $d \cdot S$. The value of the option one period before its maturity can be one of these:

$$C_u = \max[0, u \cdot S - K] \text{ with a probability equals to } p.$$

$$C_d = \max[0, d \cdot S - K] \text{ with a probability equals to } q = 1 - p.$$

Figure 6.3.b.: European Call Option value at the end of One Period.

Considering we have a portfolio consisting of A shares of stock and B monetary units in riskless asset such as bonds. Its present value will be $(A \cdot S + B)$. At the end of the period, the value of this portfolio is represented in (Figure: 7.3.c.).

$$A \cdot u \cdot S + r_f \cdot B \text{ with a probability equals to } p.$$

$$A \cdot d \cdot S + r_f \cdot B \text{ with a probability equals to } q = 1 - p.$$

This performed portfolio consists of two kind of assets (shares and bonds) which will have two possible directions, upwards or downwards.

If we choose one possible value for A and B , we will be able to replicate the return of the call option previously defined. Therefore, the new portfolio thus formed is the replicate portfolio of our option. This requires that:

$$C_u = A \cdot u \cdot S + r_f \cdot B \quad \text{(Equation 6.3.4.)}$$

$$C_d = A \cdot d \cdot S + r_f \cdot B \quad \text{(Equation 6.3.5.)}$$

Solving (Equation 6.3.4.) and (Equation 6.3.5.):

$$A = \frac{C_u - C_d}{(u-d) \cdot S}, \quad B = \frac{u \cdot C_u - d \cdot C_d}{(u-d) \cdot r_f} \quad (\text{Equation 6.3.6.})$$

The new portfolio thus formed consists of A shares and B monetary units of a riskless asset and has the same cash flows as the European call option previously defined. This is possible because the market is complete²⁵ and the portfolio provides the same returns as the option.

Figure 6.3.c.: Value of a portfolio composed by A shares and B monetary units in riskless assets.

If there are to be no riskless arbitrage opportunities, the present value of the call, C , cannot be less than the present value of the hedging portfolio, $A \cdot S + B$. If it were, we could make a riskless profit by selling short A shares of the stock, investing $-B$ monetary units of riskless bonds and buying the call option. If $C > A \cdot S + B$ the arbitrage opportunity would be feasible by selling the call option, buying A shares of the stock and lending $-B$ monetary units of riskless bonds. But this looks over the fact that the person who bought the call we sold, has the right to exercise it immediately.

$$C = A \cdot S + B = \frac{C_u - C_d}{(u-d)} + \frac{u \cdot C_d - d \cdot C_u}{(u-d) \cdot r_f} = \frac{\left[\left(\frac{r_f - d}{u-d}\right) \cdot C_u + \left(\frac{u - r_f}{u-d}\right) \cdot C_d\right]}{r_f} \quad (\text{Equation 6.3.7.})$$

Where:

$$C_u = \max[0, u \cdot S - K]$$

$$C_d = \max[0, d \cdot S - K]$$

As we can see in (Equation 6.3.7.), the value of the option does not depend on the probability to increase (p), or decrease ($q = 1 - p$). Once the stock price (S) is defined, investors will agree with the price of the call option, even if they do not agree with the

²⁵ A complete market is one in which every agent is able to exchange every good, either directly or indirectly, with every other agent without transaction costs.

probability (p or q), the value of the option will not depend on the investors' aversion to risk. Nevertheless, we need to know the up-factor (u) and the down-factor (d), whose depend on the volatility.

We can simplify (Equation 6.3.7.) by calling:

$$p^* = \frac{r_f - d}{u - d} \quad \text{and} \quad 1 - p^* = \frac{u - r_f}{u - d} \quad (\text{Equation 6.3.8.})$$

and substituting on (Equation 6.3.7.), we have:

$$C = \frac{[p^* \cdot C_u + (1 - p^*) \cdot C_d]}{r_f} \quad (\text{Equation 6.3.9.})$$

Because of $0 < p^* < 1$. p^* has the property of a probability. This pseudo-probability would match the real probability p if investors were neutral to risk. Therefore the expected return would be the risk-free rate of return.

Another important property (Equation 6.3.9.) shows us that even if different investors have different subjective probabilities about an upward or downward movement in the stock, they could still agree on the relationship of C to S, u, d and r . That is due to the probability q does not appear in the equation.

The value of the call does not depend on the investors' attitudes towards risk. In constructing the formula, the only assumption we made about an individual's behavior was that he prefers more wealth to less wealth and therefore has an incentive to take advantage of profitable riskless arbitrage opportunities. The only random variable on which the call value depends is the stock price.

Considering the (Equation 6.3.9.), the value of the call can be interpreted as the expectation of its discounted future value in a risk-neutral basis.

If we consider a call option with two periods remaining before its expiration date, the stock price can take on three possible values after two periods as it is shown in (Figure 6.3.d.).

Figure 6.3.d.: Binomial Decision Tree (Two Steps).

The binomial decision tree shown in (Figure 6.3.d.) is also called a recombining tree, where at time-step number two the node in the middle (duS) is the same as time-step one's lower bifurcation of (uS) and upper bifurcation of (dS). There is also a variation of the recombining trees, which is called the non-recombining trees. In this case, the node in the middle is not the same for the lower and upper bifurcation of the previous node, but it is different. The main drawback of non-recombining trees is the computational time and resources necessary to calculate the entire binomial tree. However, both recombining and non-recombining binomial trees yields the same result in the limit. Nevertheless, there are some particular cases when non-recombining binomial trees are required, especially when there more than one stochastic underlying variables or when the volatility of a single stochastic variable changes over time.

And the value of the call option is:

Figure 6.3.e.: European call option value at the end of the second period.

$$C_u = \frac{[p \cdot C_{uu} + (1-p) \cdot C_{du}]}{r_f} ; \quad C_d = \frac{[p \cdot C_{du} + (1-p) \cdot C_{dd}]}{r_f} \quad (\text{Equation 6.3.10.})$$

Remaining two periods until expiration date, the return of our option can be replicated through a portfolio composed by Δ shares and B bonds (Equation 6.3.6.).

No arbitrage conditions involve:

$$C = \Delta S + B = \frac{[p \cdot C_u + (1-p) \cdot C_d]}{r_f} \quad (\text{Equation 6.3.11.})$$

By replacing C_u and C_d from (Equation 6.3.10.) in (Equation 6.3.11.) we have:

$$C = \frac{[p^2 \cdot C_{uu} + 2 \cdot p \cdot (1-p) \cdot C_{du} + (1-p)^2 \cdot C_{dd}]}{r_f^2} = \frac{1}{r_f^2} \cdot [p^2 \cdot \max(0, u^2 S - X) + 2 \cdot p \cdot (1-p) \cdot \max(0, duS - X) + (1-p)^2 \cdot \max(0, d^2 S - X)] \quad (\text{Equation 6.3.12.})$$

By repeating the analysis for n periods of time, we have the following general equation:

$$C = \frac{1}{r_f^n} \cdot \left[\sum_{j=0}^n \left(\frac{n!}{j! \cdot (n-j)!} \right) \cdot p^j \cdot (1-p)^{n-j} \cdot \max(0, u^j d^{n-j} S - X) \right] \quad (\text{Equation 6.3.13.})$$

The expected Net Present Values of all the decision alternatives at a given node are compared, and the decision with the highest NPV is selected. The expected NPV of a given decision is the sum of expected values of the corresponding outcomes, and the expected value of a given outcome is the product of the probability of the outcome and the payoff associated with it. The payoff is derived from the cash flows associated with that outcome and is calculated using the DCF Method where the discount rate is not adjusted for risk. The reason for not adjusting the discount rate is that the risk is already accounted for by the expected value calculation, where the cash flows are multiplied by their corresponding probabilities.

Decision trees offer additional information and insight into the project decision process compared to the DCF method alone when contingent decisions are involved. Decision Tree analysis is not an alternative to but an extension of the DCF method. In fact, the payoffs for different outcomes used in the Decision Tree analysis are derived based on the DCF analysis in the first place. The final project expected Net Present Value is calculated based on this payoff by incorporating contingent decisions at various decision nodes in the future. This is where Decision Tree Analysis adds value, because DCF assumes a fixed path and does not account for management's contingent decisions. The major drawbacks of decision trees, however, lie in estimating the probabilities of the

decision outcomes and selecting an appropriate discount rate inside the decision tree when the tree is extended for more than a year or so, that is, when the cash flows inside the tree are realized over a long period of time. The outcome probabilities are subjective and should be estimated by subject matter experts (Kodukula & Paupudesu, 2006).

The impact of these probabilities on the Net Present Value of a project can be analyzed by sensitivity analysis. Such analysis can also be applied to the other input variables of the decision trees, including the discount rate. The discount rate to be used inside the decision tree relates to the risk associated with the cash flows inside the decision tree.

When prices changes become smaller as time period gets shorter, the binomial model converges on the Black-Scholes model (Black & Scholes, 1973). This model lets us to estimate the value of any option using a small number of inputs. The model reveals that the price of a financial option contract can be computed by only knowing a price of an underlying asset, strike price, risk-free interest rate, expiration date and volatility of the price of the underlying asset.

7. THE EARLY TERMINATION OF THE PROJECT.

When investments develop positively, the quicker and easier the business can be expanded, the better. But if bad news arrives, and cash flows are far below expectations, it is useful to have the option to abandon and recover (or partially recover) the value of the project's plant, equipment, or other assets.

Project termination is one of the most difficult decisions the management team has to take. In some cases it causes frustration and also hit the company's image. A project may be terminated if one of the following situations occurs:

- Specifications or requirements of the project suffer a great change so that the contract cannot be changed accordingly and the financial and economic balance is severely affected.
- By a default of the special purpose vehicle (SPV) company.
- By the decision of the Contracting Authority.
- Because a force majeure event has made it impossible to complete or continue operating the project.

Nevertheless, the early termination of the contract by the concessionaire is often considered as a last resort, and the contracting authority is willing to remedy its risk of an early termination of the contract.

If the project is terminated or abandoned because of a contractor default, or a situation of bankruptcy, the problem of how to compensate the concessionaire takes place. Someone may ask why a compensation should be paid to the concessionaire when it has failed to perform the service in accordance with the contract. Apparently, in the case of a breach of contract by the private partner, the existence of compensation would be questionable; in fact, an indemnity to the Public Administration should be considered. However, the underlying principle on which concession contracts are supported is the unfair non-enrichment of the parties involved in the contract. Therefore, when an asset built by the private partner returns to the Public Administration due to an early termination of the contract, the absence of compensation to the private partner would

cause an unfair benefit for the Public Administration (H.M Treasury, 2007). This would be the case of most of the infrastructure transportation contracts, where a particular asset is developed to deliver a particular service and the Authority is entitled to have the asset transferred to it on a termination without compensating the concessionaire for its value.

The legal framework states as a basic principle that any contract relative to a PPP's must keep its economic balance on the terms under which it was awarded, taking into account the general interest and the grantee's interest. The transfer of risks to the private partner, as regards the Eurostat Decision, requires that the contract includes the clause relative to maintaining the economic balance in the following cases:

- When cause of force majeure appears.
- When any modification of the conditions of performance of the contract is not derived from the express will of the contracting authority, but from a public entity other than the contracting authority which has an impact on the maintenance of the economic and finance balance of the contract. This event is so-called "*factum principis*".
- When the public administration carries out any action directly affecting demand level or having repercussions on the quality of the services supplied by the private partner. This situation is so-called "*ius variandi*".

Under the real options framework, the early termination of the contract resembles to an option to abandon the project, which is equivalent to a put option taking into account the equivalence relation between real options and financial options. The company will exercise that abandonment option if the value recovered from the project's assets is greater than the present value of continuing the project. The option to abandon is considered as an insurance policy that pays off if the company or project performs below expectations (Berger, Ofek, & Swary, 1996) and it has a character of irreversible. The option thus has value, and information about the exit value of the company's assets should affect its market value.

An early possibility to abandon a project is very valuable for its owners, because of it allows them to appropriate of the project market value in unfavorable situations. The

total value of a project will be given by the sum of cash flows and the value of the abandonment option. In that regard, the value of the abandonment options is equal to the difference between the abandonment value and the present value of future cash flows as (Equation 7.1.2.18.) states.

When the present value of the project at a given time falls below its liquidation value, the decision to abandon or sell the project is equivalent to the exercise of a sale option, with an exercise price equals to its liquidation or abandonment value, which sets an upper limit to this value. In general, a project should be abandoned at the time at which its abandonment value exceeds the net present value of the project's subsequent expected future cash flows discounted at the cost of capital rate (Robichek & Van Horne, 1967) and consequently the abandonment option represents an American put option defined on the current cash flows that the project provides (Lara Galera A. , 2006).

(Robichek & Van Horne, 1967) considered the abandonment option as a contingency in the forecast of future cash flows used for calculating the net present value or internal rate of return of an investment project. Their contingency approach as correlated by (Dyl & Long, 1969) does not provide a practical procedure for calculating the abandonment's option value.

(Kensinger, 1980) modeled the abandonment option's value but considering it as an European option with a non-stochastic exercise price. On the other hand, (Myers & Majd, 1990) improved Kensinger's approach by recognizing that the abandonment option is equivalent to a complex American put with both an uncertain underlying stock value (the cash flows) and an uncertain exercise price (the abandonment value). In this regard, (Berger, Ofek, & Swary, 1996) developed an hypotheses where the firm's market value is equal to the sum of the value of its expected operating cash flows plus the value of the abandonment option (Equation 7.1.) and (Equation 7.2.).

$$Value = PVCF + P(PVCF, Exit, SDEV) \quad (\text{Equation 7.1.})$$

$$\left(\frac{Value}{PVCF} - 1 \right) = P\left(1. \frac{Exit}{PVCF}, SDEV\right) \quad (\text{Equation 7.2.})$$

Where:

- *Value* : The firm's market value.
- *PVCF* : Present value of the firm's expected operating cash flows.
- *P()* : Operator representing an American put option.
- *Exit* : Exit value of the firm's assets.
- *SDEV* : Standard deviation of the ratio of PVCF over EXIT.

Using the internal rate of return method, the decision to abandon the project would be possible when the rate of return on abandonment value is less than the cost of capital. In either case, funds will be removed from a project whenever their incremental return is less than the cost of capital. Abandonment value is assumed to represent the net disposal value of the project that would be available to the company in either cash or cash saving (Shillinglaw, 1959).

(Pollio, 1998) proposes the real options approach for assessing project finance structures with limited recourse. In this structure, the sponsors have an additional flexibility given by an implicit right of abandonment at each repayment date. Its payoff can be defined as:

$$\max(\text{project value} - \text{the value of outstanding debt}, 0) \quad (\text{Equation 7.3.})$$

This means that the project involves a loan with a series of options. The borrower will only exercise it if project equity is zero or negative. Since the project finance structure results in a responsibility limitation to the sponsors, they could decide whether or not to invest more whenever the cash flow is negative.

(Trigeorgis & Mason, 1987) divided the abandonment option in two classes:

- **Option to abandon during construction period:** Most of the projects do not require the investment to be concentrated in a single payment in advance; such payments are usually made in construction work certifications. Nevertheless, a down-payment is performed at the beginning of the project when the contract signing event takes place. The actual staging of the investment as a series of outlays over a time horizon creates valuable options to abandon the project at

any given stage (e.g., a copper mine exploitation when the respective reservoir values or copper prices become too low to justify the continuation of that investment project). Thus, each stage of the investment in question can be viewed as an option on the value of the subsequent stages by incurring the next cost outlay required to proceed to the next stage. It is also important to keep in mind that the contractor shall submit a performance bond required as a security to the job completion once the project begins. If the contractor abandons the project, then this bond is claimed.

- **Option to abandon for its salvage value:** If, for any reason, the project is no longer profitable, management is not required to continue incurring the fixed costs of that investment. In such a situation, management may be holding a valuable option to completely abandon the investment in exchange for its salvage value, which is equivalent to the secondary market resale price of the equipment and/or other investment assets. As we will see, in concession contracts the concessionaire cannot perform the abandonment at his will.

7.1. THE ABANDONMENT OF A CONCESSION PROJECT.

The value of a capital investment depends on the stream of future cash flows that it generates, but in most cases, those cash flows are uncertain. In the case of motorway concession projects, the origin of this uncertainty comes from the accuracy in the estimation of future traffic by the planners which predetermine the feasibility of the project. Traffic forecasts are also used to dimension the construction of transportation infrastructure projects. Accuracy in such forecasts is a point of considerable importance for the effective allocation of scarce funds.

At some unspecified time in the future, the project would be abandoned, either because its physical life of it has been achieved or because the current and future cash flows do not justify the feasibility of the project already. But it is not necessary for cash flows to be negative before abandon the project. Abandonment itself may produce positive cash flows such as tax effects for depreciation, sale of equipment, return of working capital, or the use of space by more profitable projects (this case is not applicable

to infrastructure projects because of their nature of sunk costs). Therefore, any project is susceptible to be abandoned if project cash flows will not exceed the current abandonment value.

The value obtained from abandoning the project has two main components. A deterministic value which would be known in advance and depends on the time when the project is abandoned. And a second component that would result from the cash flows generated by the project.

The option to abandon a project is formally equivalent to an American put option on a dividend-paying stock and can be valued by applying the techniques developed to value options on stocks (Black & Scholes, 1973). However, it is not a simple put option because the project yields uncertain cash flows and has an uncertain salvage value. These factors significantly complicate the solution procedure (Brennan & Schwartz, 1977). Nevertheless, in concession agreements in Spain, the salvage value can be determined because we can calculate the abandonment value at any point in time in the future. This abandonment value is so called the Administration's Patrimonial Liability (RPA (*Responsabilidad Patrimonial de la Administración*) for its acronym in Spain) and it is fully explained in Section 8.1.1.. Moreover, we can forecast future cash flows thanks to Monte Carlo simulation. This procedure has been followed in this dissertation to study the abandonment option in motorway concession contracts.

By applying the analogy with financial options, the exercise price of the put is the salvage value of the project; the cash flows from the project are equivalent to the dividend payments on the stock. Standard capital budgeting procedure assigns an expected pre-determined salvage value to assets at the end of their project life. However, salvage value also affects the value of an investment because of the option to abandon the project early. The project will be abandoned if the value of continuing is less than the salvage value at that time. Conventional capital budgeting fails to take this option into account (Myers & Majd, 1983). Also, the project can be abandoned at any time during its life. In stock valuation, the value of a stock is the present value of its expected dividends. Applying the equivalence, the value of a project is determined by the present value of its

expected cash flows. The uncertainty in the value of the project comes from the related future cash flows.

7.1.1.1. THE ADMINISTRATION'S PATRIMONIAL LIABILITY INVOLVED IN CONCESSION CONTRACTS IN SPAIN.

The infrastructure concession agreement has always been used as a mechanism to rendering public and private's concerns in an effective way. Under a PPP contract, the legal ownership of the concession-related assets and the responsibility of the service are in all cases by the Public Administration or the Public Granting Authority. Therefore, through the bidding process, Public Administration makes sure that the concessionaire provides capability guarantees both technical and financial, in order to meet the contract properly.

The Administration's Patrimonial Liability, hereinafter the RPA (*Responsabilidad Patrimonial de la Administración*) for its Spanish acronym, relies on the principle of the obligation of the Public Administration has to amend the damage caused by an action which has affected the heritage of a subject and the existence of a right or interest protected. The concept of RPA is considered as a compensation for malfunctioning when due to an act of the Public Administration, a patrimonial damage is caused that must be repaired. This fact comes from a particularity of the Spanish law in which an unfair enrichment of the parties involved in the contract is not permitted. If the Public Administration receives something (an infrastructure) as a consequence of an early termination, the absence of compensation to the private partner would cause an unfair benefit for the Public Administration. This principle is contained in the Article 9.3. of the Spanish Constitution of December the 27th 1978. Moreover, the Article 106.2 of the Spanish Constitution says, "*Private individuals shall, under the terms established by law, be entitled to compensation for any loss that they may suffer to their property or rights, except in cases of force majeure, whenever such loss is the result of the operation of public services*".

As a consequence of the RPA, the Public Administration would have to pay a large amount of money to the concessionaire in the case of the latter get into bankruptcy, with

the resulting impact on the public deficit. This situation provides an incentive to the Public Administration to avoid that situation of bankruptcy and therefore to renegotiate the contract with the concessionaire (Baeza Muñoz & Vassallo Magro, 2012).

The main difference between the non-contractual liability and the RPA comes from the Civil Law. When the relations of private law are regulated, the liability shall only be claimed if there is a fault or negligence. Whereas in the RPA shall only be claimed the existence of injury regardless of there is not such fault or negligence.

As it has set the doctrine of the Supreme Court, in order to claim the Administration's Patrimonial Liability the following requirements must be fulfilled:

- An irregularity attributable to the Public Administration.
- Anti-juridical damage or prejudice, effective, economically assessable and individualized in relation to a person or group of people.
- Relationship of causality between fact and prejudice.
- Non-occurrence of force majeure or another cause of exclusion of the liability.

The existing regulation regarding the Administration's Patrimonial Liability is integrated in:

- The Spanish Constitution within its Article 33.3 establishes that: *No one may be deprived of his or her property and rights, except on justified grounds of public utility or social interest and with a proper compensation in accordance with the provisions of the law.*
- Law 30/1992 of 26 November, on Rules governing general government institutions and Common Administrative Procedure (*Ley 30/1992. de 26 de noviembre, de Régimen Jurídico y del Procedimiento Administrativo Común*).
 - Article 139: Principles of liability.
 - Article 139.1.: Individuals are entitled to be compensated by the corresponding public administrations, of all injury suffering in any of their property and rights, except in cases of force majeure, provided that the injury is a consequence of the normal or abnormal functioning of public services.

- Article 139.2.: In any case, the damage alleged must be effective, measurable economically and individualized in relation to a person or group of persons.

The Ministry of Justice will be in charge of processing the procedure to determine the quantity of the compensation to be paid to the concessionaire, in audience with the Council of State, according to the Spanish Royal Decree Law 429/1993 of 26 March, Rules of Procedures Regarding Public Administration's Patrimonial Liabilities (*Real Decreto 429/1993. de 26 de marzo, Reglamento de los Procedimientos en material de Responsabilidad Patrimonial de las Administraciones Públicas*).

It is in the Law 8/1972 of May the 10th, of construction, maintenance and operation of motorways under concession agreement when the concept "Administration's Patrimonial Liability (RPA)" applied to motorway concessions was introduced. Moreover, the Spanish Royal Decree Law 3/2011 of 14 November, which approves the Consolidated Text of the Public Sector Contracts Act (*Real Decreto Legislativo 3/2011. de 14 de noviembre, por el que se aprueba el texto refundido de la Ley de Contratos del Sector Público (BOE 276/2011)*) covers this concept.

7.1.1.1. REASONS FOR TERMINATION OF CONCESSION CONTRACTS AND THEIR EVOLUTION OVER TIME.

The duration of the concession agreement will be determined by the awarding Royal Decree in accordance with the special specifications and the proposal, and not exceeding the period considered in the Law 8/1972 of May the 10th, which is fifty (50) years. Once this period has been reached, the infrastructure reverts to the Public Administration. Notice that a contract may be terminated if its compliance or resolution occurs. Nevertheless, this period has been reduced to forty (40) years for those concession contracts for the construction and operation of public infrastructures, according to the Article 268 of the Spanish Royal Decree Law 3/2011.

In accordance with the Article 32 of the Law 8/1972 of May the 10th, of construction, maintenance and operation of motorways under concession agreement; six possible facts may trigger the termination of the concession contract, which are the following:

- The compliance of the deadline for which the contract was awarded.
- Failure to comply with the obligations imposed on the concessionaire.
- The Declaration of bankruptcy of the concessionaire.
- The mutual agreement between the Public Administration and the concessionaire.
- Rescue of the operation of the public work by the contracting authority.
- Any other causes expressly referred to in this or any other law, or the contract.

The abovementioned criteria are fully explained in the Royal Decree 215/1973 of January the 25th, were the general administrative specifications (PCG for its Spanish acronym) of construction, maintenance and operation of motorways under concession agreement is approved. The most relevant fact which affects the majority of existing motorways in Spain is the declaration of bankruptcy of the concessionaire which will cause the termination of the concession contract and the loss of the performance bond, according to the clause 109 of the Royal Decree 215/1973. In this case, the Public Administration shall conduct the liquidation of the investments made by the concessionaire according to the clause 107.e) of the Royal Decree 215/1973.

These facts have been extended over the years, and the Spanish Royal Decree Law 3/2011 establishes in its Article 269 the reasons when the contract is terminated:

- a) Death or sudden inability of the individual contractor or the extinction of the legal personality of the contractor, without prejudice to the provisions of Article 85.
- b) The Declaration of bankruptcy.
- c) Deserted declared foreclosure or inability to initiate the procedure of foreclosure due to a lack of authorized interested to do so in cases in which thus appropriate, in accordance with the provisions of the law.
- d) The mutual agreement between the Public Administration and the contractor.

- e) The abduction of the concession for a period exceeding the established maximum unless the contractor has guaranteed the full assumption of its obligations.
- f) The delay of more than six months in the delivery of the compensation, the land or auxiliary means by the contracting authority to the concessionaire, which were committed according to the contract.
- g) Rescue of the operation of the public work by the contracting authority. Rescue means the unilateral declaration of the contracting authority, discretionally adopted, terminating the concession agreement, despite the sound management of its holder.
- h) Suppression of the operation of the public work for reasons of public interest.
- i) The impossibility of operation of the public work as a result of agreements adopted by the awarding administration after the contract awarding.
- j) The abandonment, the one-sided waiver, as well as the breach by the concessionaire of essential contractual duties.
- k) Any other causes expressly referred to in this or any other law, or the contract.

The declaration of bankruptcy and, in the case of an arrangement process with creditors, when the liquidation phase takes place; as well as those situations described in letters e), g), h) and i); always originate the termination of the contract.

According to the Article 271 contained in the Consolidated Text of the Public Sector Contracts Act, in those termination assumptions attributable to the Public Administration, it shall pay to the concessionaire the amount of investments made by reason of the expropriation of land, execution of construction and acquisition of goods which are necessary for the operation of the infrastructure covered by the concession contract. To that effect, there have been taken into account their depreciation degree according to the time until the term of the concession and the established in the economic-financial plan. The resulting amount shall be fixed within the following six (6) month period, unless the specific administrative clauses (PCAP for its Spanish acronym) provide otherwise.

This clause is very appreciated by financial institutions because it ensures them that in the case of an early termination of the contract; the concessionaire has the right to receive

a large amount of cash inflows by the Public Administration. This article recognizes the right of the concessionaire to be compensated by the Public Administration in case of termination of the contract.

In 2014 a new paragraph was added to the Article 271 of the Consolidated Text of the Public Sector Contracts Act related to expropriations in which if the concessionaire does not comply with the obligations of the beneficiary of the expropriations, the granting authority had to be in charge of paying the compensation to the expropriated, the former will be subrogated in the credit of the expropriated. In any case, from the moment the granting authority has the obligation to pay; those amounts that are not reimbursed will reduce the overall amount of the RPA. This paragraph makes sense since once the termination of the contract takes place; the concessionaire is no longer in charge of the expropriations, so the RPA amount does not increase due to expropriations anymore.

In the event when the delivery of the compensation cited in letter f) exceeds the period of six (6) months, the concessionaire has the right either to terminate the contract, or demand the payment of the legal interest of the outstanding amounts, or the agreed economic values, from the foreseen deadline. In addition, if events g), h) or i) abovementioned; the Public Administration shall compensate the concessionaire for any damages and prejudice caused. The compensation should take into account expected future profits by taking into account both last five years operation earnings and assets depreciation.

On the contrary, in those termination assumptions attributable to the concessionaire, the operation performance bond shall be seized, in addition, the concessionaire shall compensate the Public Administration for the liquidated damages caused in which exceed the amount of the claimed security. In this case, the Article 271.4 of the Spanish Royal Decree Law 3/2011 of November the 14th, which approves the Consolidated Text of the Public Sector Contracts Act (Real Decreto Legislativo 3/2011. de 14 de noviembre, por el que se aprueba el texto refundido de la Ley de Contratos del Sector Público (BOE 276/2011)) says that when the contract is terminated for reasons attributable to the concessionaire, the operation performance bond shall be claimed, in addition, the concessionaire shall compensate the Public Administration for the liquidated damages

caused in which exceed the amount of the seized security. The operation performance bond mention above refers to the Article 14 of the Law 8/1972 of May the 10th, of construction, maintenance and operation of motorways under concession agreement; which says that prior to the entry into service of any of the sections that make up the motorway, the concessionaire shall constitute the operation performance bond under the conditions laid down in the tender award and amount not less than 2% of the total investment of each section in service. Once the concession agreement has been granted to the concessionaire, i.e. at the beginning of the construction phase, the concessionaire has to deposit a performance bond of an amount of 5% of the total investment. Once the construction phase has been accomplished and the motorway enters the operating phase, the 5% performance bond is released and progressively reduced and in inverse proportion until the end of the contract. This reduction shall not be less than 2% according to the Spanish law. The amount of the performance bond is revised every year, once the motorway is under operation.

Regarding to the liquidated damages the concessionaire shall pay to the Public Administration in the case mentioned above, this concept encompasses the consequential damages and loss of profit. Consequential damages include all those demonstrable payments with bills (payroll of employees of the concession, cost of operating the motorway in case that the traffic revenues are not sufficient, etc....). If the Ministry of Public Works has to undertake a new public tender process, the cost of a new tender can also be included as a consequential damage. Regarding of the loss of profit, this concept is ambiguous and could also depend on the verdict of a judge. Because of an infrastructure is built in order to satisfy the general interest of the population, the loss of profit would be interpreted as the loss of social utility for not providing a public service. This concept does not make sense because once the infrastructure has been rescued; the Public Administration begins to provide the service.

7.1.1.1.1. CHANGES IN THE CONSOLIDATED TEXT OF THE PUBLIC SECTOR CONTRACTS ACT (OCTOBER 2nd 2015).

Significant changes were made in the Consolidated Text of the Public Sector Contracts Act regarding to the Administration's Patrimonial Liability. The **Article 271.bis** was introduced in the last version, published in October the 02nd 2015 which says that in those cases where the resolution occurs for reasons not attributable to the Public Administration²⁶, the concession contract shall be tendered again by the contracting authority. The type of the contract will be according to the Article 271.ter. The new tender process can only begin once the resolution record has been initiated. Nevertheless, the awarding cannot take place until the resolution has ended. The tender process will be made throughout an auction being the price the unique awarding criterion. In the case when the first tender process is declared as void, a new tender process shall be called up; being the type of the tender, the 50% of the first one. The awardee shall pay the amount of money within the first two (2) months after the concession was awarded. In the event when the amount of money was not paid within the prescribed period of two months, the awarding will terminate, being the next bidder in order the new awardee. But if there not more bidders in the process, the tender process is declared as void. If the second tender process is also declared as void, the value of the concession shall be the sort of it, without prejudice to the possibility of submitting by the original dealer or by the holding creditors of at least 5% of the total liabilities of the concessionaire, within a maximum period of three months since the process was as void; a new buyer who paid at least the mentioned type of tender in which case the value of the concession will be the amount of money paid by the new buyer.

In those instances where the resolution occurs for reasons not attributable to the Public Administration, the value of the concession obtained thereby, will be the result of the process mentioned above. The contracting authority shall pay the value of the

²⁶ In this regard, among all of those reasons when the contract is terminated (Article 269 mentioned above); letter a), b), c), e) and j) are considered reasons not attributable to the Public Administration according to the changes introduced in Article 271 of the Consolidated Text of the Public Sector Contracts Act in October the 02nd 2015.

concession to the first concessionaire within a period of three (3) months once the awarding has been made.

The resulting contract will also have the same nature the initial contract had (Public Work Concession Contract), and the same terms as well, even the period of the contract.

The type of the tender process the Article 271.bis mentions is described within the **Article 271.ter**, which was also introduced in the last version of the Consolidated Text of the Public Sector Contracts Act, published in October the 02nd 2015. It says that the type of the first tender process mentioned in the Article 271.bis shall meet the following rules:

- The type will be based on expected future cash flows to be obtained by the concessionaire, by the operation of the project, in the period remaining from the resolution of the contract until its reversion, discounted to the interest rate on the ten-year Treasury bond increased by 300 basis points.
- The debt instrument which serves as a basis for the calculation of the reasonable profit and the cited rate may be amended by the Delegate Commission of the Government for Economic Affairs, following a report of the National Office of Evaluation, to adapt to the conditions of risk and profitability observed in public sector contracts.
- Net future cash flows are quantified in the arithmetical average of cash flows obtained by the entity during a period of time equivalent to the years remaining until completion. When the remaining time until the termination is greater than the preceding time period, the latter will be taken as reference. Any price update according to the expected future inflation rate shall not be applied.
- The value of the cash flows shall be that set for the General Accounting Plan in the Statement of Cash Flows as Cash Flows from Operating Activities without computing any payments and interest charges, payments of dividends and payments or payments for income tax.
- If the resolution of the contract would take place before the end of the construction of the whole infrastructure, the type of the tender will be the 70%

of the equivalent amount of money of the executed investment according to the last approved financial statements, increased

On the contrary, when the early termination of the contract is due to the rescue of the operation of the infrastructure or the impossibility of its operation as a result of the agreements with the Public Administration, the concessionaire has the right to be compensated for caused damages. Therefore, the Public Administration shall compensate the concessionaire by the future loss of profit based on the results obtained during the last five-year period as well as the loss of the value of the infrastructure and goods that do not have be delivered to the Public Administration, considering its degree of depreciation.

These changes introduced in the law have a great impact in the RPA, because if the default takes place before the mid-point of its operational period, the analysts shall use those cash flows that led the previous concessionaire to default. Therefore, because of the concession is bankrupted, it is worth barely nothing. The only element with value is the infrastructure in itself and maybe traffic can change in the future; but the concept of RPA as everybody knew, has disappeared.

7.1.1.2. DEPRECIATION CRITERION AND ITS INFLUENCE IN THE RPA AMOUNT.

Regarding to the Clause 107.e) (Non-compliance with the obligations imposed to the concessionaire) of the Royal Decree 215/1973 the Public Administration will return to the concessionaire whose contract had been declared resolved by default, all of those investments made in the motorway regarding to expropriation of land, construction and acts of incorporation of goods which are necessary for the operation. In the liquidation, the following investments shall be taken into account (Figure 7.1.1.2.a.):

- Expropriations shall be compensated by the amount actually paid to the expropriated people, deducted the depreciation that corresponds according to the number of years.

- The construction works shall be met based on the actually executed and defined in projects approved by the Ministry of Public Works at the prices approved in projects, deducting the depreciation that corresponds according to the number of years. This amount corresponds with the As-Built budget, once the construction works have been approved by the Ministry of Public Works at the price approved in the project.
- Real properties incorporated into the concession which are not included in the construction budget shall be assessed according to their state of use.
- Under no circumstances a compensation concerning expenses of society set up, studies and projects, project management team, construction management team, financial expenses, etc..., will be paid.

Figure 7.1.1.2.a.: How does the RPA Value Evolves over Time?

Source: Author.

Moreover, the Clause 74 (Variation of construction works) of the Royal Decree 215/1973 of January the 25th, the RPA is conventionally limited to the amount provided for the cost of the construction works provided by the concessionaire in the proposal, increased, where appropriate, by increases by those modifications, approved, by the Ministry of Public Works. Therefore, to the sum of the three components listed above, the RPA can also include the amount of those additional projects required by the Ministry of Public Works, i.e. the As-Built budget of those additional projects as it is shown in (Table 7.1.1.3.c.).

Regarding the depreciation of the assets, the Article 13.a) of the Law 8/1972 sets the faculty of the concessionaire to depreciate the elements of the asset perishable during the concession period or subject to reversion, based on the economic and financial plan attached to the proposal submitted by the concessionaire in the tender process. This article does not explicitly establish the criteria the concessionaire shall apply. Nevertheless, it leaves the door open to the concessionaire for the adoption of an amortization criterion which suits better for its economic and financial plan.

As it can be seen in (Figure 7.1.1.2.a.) the depreciation curve can evolve along time very differently depending on the depreciation criteria adopted. If we consider a straight-line amortization criterion the RPA amount will evolve following the red dashed line (a) in (Figure 7.1.1.2.a.). However, if we take into account the accounting criteria that considers an amortization criterion which depends on the traffic that circulate on the motorway, the RPA amount will evolve following the red dashed line (b) in (Figure 7.1.1.2.a.). Nevertheless, if we consider a new possible directive that shall be applied to the motorway during the operation phase, and that directive involves new investments, the RPA amount will be increased during the operation phase. This criterion is shown in the red dashed line (c) in (Figure 7.1.1.2.a.). In that regard, the main problem the Public Administration is dealing with is how to determine the amount of the RPA. Therefore, it would make sense that the public Administration should accept (or consider in the calculation of the RPA amount), the one adopted by the concessionaire in the tender process, which was approved by the granting authority in the award of the contract.

7.1.1.2.1. ACCOUNTING CRITERION. INTANGIBLE ASSET vs. FINANCIAL ASSET.

The accounting criterion for a concession arrangement will be determined by the specific terms of the contract. There is a specific General Accounting Plan for concession agreements and its rules are contained in the order EHA/3362/2010 based on different contractual agreements regulated under the Law 30/2007 of October the 30th of the Public Sector Contracts. The European applicable law is based on an interpretation of the International Financial Reporting Standards Interpretations Committee (CINIIF for its

acronym in Spanish) published in November 2006 adopted by the European Union through the regulation 254/2009 of March 25th.

The concessionaire company shall recognize revenues according to the general regulations as “Revenue from sales and services rendered” whether they are:

- Incomes from construction services rendered or infrastructure upgrading.
- Incomes from operation services.

The remuneration of the concessionaire company for the construction services or infrastructure upgrading will be accounting as:

- Intangible Asset, or
- Financial Asset.

If the concessionaire has a contractual right to receive cash from or at the direction of the granting authority and the latter has little, if any, discretion to avoid payment; the financial asset model applies. The financial asset model applies when the infrastructure shall meet or ensure some specified quality criterion or efficiency requirements. The financial asset is accounted for in accordance with IAS 39 (Financial Instruments: Recognition and Measurement), IFRS 9 (Financial Instruments) and IAS 32 (Financial Instruments: Presentation and IFRS 7 Financial Instruments: Disclosures). In general, it is not deemed to be an unconditional payment right when the demand risk is assumed by the concessionaire. When there are any clause in the concession agreement that contributes to mitigate the risk demand beard by the concessionaire, such as changes in tariffs or an extension of the concession period; the accounting criterion cannot be as a financial asset because the concessionaire does not have an unconditional payment right at the beginning. The main problem of considering the infrastructure as a financial asset that is, when incomes are guaranteed by the granting authority (such as shadow toll motorways), is that it leads to a less EBITDA in the concessionaire’s financial statements. This fact is particularly important since some covenants are linked to the evolution of the EBITDA. In addition, many financial valuation methods are based on multiples of EBITDA,

so a concession which accounting criterion is based on financial asset method will be worth less than other based on the intangible asset method.

Figure 7.1.1.2.1.a. shows the difference in the net income evolution for 30 year motorway concession, with the difference that the green line is accounted following the intangible asset criterion; and the blue line following the financial asset criterion. Regarding the financial asset model, net incomes at the beginning of the operation period will be higher than those at the end of the concession agreement. On the contrary, the intangible asset model will have the opposite consequences and will give rise to lower income in the first few years of the concession term compared to the financial asset model and higher income in later years. This difference between the two models normally arises because under the financial asset model the income is front-loaded in the early years due to the use of the effective interest rate method and no amortization of the asset.

Figure 7.1.1.2.1.a.: Accounting Criterion. Intangible Asset vs. Financial Asset.

Source: Author.

On the other hand, the intangible asset model applies if the concessionaire receives a right to charge users, or the granting authority, based on usage of the infrastructure or public service. There is no unconditional right to receive cash as the amounts are contingent on the extent that the public uses the service. During the construction phase the operator recognizes revenue in respect of construction activities with the corresponding entry increasing the amount recognized for the intangible asset. This is because the operator exchanges construction services in return for a license. The granting

authority makes a non-cash payment for the construction services by giving the operator an intangible asset in exchange for the construction services. The intangible asset generates a second stream of revenue when the concessionaire receives cash from users or from the grantor based on usage. This is in contrast with the financial asset model in which cash received is treated as partial repayment of the financial asset. In the intangible asset model, the intangible asset is reduced by amortization rather than repayment. The intangible asset must be accounted for in accordance with IAS 38 (Intangible Assets). The intangible asset should be amortized over the period of the concession rather than the annuity method of amortization which is specifically banned. The most appropriate method of amortization of the intangible asset is usually the straight-line method, unless another method better reflects the pattern of consumption of the asset's future economic benefits. However, in some circumstances, where the expected pattern of consumption of the expected economic benefits is based on usage, it may be appropriate to use an alternative method of amortization.

In this regard, a modification in the Consolidated Text of the Public Sector Contracts Act (published in October the 02nd 2015) was made regarding the depreciation criteria. It establishes that the depreciation criteria shall be straight-line method. There is a controversy in this regard because the adaptation of the General Accounting Plan to infrastructure concessionaire companies mentions that when the asset can be classified as intangible asset, the amortization rate of each exercise will be obtained by applying the percentage that results from comparing the use provided for in each fiscal year and the total intended use at the cost of the asset. The straight-line method can also be applied but if it may be demonstrated that the infrastructure's usage pattern can be reliable estimated, the amortization criteria can be the one mentioned before. There is no unconditional right to receive cash as the amounts are contingent on the extent that the public uses the service according to the IFRIC 12 criteria. Nevertheless, the changes in the Consolidated Text of the Public Sector Contracts Act mentioned above have not retrospective nature and cannot be applied to existing concession contracts.

Regarding financial expenses, they will depend on the concessionaire remuneration of its construction services or upgrading ones, if they are accounted as intangible asset or

financial asset. If they are considered as financial asset, financial expenses are considered as a financial liability according to the General Accounting Plan. On the contrary, if they are accounted as intangible asset, financial expenses incurred by external financing will be added to the initial value of the intangible asset until the infrastructure is ready to operation. Once the infrastructure is under operation financial expenses will be capitalized if they are separately identifiable and reliably measured. Moreover, there should be reasonable evidence that future income will be able to recover the amount that was capitalized.

7.1.1.3. UPPER LIMIT OF THE RPA AMOUNT.

In many contracts, the upper limit amount of the RPA has been set in the contract signing act once the granting has taken place. Table 7.1.1.3.a. shows the upper limit amount of the RPA of those Spanish motorway concessions which are going through a difficult financial situation.

Table 7.1.1.3.a.: Upper Limit of the RPA of Nine Spanish Toll Motorways.

COMPANY HOLDING THE CONCESSION	Upper RPA Limit (million €)
Henarsa (R-2 and M-50)	86.1
Accesos de Madrid (R-3. R-5 and M-50)	823.9
Madrid Sur (R-4 and M-50)	652.3
Madrid – Levante (AP-36. Ocaña – La Roda)	487.2
Madrid – Toledo (AP-41)	351.4
Eje Aeropuerto (M-12)	348.2
Aucosta (AP-7. Cartagena – Vera)	529.3
Ciralsa (AP-7. Circunvalación de Alicante)	452.8
Ausur (AP-7. Alicante – Cartagena)	221.1
TOTAL	3,952.30

Source: Spanish Senate.

These figures shown in (Table 7.1.1.3.a.) involve that the maximum amount the Public Administration will pay to the concessionaire in respect of RPA, is the upper limit. But it is not clear what the concepts that have been considered in the total amount for each motorway are. Table 7.1.1.3.b. and (Table 7.1.1.3.c.) show what is the value of the RPA according to each Royal Decree Awarding the contract (separating construction works on

one side, and expropriations on the other side) (Table 7.1.1.3.b.) and the additional construction works approved by the Ministry of Public Works (Table 7.1.1.3.c.), whose investment shall be added to the RPA.

Table 7.1.1.3.b.: RPA Value of Nine Spanish Toll Motorways According to the Royal Decree Awarding the Contract.

COMPANY HOLDING THE CONCESSION	RPA Value According to the Granting Royal Decree		
	Construction Works ²⁷	Expropriations	<u>RPA</u>
Henarsa (R-2 and M-50)	-	-	40,724,580 €
Accesos de Madrid (R-3. R-5 and M-50)	637,970,000 €	39,040,000 €	677,010,000 €
Madrid Sur (R-4 and M-50)	-	-	559,656,461 €
Madrid – Levante (AP-36. Ocaña – La Roda)	462,704,717 €	24,536,532 €	487,241,249 €
Madrid – Toledo (AP-41)	294,731,000 €	54,155,000 €	348,886,000 €
Eje Aeropuerto (M-12)	268,498,917 €	36,972,339 €	305,471,256 €
Aucosta (AP-7. Cartagena – Vera)	496,000,000 €	30,819,000 €	526,819,000 €
Ciralsa (AP-7. Circunvalación de Alicante)	309,826,000 €	88,839,000 €	398,665,000 €
Ausur (AP-7. Alicante – Cartagena)	196,212,422 € ²⁸	24,896,926 € ²⁹	221,109,348 €
TOTAL			3,565,582,894 €

Source: Author.

Table 7.1.1.3.c.: RPA Value after Adding Additional Construction Works Approved by the Ministry of Public Works.

COMPANY HOLDING THE CONCESSION	RPA Value after Adding Additional Construction Works	
	Additional Construction Works	<u>RPA</u>
Henarsa (R-2 and M-50)	45,351,840 €	86,076,420 €
Accesos de Madrid (R-3. R-5 and M-50)	146,948,554 €	823,958,554 €
Madrid Sur (R-4 and M-50)	92,525,380 €	652,181,841 €
Madrid – Levante (AP-36. Ocaña – La Roda)	-	487,241,249 €
Madrid – Toledo (AP-41)	-	348,886,000 €
Eje Aeropuerto (M-12)	42,000,000 €	347,471,256 €
Aucosta (AP-7. Cartagena – Vera)	-	526,819,000 €

²⁷ It involves both “Construction works actually executed” and “Real property incorporated into the concession”.

²⁸ 32.647 million pesetas (rate of change -> EUR/PESETA = 166,386)

²⁹ 4.142,5 million pesetas (rate of change -> EUR/PESETA = 166,386)

COMPANY HOLDING THE CONCESSION	RPA Value after Adding Additional Construction Works	
	Additional Construction Works	<u>RPA</u>
Ciralsa (AP-7. Circunvalación de Alicante)	54,135,000 €	452,800,000 €
Ausur (AP-7. Alicante – Cartagena)	-	221,109,348 €
TOTAL		3,946,543,668 €

Source: Author.

7.1.1.3.1. A CHANGE IN THE EXPROPRIATION ASSESSMENT CRITERION.

According to the Article 17 of the Law 8/1972 of May 10th, the concessionaire will assume all rights and obligations in the expropriation process and shall pay all compensations to expropriates with regard to expropriations and temporary occupations required to execute the infrastructure. This article has suffered a modification in January 25th 2014 (Royal Decree Law 1/2014) by adding that if the concessionaire will not be able to meet its obligation whenever it happens, and the Public Administration has to take up the payment of the compensation to expropriates, it will be subrogated to the expropriation credit. From then on, all amounts paid by the Public Administration will not sum up the RPA amount anymore.

As a result of a judgment of the Supreme Court, the amount that concessionaire companies had to pay to the expropriated increased significantly (because of the rate of the land changed from rural to developable). This fact has been particularly severe to those Madrid radial motorways such as R-2 to R-5 and Eje Aeropuerto motorways, which have suffered a great increase in the amount they shall pay to expropriates. The Provincial Jury of Expropriation in Madrid calculated the fair value of the land as an undeveloped one. Therefore, all concessionaires valued the expropriations taking into account this criterion. Nevertheless, a few years after the projects were granted, a judgment by the Supreme Court considering that those infrastructures let to “build city”. Therefore, land where all those infrastructures were being built became developable instead of undevelopable, fact that affected negatively the balance sheet of the concessionaires.

In the tender submitted by the awarded concessionaires, the required expropriations of the land where the motorway was going to be built, suffered an important increase in price. As a result of the fair price of the land issued by the Provincial Expropriation Jury as well as other court judgments, the value of the land has been much higher than the one considered by the concessionaire in its tender. This circumstance, has significantly affected the financial and economic balance. This issue has affected several motorway concessions in Spain in the last fifteen (15) years. Therefore, the aforementioned concessionaire companies have claimed to the Public Administration in order to compensate them for the expropriations overrun. This situation cannot be considered a concessional risk the concessionaire should bear because of its uncertain nature that seriously affects its financial and economic balance.

In order to tackle this situation and let the concessionaire companies meet their obligation to pay the expropriations, a participation loan (Table 7.1.1.3.1.a.) will be granted to the concessionaires (Law 26/2009 of December the 23rd on the State Budget 2010). Some modifications to the concessional agreement were made in order to repay the participation loans, such as an extension of the concessional agreement or a staggered rate increase. The maximum amount of those loans granted to a concessionaire company regarding to expropriations are calculated by subtracting from the total amount paid by the concessionaire, the amount that represents 175 per 100 of the tender by that concept and add interests for delay in the payment of the fair compensation (as long as this delay is not attributable to the concessionaire).

Table 7.1.1.3.1.a.: Participation Loans for Expropriations Overrun.

COMPANY HOLDING THE CONCESSION	Participation Loans for Expropriations Overrun		
	Participation Loan	Principal + Interests	<i><u>Amount Actually Paid</u></i>
Henarsa (R-2 and M-50)	275,318,900 €	288,489,620 €	287,862,071 €³⁰
Accesos de Madrid (R-3. R-5 and M-50)	168,453,380 €	176,529,500 €	251,063,380 €
Madrid Sur (R-4 and M-50)	-	-	
Madrid – Levante (AP-36. Ocaña – La Roda)	-	-	
Madrid – Toledo (AP-41)	-	-	

³⁰ This amount has been estimated by considering an amount of 4,561,153 € for expropriations in the RPA amount.

COMPANY HOLDING THE CONCESSION	Participation Loans for Expropriations Overrun		
	Participation Loan	Principal + Interests	<u>Amount Actually Paid</u>
Eje Aeropuerto (M-12)	-	-	
Aucosta (AP-7. Cartagena – Vera)	-	-	
Ciralsa (AP-7. Circunvalación de Alicante)	-	-	
Ausur (AP-7. Alicante – Cartagena) ³¹	25,199,440 €	26,442,570 €	93,665,987 €

Source: Author.

Table 7.1.1.3.1.b.: RPA Value after Adding Expropriations Overrun and Detracting Participation Loans.

COMPANY HOLDING THE CONCESSION	RPA Value after Adding Expropriations Overrun and Detracting Participation Loans	
	Extra Cost ³²	<u>RPA</u>
Henarsa (R-2 and M-50)	7,982,018 €	94,058,438 €
Accesos de Madrid (R-3. R-5 and M-50)	52,570,000 €	876,582,554 €
Madrid Sur (R-4 and M-50)	-	652,181,841 €
Madrid – Levante (AP-36. Ocaña – La Roda)	-	487,241,249 €
Madrid – Toledo (AP-41)	-	348,886,000 €
Eje Aeropuerto (M-12)	-	347,471,256 €
Aucosta (AP-7. Cartagena – Vera)	-	526,819,000 €
Ciralsa (AP-7. Circunvalación de Alicante)	-	452,800,000 €
Ausur (AP-7. Alicante – Cartagena)	43,569,621 €	264,678,969 €
TOTAL		4,050,719,307 €

Source: Author.

In addition to the expropriation issues, the traffic volume has been less than considered in the tender by all concessionaires. This was because many of them trusted in the studies made by the Ministry of Public Works which were more optimistic than the reality. All concessionaires had the right of performing a traffic study by themselves but the high cost of making a reliable and accurate assessment together with the scarce available time; concessionaires based their traffic on the one provided by the Ministry of Public Works.

³¹ In this case, the compensation has not been made throughout a loan, but through a gradual increase in the tariff.

³² This amounts have been estimated by subtracting from the amount actually paid, the value of the RPA calculated in the tender plus the participation loan (without interests).

Once the RPA has been determined, and whenever the concessionaire agrees with the liquidation and does not appeal it, the payment deadline would depend on the existence or not of a budgetary allocation for that purpose. In the case of not having budgetary allocations which would be the most likely situation, the Ministry of public works should initiate procedures for the budget amendment, with duration of another 6 or 8 months. It is difficult to predict what can last the procedure, but it can be estimated at a minimum of one (1) year if there are no appeals.

7.1.2. THE ABANDONMENT DECISION AND ITS APPLICATION IN TOLL MOTORWAY CONCESSIONS.

In several countries, public work concessions have been often used for the development of transport infrastructures, especially toll motorways. These projects demand big investments in an almost irreversible way ((Abel, Dixit, Eberly, & Pindyck, 1996), (Abel & Eberly, 1994), (Abel & Eberly, 1999)) and a long-term return, and have not sometimes had the expected success. That irreversibility of the transport infrastructure investment is mainly due to the sunk costs associated to this kind of projects and the specific nature of the constructed assets. These sunk costs may tempt governments to behave opportunistically, taking regulatory actions that expropriate rents once costs are sunk, such as unilateral renegotiations of agreed-upon contract terms.

In general, there seems to be a consensus about that the initial expectations of the transport infrastructure projects have been often too optimistic (Flyvbjerg, Skamris & Buhl, 2005). It is also true that the current economic crisis does not favor the expected evolution of the contracts, because on the one hand, traffic is lower than forecasted and, on the other hand, the necessary financing is not found in a scenario of credit restriction. In this context, the classic methods for selection and evaluation of investments, based on the discounting of future cash flows generated by the project, have proved to be more inadequate than ever, especially when there is a certain flexibility in the contract (for example, a tool for the mitigation of demand risk). In these cases, the use of the Net Present Value (NPV) of the project as a decision criterion presents the problem of the selection of the adequate discount rate, in the presence of a mitigated risk. For this

reason, the application of the real options theory to the selection and valuation of infrastructure projects is becoming increasingly important. The analysis of projects based on the use of the real options theory explicitly takes into account the ability to review future operational decisions in response to the information gained (McDonald, 2003), thereby providing greater value to the projects. Moreover, the real options theory is based on a risk neutral approach, and therefore the problem of the selection of the discount rate is avoided. This assumption means that investors do not require a compensation for the risk they are facing up. In such an environment the expected return on the investment is the risk-free rate. According to Girsanov theorem, the random walk described in (Equation 5.3.1.8.) can be transformed to the neutral-risk random walk:

$$dS_t = r_f \cdot S_t \cdot dt + \sigma \cdot S_t \cdot dZ_t \quad (\text{Equation 7.1.2.1.})$$

Where:

- r_f : The risk-free rate of return.

If the asset pays a continuous dividend yield “ δ ”, the growth rate of the asset price has to be reduced this amount in order to provide the same overall return (dividend + capital gain) as an asset without dividends:

$$dS_t = (r_f - \delta) \cdot S_t \cdot dt + \sigma \cdot S_t \cdot dZ_t \quad (\text{Equation 7.1.2.2.})$$

In toll motorway concessions, real options arise from the interpretation of the terms and conditions contained in the tender documents and in the concession contracts themselves regulating rights and obligations for the concessionaire and possible operational options that may be exercised. Therefore, the abandonment option can be implicit in the specifications of the tender or in the clauses of the contract itself. The possibility of an early abandon of the project can be very valuable for its owners if market conditions turn unfavorable threatening the feasibility of the project. In the legal systems of certain countries, regardless the way or reason that results in a termination of the contract, such termination results in some kind of payment to the concessionaire which in the worst case will never be less than the book value of the investments made even if being penalized with fines or executing the bank guarantees.

We are dealing with contracts in which the concessionaire cannot abandon the project at any time, but the concessionaire can only abandon it in those specific points in time determined by the contract or the specifications. This kind of contracts require the mobilization of huge amounts of resources, with a long time horizon. In that period of time, the variability in the cash flows can be affected by many different factors. For this reason, it is necessary the abandonment option to be treated as a European put option. Note that in other kind of projects it is conceivable that the abandonment may occur at any time, but this will be unlikely in a toll motorway concession contract due to the public good nature inherent to transport infrastructures.

Let us suppose a concession of a duration of N years where the cash flow generated within the period $(t, t+dt)$ is defined according to existing traffic in the concession within that period, θ_t , that is: $FCL_t = f_t(\theta_t)$, considering FCL_t the free cash flow of the project in t .

Moreover, we assume that time evolves along the established period as a Geometric Brownian Motion (Lara Galera & Sánchez Soliño, 2010) with constant parameters α (traffic growth rate) and σ (volatility). This hypothesis is common when valuing traffic modeling as a diffusion process.

$$\frac{d\theta_t}{\theta_t} = \alpha \cdot dt + \sigma \cdot dz \quad (\text{Equation 7.1.2.3.})$$

Where:

- θ_t : Traffic Volume.
- α, σ : Constants.
- dt : Differential Period of Time.
- dz : Wiener process.

There is another stochastic process associated to the traffic volume (θ_t) and is called $\theta_t^{adjusted}$ in such a manner that systematic risk is removed. So (Equation 7.1.2.3.) can be written as follows:

$$\frac{d\theta_t^{adjusted}}{\theta_t^{adjusted}} = (r_f - \delta) \cdot dt + \sigma \cdot dz \quad (\text{Equation 7.1.2.4.})$$

Where:

- $\theta_t^{adjusted}$: Traffic growth rate adjusted by risk.
- r_f : Risk-free rate.
- δ : Dividend given by the non-financial asset.
- σ : Volatility.
- dz : Wiener process ($dz = \xi \cdot \sqrt{dt}$).
- $\theta_0 = \theta_0^{adjusted}$

From this adjusted process, we can determine a certain equivalent future value of those assets whose volatility is induced by the state variable (the traffic), in a neutral to risk framework (Lara Galera A. , 2006).

The stochastic process described by (Equation 7.1.2.4.) has a solution of the type:

$$\theta_t^{adjusted} = \theta_0^{adjusted} \cdot e^{\left[\left(r_f - \delta - \frac{1}{2}\sigma^2\right) \cdot t + \sigma \cdot \xi \cdot \sqrt{t}\right]} \quad (\text{Equation 7.1.2.5.})$$

So the project's value at any time "T" will be defined by the (Equation 7.1.2.6.).

$$V_T = \sum_{i=T}^N \frac{FCL_i(\theta_t^{adjusted})}{(1+r_f)^{i-T}} + \frac{V_{reversion}}{(1+r_f)^{N-T}} \quad (\text{Equation 7.1.2.6.})$$

If we suppose that we can abandon the project in year T (being $T < N$) with an abandonment value of A_T , the abandonment will only take place if AV_T is greater than the present value in T , of the free cash flows in the $(N - T)$ remaining years (PV_T). Otherwise, continuing with the project is more valuable than abandon it. In that case, the value of the abandonment option is:

$$P_T = \begin{cases} 0 & \text{if } AV_T < PV_T \\ AV_T - PV_T & \text{if } AV_T > PV_T \end{cases} \quad (\text{Equation 7.1.2.7.})$$

At any given time "t":

$$P_t = e^{-r_f \cdot (T-t)} \cdot E(P_T) \quad (\text{Equation 7.1.2.8.})$$

Where:

- $E()$: Expectation of a random variable operator
- r_f : Risk-free rate.
- P_t : The value of the abandonment option.

- T : Time when the option can be exercised.
- t : Time.

The true value of a project includes its abandonment value, which depends on the salvage value and the optimal time to abandon. So the value of the project would be given by its cash flows, added by the value of the abandonment option. However, classical models of investment valuation do not take into account this additional value.

The most common methods to estimate the salvage value of any asset are discussed in (Table 7.1.2.a.).

Table 7.1.2.a.: The Most Common Models Used to Calculate the Terminal Value in Discounted Cash Flow Analysis.

Liquidation	<p>A certain number of years for the service is assumed at the end of which the product becomes obsolete and is no longer made, marketed, sold, and supported. The sale price of the project assets at this point, if sold to the highest bidder, will represent the liquidation value of the project. Sometimes, the project may yield a negative cash flow for the terminal value if it involves cost burden such as environmental cleanup. This approach can be used when a project is known to have a finite life.</p>
Multiple Approach	<p>A year when you want to apply the terminal value is selected. Then the expected project cash flow for that year is multiplied by a number that represents the cumulative expected cash flows for the rest of the project life following that year. The multiplier is typically obtained by historical information related to comparable products/services and management judgment. The biggest drawback of this method is that it is subjective and does not provide an estimate of the intrinsic value of the project.</p>
Constant Growth Model	<p>By using this model, it is assumed that, beyond the terminal year, the cash flows will grow at a constant growth rate in perpetuity. The constant growth model is based on fundamentals and provides more accurate valuation. This approach is more appropriate when the project or investment is going to generate cash flows forever.</p>

Source: (Kodukula & Paupudesu, 2006).

Capital budgeting address the asset's remaining value, allotting a pre-specified value at the end of its lifetime. However, we can define three kind lifetime of a project:

- **Physical life of an asset:** It corresponds with the period of time when the asset lasts and shall be replaced. This period of time is well known as maximum lifetime of the asset.
- **Economic life of an asset:** It corresponds with the period of time when the asset can still be used. So, even though a Project has left, if certain assets can still be used for alternative purposes, their economic life is still going on.
- **Lifetime of the Project:** It is not fixed, but is determined by the abandonment decision. A project might not ever be abandoned, so in this case the three kinds of periods of time discussed are the same.

Generally, the lifetime of a certain Project is less than its economic life, and this, in turn, less than the physical life. Because of a project can be abandoned during the entire life of the project's physical life, the assumption that the abandonment option can be held until the end of the period can be considered (Myers & Majd, 1983).

By using the Internal Rate of Return (IRR) criteria, the abandonment decision will be carried out when the rate of return over the abandonment value is less than its cost of capital. In that regard, (Robichek & Van Horne, 1967) provide an early analysis of abandonment value throughout Monte Carlo Simulation. They recognize that the option to abandon a project can be measure at the beginning of it. They assume that a project should be abandoned at that point in time when its abandonment value exceeds the Net Present Value of the subsequent expected future cash flows discounted at the cost of capital rate.

$$AV_T > PV_T \quad \text{(Equation 7.1.2.9.)}$$

Where:

- AV_T : The Abandonment Value in year T.
- PV_T : The Present Value of future Cash Flows from the project discounted to the year T.

$$PV_T = \sum_{t=T+1}^n \frac{EC_{t*T}}{(1+k)^{(t-T)}} \quad (\text{Equation 7.1.2.10.})$$

Where:

- EC_{t*T} : Expected cash flow in year t as of year T .
- k : Cost of capital of the firm.
- n : Life of the project.

Thus, under the (Robichek & Van Horne, 1967) procedure, the decision to hold or liquidate is made in each year T based on whether or not the present value of the expected cash flows from the project is greater than the abandonment value in year T . They assumed that the abandonment values over time are known and invariant with respect to the cash flow patterns, noting that, when these assumptions are inappropriate, their approach can be modified by specifying probability distributions for the abandonment values (Dyl & Long, 1969). (Robichek & Van Horne, 1967) stated that projects with significant abandonment values, the abandonment option must be incorporated in the capital budgeting process for optimal capital allocation within the firm. But, the abandonment decision will depend on the optimal timing of the abandonment decision. An optimal abandonment decision allows us to choose among the following options:

- Hold the project for the life of the project.
- Abandon now.
- Hold now and abandon at some time in the future prior to the end of the project's life.

(Robichek & Van Horne, 1967) demonstrated that the presence of abandonment value may reduce the "risk" of a project over that which would be present if there were no abandonment value. By a reduction in risk either or both of the following:

- A lower variance of the probability distribution around the expected value of returns.

- A shift in the skewness³³ of the probability distribution toward the right, reducing both the range and the magnitude of undesirable returns, i.e., those to the left of the expected value of returns.

Nevertheless, (Dyl & Long, 1969) emphasize that the optimal time to abandon the project will not, in general, be the first instance where salvage value exceeds the present value of the remaining expected cash flows. Rather, the abandonment decision at each point in time must recognize that, if the project is not abandoned, the firm retains the option to abandon in the future. They consider a modification in (Equation 7.1.2.10.).

$$Max_{T+1 \leq a \leq n} PV_{T,a} \quad (\text{Equation 7.1.2.11.})$$

$$PV_T = \sum_{t=T+1}^a \frac{EC_{t,T}}{(1+k)^{(t-T)}} + \frac{AV_a}{(1+k)^{(a-T)}} \quad (\text{Equation 7.1.2.12.})$$

Where:

- a : The period in which we consider the abandonment.

Therefore, the abandonment decision will be carried out when:

$$Max_{T+1 \leq a \leq n} PV_{T,a} < AV_{a=T} \quad (\text{Equation 7.1.2.13.})$$

and continue to hold the project when:

$$Max_{T+1 \leq a \leq n} PV_{T,a} \geq AV_{a=T} \quad (\text{Equation 7.1.2.14.})$$

Other approach consists on evaluate how far cash flows can deviate from expectations before the decision to abandon appears (Bonini, 1977). This author develops a model called Dynamic Programming Recursion (or DPR by its acronym) and is modeled as follows:

$$f_n^*(S_i) = AV_t(S_i) \quad (\text{Equation 7.1.2.15.})$$

$$f_t^*(S_i) = \max \left[AV_t(S_i); \alpha \cdot \left\{ \sum_{j=1}^d p_{ij} \cdot (CF_{t+1}(S_j) + f_{t+1}^*(S_j)) \right\} \right] \quad \text{for} \\ \text{periods } t=1 \text{ to } t=n-1 \text{ (to be solved backwards starting with period } n-1) \text{ and for } i=1,2,\dots,d. \\ (\text{Equation 7.1.2.16.})$$

$$f_0^* = \alpha \cdot \sum_{j=1}^d p_{0j} \cdot (CF_1(S_j) + f_1^*(S_j)) - I \quad (\text{Equation 7.1.2.17.})$$

³³ Skewness refers to asymmetry of the return distribution, that is, returns that are not symmetric around the mean.

Where:

- $f_t^*(S_i)$: The optimal expected present value of future cash flows at time t associated with being in state S_i at time t .
- f_0^* : The expected Net Present Value associated with the investment.
- d : The number of possible states which coincides with the number of periods.
- $CF_t(S_j)$: The Cash Flow in period t associated with being in state S_j in that period.
- p_{ij} : The transition probability from state i to j .
- p_{0j} : The probability for the initial cash flow state in period 1.
- $AV_t(S_i)$: The Abandonment Value at the end of the period t , given cash flow state S_i during period t .
- α : $\alpha = \frac{1}{1+k}$, is the discount factor and k is the cost of capital.
- I : The initial investment in year zero.

In (Equation 7.1.2.16.) it is necessary to compare the abandonment value at each period with the expected cash flow for state j in the next period, plus the optimal future discounted cash flows from state j with probability p_{ij} .

Because concession projects cannot be abandoned whenever the concessionaire wants, in this thesis the abandonment criterion is based on the fact that the project is no longer feasible. Therefore, for modeling purposes, such situation of unfeasibility will be fulfilled when the project value is lower than the outstanding debt of the project. This situation takes place when the concessionaire has suffered bankruptcy of the concessionaire. Because of the declaration of bankruptcy involves the termination of the contract according to the Article 269 of the Spanish Royal Decree Law 3/2011 of 14th November, (*Real Decreto Legislativo 3/2011. de 14 de noviembre, por el que se aprueba el texto refundido de la Ley de Contratos del Sector Público (BOE 276/2011)*), the abandonment decision shall be formulated as follows:

$$P_T = \begin{cases} 0 & , \text{ if } PV_T \geq D_T \\ AV_T - PV_T & , \text{ if } PV_T < D_T \end{cases} \quad (\text{Equation 7.1.2.18.})$$

Where:

- P_T : The value of the abandonment option in year T.
- AV_T : The Abandonment Value in year T.
- $AV_T = RPA_T$: Administration's Patrimonial Liability in year T.
- PV_T : The Present Value of future Cash Flows from the project discounted to the year T.
- D_T : The outstanding debt in year T.

Given the abandonment option may be exercised at different times, the value of PV_T can be modelled using Monte Carlo simulation, under the following scheme:

- First a trajectory of random variables is generated, following the outline given by (Equation 7.1.2.5.) to determine the $\theta_t^{adjusted}$ for each year of the concession contract.
- In each generated trajectory, the first time "T" when the abandonment option would be exercise is observed taking into account the (Equation 7.1.2.18.). From that moment "T", the trajectory would be truncated or, alternatively, it would lead to the result that for such trajectory the option would not be exercised throughout the concession period, according to the criteria defined by (Equation 7.1.2.18.) and the value($AV_T - PV_T$) would be calculated.
- Then the previous two steps shall be repeated a significant number of times, counting for each "T" the number of trajectories where the abandonment option is exercised on that date. In this way, we would calculate for each "T" the expected value of the abandonment option.
- The risk-free rate (r) would be used to obtain the total present value of the option at the desired time "t".
- Additionally, it is possible to obtain the value of the likelihood when the abandonment option is exercised at each time during the concession period. In order to do this, it is necessary to take into account that the exercise of the option in a given year is conditional upon not exercising it in any of the previous years.

Monte Carlo simulation enables to generate different traffic trajectories considering the initial traffic as a random variable. There has been considered a normal distribution of the variable consisting on the ratio between the real traffic and the traffic expected by the concessionaire. Additionally, it is assumed that future traffic growth is independent from the initial traffic, which is consistent with the traffic behavior as a variable that follows a Geometric Brownian Motion.

There are several studies that show the empirical evidence concerning with the distribution of the variable $\frac{\theta_{0,real}}{\theta_{0,expected}}$, including (Flyvbjerg, Holm, & Buhl, 2005) and (Næss, Flyvbjerg, & Buhl, 2006), which give a high dispersion of initial real traffic in relation to the expected initial traffic, though it referred to a sample that includes both toll and toll-free motorways. More recently, (Bain, 2009) provided the results for a large sample of more than one hundred (100) projects in various countries, on toll motorways. According to the evidence provided by this study, the relationship between the initial real traffic and the expected initial traffic on toll motorways follows a normal distribution $N(0.81,0.24)$; for countries with a certain tradition in the construction of toll roads. This distribution has been taken into account in this thesis in order to determine the initial random traffic.

7.1.3. ACCURACY IN TRAFFIC FORECASTS.

The accuracy in traffic forecast³⁴ is evaluated ex-post by contrasting the estimated traffic and the real traffic. The difference between the forecast and the real traffic causes misallocation of public resources, hence resulting in socio-economic losses. Therefore, it is important to keep in mind the importance of the accuracy in traffic forecasts because of the high cost of transportation projects, limited availability of resources required to carry out those projects and the irreversibility of investment decisions.

The errors committed in traffic forecasting may be unintentionally and committed intentionally by the forecaster for strategic decisions. In this regard (Vassallo, 2007)

³⁴ Traffic estimated for the first year of operations as estimated at the time of decision to build the project and projected it towards the future. The ability of planners to predict accurately the traffic volume that will come up into the future will determine the level of risk that the concessionaire will bear. This is called as traffic risk.

distinguish between two kinds of traffic projections; “*true projections*”, that would be honestly conducted by the forecaster in order to be as accurate as possible; and “*manipulated projections*”, that have been intentionally modified by the forecaster for strategic reasons.

The main source of income in a motorway concession project comes from a traffic that behaves randomly. In this regard, there is a study made by (Baeza Muñoz & Vassallo Magro, 2012) studying the deviation between real traffic and the one considered by the concessionaire in the tender. Table 7.1.3.a. shows those Spanish motorways which are nowadays with financial problems, under an arrangement with creditors or in the liquidation phase.

Table 7.1.3.a.: Traffic Deviation in Initial Traffic Volume.

COMPANY HOLDING THE CONCESSION	Operation Since:	Deviation (%)
Henarsa (R-2 and M-50)	2003	-63%
Accesos de Madrid (R-3. R-5 and M-50)	2004	-57% (R-3) / -58% (R-5)
Madrid Sur (R-4 and M-50)	2004	-56%
Madrid – Levante (AP-36. Ocaña – La Roda)	2006	-49%
Madrid – Toledo (AP-41)	2006	-82%
Eje Aeropuerto (M-12)	2005	-79%
Aucosta (AP-7. Cartagena – Vera)	2007	-70%
Ciralsa (AP-7. Circunvalación de Alicante)	2007	-40%
Ausur (AP-7. Alicante – Cartagena)	2001	-24%

Source: Author based on (Baeza Muñoz & Vassallo Magro, 2012).

Reality has shown us that most of the traffic forecasts made by planners at the beginning of the project have been more optimistic than the reality. In this regard, many studies have been conducted in order to report the toll road forecasting performance. (Flyvbjerg, Bruzelius, & Buhl, 2003) made a study of demand analyses of 200 large-scale transport infrastructure projects in Europe and the USA and found considerable deviations between forecast and real traffic density. The studies made by Flyvbjerg generally show considerable deviations between forecasted and real traffic. In general, the forecasts for road transportation projects are often inaccurate, with deviations between forecast and real traffic volumes of more than 20%. The reasons why traffic is

such inaccurate are pointed out by (Flyvbjerg, Bruzelius, & Buhl, 2003) and (Flyvbjerg, Holm, & Buhl, 2005) such as:

- Poor forecasting methods or database.
- Discontinuous behavior and the influence of complementary factors.
- Unexpected changes of exogenous factors.
- Unexpected political activities or missing realization of complementary policies.
- Uncertainties about trip generations. It normally depends on demographic and geographic data which are often incomplete.
- Uncertainties about land-use generation, which depends on land use plans.
- Implicit appraisal bias of the consultant.
- Appraisal bias of the project promoter.

The last reason is highly influenced by the need of the promoter to carry out the project and in general, the higher the need, the higher the appraisal bias. According to (Flyvbjerg, Bruzelius, & Buhl, 2003), the tendency to overestimate predictions may be even stronger when forecasts are made by the promoters of the project than those made by consultants.

Forecasts deviations depend on also where the project is located; in general forecast deviations for road projects might follow a pattern where future traffic is underestimated in geographical locations where traffic growth is considered undesirable and overestimated in locations where a high amount of traffic is considered desirable (Næss, Flyvbjerg, & Buhl, 2006).

In 1997 the investment bank JP Morgan published a study examining the predictive accuracy of traffic forecasts prepared for 14 recently constructed toll roads in the USA (Morgan, 1997). Of the 14 toll road projects evaluated, JP Morgan reports that only one exceeded its original revenue forecast. Three forecasts were wrong (optimistic) by up to 25% and, for four of the projects, revenue was lower than 30% of the forecasts.

7.2. TRAFFIC EVOLUTION IN SPANISH TOLL MOTORWAY CONCESSIONS.

It has been considered traffic data provided by the Ministry of Public Works until the year 2014. The study has been focused in the evaluation of traffic growth and volatility. Therefore, it has been considered all toll motorways that exist in Spain, particularly those with time data series of more than 10 years (ANNEX IV).

In order to determine the annual growth of the traffic the (Equation 7.2.1.) has been applied:

$$\text{Traffic growth rate} = \frac{\theta_i}{\theta_{i-1}} \quad (\text{Equation 7.2.1.})$$

Where:

- θ_i : The annual average daily traffic in year i .
- θ_{i-1} : The annual average daily traffic in year $(i - 1)$.

Spain is a country with a very large tradition in concession contracts; therefore all motorways have been divided into three groups depending on how long they have been under operation. The three clusters have been divided as follows:

- Motorways with Operational Period below 10 years.
- Motorways with Operational Period between 10 and 20 years.
- Motorways with Operational Period over 20 years.

Table 7.2.a.: Volatility in Motorways with Operational Period below 10 years.

HIGHWAYS WITH OPERATIONAL PERIOD BELOW 10 YEARS					
Motorway	Nº	Period.0	Oper. Period	Volatility (AADT)	Volatility (veh-km)
Ocaña- La Roda	1	2006	9	9.65%	9.65%
Madrid - Toledo	2	2006	9	28.82%	32.91%
Cartagena - Vera	3	2007	8	5.36%	5.36%
Circunvalación de Alicante	4	2007	8	12.40%	12.40%
Alto de las Pedrizas - Málaga	5	2011	4	8.22%	8.21%

Source: Author.

Figure 7.2.a.: Volatilities of each Motorway with Operational Period Below 10 Years.

Source: Author.

Table 7.2.b.: Volatility in Motorways with Operational Period between 10 and 20 years.

HIGHWAYS WITH OPERATIONAL PERIOD BETWEEN 10 - 20 YEARS					
Motorway	Nº	Period.0	Oper. Period	Volatility (AADT)	Volatility (veh-km)
Málaga - Guadiaro	1	1999	16	6.64%	9.01%
Alicante - Cartagena	2	2001	14	7.73%	7.75%
Ávila - Villacastín	3	2002	13	18.14%	18.14%
León - Astorga	4	2002	13	10.62%	10.62%
Santiago - Alto de Sto. Domingo	5	2003	12	10.43%	21.70%
Segovia - San Rafael	6	2003	12	5.15%	5.14%
Madrid - Guadalajara (R-2)	7	2003	12	18.68%	18.64%
Madrid - Arganda (R-3)	8	2004	11	13.37%	13.37%
Madrid - Navalcarnero (R-5)	9	2004	11	14.87%	14.76%
Madrid - Ocaña (R-4)	10	2004	11	17.74%	17.74%
Eje Aeropuerto (M-12)	11	2005	10	19.70%	19.70%

Source: Author.

Figure 7.2.b.: Volatility of each Motorway with Operational Period Between 10 and 20 Years.

Source: Author.

Table 7.2.c.: Volatility in Motorways with Operational Period over 20 years.

HIGHWAYS WITH OPERATIONAL PERIOD OVER 20 YEARS					
Motorway	Nº	Period.0	Oper. Period	Volatility (AADT)	Volatility (veh-km)
Montmeló La Junquera (A-7)	1	1974	41	5.41%	5.36%
Barcelona - Tarragona (A-7)	2	1974	41	6.02%	6.02%
Montmeló - Papiol (A-7)	3	1978	37	23.68%	23.74%
Zaragoza - Mediterráneo (A-2)	4	1976	39	13.08%	18.87%
Villalba - Adanero (A-6)	5	1974	41	6.64%	6.63%
Sevilla - Cádiz (A-4)	6	1974	41	9.26%	9.26%
Tarragona - Valencia (A-7)	7	1974	41	7.11%	11.13%
Valencia - Alicante (A-7)	8	1976	39	8.87%	12.11%
Ferrol - Front. Portuguesa (A-9)	9	1979	36	8.19%	10.47%
Bilbao - Zaragoza (A-68)	10	1978	37	8.29%	12.23%
Burgos - Armiñón (A-1)	11	1978	37	9.70%	12.31%
León - Campomanes (A-66)	12	1983	32	8.01%	8.04%

Source: Author.

Figure 7.2.c.: Volatility of each Motorway with Operational Period over 20 Years.

Source: Author.

The results obtained in (Table 7.2.a.), (Table 7.2.b.) and (Table 7.2.c.) are very intuitive because the more years under operation, the more consolidated the traffic will be. This is the same of saying that the fewer the years in which the motorway is under operation, the greater the dispersion of the volatility. Analyzing the results obtained in (Table 7.2.a.), the motorway Madrid – Toledo has the highest volatility (28.82% in terms of AADT) and the gap between the minimum and the maximum volatility is 23.46%. This great value is normal because we are facing with motorways that are in their ramp-up period or have just finished it, when the volatility is higher. If we consider this cluster as a whole, we can obtain a characteristic volatility value for this group of motorways (Table 7.2.d.) equals to 19.79%. This value has been obtained by the application of (Equation 6.1.1.) to the ratio $(AADT_i/AADT_{(i-1)})$.

Table 7.2.d.: Average Traffic in Toll Motorways with Operational Period below 10 years.

AVERAGE TRAFFIC IN TOLL MOTORWAYS (Operational Period Below 10 years)							
Period	AADTi	% Variation	Length	veh-km	% Variation	AADTi/AADT(i-1)	(veh-km) _i /(veh-km) _(i-1)
2006	5,935		186	404			
2007	19,022	220.51%	332	2,306	471.36%	3.205	5.714
2008	20,906	9.90%	332	2,534	9.90%	1.099	1.099
2009	17,964	-14.07%	332	2,178	-14.07%	0.859	0.859
2010	16,521	-8.03%	332	2,003	-8.03%	0.920	0.920
2011	23,386	41.55%	360	3,074	53.50%	1.416	1.535
2012	21,201	-9.34%	360	2,787	-9.34%	0.907	0.907
2013	20,303	-4.24%	360	2,669	-4.24%	0.958	0.958
2014	21,146	4.15%	351	2,710	1.52%	1.042	1.015

Source: Author.

For the cluster comprised by the motorways with operational period between ten (10) and twenty (20) years, the motorway León – Astorga has the highest volatility in terms of AADT (52.33%). If we dig into the data, we can see that the first year of operation of this motorway, it has only four (4) Kilometres under operation with and AADT equals to 25,678 vehicles. This value is not significant, so it has been removed from the calculations. If we do that, the volatility of this motorway drops to 10.62% which is more common to this cluster. The gap between maximum and minimum volatilities is 14.55%. We can observe that the gap between the extreme values is getting closer as the operational period gets greater. If we consider this cluster as a whole, we can obtain a characteristic volatility value for this group of motorways (Table 7.2.e.) equals to 17.90%. This value has been obtained by the application of (Equation 6.1.1.) to the ratio (AADTi/AADT(i-1)). Because of we are dealing with more mature motorways, this value has decreased over the previous cluster.

Table 7.2.e.: Average Traffic in Toll Motorways with Operational Period between 10 and 20 years.

AVERAGE TRAFFIC IN ALL TOLL MOTORWAYS (Operational Period Between 10 and 20 years)							
Period	AADTi	% Variation	Length	veh-km	% Variation	AADTi/AADT(i-1)	(veh-km) _i /(veh-km) _(i-1)
1999	22,063		76	610			
2000	24,939	13.04%	76	689	13.04%	1.130	1.130

AVERAGE TRAFFIC IN ALL TOLL MOTORWAYS (Operational Period Between 10 and 20 years)							
Period	AADTi	% Variation	Length	veh-km	% Variation	AADTi/AADT(i-1)	(veh-km) _i /(veh-km) _(i-1)
2001	40,138	60.94%	152	2,231	223.80%	1.609	3.238
2002	75,539	88.20%	202	5,567	149.49%	1.882	2.495
2003	65,735	-12.98%	360	8,635	55.12%	0.870	1.551
2004	95,746	45.65%	496	17,320	100.57%	1.457	2.006
2005	115,958	21.11%	505	21,376	23.42%	1.211	1.234
2006	137,110	18.24%	505	25,275	18.24%	1.182	1.182
2007	148,896	8.60%	505	27,440	8.57%	1.086	1.086
2008	142,520	-4.28%	505	26,265	-4.28%	0.957	0.957
2009	135,492	-4.93%	508	25,106	-4.41%	0.951	0.956
2010	133,646	-1.36%	508	24,764	-1.36%	0.986	0.986
2011	124,334	-6.97%	508	23,039	-6.97%	0.930	0.930
2012	112,437	-9.57%	508	20,834	-9.57%	0.904	0.904
2013	107,739	-4.18%	508	19,964	-4.18%	0.958	0.958
2014	109,718	1.84%	507	20,314	1.76%	1.018	1.018

Source: Author.

In (Table 7.2.c.), the difference between the maximum volatility and the minimum volatility is 18.27%. This result could seem a little bit high taking into account that we are dealing with motorways which have been under operation a long time, more than thirty years. But if we pay attention on the traffic evolution of the motorway Montmeló - Papiol (A-7) in (Table 7.2.f.), there is a growth of 272.74% in the year 1986. Annual Average Daily Traffic (AADT) passed of being 7,352 vehicles in 1985 to 27,404 vehicles in 1986. This strange value has been due to the San Cugat del Vallés' tollgate was opened and that road section became free of toll. This jump in the traffic evolution path biases the result to a higher volatility. This is the reason why the range between the minimum and maximum volatility is so high for this cluster. If we do not take into account this motorway the gap between minimum and maximum volatility drops to 7.67%; much lower than the previous result.

If we consider this cluster as a whole, we can obtain a characteristic volatility value for this group of motorways (Table 7.2.f.) equals to 7.31%. This value has been obtained by the application of (Equation 6.1.1.) to the ratio (AADTi/AADT(i-1)). These highways have the highest operational period among all motorways analyzed. Because of we are dealing with motorways with operational period over twenty (20) years, the characteristic volatility is the lowest.

If we take into account the group of toll motorways with operational period over ten (10) years, the volatility (in terms of AADT) the characteristic volatility value is 8.00%, similar to the characteristic volatility value of those motorways with operational period over twenty (20) years. Therefore, this value has been considered in the base case on the case study.

Table 7.2.f.: Average Traffic in Toll Motorways with Operational Period Over 20 years.

AVERAGE TRAFFIC IN ALL TOLL MOTORWAYS (Operational Period Over 20 years)							
Period	AADTi	% Variation	Length	veh-km	% Variation	AADTi/AADT(i-1)	(veh-km)i/(veh-km)(i-1)
1974	46.137	-	506	8,521	-	-	
1975	45.696	-0.96%	528	8,803	3.31%	0.990	1.033
1976	55.658	21.80%	724	14,716	67.17%	1.218	1.672
1977	60.611	8.90%	877	19,391	31.76%	1.089	1.318
1978	85.603	41.23%	1,141	35,660	83.90%	1.412	1.839
1979	92.709	8.30%	1,288	43,598	22.26%	1.083	1.223
1980	94.136	1.54%	1,410	48,451	11.13%	1.015	1.111
1981	94.700	0.60%	1,442	49,850	2.89%	1.006	1.029
1982	94.503	-0.21%	1,442	49,747	-0.21%	0.998	0.998
1983	94.510	0.01%	1,529	52,745	6.03%	1.000	1.060
1984	94.961	0.48%	1,540	53,391	1.23%	1.005	1.012
1985	100.091	5.40%	1,576	57,569	7.82%	1.054	1.078
1986	128.226	28.11%	1,576	73,751	28.11%	1.281	1.281
1987	145.027	13.10%	1,576	83,415	13.10%	1.131	1.131
1988	171.288	18.11%	1,584	99,013	18.70%	1.181	1.187
1989	197.667	15.40%	1,584	114,262	15.40%	1.154	1.154
1990	207.081	4.76%	1,602	121,064	5.95%	1.048	1.060
1991	218.116	5.33%	1,619	128,868	6.45%	1.053	1.064
1992	215.133	-1.37%	1,642	128,904	0.03%	0.986	1.000
1993	207.804	-3.41%	1,642	124,513	-3.41%	0.966	0.966
1994	211.543	1.80%	1,642	126,753	1.80%	1.018	1.018
1995	218.233	3.16%	1,628	129,686	2.31%	1.032	1.023
1996	221.917	1.69%	1,628	131,876	1.69%	1.017	1.017
1997	245.439	10.60%	1,638	146,750	11.28%	1.106	1.113
1998	261.155	6.40%	1,647	156,985	6.97%	1.064	1.070
1999	285.356	9.27%	1,663	173,241	10.36%	1.093	1.104
2000	317.601	11.30%	1,663	192,817	11.30%	1.113	1.113
2001	340.300	7.15%	1,663	206,598	7.15%	1.071	1.071
2002	356.217	4.68%	1,663	216,261	4.68%	1.047	1.047
2003	370.260	3.94%	1,680	227,070	5.00%	1.039	1.050

AVERAGE TRAFFIC IN ALL TOLL MOTORWAYS (Operational Period Over 20 years)							
Period	AADTi	% Variation	Length	veh-km	% Variation	AADTi/AADT(i-1)	(veh-km) _i /(veh-km) _(i-1)
2004	384.240	3.78%	1,680	235,644	3.78%	1.038	1.038
2005	402.980	4.88%	1,692	248,843	5.60%	1.049	1.056
2006	424.477	5.33%	1,692	262,114	5.33%	1.053	1.053
2007	442.496	4.24%	1,692	273,230	4.24%	1.042	1.042
2008	417.528	-5.64%	1,692	257,828	-5.64%	0.944	0.944
2009	394.020	-5.63%	1,692	243,312	-5.63%	0.944	0.944
2010	385.813	-2.08%	1,692	238,244	-2.08%	0.979	0.979
2011	368.465	-4.50%	1,692	227,531	-4.50%	0.955	0.955
2012	338.859	-8.03%	1,692	209,249	-8.03%	0.920	0.920
2013	325.481	-3.95%	1,692	200,988	-3.95%	0.961	0.961
2014	333.049	2.33%	1,693	205,783	2.39%	1.023	1.024

Source: Author.

As we can see in (Figure 7.2.d.), the volatility in the first five (5) years is higher than the subsequent years, because of the ramp-up period. Once this period has been passed, the volatility is stabilized unless special events happen.

By analyzing the traffic growth of every toll motorways, we have studied the arithmetic mean growth, is simply the sum of the all of the traffic growths divided by the number of periods over which the sum total is calculated. It is also called the average.

$$\text{Arithmetic mean} = \frac{\sum_{i=1}^n \left(\frac{\theta_i}{\theta_{i-1}} \right)}{n} \quad (\text{Equation 7.2.1.})$$

Where:

- θ_i : The Annual Average Daily Traffic at year i .
- θ_{i-1} : The Annual Average Daily Traffic at year $i-1$.
- n : The number of periods over which we calculate the average.

Figure 7.2.d.: Evolution of the Volatility of Each Toll Motorway and for the Whole Network.

Source: Author.

But if we want to know at what rate the traffic has evolved over one determined period, then the arithmetic mean is not the right answer. In this case, we have to calculate the geometric mean growth. It is a mean growth compounded over time.

$$\text{Geometric mean} = \left[\left(1 + \left(\frac{\theta_i}{\theta_{i-1}} \right)_1 \right) \cdot \left(1 + \left(\frac{\theta_i}{\theta_{i-1}} \right)_2 \right) \cdot \dots \cdot \left(1 + \left(\frac{\theta_i}{\theta_{i-1}} \right)_n \right) \right]^{1/n} - 1$$

(Equation 7.2.2.)

Table 7.2.g.: Mean Growths in Motorways with Operational Period below 10 years.

HIGHWAYS WITH OPERATIONAL PERIOD BELOW 10 YEARS					
Motorway	Nº	Period.0	Oper. Period	GMG	AMG
Ocaña- La Roda	1	2006	9	-4.61%	-4.22%
Madrid - Toledo	2	2006	9	-9.92%	-6.40%
Cartagena - Vera	3	2007	8	-1.66%	-1.54%
Circunvalación de Alicante	4	2007	8	-6.40%	-5.76%
Alto de las Pedrizas - Málaga	5	2011	4	4.77%	5.01%

Source: Author.

Figure 7.2.e.: Mean Growths of each Motorway with Operational Period Below 10 Years.

Source: Author.

Table 7.2.h.: Mean Growths in Motorways with Operational Period between 10 and 20 years.

HIGHWAYS WITH OPERATIONAL PERIOD BETWEEN 10 - 20 YEARS					
Motorway	Nº	Period.0	Oper. Period	GMG	AMG
Málaga - Guadiaro	1	1999	16	1.10%	1.31%
Alicante - Cartagena	2	2001	14	3.46%	3.74%
Ávila - Villacastín	3	2002	13	-2.13%	-0.81%
León - Astorga ³⁵	4	2002	13	-1.36%	-0.98%
Santiago - Alto de Sto. Domingo	5	2003	12	4.17%	4.57%
Segovia - San Rafael	6	2003	12	2.75%	2.88%
Madrid - Guadalajara (R-2)	7	2003	12	-1.32%	0.26%
Madrid - Arganda (R-3)	8	2004	11	-1.17%	-0.34%
Madrid - Navalcarnero (R-5)	9	2004	11	-0.87%	0.14%
Madrid - Ocaña (R-4)	10	2004	11	-3.35%	-1.90%
Eje Aeropuerto (M-12)	11	2005	10	6.75%	8.89%

Source: Author.

Figure 7.2.f.: Mean Growths of each Motorway with Operational Period Between 10 and 20 Years.

Source: Author.

Table 7.2.i.: Mean Growths in Motorways with Operational Period over 20 years.

HIGHWAYS WITH OPERATIONAL PERIOD OVER 20 YEARS					
Motorway	Nº	Period.0	Oper. Period	GMG	AMG
Montmeló La Jonquera (A-7)	1	1974	41	2.64%	2.78%
Barcelona - Tarragona (A-7)	2	1974	41	2.83%	3.01%
Montmeló - Papiol (A-7)	3	1978	37	6.85%	11.10%
Zaragoza - Mediterráneo (A-2)	4	1976	39	1.63%	2.52%
Villalba - Adanero (A-6)	5	1974	41	3.14%	3.36%
Sevilla - Cádiz (A-4)	6	1974	41	4.43%	4.87%

³⁵ There is an almost vertical drop between the first year of operation and the second year, from an Annual Average Daily Traffic of 25,678 vehicles, to 4,272 vehicles; a drop of 83,36%. Because of there were only four (4) kilometers under operation in 2002, this year has been removed in order to avoid the bias.

HIGHWAYS WITH OPERATIONAL PERIOD OVER 20 YEARS					
Motorway	Nº	Period.O	Oper. Period	GMG	AMG
Tarragona - Valencia (A-7)	7	1974	41	2.63%	2.88%
Valencia - Alicante (A-7)	8	1976	39	4.08%	4.48%
Ferrol - Front. Portuguesa (A-9)	9	1979	36	3.76%	4.02%
Bilbao - Zaragoza (A-68)	10	1978	37	2.52%	2.86%
Burgos - Armiñón (A-1)	11	1978	37	5.65%	6.15%
León - Campomanes (A-66)	12	1983	32	3.62%	3.93%

Source: Author.

Figure 7.2.g.: Mean Growths of each Motorway with Operational Period over 20 Years.

Source: Author.

As we can see, in all toll motorways the Arithmetic Mean Growth (AMG) is larger than the Geometric Mean Growth (GMG). The difference between both means depends on the volatility. The more volatile the traffic, the larger the difference between the AMG and the GMG. In fact, there is an approximate relationship between the two:

$$GMG \sim AMG - \frac{1}{2} \cdot Var\left(\frac{\theta_i}{\theta_{i-1}}\right) \quad (\text{Equation 7.2.3.})$$

Where:

- GMG : The Geometric Mean Growth.
- AMG : The Arithmetic Mean Growth.
- θ_i : The Annual Average Daily Traffic at year i .
- θ_{i-1} : The Annual Average Daily Traffic at year $i-1$.
- $Var\left(\frac{\theta_i}{\theta_{i-1}}\right)$: The variance of the rate of growth.

We can confirm the above statement by analyzing the following motorways: “Montmeló – Papiol (A-7)”, “Ávila – Villacastín”, “León – Astorga”, “Madrid – Guadalajara (R-2)”, “Madrid – Navacarnero (R-5)”, “Madrid – Ocaña (R-4)”, “Eje Aeropuerto (M-12)” and “Madrid – Toledo”.

Table 7.2.j.: Motorways with Larger Volatility and its Influence in the Difference between AMG and GMG.

Motorway	Period.0	Oper. Period	Volatility	GMG	AMG	AMG - GMG
Montmeló - Papiol (A-7)	1978	37	23.68%	6.85%	11.10%	4.25%
Ávila - Villacastín	2002	13	18.14%	-2.13%	-0.81%	1.32%
Madrid - Guadalajara (R-2)	2003	12	18.68%	-1.32%	0.26%	1.57%
Madrid - Navacarnero (R-5)	2004	11	14.87%	-0.87%	0.14%	1.01%
Madrid - Ocaña (R-4)	2004	11	17.74%	-3.35%	-1.90%	1.45%
Eje Aeropuerto (M-12)	2005	10	19.70%	6.75%	8.89%	2.14%
Madrid - Toledo	2006	9	28.82%	-9.92%	-6.40%	3.52%

Source: Author.

As we can see, those motorways with the highest volatility, i.e. higher than 14.87%; has the largest difference between AMG and GMG, i.e. above 1.00%. Therefore (Table 7.2.j.) confirms the statement that, the more volatile the traffic, the larger the difference between the AMG and the GMG.

There have been taking into account for the sum of Spanish toll motorways, those motorways with a traffic track record of more than ten (10) years. For this mentioned cluster, the average traffic, i.e. the AMG is 2.18% (in terms of AADT). And the rate at which the traffic has evolved between 1974 and 2014 has been 1.86% (in terms of AADT), in terms of annual continuously compounded.

7.3. TRAFFIC-RISK MARKET VALUE.

In order to study the existing correlation between the traffic and the market, there have been considered the Abertis share prices and the evolution of the Madrid Stock Exchange (IBEX-35). The reason why Abertis has been taken is because of the core business of this company is motorway concessions. There have been taken into account time series of twenty one (21) years for Abertis, since 1994 to 2014; and twenty six years (26) for the IBEX-35. since 1989 to 2014. Values shown in (Table 7.3.a.) have been calculated as follows:

- There have been considered the last price of each year.
- Then the returns have been calculated following the (Equation 7.3.1.).

$$Return (\%) = \frac{P_i - P_{i-1}}{P_{i-1}} \quad (\text{Equation 7.3.1.})$$

Where:

- P_i : The price of the share for the year i.
- P_{i-1} : The price of the share for the year i-1.

In order to study the correlation between the traffic and the market, the following formula has been taken into account:

$$\beta = \frac{Cov(r_\theta, r_m)}{Var(r_m)} \quad (\text{Equation 7.3.2.})$$

Where:

- β : The beta, which represents the correlation between the asset and the market.
- r_θ : Traffic growth rate $\left(\frac{\theta_i}{\theta_{i-1}}\right)$.
- r_m : Returns of the General Index of the Madrid Stock Exchange.

Table 7.3.a.: Returns of Abertis and IBEX-35.

	ABERTIS	Variation (%)	IBEX-35	Variation (%)
1989			3,000.00	
1990			2,248.80	-25.04%
1991			2,603.30	15.76%
1992			2,344.57	-9.94%
1993			3,615.22	54.20%
1994	3.87		3,087.68	-14.59%
1995	5.61	44.96%	3,630.76	17.59%
1996	7.65	36.36%	5,154.77	41.97%
1997	9.17	19.87%	7,255.40	40.75%
1998	11.11	21.16%	9,836.60	35.58%
1999	7.94	-28.53%	11,641.70	18.35%
2000	8.04	1.26%	9,109.80	-21.75%
2001	10.15	26.24%	8,397.60	-7.82%
2002	10.29	1.38%	6,036.90	-28.11%
2003	11.99	16.52%	7,737.20	28.17%
2004	16.20	35.11%	9,080.80	17.37%
2005	21.26	31.23%	10,733.90	18.20%

	ABERTIS	Variation (%)	IBEX-35	Variation (%)
2006	22.50	5.83%	14,146.50	31.79%
2007	22.04	-2.04%	15,182.30	7.32%
2008	12.60	-42.83%	9,195.80	-39.43%
2009	15.72	24.76%	11,940.00	29.84%
2010	13.46	-14.38%	9,859.10	-17.43%
2011	12.34	-8.32%	8,566.30	-13.11%
2012	12.42	0.65%	8,167.50	-4.66%
2013	16.15	30.03%	9,916.70	21.42%
2014	16.43	1.73%	10,279.50	3.66%
	AMR	10.05%	AMR	8.00%
	GMR	7.50%	GMR	5.05%
	Std.Deviation	22.16%	Std.Deviation	24.57%
	Beta (IBEX-35)	59.61%		

Source: Author.

Abertis' average returns (10.05%), i.e. the Arithmetic Mean Return (AMR), are higher than IBEX-35's AMR (8.00%). If we consider the same period for both, i.e. since 1994; the Abertis' AMR is equal to 9.32% a little bit lower than before, and the IBEX-35's arithmetic mean return is increased to 8.99%.

On the other hand, the rate at which the capital invested has evolved over time, i.e. the Geometric Mean Return (GMR), has been almost the same; 7.50% for Abertis, but lower for the IBEX-35's GMR (5.05%). If we consider the same period, i.e. since 1994; the IBEX-35's GMR turns to 6.20%.

The deviation between each return and the arithmetic mean return, i.e. the Standard Deviation which is the same as the volatility, is 22.16% for Abertis and 24.57% for the Spanish Stock Exchange. If we consider the same period for both, i.e. since 1994; the IBEX-35's volatility is equal to 23.40%.

The risk-free rate represents the interest an investor would expect from an absolutely risk-free investment over a specified period of time. Therefore investors take into account the Government Treasury bonds. Because of motorway concession projects have a maturity between twenty (20) and thirty (30) years; the Spanish 30-year Treasury bond has been considered. In our case, the Spanish 30-year Treasury bond in December the 31st 2014 was 2.935%.

In order to study the correlation between the traffic and the market, it has been studied those toll motorways with a track record of more than ten (10) years. Therefore,

twenty three (23) out of the twenty eight (28) toll motorways that are nowadays under operation in Spain, belonging to the Central State Government, have been studied.

In (Table 7.3.b.), it is shown the correlation coefficients for each toll motorway excluding those with a data track record below ten (10) years, i.e. “Ocaña – La Roda”, “Madrid – Toledo”, “Cartagena – Vera”, “Circunvalación de Alicante” and “Alto de las Pedrizas – Málaga”.

By remembering what we have mentioned in Section 4.7.1. when we assess a non-financial asset. Every asset with depends on a non-financial asset (X) can be valued by adjusting the expected growth rate (μ), to $(\mu - \lambda \cdot \sigma)$, and then we can operate under a risk neutrality environment. Taking into account the (Equation 4.7.1.16.) and considering $\mu = \alpha$ and $\mu_{adjusted} = \alpha_{adjusted}$, we can assume that:

$$\alpha_{adjusted} = \alpha - \beta \cdot (r_m - r_f) = r_f - \delta \quad (\text{Equation 7.3.3.})$$

By considering $\alpha_{adjusted}$ instead of α , we can operate under a risk neutrality environment.

For further calculations, the value for the 30-year treasury bond (2.935%) has been those in December the 31st 2014. This value has been considered because traffic time data in toll motorways are only available until 2014.

**Table 7.3.b.: Correlation between Traffic and the Spanish Stock Exchange (IBEX-35).
The Adjusted Expected Growth Rate.**

Motorway	Years Considered	α (%)	Beta (IBEX-35)	30-year treasury bond	
				α adjusted (%)	δ
Montmeló La Junquera (A-7)	1974 - 2014	2.78%	0.06199	2.55%	-0.38%
Barcelona - Tarragona (A-7)	1974 - 2014	3.01%	0.05064	2.82%	-0.11%
Montmeló - Papiol (A-7)	1978 - 2014	11.10%	0.04440	10.93%	8.00%
Zaragoza - Mediterráneo (A-2)	1976 - 2014	2.52%	0.15250	1.95%	-0.99%
Villalba - Adanero (A-6)	1974 - 2014	3.36%	0.08769	3.03%	0.09%
Sevilla - Cádiz (A-4)	1974 - 2014	4.87%	0.14627	4.32%	1.39%
Tarragona - Valencia (A-7)	1974 - 2014	2.88%	0.12266	2.42%	-0.52%
Valencia - Alicante (A-7)	1976 - 2014	4.48%	0.11841	4.04%	1.10%
Ferrol - Front. Portuguesa (A-9)	1979 - 2014	4.02%	0.07336	3.74%	0.81%
Bilbao - Zaragoza (A-68)	1978 - 2014	2.86%	0.08147	2.56%	-0.38%
Burgos - Armiñón (A-1)	1978 - 2014	6.15%	0.05452	5.95%	3.01%
León - Campomanes (A-66)	1983 - 2014	3.93%	0.11033	3.52%	0.58%
Málaga - Guadiaro	1999 - 2014	1.31%	0.00649	1.32%	-1.61%
Alicante - Cartagena	2001 - 2014	3.74%	0.13470	3.57%	0.63%
Ávila - Villacastín	2002 - 2014	-0.81%	0.00989	-0.85%	-3.79%

Motorway	Years Considered	α (%)	Beta (IBEX-35)	30-year treasury bond	
				α adjusted (%)	δ
León - Astorga	2002 - 2014	-0.98%	0.00412	-0.99%	-3.93%
Santiago - Alto de Sto. Domingo	2003 - 2014	4.57%	0.16226	4.23%	1.30%
Segovia - San Rafael	2003 - 2014	2.88%	0.11755	2.63%	-0.30%
Madrid - Guadalajara (R-2)	2003 - 2014	0.26%	0.28100	-0.32%	-3.26%
Madrid - Arganda (R-3)	2004 - 2014	-0.34%	0.31382	-0.60%	-3.54%
Madrid - Navalcarnero (R-5)	2004 - 2014	0.14%	0.26947	-0.08%	-3.02%
Madrid - Ocaña (R-4)	2004 - 2014	-1.90%	0.32612	-2.17%	-5.10%
Eje Aeropuerto (M-12)	2005 - 2014	8.89%	0.52660	9.30%	6.36%
GLOBAL SPANISH NETWORK		2.18%			

Source: Author.

Table 7.3.c.: Correlation between Traffic and the Return of Abertis' Shares without Dividends. The Adjusted Expected Growth Rate.

Motorway	Years Considered	α (%)	Beta (ABERTIS)	30-year treasury bond	
				α adjusted (%)	δ
Montmeló La Junquera (A-7)	1974 - 2014	2.54%	0.04111	2.39%	-0.54%
Barcelona - Tarragona (A-7)	1974 - 2014	0.54%	0.08705	0.22%	-2.72%
Montmeló - Papiol (A-7)	1978 - 2014	3.95%	0.04841	3.77%	0.84%
Zaragoza - Mediterráneo (A-2)	1976 - 2014	0.85%	0.03770	0.71%	-2.22%
Villalba - Adanero (A-6)	1974 - 2014	2.06%	0.04186	1.90%	-1.03%
Sevilla - Cádiz (A-4)	1974 - 2014	5.48%	0.11398	5.05%	2.12%
Tarragona - Valencia (A-7)	1974 - 2014	1.40%	0.04677	1.23%	-1.71%
Valencia - Alicante (A-7)	1976 - 2014	2.00%	0.07039	1.74%	-1.19%
Ferrol - Front. Portuguesa (A-9)	1979 - 2014	2.44%	0.02007	2.36%	-0.57%
Bilbao - Zaragoza (A-68)	1978 - 2014	3.21%	0.07236	2.95%	0.01%
Burgos - Armiñón (A-1)	1978 - 2014	2.73%	0.02902	2.62%	-0.32%
León - Campomanes (A-66)	1983 - 2014	2.85%	0.07407	2.57%	-0.36%
Málaga - Guadiaro	1999 - 2014	1.31%	0.12777	0.78%	-2.16%
Alicante - Cartagena	2001 - 2014	3.74%	0.18758	3.14%	0.21%
Ávila - Villacastín	2002 - 2014	-0.81%	0.06406	-1.04%	-3.98%
León - Astorga	2002 - 2014	-0.98%	-0.13961	-0.48%	-3.41%
Santiago - Alto de Sto. Domingo	2003 - 2014	4.57%	0.13984	4.19%	1.26%
Segovia - San Rafael	2003 - 2014	2.88%	0.02984	2.80%	-0.14%
Madrid - Guadalajara (R-2)	2003 - 2014	0.26%	0.18062	-0.23%	-3.16%
Madrid - Arganda (R-3)	2004 - 2014	-0.34%	0.24308	-0.28%	-3.21%
Madrid - Navalcarnero (R-5)	2004 - 2014	0.14%	0.07388	0.16%	-2.77%
Madrid - Ocaña (R-4)	2004 - 2014	-1.90%	0.03239	-1.89%	-4.83%
Eje Aeropuerto (M-12)	2005 - 2014	8.89%	0.10366	9.25%	6.31%
GLOBAL SPANISH NETWORK		2.18%			

Source: Author.

Table 7.3.d.: Values of the Average Growth Rate (α) and the Adjusted Average Growth Rate (α adjusted).

30-YEAR TREASURY BOND			IBEX-35
Motorway	α (%)	$\beta\theta$	α adjusted (%)
Montmeló La Junquera (A-7)	2.78%	0.2038	2.02%
Barcelona - Tarragona (A-7)	3.01%	0.2038	2.25%
Montmeló - Papiol (A-7)	11.10%	0.2038	10.34%
Zaragoza - Mediterráneo (A-2)	2.52%	0.2038	1.76%
Villalba - Adanero (A-6)	3.36%	0.2038	2.59%
Sevilla - Cádiz (A-4)	4.87%	0.2038	4.11%
Tarragona - Valencia (A-7)	2.88%	0.2038	2.12%
Valencia - Alicante (A-7)	4.48%	0.2038	3.72%
Ferrol - Front. Portuguesa (A-9)	4.02%	0.2038	3.26%
Bilbao - Zaragoza (A-68)	2.86%	0.2038	2.10%
Burgos - Armiñón (A-1)	6.15%	0.2038	5.39%
León - Campomanes (A-66)	3.93%	0.2038	3.17%
Málaga - Guadiaro	1.31%	0.2038	0.55%
Alicante - Cartagena	3.74%	0.2038	2.98%
Ávila - Villacastín	-0.81%	0.2038	-1.57%
León - Astorga	-0.98%	0.2038	-1.74%
Santiago - Alto de Sto. Domingo	4.57%	0.2038	3.80%
Segovia - San Rafael	2.88%	0.2038	2.12%
Madrid - Guadalajara (R-2)	0.26%	0.2038	-0.50%
Madrid - Arganda (R-3)	-0.34%	0.2038	-1.10%
Madrid - Navacarnero (R-5)	0.14%	0.2038	-0.62%
Madrid - Ocaña (R-4)	-1.90%	0.2038	-2.66%
Eje Aeropuerto (M-12)	8.89%	0.2038	8.13%
GLOBAL SPANISH NETWORK	2.18%		

Source: Author.

For simulation purposes, the following parameters have been considered in order to perform the calculations:

- **Risk-free Interest Rate:** There has been considered the 30-year Spanish treasury bond because the average maturity of toll motorways is almost thirty (30) years. Depend on the case but never above forty (40) years according to the Article 268 of the Spanish Royal Decree Law 3/2011 of 14 November, which approves the Consolidated Text of the Public Sector Contracts Act. In December the 31st 2014. the 30-year Spanish treasury bond was 2.935%.
- **Traffic Volatility:** The average annual value for the Spanish toll motorway network, is 8.00%.

- Traffic Growth Rate (α_θ): It has been considered a value of 2.18%. This value corresponds to the average growth of traffic of those Spanish motorways with a maturity over ten (10) years.
- Market Yield: The average yield in the Spanish stock exchange (IBEX-35), i.e. the AMR (Arithmetic Mean Return) since 1994 has been 8.99%.
- β of Traffic: The representative parameter of the traffic-risk market value (the parameter λ) for the project (i.e., for the cash flows obtained by the concessionaire) and for the traffic must be equal. This can be expressed:

$$\lambda = \frac{\alpha_\theta + \delta - r_f}{\sigma_\theta} = \frac{\mu_{project} - r_f}{\sigma_{project}} \quad (\text{Equation 7.3.4.})$$

Where:

- λ : Price for the traffic-risk market value.
- $\mu_{project}$: Total expected return of the project.
- r_f : The risk-free rate.
- $\sigma_{project}$: Volatility of the cash flows for the concessionaire.

Replacing and operating in (Equation 7.3.3.), we can arrive at the (Equation 7.3.4.) which is similar to (Equation 3.3.5.).

$$\beta_\theta = \frac{\sigma_\theta}{\sigma_{project}} \cdot \beta_{project} \quad (\text{Equation 7.3.5.})$$

Where:

- β_θ : Beta of traffic volume.
- $\beta_{project}$: Beta of the cash flows for the concessionaire.
- σ_θ : Traffic volatility.
- $\sigma_{project}$: Volatility of the cash flows for the concessionaire.

For the estimation of $\beta_{project}$ and $\sigma_{project}$, there has been used as a proxy, the parameters obtained for the series of the return of the shares of listed motorway concessionaire firms in the Spanish stock exchange. In this case there has been considered the returns of the listed company, Abertis. The volatility of this series of

returns is 22.16% for $\sigma_{project}$. For the calculation of the parameter $\beta_{project}$, (Equation 7.3.6.) has been used.

$$\beta_{project} = \frac{\sigma_{project}}{\sigma_m} \cdot \rho_{qm} \quad (\text{Equation 7.3.6.})$$

Where:

- $\beta_{project}$: Beta of the cash flows for the concessionaire.
- $\sigma_{project}$: Volatility of the cash flows for the concessionaire.
- ρ_{qm} : The correlation coefficient between the series of the return of the whole market portfolio and the series of the return of the shares of Abertis.
- σ_m : The volatility of the return of the whole market portfolio.

The value of ρ_{qm} and σ_m , according to (Table 7.3.a.) are 0.5961 and 0.2340 respectively. Then, the estimated value of $\beta_{project}$ according to (Equation 7.3.6.) is $\beta_{project} = 0.5645$. By substituting all these values into (Equation 7.3.5.), the beta of traffic volume is $\beta_{\theta}^{36} = \mathbf{0.2038}$.

³⁶ Beta leveraged.

Figure 7.3.a.: Values of the Average Growth Rate (α) and the Adjusted Average Growth Rate (α adjusted).

Source: Author.

8. CASE STUDY.

In order to study the abandonment option according to the criterion for abandonment discussed in this dissertation (Equation 7.1.2.18.), a financial model has been applied to an ongoing Spanish greenfield motorway concession.

The motorway concession was granted in 2004 as part of the Mediterranean Corridor. Although the motorway is 33.2 kilometres long, only 28.5 kilometres are operated under the toll system.

Despite changes in the law regarding the RPA calculations, as explained in Section 7.1.1.1.1., the applicable legislation was taken into account when the concession was awarded. Regardless, said changes are not retroactive and are only applicable to future concession contracts. Therefore, this dissertation is based on the following assumptions regarding RPA calculations:

- The concession agreement will be terminated if the concessionaire is declared insolvent. Therefore, the abandonment decision is not actually an option in and of itself since it is a result of bankruptcy. Nevertheless, it can only be assessed through a real options valuation.
- The concessionaire will not abandon the project during the ramp-up period, i.e. during the first three (3) years following the construction phase. This consideration is based on the idea that traffic is very volatile; it does not make any sense to abandon the project before traffic growth patterns can be studied and traffic flows become more stable.
- The project will not be abandoned during the last ten (10) years of the concession period since, by that time, it will be in an advanced stage. Furthermore, by the end of the project, any outstanding debt will have been paid off and the project's cash flows will most likely be positive.
- The 2% performance bond mentioned in Section 7.1.1. will be claimed if the contract is terminated.
- The RPA includes expropriations, with deductions for depreciation corresponding to the respective number of years.

- The RPA includes the cost of the construction works that are actually executed, according to the prices defined in the projects approved by the Ministry of Public Works, with deductions for depreciation corresponding to the respective number of years.
- Real property that is part of the concession but not included in the construction budget will be assessed according to its current condition. This is also included in the RPA.
- No extra costs such as those associated with business start-up, studies and projects, the project management team, the construction management team, financial expenses, etc., are included in the RPA.

8.1. TARIFFS.

Table 8.1.a. shows the applicable tariffs by vehicle type at the beginning of the operation period. The distribution between light-duty vehicles and heavy-duty vehicles is based on the tender submitted by the concessionaire. Tariffs are indexed at an annual inflation rate of 2%.

Table 8.1.a.: Toll Rates per Type of Vehicle.

	Initial Tariff per km	Km of toll motorway
Light Vehicles	0.1744 €/km	28.5 kms
Heavy Vehicles	0.2951 €/km	28.5 kms

In addition to direct income from traffic, other commercial income was also considered, such as earnings from gas stations and rest stops, which accounts for 3% of total traffic income.

If $\theta_0, \theta_1, \dots, \theta_n$ are the values (positive) of a toll motorway traffic for years 0. 1. 2. 3..., n, the continuously compounded annual traffic growth rate for any consecutive two years can be calculated as follows:

$$\alpha_i = \ln\left(\frac{AADT_i}{AADT_{i-1}}\right) \quad (\text{Equation 8.1.1.})$$

Where:

- $AADT_i$: Traffic Volume (Annual Average Daily Traffic) at year i .
- α_i : Traffic growth rate at year i .

And average growth, up to any year n , is defined as:

$$\bar{\alpha} = \frac{1}{n} \sum_{i=1}^{i=n} \alpha_i \quad (\text{Equation 8.1.2.})$$

The concessionaire considered an initial traffic volume of 11.126 vehicles in terms of AADT with a cumulative annual growth of 4% (Figure 8.1.a.).

Traffic volatility is therefore defined as:

$$\sigma = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{i=n} (\alpha_i - \bar{\alpha})^2} \quad (\text{Equation 8.1.3.})$$

Where:

- $n - 1$: Since there is no traffic growth in Year 0. we have to consider $(n-1)$ traffic growth data.

Figure 8.1.a.: Traffic Growth Forecast According to the Concessionaire.

8.2. RESULTS.

To simulate real conditions, a Monte Carlo simulation was conducted in order to analyse the abandonment option's sensitivity to the critical variables that affect a concession project. It is important to keep in mind that the expected abandonment value is calculated ex-ante and that the abandonment decision is affected by the concessionaire's possible bankruptcy.

The input data for the valuation is as follows:

- Annual risk-free rate of return $r_f = 2.94\%$. This is the value of the 30-year Treasury bond as of December 31 2014.
- Annual market return rate $r_m = 8.99\%$. The market return rate was calculated by averaging the performance of the IBEX-35 stock index over the last 10 years.
- Annual growth rate of expected traffic $\alpha = 2.18\%$ ³⁷.
- Volatility, $\sigma = 8.00\%$ ³⁸.
- $\alpha_{adjusted} = 0.95\%$. This is the adjusted growth that allows us to operate in a risk-neutral environment, according to (Equation 7.3.1.).
- $\beta_\theta = 0.2038$. This is the beta of traffic volume, according to (Equation 7.3.3.).
- $\delta^{39} = 1.99\%$.

Considering the fact that the length of some motorway infrastructures may change over time, the ratio $[(veh - km)_i / (veh - km)_{i-1}]$ could be misleading since the aforementioned ratio may change due to a change in the motorway's length rather than traffic volume.

As mentioned in the previous section, the relationship between actual initial traffic volume and expected initial traffic volume is characterized as a random variable with distribution $N(0.81, 0.24)$. This consideration is based on research by (Flyvbjerg, Bruzelius, & Buhl, 2003). This assumption takes into account that real traffic volume

³⁷ This value corresponds to average traffic growth (in terms of AADT) for Spanish motorway concessions with a maturity of over ten (10) years.

³⁸ This value corresponds to the volatility of average traffic growth (in terms of AADT) for Spanish motorways that have been in operation for over ten (10) years.

³⁹ Dividend from the non-financial asset (traffic) according to Section 4.7.1.

during the first year in operation is 19% lower than forecasted traffic volume. This result means that traffic in subsequent years will be even more sensitive to variations in the initial value.

The abandonment option has been assessed by changing different critical variables that directly affect the project. Therefore, the value of the resulting abandonment option is the expected value at the beginning of the project.

The first variable we will analyse is initial traffic volume (Figure 8.2.a.).

Figure 8.2.a.: Abandonment Option Value with Variations in Initial Traffic Volume.

Source: Author.

Starting with an initial traffic volume of $\theta_0 = 4,050,17$ vehicles per year, i.e. $AADT_0 = 11,126$ vehicles, the next scenario considered was 10% less, and then 20% for the next, and so on until an initial traffic volume of 50% less than the expected initial traffic volume was reached. A random initial traffic volume was then considered in order to simulate a real case scenario.

As shown in the figure above, the ($\theta_0 -50\%$) line crosses all the others due to the fact that when initial traffic volume is much lower than the volume expected by the concessionaire, there is a very high probability of project abandonment during the first year after the ramp-up period (51.46%) (Figure 8.2.b.). Therefore, there will be fewer

dropouts in subsequent years and the value of the abandonment option drops dramatically in the first five (5) years after the ramp-up period.

Figure 8.2.b.: Abandonment Probability with Variations in Initial Traffic Volume.

Source: Author.

We can conclude from (Figure 8.2.b.) that the concessionaire will most likely abandon the project within the first five (5) years after the ramp-up period if the initial traffic volume is over 30% lower than the expected value. We already know that this motorway's initial traffic volume was 40% less than the volume considered in the tender. Therefore, according to (Figure 8.2.b.), the cumulative abandonment probability is greater than 70% for the first five (5) years after the ramp-up period. We also know that the concession in question has entered into an arrangement with creditors, which confirms the model's validity.

It is important to note that when the initial traffic volume considered in the simulation is random, it has a similar effect as when the initial traffic volume falls between 30% and 40% of the initial traffic volume considered by the concessionaire in the tender (Figure 8.2.c.).

Figure 8.2.c.: Cumulative Abandonment Probability with Variations in Initial Traffic Volume.

Source: Author.

As initial traffic volume falls below the expected value, abandonment probability increases. Moreover, the present value (in 2004) of the abandonment option for each scenario increases as initial traffic volume decreases (Figure 8.2.d.). In this regard, if we compare the abandonment option's present value to the initial investment⁴⁰, it has a great impact (Table 8.2.a.), exceeding the value of 10% if initial traffic volume falls below 30%.

Table 8.2.a.: Abandonment Option / Investment Ratio with Respect to Initial Traffic Volume.

Investment	446,500	(Eur'000)
Initial Traffic Volume	Present Value (A.O.)	A.O./Inv. Ratio
($\theta_0 = 4,050,017$)	3,285	0.74%
($\theta_0 -10\%$)	6,452	1.45%
($\theta_0 -20\%$)	21,302	4.77%
($\theta_0 -30\%$)	47,684	10.68%
($\theta_0 -40\%$)	69,099	15.48%
($\theta_0 -50\%$)	86,486	19.37%
($\theta_0 = \text{Random}$)	78,018	17.47%

Source: Author.

⁴⁰ Initial Investment considered in the model = 446.5 MM€.

Figure 8.2.d.: Present Value of the Abandonment Option per Year with Variations in Initial Traffic Volume.

Source: Author.

We can therefore conclude that the value of the abandonment option is very sensitive to variations in the initial traffic volume. With initial traffic volume at $\theta_0 = 4,050,017$ vehicles per year, the present value of the abandonment option is 3,285 million Euros. If we consider an initial traffic volume of 10% less than θ_0 (i.e. 3,645,015 vehicles per year), the present value increases to 6,452 million Euros. If we consider an initial traffic volume of 20% less than θ_0 (i.e. 3,240,014 vehicles per year), the present value increases to 21,302 million Euros. For an initial traffic volume of 30% less than θ_0 (i.e. 2,835,012 vehicles per year), the present value increases to 47,683 million Euros. For an initial traffic volume of 40% less than θ_0 (i.e. 2,430,010 vehicles per year), the present value increases to 69,099 million Euros. For an initial traffic volume of 50% less than θ_0 (i.e. 2,025,009 vehicles per year), the present value increases to 86,486 million Euros.

The second critical variable is traffic volatility (Figure 8.2.e.), which measures how traffic volume can change or evolve over time. Therefore, the higher the volatility, the less predictable the traffic will be and, consequently, the more the abandonment option is justified.

Considering a random initial traffic volume, different volatility values were established in order to study the effect on the abandonment option. As traffic volatility increases, the abandonment option's present value becomes more valuable. These results are consistent with the real options theory. The higher the volatility, the more valuable the option.

Figure 8.2.e.: Abandonment Option Value with Respect to Volatility.

Source: Author.

As shown above, the ($\sigma = 30\%$) line crosses all the others due to the fact that as volatility increases, traffic is less predictable and variation increases per unit of time. Therefore, there will be fewer dropouts in subsequent years and the value of the abandonment option drops dramatically in the first five (5) years after the ramp-up period.

Considering these results, the concessionaire will most likely abandon the project in the first five (5) years after the ramp-up period if traffic volatility exceeds 10%. Although volatility is not a direct cause of abandonment in and of itself, since greater volatility results in greater variation, it can lead to lower traffic volumes. This motorway has been in operation since 2007 for a total operational period of eight years to date with a real traffic volatility of 12.40%. The simulated results therefore confirm actual situation.

Similar to the issue of variations in initial traffic volume, the abandonment probability is very sensitive to changes in traffic volatility. Nevertheless, slight changes in traffic volatility affect in a significant way to the abandonment probability. As we can see in (Figure 8.2.f.) if traffic volatility rises over 10%, the probability of abandoning the project is higher than 90% in all cases.

Figure 8.2.f.: Abandonment Probability by Volatility.

Source: Author.

The present value (in 2004) of the abandonment option increases as traffic volatility increases in each scenario (Figure 8.2.g.). Comparing the abandonment option's present value with the initial investment shows that it has a great impact (Table 8.2.b.). Nevertheless, higher traffic volatility is more common at the beginning of the operation phase (ramp-up period) and as the operation phase progresses, the volatility decreases as shown in Section 7.2.

Table 8.2.b.: Abandonment Option / Investment Ratio with Respect to Traffic Volatility.

Investment	446,500	(Eur'000)
Traffic Volatility	Present Value (A.O.)	A.O./Inv. Ratio
($\sigma = 5.00\%$)	69,313	15.52%
($\sigma = 10.00\%$)	95,105	21.30%
($\sigma = 15.00\%$)	118,746	26.59%
($\sigma = 20.00\%$)	140,982	31.57%
($\sigma = 25.00\%$)	160,844	36.02%
($\sigma = 30.00\%$)	181,423	40.63%

Source: Author.

Figure 8.2.g.: Present Value of the Abandonment Option per Year with Variations in Traffic Volatility.

Source: Author.

The third critical variable is the percentage of debt (Figure 8.2.h.). This is also very important since it represents the trigger to exercise the option, as explained in (Equation 7.1.2.18.).

Figure 8.2.h.: Abandonment Probability by Debt Levels.

Source: Author.

The (Debt = 90%) line crosses the others starting in 2017. This is due to the fact that as the percentage of debt increases, the outstanding debt draws nearer to the present value of future cash flows.

As shown in (Figure 8.2.h.), as the percentage of debt increases, the probability of abandoning the project due to the concessionaire's bankruptcy increases. Nevertheless, the abandonment option is not as sensitive to variations in debt as it is to initial traffic volume and traffic volatility. As shown in (Figure 8.2.h.), abandonment probability decreases gradually rather than sharply in the first few years after the ramp-up period.

As expected, the cumulative abandonment probability when random initial traffic volume is considered (Figure 8.2.c.) (85.30%) corresponds to a level of debt equivalent to 80%, which is the same value considered by the concessionaire for the base case. Historically, motorway infrastructure projects are usually highly leveraged. Considering the results of this study in light of this fact leads to the conclusion that such a high level of debt would be risky for the concessionaire if conditions become unfavourable. As shown in (Figure 8.2.i.), as the percentage of debt increases, the cumulative abandonment probability increases due to default.

Figure 8.2.i.: Cumulative Abandonment Probability by Debt Levels.

Source: Author.

The abandonment option does not have the same value for lenders as it does for the concessionaire. As the project progresses and the concessionaire gradually pays off the debt with the cash flows collected from users, the abandonment option becomes more valuable to the concessionaire. According to (Equation 7.1.2.18.), if abandonment occurs, the value of the abandonment option will be equal to $(AV_T - PV_T)$. Nevertheless, this value will be distributed between the lenders and the concessionaire. If the contract is terminated prematurely, the concessionaire will collect a high sum of funds from the Public Administration as compensation. Since the concessionaire must pay off the outstanding debt with lenders, the remaining amount for the concessionaire will be equivalent to $(AV_T - D_T)$. Since the outstanding debt decreases as the concession matures, the abandonment option becomes more valuable in subsequent years (Figure 8.2.j.).

Figure 8.2.j.: Percentage of the Abandonment Value Distributed to the Concessionaire.

Source: Author.

On the other hand, the value of the abandonment option distributed to lenders is calculated as $(D_T - PV_T)$. Since the outstanding debt is higher towards the beginning of the project, the value of the abandonment option for lenders increases during the first few years of the concession (Figure 8.2.k.).

Figure 8.2.k.: Percentage of the Abandonment Value Distributed to Lenders.

Source: Author.

Combining (Figure 8.2.j.) and (Figure 8.2.k.) shows an equilibrium point between the value of the abandonment option distributed to the concessionaire and the value distributed to lenders for the same level of debt (Figure 8.2.l.), where the value of the abandonment option is the same for the concessionaire and the lenders. This equilibrium point moves farther away from the beginning of the operation phase as the level of debt increases.

Figure 8.2.l.: Abandonment Value Distribution by Debt Levels.

Source: Author.

The fourth critical variable is the amount fined by the Public Administration (or the grantor) to the concessionaire for exercising the abandonment option (Figure 8.2.m.).

Figure 8.2.m.: Abandonment Option Value with Respect to Different Fines.

Source: Author.

As mentioned in Section 7.1.1., if the contract is terminated due to the concessionaire, the operation performance bond will be claimed. In addition, the concessionaire must compensate the Public Administration for any liquidated damages that exceed the amount of the seized security. Since the abandonment criterion considered in this study is not related to inefficient management on the part of the concessionaire, the value of the claimed performance bond alone will suffice as a penalty for the base case.

Nevertheless, additional fines may be considered to compensate for liquidated damages, as well as their impact on the abandonment option. Since these fines involve less RPA paid by the Public Administration to the concessionaire, we can conclude that the higher the penalty, the lower the value of the abandonment option.

As expected, the present value of the abandonment option decreases as the amount of fines increases.

Figure 8.2.n.: Present Value of the Abandonment Option per Year with Variations in Fines.

Source: Author.

Figure 8.2.n. shows the sensitivity of the total value of the abandonment option to the amount fined by the Public Administration to the concessionaire. The value of the abandonment option decreases significantly as the amount of fines increases.

Another important aspect that affects many concessions in Spain is expropriation overruns, as explained in Section 7.1.1.3.1. It is therefore important to study the effect of these overruns on the abandonment option (Figure 8.2.o.).

Considering random initial traffic volume, the value of the abandonment option increases as expropriation overruns increase. This extra cost requires more funds to finance the project and, as shown above, the greater the debt, the higher the value of the option, up to the optimal value. Moreover, expropriations are related to the value of the RPA, as shown in Section 7.1.1., since expropriations are compensated by the amount actually paid to the dispossessed, with deductions for depreciation corresponding to the respective number of years. Therefore, the higher the expropriation costs, the higher the RPA and the higher the abandonment option value.

Figure 8.2.o.: Abandonment Option Value with Respect to Expropriation Overruns.

Source: Author.

Figure 8.2.p.: Abandonment Probability by Expropriation Overrun Percentages.

Source: Author.

Figure 8.2.q.: Present Value of the Abandonment Option per Year with Variations in Expropriation Overruns.

Source: Author.

According to Article 17 of Law 8/1972 dated May 10th, the concessionaire must assume all rights and obligations in the expropriation process and pay all compensations to the dispossessed for expropriations and temporary occupations required for the execution of the infrastructure project. Nevertheless, the concessionaire bears a great risk of the cost of expropriations eventually increasing. Therefore, if the Public Administration were to bear this risk from the very beginning, this cost would not be added to the RPA and would no longer have an impact on the abandonment option.

9. CONCLUSIONS AND FUTURE RESEARCH LINES.

9.1. PRACTICAL APPLICATION OF THIS DOCTORAL THESIS.

Although the real options approach is not as widely used in business practices as traditional approaches, it is a valuable tool for assessing investment projects that have a high degree of uncertainty. Although this method is more commonly used in sectors such as pharmaceuticals, healthcare, oil & gas, mining, research & development projects, and technology, the abandonment option specifically is very useful for private equity investors and infrastructure funds as it offers the option to liquidate the asset or project in question. This method has great potential for use in motorway concession projects and other public-private partnerships since, as demonstrated in this dissertation, motorway projects are subject to a high level of uncertainty due to traffic.

This model is not intended to replace traditional valuation methods, but rather complement them when dealing with projects that require a substantial disbursement of funds. By following this methodology, managers can apply certain embedded clauses from contracts into their financial models. It also allows them to add additional clauses to contracts when possible options are identified in the project, taking into account the value of flexibility. In the case of the abandonment option, motorway concession agreements may include a clause permitting private partners to abandon the project if certain events occur (such as substantially less traffic volume than expected) and sell it to the public administration for its abandonment value.

This dissertation assesses the abandonment option, considering an American put option or multiple European puts, in order to understand how the value of the abandonment option evolves over time. Since concessionaires cannot just abandon a project whenever they want, for the purposes of this study, the criterion for abandonment is based on the fact that the project is no longer feasible. For the purposes of modelling, the project is considered to be unfeasible when the project value is lower than the outstanding debt (for example, when a concessionaire goes bankrupt). Since declaring bankruptcy involves contract termination, the abandonment option is covered by the legal framework, in accordance with Article 269 of Spanish Royal Decree 3/2011.

This study analyses the bankruptcy situation using the real options approach. From a methodological perspective, the real options approach is a practical tool for infrastructure concession valuations when certain elements add a degree of flexibility to the contract, such as the abandonment option.

Abandonment options are very valuable for projects with high volatility or when the main source of income is unpredictable. If traffic operates as expected, the value of continuing the project is more valuable than abandoning it. Nevertheless, when the project's present value at any given time falls below its liquidation value and external conditions affect the project's proper value, abandonment will inevitably occur as a result of bankruptcy.

The outcome of this dissertation shows a significant value of the abandonment option, which represents an implicit subsidy from the Public Administration to the concession. In addition, the results show a very high probability on an early termination of motorway concession contracts. In this way, the methodology presented in this work will be useful for all the stakeholders in motorway concessions, since it can contribute to gaining a better understanding of the risks involved and enhancing the transparency in concession contracts.

9.2. CONCLUSIONS.

In the field of transportation infrastructure, investment projects have specific features that differ from other types of investments. Firstly, they present a high degree of uncertainty (for motorway concessions, income comes from traffic that is unpredictable). Secondly, they require a significant amount of resources, which generally have an irreversible commitment. These are common features of motorway concessions, which offer great potential for applying the real options method.

A hypothesis that must be considered in order to apply the real options approach is that the structure of the underlying asset follows a Geometric Brownian Motion (GBM) with static drift and volatility parameters. This study has considered traffic volume as the underlying asset in motorway concessions. One of the objectives of this dissertation is to

verify that traffic can be modelled as a GBM. In order to compare the hypothesis that the underlying asset follows a GBM, a unit root test analysis was conducted. The main conclusion drawn from this analysis is that we cannot reject the hypothesis that traffic follows a GBM in most toll and free motorways in Spain; this stochastic process can therefore be used to model the evolution of traffic. According to this approach and considering the aforementioned results, the underlying asset in an option contract would be traffic volume on the motorway. Traffic is therefore the source of uncertainty that determines the option's value. Some authors have criticized the use of GBM to model traffic because the process does not take into account the motorway's maximum traffic capacity (Blank, Samanez, Baidya, & Dias, 2015). However, a condition can easily be added to the model so that if the GBM process exceeds the motorway's maximum traffic capacity, the traffic value for that year will correspond to the maximum traffic capacity. Consequently, in this case the project would have an implicit expansion option.

When initial traffic was simulated in the base case⁴¹, the value of the abandonment option accounted for 17.47% of the initial investment. This significant value reflects the implicit subsidy granted by the Public Administration to the concessionaire through the RPA, analysing the Abandonment Option Value/Investment ratio. The results highlight the importance of traffic studies in order to anticipate initial traffic volume, since the abandonment probability is highly influenced by this value.

Many motorway concession projects in Spain have had financial problems in recent years. In all of these cases, initial traffic volume was overestimated, and real traffic volumes were actually at least 40% lower than the predicted values. When random initial traffic volume is considered, the cumulate probability of abandoning the project at some time during the concession period is 85.3%. This percentage corresponds to the base case, where the percentage of debt is approximately 80%. Historically, motorway infrastructure projects are usually highly leveraged. Considering the results of this study in light of this fact leads to the conclusion that such a high level of debt would be risky for the concessionaire if conditions become unfavourable.

⁴¹ Volatility = 8.0%
Equity = 19.5% / Debt = 80.5%
Penalty = 2.0%

This tool is particularly attractive to financial institutions that provide extensive funds for these projects, since they may consider certain agreements to be a trigger for the abandonment option. Furthermore, lenders have preferential recovery rights for executing the RPA. An important conclusion of this dissertation is that the abandonment option is particularly attractive to lenders towards the beginning of the operation phase (i.e. the first few years after the ramp-up period), as the percentage of debt increases since outstanding debt is higher at the beginning of the project. On the other hand, the concessionaire will collect a high sum of funds from the Public Administration as compensation for premature contract termination. Nevertheless, the outstanding debt is highest towards the beginning of the operation phase and, consequently, the difference between the RPA and the outstanding debt is lower than in subsequent years.

The value of the abandonment option is very sensitive to changes in traffic volatility – the higher the volatility, the less predictable the income will be. The concession in question started operations in 2007 and its traffic volatility to date is 12.4%. Considering the traditional classification of financial assets, these would be considered low to moderate risky assets⁴². To calculate the traffic growth rate adjusted for risk ($\alpha_{adjusted}$), this study considered the volatility of average traffic growth for motorways that have been in operation for over ten (10) years, or 8.0% volatility. As traffic volatility increases, project revenues become more uncertain, which can lead to the concessionaire's possible bankruptcy. Therefore, the value of the abandonment option increases as traffic volatility increases.

Regarding the fines applied to the concessionaire as a result of premature contract termination, the value of the abandonment option decreases as the fines increase. The abandonment probability remains almost constant, since the criterion for exercising this option only considers the value of the project and the outstanding debt. These results are consistent, since the abandonment value matches the RPA at any time. Since the fine

⁴² Financial assets can be classified according to volatility in three groups:

- Low Risky Assets: Volatility < 15%.
- Moderate Risky Assets: 15% < Volatility < 30%.
- High Risky Assets: 30% < Volatility.

directly affects the amount of RPA the concessionaire will receive upon liquidation, the higher the fine, the lower the RPA.

Finally, a sensitivity analysis of expropriation overruns was conducted, since the extra costs incurred by most concessionaires usually lead to serious financial problems. Since expropriations are added to the RPA, one could argue that the higher the expropriations value, the higher the RPA. Therefore, according to the results, the value of the abandonment option will increase as expropriation overruns increase. Nevertheless, not every extra cost has the same result. If the concessionaire incurs extra construction or O&M⁴³ costs, they will not be added to the RPA, since the concessionaire is responsible for that risk. The probability of abandonment would therefore increase since the concessionaire will need more funds to cover the extra costs and, consequently, free cash flows will decrease. Therefore, according to the abandonment criterion studied in this dissertation, the difference between the outstanding debt and the present value of future cash flows would decrease, thereby increasing the abandonment probability. It is important to consider technical developments, since they involve extra costs for the concessionaire. According to Royal Decree 3/2011, the concessionaire must maintain the infrastructure up-to-date with the latest technological advances and compliant to current applicable legislation. However, if the required modifications were to dramatically affect the infrastructure's financial balance, said maintenance could be problematic.

The RPA established in the Official Bulletin of the State ("BOE" according to its acronym in Spanish) is intended to serve as a guarantee to lenders and investors entering a motorway project, which would, theoretically, allow them to recover their investment if necessary. However, this is a relatively intangible concept since it has never actually applied in practice. Spain currently has two motorways undergoing liquidation processes (Eje Aeropuerto (M-12) and Ocaña-La Roda (AP-36) motorways) and others that have entered an arrangement with creditors (R-3, R-4, R-5 and Circunvalación de Alicante motorways).

⁴³ Operation and Maintenance.

The way the Public Administration has dealt with this serious problem casts doubt on the concept of RPA and creates excessive legal uncertainty for financial investors. As budgetary constraints have been extremely severe in the years following the economic crisis, it is necessary to have a line item in the budget to cover potential RPA payments to concessionaires if the Public Administration has to prematurely terminate any contracts due to bankruptcy. However, if such a budget were in fact established, it would increase the national government's deficit, which is why the Public Administration has been avoiding paying the RPA. Consequently, lenders may be less likely to trust in the Spanish concession system, which would lead to more expensive loans in the future.

Nevertheless, the new modifications to the RPA law⁴⁴ will most likely render this practice obsolete. According to the Article 271.ter (referenced in Section 7.1.1.1.1.), if default occurs before reaching the mid-point of the operational period, the value of the concession would be calculated using the same cash flows that led the previous concessionaire to default. Consequently, if the concession is bankrupt, its value would be negligible.

However, as previously discussed, the main sources of uncertainty in motorway concession agreements are initial traffic volume and traffic volatility, and these risks are still there.

At the outset, the abandonment option would serve as a guarantee for investors and lenders to protect or at least partially protect their investment. Exercising the abandonment option would therefore be considered an irreversible commitment, and should only be exercised as a last alternative. However, investors always have the possibility of maintaining the value of the option until market conditions become more favourable; that is, holding onto the option and waiting to see if market conditions improve. This kind of option is particularly attractive when real traffic volume is substantially less than anticipated traffic. However, the abandonment option is often considered to be a European Option in bidding documents, since the infrastructure provides a public service and the Public Administration would therefore not make it easy

⁴⁴ Latest version of the Consolidated Public Sector Contracts Act, published on 2 October 2015.

for concessionaires to abandon a project. One possible alternative would be to include demand risk mitigation mechanisms in the contract, such as a variable-term concession agreement in which the concessionaire has the right to collect toll revenues until a total accumulated discounted sum is reached (Albalade & Bel, 2009). Another possibility would be to establish a stricter degree of leverage for concession agreements, or perhaps a combination of these two possibilities. In this regard, the real options approach is a valuable tool to perform the analysis of these kinds of mechanisms, which is one of the future lines of research suggested in the following section.

9.3. FUTURE RESEARCH LINES.

Future lines of research and improvements to the applied methodology include the following:

- Using the unit root test analysis when there are abrupt changes in traffic patterns. This study analysed data from motorway traffic time series and Automatic Traffic Recorders (ATR), which showed evidence of abrupt changes in traffic for all the cases in which the unit root hypothesis was rejected.
- As discussed in the conclusions, Geometric Brownian Motion can lead to levels of traffic that may exceed the motorway's capacity. These cases involve another real option, which is the possibility of adding additional lanes to the motorway. It would therefore be interesting analyse the project when compound options are involved.
- This study considers traffic growth and traffic volatility as constant variables, analysing the motorway concession sector. It would be very interesting to consider a case in which traffic growth and traffic volatility are random rather than constant. In this case, traffic volatility would be higher during the ramp-up period in the first few years of the concession, and then progressively decrease.
- This study analyses the Public Administration's Patrimonial Liability, taking into account the existing criterion for RPA valuation when the motorway concession was granted. Since the new modifications are not retroactive, the effect of these changes could be analysed in the simulation.

- The Spanish concession scheme is based on a fixed-term contract. However, certain countries, such as Chile, are developing models based on variable-term contracts, reducing, but not eliminating, the demand risk. We recommend a real options-based model to study this kind of agreement, as well as the effect of the variable concession period on the RPA.

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ANNEX I: EXISTING LEGAL FRAMEWORK.

In Spain, toll motorways and concessionaire companies should be governed by the following legal framework:

- Ley 8/1972 de 10 de mayo de construcción, conservación y explotación de autopistas en régimen de concesión (BOE 113/1972).
- Decreto 215/1973 de 25 de enero, por el que se aprueba el pliego de cláusulas generales para la construcción, conservación y explotación de autopistas en régimen de concesión (BOE 41/1973).
- Orden del Ministerio de Hacienda, de 18 de mayo de 1976 sobre tratamiento fiscal de determinados aspectos económicos y financieros de las sociedades concesionarias de autopistas nacionales de peaje (BOE 122/1976).
- Orden del Ministerio de Hacienda, de 7 de junio de 1976 complementaria de la de 18 de mayo de los mismos Departamento y año (BOE 140/1976).
- Disposición adicional décima de la Ley 9/1983 de 13 de julio, de Presupuestos Generales del Estado para 1983 (BOE 167/1983).
- Real Decreto 657/1986 de 7 de marzo, sobre organización y funcionamiento de la Delegación del Gobierno en las Sociedades Concesionarias de Autopistas Nacionales de Peaje (BOE 84/1986).
- Ley 25/1988 de 29 de julio, de Carreteras (BOE 182/1988).
- Real Decreto 210/1990 de 16 de febrero, (BOE 44/1990), sobre el procedimiento de revisión de tarifas de autopistas de peaje, en la parte no derogada por la Ley 14/2000 de 29 de diciembre, de Medidas fiscales, Administrativas y del Orden Social.
- Ley 13/1996 de 30 de diciembre, de Medidas Fiscales, Administrativas y del Orden Social. (BOE 315/1996). Título V, Capítulo I, Artículo 157: Modificación de la Ley 8/1972. de 10 de mayo.
- Ley 66/1997 de 30 de diciembre, de Medidas Fiscales, Administrativas y del Orden Social. (BOE 313/1997). Disposición adicional quincuagésima primera: Modificación de la Ley 8/1972 de 10 de mayo.
- Real Decreto 114/1998 de 30 de enero, por el que se modifica la cláusula 84 del pliego de cláusulas generales para la construcción, conservación y explotación

de autopistas en régimen de concesión, aprobado por Decreto 215/1973 de 25 de enero. (BOE 42/1998).

- Ley 55/1999 de 29 de diciembre, de Medidas fiscales, Administrativas y del Orden Social. (BOE 312/1999). Título V, Capítulo IV, Artículo 59: Modificación de la Ley 8/1972 de 10 de mayo.
- Real Decreto Legislativo 2/2000 de 16 de junio, por el que se aprueba el texto refundido de la Ley de Contratos de las Administraciones Públicas (BOE 148/2000). Corrección de errores (BOE 227/2000).
- Ley 14/2000 de 29 de diciembre, de Medidas fiscales, Administrativas y del Orden Social. (BOE 313/2000). Título V, Capítulo VIII, Artículo 76: Modificación de la Ley 8/1972. de 10 de mayo.
- Ley 24/2001 de 27 de diciembre de Medidas Fiscales, Administrativas y del Orden Social. (BOE 313/2001). Título I, Capítulo II, Artículo 5: Modificación de la Ley 37/1992 de 28 de diciembre. Título V, Capítulo II, Artículo 78: Modificación de la Ley 8/1972 de 10 de mayo.
- Real Decreto 163/2002 de 8 de febrero, por el que se regulan los requisitos y el procedimiento para la obtención, por las sociedades concesionarias de autopistas nacionales de peaje, de las autorizaciones para la realización en materia de infraestructuras de transportes y de comunicaciones. (BOE 41/2002).
- Ley 53/2002 de 30 de diciembre de Medidas Fiscales, Administrativas y del Orden Social. (BOE 313/2002). Artículo 102: Modificación de la Ley 14/2000. de 29 de diciembre.
- Ley 13/2003 de 23 de mayo, reguladora del contrato de concesión de obras públicas (BOE 124/2003).
- Real Decreto 1231/2003 de 26 de septiembre, por el que se modifica la nomenclatura y el catálogo de las autopistas y autovías de la Red de Carreteras del Estado (BOE 234/2003). Corrección de errores (BOE 266/2003).
- Ley 26/2009 de 23 de diciembre, de Presupuestos Generales del Estado para el año 2010. Disposición adicional cuadragésima primera (BOE 309/2009).

- Orden EHA/3362/2010 de 23 de diciembre, por la que se aprueban las normas de adaptación del Plan General de Contabilidad a las empresas concesionarias de infraestructuras públicas (BOE 317/2010).
- Ley 43/2010 de 30 de diciembre, del servicio postal universal, de los derechos de los usuarios y del mercado postal, disposición adicional octava (BOE 318/2010).
- Real Decreto Legislativo 3/2011 de 14 de noviembre, por el que se aprueba el texto refundido de la Ley de Contratos del Sector Público (BOE 276/2011).
- Ley 17/2012 de 27 de diciembre, de Presupuestos Generales del Estado para el año 2013. (BOE 312/2012). Disposición final segunda (modificación Ley de Expropiación Forzosa, de 16 de diciembre de 1954); tercera (modificación artículos 14 y 29 de la Ley 8/1972 de 10 de mayo; décimo novena (modificación Ley 26/2009 de 23 de diciembre); y vigésimo primera (modificación de la disposición adicional octava de la Ley 43/2010. de 30 de diciembre).

ANNEX II: STOCHASTIC PROCESSES USED IN OPTIONS VALUATION.

ORNSTEIN-UHLENBECK PROCESS OR MEAN-REVERTING PROCESS.

A mean-reverting process tends to change its growth pattern (or decreasing pattern) when data reach their extreme values (i.e. historical values). These processes are characterized for having a negative self-correlation (Palacio Montoya, 2008).

The process developed by Ornstein and Uhlenbeck (Uhlenbeck & Ornstein, 1930) is a stochastic process that satisfies the following stochastic differential equation:

$$dX_t = \eta \cdot (\theta - X_t)dt + \sigma dB_t \quad (\text{Equation AI.1.})$$

Where:

- η : Is the rate of mean reversion.
- θ : The long-term mean reversion.
- σ : The volatility or average magnitude.
- B_t : Is the standard Brownian Motion $t \in [0, \infty)$.

If we ignore the random fluctuation in the process due to B_t , then we see that X_t has an overall drift towards the mean value θ . The process X_t reverts to this mean exponentially at a rate η with a magnitude in direct proportion to the distance between the current value of X_t and θ .

This can be seen by the solution to the ordinary differential equation $dx_t = \eta \cdot (\theta - X_t)dt$, which is:

$$\frac{\theta - x_t}{\theta - x_0} = e^{-\eta \cdot (t - t_0)} \quad (\text{Equation AI.2.})$$

or:

$$x_t = \theta + (x_0 - \theta) \cdot e^{-\eta \cdot (t - t_0)} \quad (\text{Equation AI.3.})$$

The solution to the stochastic differential equation (Equation AI.1.) for any $s \in R$; $0 \leq s \leq t$, is:

$$X_t = \theta + (X_s - \theta) \cdot e^{-\eta \cdot (t - s)} + \int_s^t e^{-\eta \cdot (t - u)} dB_u \quad (\text{Equation AI.4.})$$

Where the integral on the right is the Itô integral. For any fixed s and t , the random variable X_t , conditioned upon X_s is normally distributed:

- Mean = $\theta + (X_s - \theta) \cdot e^{-\eta \cdot (t-s)}$
- Variance = $\int_s^t e^{-\eta \cdot (t-u)} dB_u$

SQUARE ROOT PROCESS.

A square-root diffusion process is any stochastic process, where $\{x_t\}, t \geq 0$. defined by the following equation:

$$dx_t = \kappa \cdot (\theta - x_t)dt + \beta \cdot \sqrt{x_t}dB_t, \quad x(0) = x_0 \quad (\text{Equation A1.5.})$$

Where:

- κ, θ, β : Are positive constants.
- B_t : Is the Brownian Motion.
- σ : The volatility or average magnitude.
- B_t : Is the standard Brownian Motion $t \in [0, \infty)$.

If $x(0) > 0$. then $x(t) \geq 0$ for all t .

If $2 \cdot \kappa \cdot \theta > \beta^2$, then $x(t) > 0$ for all t .

JUMP-DIFFUSION MODELS.

In a model with continuous paths like a diffusion model, the evolution of the price behaves locally like a Brownian motion and the probability that the stock moves by a large amount over a short period of time is very small, unless the price has a high value of volatility. In such cases, if stock prices are allowed to jump, even when the time to maturity is very short, there is a non-negligible probability that after a sudden change in the stock price the option will move in the money. From a risk management perspective, jumps allow to quantify and take into account the risk of strong stock price movements over short time intervals, which appears non-existent in the diffusion framework.

THE POISSON PROCESS.

Considering the process $T_1, T_2, \dots, T_n$ of independent exponential random variables with parameter λ , with cumulative distribution function:

$$P[T_i \geq x] = e^{-\lambda \cdot x} \quad (\text{Equation AI.6.})$$

And let:

$$T_n = \sum_{i=1}^n T_i \quad (\text{Equation AI.7.})$$

The process described by (Equation AI.8.) is called the Poisson process:

$$N_t = \sum_{n \geq 1} 1_{t \geq T_n} \quad (\text{Equation AI.8.})$$

$$1_{t \geq T_n} = \begin{cases} 1 & \text{if } t \geq T_n \\ 0 & \text{if } 0 \leq t < T_n \end{cases}$$

The trajectories of a Poisson process is a piecewise constant (right-continuous with left limits), with jumps of size equal to 1. The jumps occur at times T_i and the intervals between jumps are exponentially distributed. At every date $t > 0$. N_t has the Poisson distribution with parameter λt .

$$P[N_t = n] = e^{-\lambda t} \cdot \frac{(\lambda t)^n}{n!}, \quad n \in \mathbb{N} \quad (\text{Equation AI.9.})$$

A very important property the Poisson process has is the independence and stationarity of increments, as the Brownian motion has. Therefore, for every $t > s$, the increment $N_t - N_s$ is independent from the history of the process up to time s and has the same law as N_{t-s} .

$$P[N_t - N_s = n] = e^{-\lambda(t-s)} \cdot \frac{(\lambda(t-s))^n}{n!}, \quad n \in \mathbb{N} \quad (\text{Equation AI.10.})$$

The parameter $\lambda > 0$ is also called the intensity of the Poisson process and is given by the expression:

$$\lambda = \lim_{h \rightarrow 0} \frac{1}{h} \cdot \mathbb{P}(N_h = 1), \quad h > 0 \quad (\text{Equation AI.11.})$$

The process explained before reflects jumps of size equal to 1. but there is also a compound Poisson process in which the waiting times between jumps are exponential but the jump sizes can have an arbitrary distribution. Considering a Poisson process N with parameter λ and a sequence of random variables $\{Y_i\}_{i \geq 1}$, then the process described in (Equation A1.12.) is called compound Poisson process.

$$X_t = \sum_{i=1}^{N_t} Y_i, \quad t \geq 0 \quad (\text{Equation A1.12.})$$

As was the case with the single Poisson process, its trajectories with right-continuous with left limits and piecewise constant, but the jump sizes in compound Poisson processes are random and governed by a probability distribution function f . The compound Poisson process has independent and stationary increments as the single process has. Its law at a given time t is not known explicitly but the characteristic function is known and has the form shown in the (Equation A1.13.).

$$E[e^{i \cdot u \cdot X_t}] = \exp\left\{\lambda t \cdot \int_{-\infty}^{\infty} (e^{i \cdot u \cdot x} - 1) \cdot f(dx)\right\} \quad (\text{Equation A1.13.})$$

We can combine the Brownian motion described in (Equation 5.3.1.1.) with the compound Poisson process of (Equation A1.12.) in order to obtain a diffusion process with jumps a process which sometimes jumps and has a continuous but random evolution between the jump times.

$$X_t = \mu \cdot t + \sigma \cdot B_t + \sum_{i=1}^{N_t} Y_i, \quad t \geq 0 \quad (\text{Equation A1.14.})$$

Where:

- B_t : Is the standard Brownian Motion $t \in [0, \infty)$, with $B_0 = 0$.
- N_t : Is a Poisson process with parameter λ .
- μ : The drift.
- σ : The volatility ($\sigma > 0$).
- Y_i : Jump sizes that are independent and identically distributed random variables.

ANNEX III: STATIONARITY ANALYSIS. CORRELOGRAMS OF TOLL MOTORWAYS.

Figure 1: Montmeló – La Jonquera Motorway.

Figure 4: Zaragoza – Mediterráneo Motorway.

Figure 2: Barcelona – Tarragona Motorway.

Figure 5: Villalba – Adanero Motorway.

Figure 3: Montmeló – El Papiol Motorway.

Figure 6: Sevilla – Cádiz Motorway.

Figure 7: Tarragona – Valencia Motorway.

Sample: 1974 2014
Included observations: 41

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat
1	0.947	0.947	39.529	
2	0.880	-0.165	74.521	
3	0.805	-0.097	104.56	
4	0.731	-0.010	130.01	
5	0.659	-0.022	151.30	
6	0.593	0.000	169.00	
7	0.525	-0.065	183.31	
8	0.453	-0.098	194.27	
9	0.376	-0.083	202.04	
10	0.292	-0.103	206.88	
11	0.202	-0.114	209.28	
12	0.112	-0.064	210.04	
13	0.026	-0.038	210.09	
14	-0.049	0.009	210.24	
15	-0.111	0.025	211.07	
16	-0.160	0.033	212.87	
17	-0.204	-0.042	215.93	
18	-0.241	0.021	220.38	
19	-0.277	-0.049	226.52	
20	-0.318	-0.109	234.99	

Figure 8: Valencia – Alicante Motorway.

Sample: 1976 2014
Included observations: 39

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat
1	0.928	0.928	36.258	
2	0.852	-0.073	67.594	
3	0.781	0.005	94.683	
4	0.710	-0.046	117.71	
5	0.635	-0.068	136.66	
6	0.559	-0.048	151.82	
7	0.479	-0.088	163.27	
8	0.392	-0.096	171.19	
9	0.302	-0.087	176.06	
10	0.219	-0.020	178.72	
11	0.136	-0.075	179.78	
12	0.061	-0.009	179.99	
13	-0.008	-0.021	180.00	
14	-0.069	-0.009	180.30	
15	-0.117	0.035	181.22	
16	-0.160	-0.017	182.99	

Figure 9: Ferrol – Frontera Portuguesa Motorway.

Sample: 1979 2014
Included observations: 36

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat
1	0.952	0.952	35.388	
2	0.887	-0.197	67.029	
3	0.815	-0.086	94.549	
4	0.733	-0.133	117.49	
5	0.633	-0.212	135.16	
6	0.525	-0.099	147.75	
7	0.424	0.026	156.22	
8	0.328	-0.003	161.46	
9	0.237	0.015	164.32	
10	0.155	0.003	165.57	
11	0.084	0.010	165.96	
12	0.022	-0.029	165.98	
13	-0.038	-0.097	166.07	
14	-0.103	-0.182	166.74	
15	-0.161	-0.008	168.41	
16	-0.214	-0.070	171.56	

Figure 10: Bilbao – Zaragoza Motorway.

Sample: 1978 2014
Included observations: 37

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat
1	0.954	0.954	36.479	
2	0.889	-0.237	69.043	
3	0.821	-0.020	97.648	
4	0.741	-0.178	121.66	
5	0.655	-0.071	140.98	
6	0.565	-0.077	155.83	
7	0.470	-0.097	166.45	
8	0.362	-0.205	172.96	
9	0.267	0.142	176.62	
10	0.179	-0.062	178.33	
11	0.100	0.076	178.89	
12	0.031	-0.020	178.94	
13	-0.033	-0.057	179.01	
14	-0.096	-0.077	179.59	
15	-0.156	-0.050	181.18	
16	-0.209	-0.096	184.19	

Figure 11: Burgos – Armiñón Motorway.

Sample: 1978 2014
Included observations: 37

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat
1	0.902	0.902	32.621	
2	0.831	0.090	61.065	
3	0.758	-0.030	85.419	
4	0.710	0.095	107.43	
5	0.642	-0.105	126.00	
6	0.559	-0.142	140.55	
7	0.476	-0.066	151.43	
8	0.386	-0.118	158.84	
9	0.296	-0.094	163.37	
10	0.209	-0.052	165.70	
11	0.127	-0.043	166.59	
12	0.053	-0.007	166.76	
13	-0.017	-0.022	166.77	
14	-0.081	-0.016	167.18	
15	-0.141	-0.024	168.48	
16	-0.198	-0.052	171.17	

Figure 12: León – Campomanes Motorway.

Sample: 1983 2014
Included observations: 32

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat
1	0.944	0.944	31.264	
2	0.854	-0.338	57.706	
3	0.754	-0.059	79.012	
4	0.642	-0.144	95.030	
5	0.530	-0.022	106.34	
6	0.424	-0.011	113.88	
7	0.331	0.024	118.65	
8	0.246	-0.052	121.40	
9	0.171	-0.003	122.79	
10	0.093	-0.169	123.22	
11	0.010	-0.094	123.22	
12	-0.064	0.020	123.45	
13	-0.139	-0.113	124.55	
14	-0.214	-0.068	127.32	
15	-0.278	0.016	132.26	
16	-0.329	-0.026	139.62	

ANNEX IV: TRAFFIC EVOLUTION IN SPANISH TOLL MOTORWAY CONCESSIONS.

Figure 1: Montmeló – La Jonquera (A-7) Motorway.

Table 1: Traffic Evolution of the Montmeló – La Jonquera (A-7) Motorway.

MONTMELÓ - LA JUNQUERA (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1974	120.9	14,728	650	-	-
1975	142.7	13,354	696	0.907	1.070
1976	149.7	13,002	710	0.974	1.021
1977	149.7	13,925	761	1.071	1.071
1978	149.7	15,823	865	1.136	1.136
1979	149.7	15,859	867	1.002	1.002
1980	149.7	15,026	821	0.947	0.947
1981	149.7	15,557	850	1.035	1.035
1982	149.7	15,948	871	1.025	1.025
1983	149.7	15,934	871	0.999	0.999
1984	149.7	16,478	900	1.034	1.034
1985	149.7	17,099	934	1.038	1.038
1986	149.7	18,892	1,032	1.105	1.105
1987	149.7	21,282	1,163	1.127	1.127
1988	149.7	23,671	1,293	1.112	1.112
1989	149.7	26,296	1,437	1.111	1.111
1990	149.7	26,660	1,457	1.014	1.014
1991	149.7	27,802	1,519	1.043	1.043
1992	149.7	28,488	1,557	1.025	1.025
1993	149.7	28,124	1,537	0.987	0.987
1994	149.7	28,554	1,560	1.015	1.015
1995	136.2	28,509	1,417	0.998	0.908

MONTMELO - LA JUNQUERA (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1996	136.2	27,076	1,346	0.950	0.950
1997	136.2	29,021	1,443	1.072	1.072
1998	136.2	30,717	1,527	1.058	1.058
1999	136.2	33,815	1,681	1.101	1.101
2000	136.2	35,955	1,787	1.063	1.063
2001	136.2	37,901	1,884	1.054	1.054
2002	136.2	40,464	2,012	1.068	1.068
2003	136.2	41,756	2,076	1.032	1.032
2004	136.2	43,324	2,154	1.038	1.038
2005	136.0	44,918	2,230	1.037	1.035
2006	136.0	47,122	2,339	1.049	1.049
2007	136.0	49,180	2,441	1.044	1.044
2008	136.0	46,761	2,321	0.951	0.951
2009	136.0	44,214	2,194	0.946	0.946
2010	136.0	43,522	2,160	0.984	0.984
2011	136.0	41,656	2,067	0.957	0.957
2012	136.0	39,166	1,944	0.940	0.940
2013	136.0	39,479	1,959	1.008	1.008
2014	137.0	41,718	2,086	1.057	1.064

Source: Author.

Figure 2: Annual Average Daily Traffic of the Montmeló – La Jonquera (A-7) Motorway.

Source: Author.

Figure 3: Traffic Growth Rate of the Montmeló – La Jonquera (A-7) Motorway.

Source: Author.

Figure 4: Barcelona – Tarragona (A-7) Motorway.

Table 2: Traffic Evolution of the Barcelona – Tarragona (A-7) Motorway.

BARCELONA - TARRAGONA (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	$AADTi/AADT(i-1)$	$((veh-km)i) / ((veh-km)(i-1))$
1974	99.1	15,377	556	-	-
1975	99.1	15,367	556	0.999	0.999
1976	99.1	16,630	602	1.082	1.082

BARCELONA - TARRAGONA (A-7)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / (veh-km) _(i-1)
1977	99.1	19,760	715	1.188	1.188
1978	99.1	22,811	825	1.154	1.154
1979	99.1	23,659	856	1.037	1.037
1980	99.1	24,565	889	1.038	1.038
1981	99.1	23,575	853	0.960	0.960
1982	99.1	23,613	854	1.002	1.002
1983	99.1	23,166	838	0.981	0.981
1984	99.1	23,597	854	1.019	1.019
1985	99.1	24,857	899	1.053	1.053
1986	99.1	27,154	982	1.092	1.092
1987	99.1	30,793	1,114	1.134	1.134
1988	99.1	34,963	1,265	1.135	1.135
1989	99.1	39,624	1,433	1.133	1.133
1990	99.1	40,618	1,469	1.025	1.025
1991	99.1	42,080	1,522	1.036	1.036
1992	99.1	41,379	1,497	0.983	0.983
1993	99.1	40,152	1,452	0.970	0.970
1994	99.1	41,123	1,487	1.024	1.024
1995	99.1	43,270	1,565	1.052	1.052
1996	99.1	43,530	1,575	1.006	1.006
1997	99.1	45,677	1,652	1.049	1.049
1998	99.1	47,799	1,729	1.046	1.046
1999	99.1	47,089	1,703	0.985	0.985
2000	99.1	51,278	1,855	1.089	1.089
2001	99.1	53,721	1,943	1.048	1.048
2002	99.1	55,994	2,025	1.042	1.042
2003	99.1	57,782	2,090	1.032	1.032
2004	99.1	59,053	2,136	1.022	1.022
2005	100.4	60,342	2,211	1.022	1.035
2006	100.4	63,683	2,334	1.055	1.055
2007	100.4	66,217	2,426	1.040	1.039
2008	100.4	61,694	2,260	0.932	0.932
2009	100.4	57,556	2,108	0.933	0.933
2010	100.4	54,825	2,008	0.953	0.953
2011	100.4	51,856	1,900	0.946	0.946
2012	100.4	47,589	1,743	0.918	0.918
2013	100.4	45,911	1,682	0.965	0.965
2014	100.4	46,888	1,718	1.021	1.021

Source: Author.

Figure 5: Annual Average Daily Traffic of the Barcelona – Tarragona (A-7) Motorway.

Source: Author.

Figure 6: Traffic Growth Rate of the Barcelona – Tarragona (A-7) Motorway.

Source: Author.

Figure 7: Villalba - Adanero (A-6) Motorway.

Table 3: Traffic Evolution of the Villalba – Adanero (A-6) Motorway.

VILLALBA - ADANERO (A-6)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1974	69.5	7,258	184.12	-	-
1975	69.5	7,817	198.30	1.077	1.077
1976	69.5	8,168	207.20	1.045	1.045
1977	69.5	6,690	169.71	0.819	0.819
1978	69.5	7,796	197.77	1.165	1.165
1979	69.5	8,455	214.48	1.085	1.085
1980	69.5	8,326	211.21	0.985	0.985
1981	69.5	8,380	212.58	1.006	1.006
1982	69.5	8,355	211.95	0.997	0.997
1983	69.5	8,283	210.12	0.991	0.991
1984	69.5	8,452	214.41	1.020	1.020
1985	69.5	8,810	223.49	1.042	1.042
1986	69.5	9,478	240.43	1.076	1.076
1987	69.5	10,360	262.81	1.093	1.093
1988	69.5	11,420	289.70	1.102	1.102
1989	69.5	12,929	327.98	1.132	1.132
1990	69.5	14,005	355.27	1.083	1.083
1991	69.5	15,610	395.99	1.115	1.115
1992	69.5	16,415	416.41	1.052	1.052
1993	69.5	16,504	418.67	1.005	1.005
1994	69.5	16,628	421.81	1.008	1.008
1995	69.5	17,358	440.33	1.044	1.044
1996	69.5	17,866	453.22	1.029	1.029

VILLALBA - ADANERO (A-6)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / (veh-km) _(i-1)
1997	69.5	19,235	487.94	1.077	1.077
1998	69.5	20,715	525.49	1.077	1.077
1999	69.5	22,918	581.37	1.106	1.106
2000	69.5	24,325	617.06	1.061	1.061
2001	69.5	25,482	646.41	1.048	1.048
2002	69.5	27,238	690.96	1.069	1.069
2003	69.5	28,662	727.08	1.052	1.052
2004	69.5	30,301	768.66	1.057	1.057
2005	69.6	30,770	781.68	1.015	1.017
2006	69.6	32,998	838.28	1.072	1.072
2007	69.5	34,414	873.00	1.043	1.041
2008	69.6	32,787	832.92	0.953	0.954
2009	69.6	31,325	795.78	0.955	0.955
2010	69.6	30,509	775.05	0.974	0.974
2011	69.6	28,684	728.69	0.940	0.940
2012	69.6	25,537	648.74	0.890	0.890
2013	69.6	24,430	620.62	0.957	0.957
2014	69.6	24,993	634.92	1.023	1.023

Source: Author.

Figure 8: Annual Average Daily Traffic of the Villalba - Adanero (A-6) Motorway.

Source: Author.

Figure 9: Traffic Growth Rate of the Villalba - Adanero (A-6) Motorway.

Source: Author.

Figure 10: Zaragoza - Mediterráneo (A-2) Motorway.

Table 4: Traffic Evolution of the Zaragoza – Mediterráneo (A-2) Motorway.

ZARAGOZA - MEDITERRÁNEO (A-2)					
Period	Length (Kms)	AADTi	$(veh-km)i$	$AADTi/AADT(i-1)$	$((veh-km)i) / ((veh-km)(i-1))$
1976	105.8	5,276	203.74	-	-
1977	214.4	6,179	483.54	1.171	2.373
1978	214.4	6,439	503.89	1.042	1.042
1979	214.4	7,001	547.87	1.087	1.087
1980	214.4	7,053	551.94	1.007	1.007
1981	214.4	6,920	541.53	0.981	0.981
1982	214.4	6,761	529.09	0.977	0.977

ZARAGOZA - MEDITERRÁNEO (A-2)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / (veh-km) _(i-1)
1983	214.4	6,607	517.04	0.977	0.977
1984	214.4	6,489	507.80	0.982	0.982
1985	214.4	6,659	521.11	1.026	1.026
1986	214.4	7,181	561.96	1.078	1.078
1987	214.4	8,119	635.36	1.131	1.131
1988	214.4	9,387	734.59	1.156	1.156
1989	214.4	11,423	893.92	1.217	1.217
1990	214.4	12,127	949.01	1.062	1.062
1991	214.4	12,327	964.66	1.016	1.016
1992	214.4	12,174	952.69	0.988	0.988
1993	214.4	11,425	894.07	0.938	0.938
1994	214.4	10,958	857.53	0.959	0.959
1995	214.4	11,309	885.00	1.032	1.032
1996	214.4	11,027	862.93	0.975	0.975
1997	214.4	18,687	1,462.37	1.695	1.695
1998	214.4	12,377	968.57	0.662	0.662
1999	214.4	13,350	1,044.72	1.079	1.079
2000	214.4	14,870	1,163.67	1.114	1.114
2001	214.4	15,206	1,189.96	1.023	1.023
2002	214.4	15,594	1,220.32	1.026	1.026
2003	214.4	15,464	1,210.15	0.992	0.992
2004	214.4	15,350	1,201.23	0.993	0.993
2005	215.5	14,741	1,159.49	0.960	0.965
2006	215.5	15,273	1,201.34	1.036	1.036
2007	215.5	15,541	1,222.36	1.018	1.018
2008	215.5	14,348	1,128.53	0.923	0.923
2009	215.5	13,025	1,024.47	0.908	0.908
2010	215.5	12,497	982.94	0.959	0.959
2011	215.5	11,420	898.23	0.914	0.914
2012	215.5	10,176	800.38	0.891	0.891
2013	215.5	9,467	744.62	0.930	0.930
2014	215.5	9,767	768.21	1.032	1.032

Source: Author.

Figure 11: Annual Average Daily Traffic of the Zaragoza - Mediterráneo (A-2) Motorway.

Source: Author.

Figure 12: Traffic Growth Rate of the Zaragoza - Mediterráneo (A-2) Motorway.

Source: Author.

Figure 13: Sevilla - Cádiz (A-4) Motorway.

Table 5: Traffic Evolution of the Sevilla – Cádiz (A-4) Motorway.

SEVILLA - CÁDIZ (A-4)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1974	93.5	3,171	108.22	-	-
1975	93.5	3,382	115.42	1.067	1.067
1976	93.5	3,017	102.96	0.892	0.892
1977	93.5	3,039	103.71	1.007	1.007
1978	93.5	3,470	118.42	1.142	1.142
1979	93.5	3,681	125.62	1.061	1.061
1980	93.5	3,774	128.80	1.025	1.025
1981	93.5	3,999	136.48	1.060	1.060
1982	93.5	3,929	134.09	0.982	0.982
1983	93.5	3,629	123.85	0.924	0.924
1984	93.5	3,417	116.61	0.942	0.942
1985	93.5	3,632	123.95	1.063	1.063
1986	93.5	3,959	135.11	1.090	1.090
1987	93.5	4,525	154.43	1.143	1.143
1988	93.5	5,282	180.26	1.167	1.167
1989	93.5	6,350	216.71	1.202	1.202
1990	93.5	6,835	233.26	1.076	1.076
1991	93.5	7,791	265.89	1.140	1.140
1992	93.5	9,214	314.45	1.183	1.183
1993	93.5	8,005	273.19	0.869	0.869
1994	93.5	7,978	272.27	0.997	0.997

SEVILLA - CÁDIZ (A-4)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1995	93.5	7,648	261.01	0.959	0.959
1996	93.5	7,434	253.70	0.972	0.972
1997	93.5	7,828	267.15	1.053	1.053
1998	93.5	10,101	344.72	1.290	1.290
1999	93.5	11,825	403.56	1.171	1.171
2000	93.5	13,300	453.90	1.125	1.125
2001	93.5	15,218	519.35	1.144	1.144
2002	93.5	16,534	564.26	1.086	1.086
2003	93.5	17,897	610.78	1.082	1.082
2004	93.5	19,642	670.33	1.098	1.098
2005	93.8	21,859	748.39	1.113	1.116
2006	93.8	24,244	830.04	1.109	1.109
2007	93.8	25,138	860.83	1.037	1.037
2008	93.8	24,173	827.79	0.962	0.962
2009	93.8	23,774	814.12	0.983	0.983
2010	93.8	22,671	776.35	0.954	0.954
2011	93.8	21,029	720.12	0.928	0.928
2012	93.8	19,035	651.84	0.905	0.905
2013	93.8	17,504	599.41	0.920	0.920
2014	93.8	17,971	615.40	1.027	1.027

Source: Author.

Figure 14: Annual Average Daily Traffic of the Sevilla - Cádiz (A-4) Motorway.

Source: Author.

Figure 15: Traffic Growth Rate of the Sevilla - Cádiz (A-4) Motorway.

Source: Author.

Figure 16: Montmeló – Papiol (A-7) Motorway.

Table 6: Traffic Evolution of the Montmeló – Papiol (A-7) Motorway.

MONTMELÓ - PAPIOL (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
1978	25.0	9,389	85.67	-	-
1979	25.0	6,875	62.73	0.732	0.732

MONTMELÓ - PAPIOL (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1980	25.0	7,480	68.26	1.088	1.088
1981	25.0	6,470	59.04	0.865	0.865
1982	25.0	6,723	61.35	1.039	1.039
1983	25.0	6,861	62.61	1.021	1.021
1984	25.0	6,944	63.36	1.012	1.012
1985	25.0	7,352	67.09	1.059	1.059
1986	25.0	27,404	250.06	3.727	3.727
1987	25.0	31,558	287.97	1.152	1.152
1988	25.0	42,998	392.36	1.363	1.363
1989	25.0	51,004	465.41	1.186	1.186
1990	25.0	52,226	476.56	1.024	1.024
1991	25.0	54,489	497.21	1.043	1.043
1992	25.0	49,997	456.22	0.918	0.918
1993	25.0	45,884	418.69	0.918	0.918
1994	25.0	46,960	428.51	1.023	1.023
1995	25.0	48,724	444.61	1.038	1.038
1996	25.0	52,453	478.63	1.077	1.077
1997	25.0	58,635	535.04	1.118	1.118
1998	25.0	63,220	576.88	1.078	1.078
1999	25.0	70,219	640.75	1.111	1.111
2000	25.0	83,935	765.91	1.195	1.195
2001	25.0	90,218	823.24	1.075	1.075
2002	25.0	92,636	845.30	1.027	1.027
2003	25.0	95,712	873.37	1.033	1.033
2004	25.0	99,460	907.57	1.039	1.039
2005	26.6	111,354	1.081.14	1.120	1.191
2006	26.6	115,607	1.122.43	1.038	1.038
2007	26.6	118,519	1.152.43	1.025	1.027
2008	26.6	114,760	1.115.88	0.968	0.968
2009	26.6	109,766	1.067.32	0.956	0.956
2010	26.6	108,967	1.059.55	0.993	0.993
2011	26.6	107,210	1.042.47	0.984	0.984
2012	26.6	103,289	1.004.34	0.963	0.963
2013	26.6	99,900	971.39	0.967	0.967
2014	26.6	101,976	991.57	1.021	1.021

Source: Author.

Figure 17: Annual Average Daily Traffic of the Montmeló - Papiol (A-7) Motorway.

Source: Author.

Figure 18: Traffic Growth Rate of the Montmeló - Papiol (A-7) Motorway.

Source: Author.

Figure 19: Bilbao – Zaragoza (A-68) Motorway.

Table 7: Traffic Evolution of the Bilbao – Zaragoza (A-68) Motorway.

BILBAO - ZARAGOZA (A-68)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1978	129.1	4,689	220.95	-	-
1979	188.3	4,169	286.53	0.889	1.297
1980	294.5	4,606	495.11	1.105	1.728
1981	294.5	4,681	503.17	1.016	1.016
1982	294.5	4,754	511.02	1.016	1.016
1983	294.5	4,374	470.17	0.920	0.920
1984	294.5	4,281	460.18	0.979	0.979
1985	294.5	4,275	459.53	0.999	0.999
1986	294.5	4,433	476.51	1.037	1.037
1987	294.5	4,874	523.92	1.099	1.099
1988	294.5	5,617	603.79	1.152	1.152
1989	294.5	6,494	698.06	1.156	1.156
1990	294.5	6,870	738.47	1.058	1.058
1991	294.5	7,118	765.13	1.036	1.036
1992	294.5	7,052	758.04	0.991	0.991
1993	294.5	6,956	747.72	0.986	0.986
1994	294.5	6,930	744.92	0.996	0.996
1995	294.5	7,013	753.84	1.012	1.012
1996	294.5	7,038	756.53	1.004	1.004
1997	294.5	7,343	789.32	1.043	1.043
1998	294.5	8,082	868.75	1.101	1.101
1999	294.5	9,002	967.65	1.114	1.114
2000	294.5	10,623	1,141.89	1.180	1.180

BILBAO - ZARAGOZA (A-68)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / (veh-km) _(i-1)
2001	294.5	11,742	1,262.18	1.105	1.105
2002	294.5	12,196	1,310.98	1.039	1.039
2003	294.5	12,844	1,380.63	1.053	1.053
2004	294.5	13,503	1,451.47	1.051	1.051
2005	294.4	13,542	1,455.17	1.003	1.003
2006	294.4	14,177	1,523.40	1.047	1.047
2007	294.4	17,712	1,903.39	1.249	1.249
2008	294.4	14,733	1,583.26	0.832	0.832
2009	294.4	13,681	1,470.21	0.929	0.929
2010	294.4	13,861	1,489.55	1.013	1.013
2011	294.4	13,118	1,409.70	0.946	0.946
2012	294.4	11,842	1,272.58	0.903	0.903
2013	294.4	11,223	1,206.06	0.948	0.948
2014	294.4	11,477	1,233.36	1.023	1.023

Source: Author.

Figure 20: Annual Average Daily Traffic of the Bilbao - Zaragoza (A-68) Motorway.

Source: Author.

Figure 21: Traffic Growth Rate of the Bilbao - Zaragoza (A-68) Motorway.

Source: Author.

Figure 22: Burgos – Armiñón (A-1) Motorway.

Table 8: Traffic Evolution of the Burgos – Armiñón (A-1) Motorway.

BURGOS - ARMIÑÓN (A-1)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
1978	50.3	2,479	45.51	-	-
1979	50.3	3,604	66.17	1.454	1.454
1980	62.1	4,060	92.03	1.127	1.391
1981	74.4	5,622	152.67	1.385	1.659
1982	74.4	4,966	134.86	0.883	0.883

BURGOS - ARMIÑÓN (A-1)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / (veh-km) _(i-1)
1983	74.4	4,611	125.22	0.929	0.929
1984	80.2	4,970	145.49	1.078	1.162
1985	80.2	5,142	150.52	1.035	1.035
1986	80.2	5,487	160.62	1.067	1.067
1987	80.2	5,995	175.49	1.093	1.093
1988	80.2	6,832	199.99	1.140	1.140
1989	80.2	7,777	227.66	1.138	1.138
1990	80.2	8,294	242.79	1.066	1.066
1991	80.2	8,954	262.11	1.080	1.080
1992	80.2	9,403	275.25	1.050	1.050
1993	80.2	9,680	283.36	1.029	1.029
1994	80.2	10,172	297.76	1.051	1.051
1995	80.2	11,026	322.76	1.084	1.084
1996	80.2	11,430	334.59	1.037	1.037
1997	80.9	12,198	360.19	1.067	1.077
1998	80.9	13,696	404.42	1.123	1.123
1999	80.9	15,161	447.68	1.107	1.107
2000	80.9	16,605	490.32	1.095	1.095
2001	80.9	18,062	533.34	1.088	1.088
2002	80.9	19,348	571.32	1.071	1.071
2003	80.9	20,101	593.55	1.039	1.039
2004	80.9	21,072	622.22	1.048	1.048
2005	84.3	21,206	652.50	1.006	1.049
2006	84.3	22,209	683.36	1.047	1.047
2007	84.3	23,937	736.53	1.078	1.078
2008	84.3	23,114	711.21	0.966	0.966
2009	84.3	21,553	663.18	0.932	0.932
2010	84.3	21,462	660.38	0.996	0.996
2011	84.3	19,833	610.25	0.924	0.924
2012	84.3	18,213	560.40	0.918	0.918
2013	84.3	17,587	541.14	0.966	0.966
2014	84.3	17,918	551.33	1.019	1.019

Source: Author.

Figure 23: Annual Average Daily Traffic of the Burgos – Armiñón (A-1) Motorway.

Source: Author.

Figure 24: Traffic Growth Rate of the Burgos – Armiñón (A-1) Motorway.

Source: Author.

Figure 25: León – Campomanes (A-66) Motorway.

Table 9: Traffic Evolution of the León – Campomanes (A-66) Motorway.

LEÓN - CAMPOMANES (A-66)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1983	86.8	2,494	79.01	-	-
1984	86.8	2,049	64.92	0.822	0.822
1985	86.8	2,141	67.83	1.045	1.045
1986	86.8	2,275	72.08	1.063	1.063
1987	86.8	2,445	77.46	1.075	1.075
1988	86.8	2,768	87.70	1.132	1.132
1989	86.8	3,233	102.43	1.168	1.168
1990	86.8	3,661	115.99	1.132	1.132
1991	86.8	4,254	134.78	1.162	1.162
1992	86.8	4,256	134.84	1.000	1.000
1993	86.8	4,199	133.03	0.987	0.987
1994	86.8	4,583	145.20	1.091	1.091
1995	86.8	4,680	148.27	1.021	1.021
1996	86.8	4,718	149.48	1.008	1.008
1997	86.8	4,995	158.25	1.059	1.059
1998	86.8	5,659	179.29	1.133	1.133
1999	86.8	6,320	200.23	1.117	1.117
2000	86.8	6,642	210.43	1.051	1.051
2001	86.8	7,433	235.49	1.119	1.119
2002	86.8	7,679	243.29	1.033	1.033
2003	86.8	8,048	254.98	1.048	1.048
2004	77.7	8,736	247.76	1.085	0.972

LEÓN - CAMPOMANES (A-66)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / ((veh-km) _(i-1))
2005	77.8	9,005	255.71	1.031	1.032
2006	77.8	9,683	274.97	1.075	1.075
2007	77.8	10,288	292.00	1.062	1.062
2008	77.8	9,997	283.74	0.972	0.972
2009	77.8	9,975	283.11	0.998	0.998
2010	77.8	9,568	271.56	0.959	0.959
2011	77.8	9,284	263.50	0.970	0.970
2012	77.8	7,971	226.24	0.859	0.859
2013	77.8	7,511	213.18	0.942	0.942
2014	77.8	7,506	213.04	0.999	0.999

Source: Author.

Figure 26: Annual Average Daily Traffic of the León – Campomanes (A-66) Motorway.

Source: Author.

Figure 27: Traffic Growth Rate of the León – Campomanes (A-66) Motorway.

Source: Author.

Figure 28: Tarragona – Valencia (A-7) Motorway.

Table 10: Traffic Evolution of the Tarragona – Valencia (A-7) Motorway.

TARRAGONA - VALENCIA (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
1974	123.0	5,603	251.55	-	-
1975	123.0	5,776	259.31	1.031	1.031

TARRAGONA - VALENCIA (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1976	123.0	6,002	269.46	1.039	1.039
1977	166.5	6,870	417.51	1.145	1.549
1978	226.9	7,524	623.13	1.095	1.492
1979	226.9	7,828	648.30	1.040	1.040
1980	226.9	7,773	643.75	0.993	0.993
1981	223.3	7,590	618.62	0.976	0.961
1982	223.3	7,455	607.62	0.982	0.982
1983	223.3	7,233	589.52	0.970	0.970
1984	223.3	7,178	585.04	0.992	0.992
1985	223.3	7,596	619.11	1.058	1.058
1986	223.3	8,514	693.93	1.121	1.121
1987	223.3	9,707	791.16	1.140	1.140
1988	223.3	10,873	886.20	1.120	1.120
1989	223.3	12,336	1,005.44	1.135	1.135
1990	223.3	12,501	1,018.89	1.013	1.013
1991	223.3	13,043	1,063.06	1.043	1.043
1992	223.3	12,894	1,050.92	0.989	0.989
1993	223.3	12,336	1,005.44	0.957	0.957
1994	223.3	12,469	1,016.28	1.011	1.011
1995	223.3	12,907	1,051.98	1.035	1.035
1996	223.3	13,070	1,065.26	1.013	1.013
1997	223.3	14,186	1,156.22	1.085	1.085
1998	223.3	16,692	1,360.47	1.177	1.177
1999	223.3	19,092	1,556.08	1.144	1.144
2000	223.3	20,453	1,667.01	1.071	1.071
2001	223.3	22,004	1,793.43	1.076	1.076
2002	223.3	22,796	1,857.98	1.036	1.036
2003	223.3	23,396	1,906.88	1.026	1.026
2004	223.3	23,932	1,950.57	1.023	1.023
2005	225.3	23,482	1,931.03	0.981	0.990
2006	225.3	25,215	2,073.54	1.074	1.074
2007	225.3	25,110	2,065.09	0.996	0.996
2008	225.3	22,155	1,822.07	0.882	0.882
2009	225.3	19,723	1,622.06	0.890	0.890
2010	225.3	20,091	1,652.32	1.019	1.019
2011	225.3	18,833	1,548.86	0.937	0.937
2012	225.3	16,528	1,359.29	0.878	0.878
2013	225.3	15,538	1,277.87	0.940	0.940
2014	225.3	15,797	1,299.17	1.017	1.017

Source: Author.

Figure 29: Annual Average Daily Traffic of the Tarragona – Valencia (A-7) Motorway.

Source: Author.

Figure 30: Traffic Growth Rate of the Tarragona – Valencia (A-7) Motorway.

Source: Author.

Figure 31: Valencia – Alicante (A-7) Motorway.

Table 11: Traffic Evolution of the Valencia – Alicante (A-7) Motorway.

VALENCIA - ALICANTE (A-7)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / (veh-km) _(i-1)
1976	83.8	3,563	108.98	-	-
1977	83.8	4,148	126.87	1.164	1.164
1978	83.8	5,183	158.53	1.250	1.250
1979	113.0	5,874	242.27	1.133	1.528
1980	113.0	6,059	249.90	1.031	1.031
1981	113.0	6,258	258.11	1.033	1.033
1982	113.0	6,147	253.53	0.982	0.982
1983	113.0	6,071	250.40	0.988	0.988
1984	113.0	6,124	252.58	1.009	1.009
1985	148.4	6,933	375.53	1.132	1.487
1986	148.4	7,240	392.16	1.044	1.044
1987	148.4	8,316	450.44	1.149	1.149
1988	148.4	9,376	507.86	1.127	1.127
1989	148.4	10,563	572.16	1.127	1.127
1990	148.4	12,027	651.45	1.139	1.139
1991	148.4	12,663	685.90	1.053	1.053
1992	148.4	12,595	682.22	0.995	0.995
1993	148.4	12,085	654.60	0.960	0.960
1994	148.4	12,301	666.30	1.018	1.018
1995	148.4	12,313	666.95	1.001	1.001
1996	148.4	12,423	672.90	1.009	1.009
1997	148.4	13,207	715.37	1.063	1.063

VALENCIA - ALICANTE (A-7)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1998	148.4	16,271	881.33	1.232	1.232
1999	148.4	18,987	1,028.45	1.167	1.167
2000	148.4	21,225	1,149.67	1.118	1.118
2001	148.4	23,409	1,267.97	1.103	1.103
2002	148.4	24,968	1,352.42	1.067	1.067
2003	148.4	26,640	1,442.98	1.067	1.067
2004	148.4	27,302	1,478.84	1.025	1.025
2005	148.5	28,180	1,527.43	1.032	1.033
2006	148.5	29,207	1,583.09	1.036	1.036
2007	148.5	29,411	1,594.36	1.007	1.007
2008	148.5	26,180	1,419.21	0.890	0.890
2009	148.5	22,928	1,242.92	0.876	0.876
2010	148.5	21,445	1,162.53	0.935	0.935
2011	148.5	20,831	1,129.24	0.971	0.971
2012	148.5	17,691	959.03	0.849	0.849
2013	148.5	16,273	882.16	0.920	0.920
2014	148.5	16,304	883.84	1.002	1.002

Source: Author.

Figure 32: Annual Average Daily Traffic of the Valencia – Alicante (A-7) Motorway.

Source: Author.

Figure 33: Traffic Growth Rate of the Valencia – Alicante (A-7) Motorway.

Source: Author.

Figure 34: Ferrol – Frontera Portuguesa (A-9) Motorway.

Table 12: Traffic Evolution of the Ferrol – Frontera Portuguesa (A-9) Motorway.

FERROL - FRONTERA PORTUGUESA (A-9)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
1979	58.7	5,704	122.21	-	-
1980	62.4	5,414	123.31	0.949	1.009

FERROL - FRONTERA PORTUGUESA (A-9)					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / (veh-km) _(i-1)
1981	85.8	5,648	176.88	1.043	1.434
1982	85.8	5,852	183.27	1.036	1.036
1983	85.8	5,247	164.32	0.897	0.897
1984	91.4	4,982	166.20	0.949	1.011
1985	91.4	5,595	186.65	1.123	1.123
1986	91.4	6,209	207.14	1.110	1.110
1987	91.4	7,053	235.30	1.136	1.136
1988	99.3	8,101	293.62	1.149	1.248
1989	99.3	9,638	349.32	1.190	1.190
1990	117.3	11,257	481.96	1.168	1.380
1991	134.3	11,985	587.50	1.065	1.219
1992	157.2	11,266	646.42	0.940	1.100
1993	157.2	12,454	714.59	1.105	1.105
1994	157.2	12,887	739.43	1.035	1.035
1995	157.2	13,476	773.23	1.046	1.046
1996	157.2	13,852	794.80	1.028	1.028
1997	166.5	14,427	876.76	1.042	1.103
1998	175.3	15,826	1,012.62	1.097	1.155
1999	191.7	17,578	1,229.94	1.111	1.215
2000	191.7	18,390	1,286.76	1.046	1.046
2001	191.7	19,904	1,392.69	1.082	1.082
2002	191.7	20,770	1,453.29	1.044	1.044
2003	208.6	21,958	1,671.86	1.057	1.150
2004	217.7	22,565	1,793.03	1.028	1.072
2005	219.6	23,581	1,890.11	1.045	1.054
2006	219.6	25,059	2,008.58	1.063	1.063
2007	219.6	27,029	2,166.48	1.079	1.079
2008	219.6	26,826	2,150.21	0.992	0.992
2009	219.6	26,500	2,124.08	0.988	0.988
2010	219.6	26,395	2,115.66	0.996	0.996
2011	219.6	24,711	1,980.69	0.936	0.936
2012	219.6	21,822	1,749.12	0.883	0.883
2013	219.6	20,658	1,655.82	0.947	0.947
2014	219.6	20,734	1,661.91	1.004	1.004

Source: Author.

Figure 35: Annual Average Daily Traffic of the Ferrol – Frontera Portuguesa (A-9) Motorway.

Source: Author.

Figure 36: Traffic Growth Rate of the Ferrol – Frontera Portuguesa (A-9) Motorway.

Source: Author.

Figure 37: Malaga – Guadiaro Motorway.

Table 13: Traffic Evolution of the Malaga – Guadiaro Motorway.

MÁLAGA - GUADIARO					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1999	75.7	22,063	609.61	-	-
2000	75.7	24,939	689.08	1.130	1.130
2001	75.7	28,595	790.09	1.147	1.147
2002	98.2	28,286	1,013.86	0.989	1.283
2003	98.2	28,060	1,005.75	0.992	0.992
2004	98.2	30,429	1,090.67	1.084	1.084
2005	98.2	31,894	1,143.18	1.048	1.048
2006	98.2	33,136	1,187.69	1.039	1.039
2007	98.2	34,070	1,220.55	1.028	1.028
2008	98.2	32,039	1,147.79	0.940	0.940
2009	98.2	29,469	1,055.72	0.920	0.920
2010	98.2	28,695	1,027.99	0.974	0.974
2011	98.2	27,354	979.95	0.953	0.953
2012	98.2	25,814	924.78	0.944	0.944
2013	98.2	25,227	903.75	0.977	0.977
2014	98.2	26,012	931.87	1.031	1.031

Source: Author.

Figure 38: Annual Average Daily Traffic of the Malaga – Guadiaro Motorway.

Source: Author.

Figure 39: Traffic Growth Rate of the Malaga – Guadiaro Motorway.

Source: Author.

Figure 40: Alicante – Cartagena Motorway.

Table 14: Traffic Evolution of the Alicante – Cartagena Motorway.

ALICANTE - CARTAGENA					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2001	76.6	11,543	322.73	-	-
2002	76.6	12,372	345.91	1.072	1.072
2003	76.6	14,608	408.43	1.181	1.181
2004	76.6	16,560	463.00	1.134	1.134
2005	76.8	18,521	519.18	1.118	1.121
2006	76.8	19,656	551.00	1.061	1.061
2007	76.8	20,410	571.84	1.038	1.038
2008	76.8	18,625	521.82	0.913	0.913
2009	76.8	16,919	474.03	0.908	0.908
2010	76.8	17,173	481.14	1.015	1.015
2011	76.8	17,507	490.50	1.019	1.019
2012	76.8	16,931	474.36	0.967	0.967
2013	76.8	17,329	485.51	1.024	1.024
2014	76.6	17,955	502.00	1.036	1.034

Source: Author.

Figure 41: Annual Average Daily Traffic of the Alicante – Cartagena Motorway.

Source: Author.

Figure 42: Traffic Growth Rate of the Alicante – Cartagena Motorway.

Source: Author.

Figure 43: Ávila – Villacastín Motorway.

Table 15: Traffic Evolution of the Ávila – Villacastín Motorway.

ÁVILA - VILLACASTÍN					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2002	23.1	9,203	77.60	-	-
2003	23.1	5,372	45.29	0.584	0.584
2004	23.1	5,999	50.58	1.117	1.117
2005	23.1	6,141	51.78	1.024	1.024
2006	23.1	6,397	53.94	1.042	1.042
2007	23.1	7,180	60.54	1.122	1.122
2008	23.1	7,228	60.94	1.007	1.007
2009	23.1	8,458	71.31	1.170	1.170
2010	23.1	8,386	70.71	0.991	0.991
2011	23.1	7,782	65.61	0.928	0.928
2012	23.1	6,797	57.31	0.873	0.873
2013	23.1	6,888	58.08	1.013	1.013
2014	23.1	7,104	59.90	1.031	1.031

Source: Author.

Figure 44: Annual Average Daily Traffic of the Ávila - Villacastín Motorway.

Source: Author.

Figure 45: Traffic Growth Rate of the Ávila - Villacastín Motorway.

Source: Author.

Figure 46: León – Astorga Motorway.

Table 16: Traffic Evolution of the León – Astorga Motorway.

LEÓN - ASTORGA					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i / (veh-km) _(i-1))
2002	4.0	25,678	37.49	-	-
2003	37.7	4,272	58.78	0.166	1.568
2004	37.7	3,749	51.59	0.878	0.878
2005	37.7	3,943	54.26	1.052	1.052
2006	37.7	4,270	58.76	1.083	1.083
2007	37.7	5,123	70.50	1.200	1.200
2008	37.7	5,347	73.58	1.044	1.044
2009	37.7	5,152	70.89	0.964	0.964
2010	37.7	5,357	73.71	1.040	1.040
2011	37.7	4,745	65.29	0.886	0.886
2012	37.7	4,017	55.28	0.847	0.847
2013	37.7	3,656	50.31	0.910	0.910
2014	37.7	3,623	49.85	0.991	0.991

Source: Author.

Figure 47: Annual Average Daily Traffic of the León - Astorga Motorway.

Source: Author.

Figure 48: Traffic Growth Rate of the León - Astorga Motorway.

Source: Author.

Figure 49: Santiago – Alto de Santo Domingo Motorway.

Table 17: Traffic Evolution of the Santiago – Alto de Santo Domingo Motorway.

SANTIAGO - ALTO DE SANTO DOMINGO					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
2003	34.1	3,614	44.98	-	-
2004	56.6	4,369	90.26	1.209	2.007
2005	56.6	4,448	91.89	1.018	1.018
2006	56.6	4,833	99.84	1.087	1.087
2007	56.6	5,483	113.29	1.134	1.135
2008	56.6	5,683	117.42	1.036	1.036
2009	56.6	5,865	121.18	1.032	1.032

SANTIAGO - ALTO DE SANTO DOMINGO					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / ((veh-km)(i-1))
2010	56.6	6,159	127.25	1.050	1.050
2011	56.6	5,784	119.50	0.939	0.939
2012	56.6	4,954	102.36	0.857	0.857
2013	56.6	5,524	114.13	1.115	1.115
2014	56.4	5,662	116.48	1.025	1.021

Source: Author.

Figure 50: Annual Average Daily Traffic of the Santiago – Alto de Santo Domingo Motorway.

Source: Author.

Figure 51: Traffic Growth Rate of the Santiago – Alto de Santo Domingo Motorway.

Source: Author.

Figure 52: Segovia – San Rafael Motorway.

Table 18: Traffic Evolution of the Segovia – San Rafael Motorway.

SEGOVIA - SAN RAFAEL					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2003	27.7	4,806	48.59	-	-
2004	27.7	4,769	48.22	0.992	0.992
2005	27.7	5,015	50.70	1.052	1.052
2006	27.7	5,544	56.05	1.105	1.105
2007	27.7	6,177	62.41	1.114	1.113
2008	27.7	5,966	60.28	0.966	0.966
2009	27.7	6,297	63.62	1.055	1.055
2010	27.7	6,556	66.24	1.041	1.041
2011	27.7	6,472	65.39	0.987	0.987
2012	27.7	6,288	63.53	0.972	0.972
2013	27.7	6,136	61.99	0.976	0.976
2014	27.7	6,479	65.46	1.056	1.056

Source: Author.

Figure 53: Annual Average Daily Traffic of the Segovia – San Rafael Motorway.

Source: Author.

Figure 54: Traffic Growth Rate of the Segovia – San Rafael Motorway.

Source: Author.

Figure 55: Madrid – Guadalajara (R-2) Motorway.

Table 19: Traffic Evolution of the Madrid – Guadalajara (R-2) Motorway.

MADRID - GUADALAJARA (R-2)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
2003	62.5	5,003	114.13	-	-
2004	62.5	6,180	140.98	1.235	1.235
2005	62.3	7,668	174.37	1.241	1.237
2006	62.3	9,500	216.03	1.239	1.239
2007	62.3	11,034	250.91	1.161	1.161
2008	62.3	10,594	240.90	0.960	0.960
2009	62.3	9,378	213.25	0.885	0.885
2010	62.3	9,278	210.98	0.989	0.989

MADRID - GUADALAJARA (R-2)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2011	62.3	7,800	177.37	0.841	0.841
2012	62.3	5,928	134.80	0.760	0.760
2013	62.3	4,588	104.33	0.774	0.774
2014	62.3	4,325	98.35	0.943	0.943

Source: Author.

Figure 56: Annual Average Daily Traffic of the Madrid – Guadalajara (R-2) Motorway.

Source: Author.

Figure 57: Traffic Growth Rate of the Madrid – Guadalajara (R-2) Motorway.

Source: Author.

Figure 58: Madrid – Arganda (R-3) Motorway.

Table 20: Traffic Evolution of the Madrid – Arganda (R-3) Motorway.

MADRID - ARGANDA (R-3)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2004	31.8	10,504	121.92	-	-
2005	31.8	13,499	156.68	1.285	1.285
2006	31.8	16,136	187.29	1.195	1.195
2007	31.8	16,230	188.38	1.006	1.006
2008	31.8	15,193	176.35	0.936	0.936
2009	31.8	14,842	172.27	0.977	0.977
2010	31.8	14,073	163.35	0.948	0.948
2011	31.8	12,387	143.78	0.880	0.880
2012	31.8	10,309	119.66	0.832	0.832
2013	31.8	9,345	108.47	0.906	0.906
2014	31.8	9,339	108.40	0.999	0.999

Figure 59: Annual Average Daily Traffic of the Madrid – Arganda (R-3) Motorway.

Source: Author.

Figure 60: Traffic Growth Rate of the Madrid – Arganda (R-3) Motorway.

Source: Author.

Figure 61: Madrid – Ocaña (R-4) Motorway.

Table 21: Traffic Evolution of the Madrid – Ocaña (R-4) Motorway.

MADRID - OCAÑA (R-4)					
Period	Length (Kms)	AADTi	((veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
2004	52.5	6,350	121.68	-	-
2005	52.5	6,664	127.70	1.049	1.049
2006	52.5	9,150	175.34	1.373	1.373
2007	52.5	11,346	217.42	1.240	1.240
2008	52.5	10,402	199.33	0.917	0.917

MADRID - OCAÑA (R-4)					
Period	Length (Kms)	AADTi	$(\text{veh-km})_i$	$\text{AADTi}/\text{AADT}(i-1)$	$((\text{veh-km})_i) / (\text{veh-km})(i-1))$
2009	52.5	8,835	169.30	0.849	0.849
2010	52.5	8,096	155.14	0.916	0.916
2011	52.5	6,676	127.93	0.825	0.825
2012	52.5	5,489	105.18	0.822	0.822
2013	52.5	4,651	89.12	0.847	0.847
2014	52.5	4,516	86.54	0.971	0.971

Source: Author.

Figure 62: Annual Average Daily Traffic of the Madrid – Ocaña (R-4) Motorway.

Source: Author.

Figure 63: Traffic Growth Rate of the Madrid – Ocaña (R-4) Motorway.

Source: Author.

Figure 64: Madrid – Navalcarnero (R-5) Motorway.

Table 22: Traffic Evolution of the Madrid – Navalcarnero (R-5) Motorway.

MADRID - NAVALCARNERO (R-5)					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2004	28.9	6,837	72.12	-	-
2005	28.9	7,923	83.58	1.159	1.159
2006	28.9	10,208	107.68	1.288	1.288
2007	28.9	11,864	124.97	1.162	1.161
2008	28.9	11,309	119.13	0.953	0.953
2009	31.6	10,668	123.16	0.943	1.034
2010	31.6	10,478	120.97	0.982	0.982
2011	31.6	9,491	109.57	0.906	0.906
2012	31.6	7,612	87.88	0.802	0.802
2013	31.6	6,511	75.17	0.855	0.855
2014	31.6	6,268	72.36	0.963	0.963

Source: Author.

Figure 65: Annual Average Daily Traffic of the Madrid – Navalcarnero (R-5) Motorway.

Source: Author.

Figure 66: Traffic Growth Rate of the Madrid – Navalcarnero (R-5) Motorway.

Source: Author.

Figure 67: Eje Aeropuerto (M-12) Motorway.

Table 23: Traffic Evolution of the Eje Aeropuerto (M-12) Motorway.

EJE AEROPUERTO					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
2005	9.4	10,242	35.29	-	-
2006	9.4	18,280	62.99	1.785	1.785
2007	9.4	19,979	68.84	1.093	1.093
2008	9.4	20,134	69.37	1.008	1.008
2009	9.4	19,609	67.56	0.974	0.974
2010	9.4	19,395	66.83	0.989	0.989
2011	9.4	18,336	63.18	0.945	0.945
2012	9.4	18,298	63.05	0.998	0.998
2013	9.4	17,884	61.62	0.977	0.977
2014	9.4	18,435	63.52	1.031	1.031

Source: Author.

Figure 68: Annual Average Daily Traffic of the Eje Aeropuerto (M-12) Motorway.

Source: Author.

Figure 69: Traffic Growth Rate of the Eje Aeropuerto (M-12) Motorway.

Source: Author.

Figure 70: Ocaña – La Roda Motorway.

Table 24: Traffic Evolution of the Ocaña – La Roda Motorway.

OCAÑA - LA RODA					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2006	127.5	4,194	195.18	-	-
2007	127.5	4,646	216.21	1.108	1.108
2008	127.5	4,770	221.98	1.027	1.027
2009	127.5	4,441	206.67	0.931	0.931
2010	127.5	4,003	186.29	0.901	0.901
2011	127.5	3,724	173.31	0.930	0.930
2012	127.5	3,015	140.31	0.810	0.810
2013	127.5	2,802	130.40	0.929	0.929
2014	127.5	2,876	133.84	1.026	1.026

Source: Author.

Figure 71: Annual Average Daily Traffic of the Ocaña – La Roda Motorway.

Source: Author.

Figure 72: Traffic Growth Rate of the Ocaña – La Roda Motorway.

Source: Author.

Figure 73: Madrid - Toledo Motorway.

Table 25: Traffic Evolution of the Madrid - Toledo Motorway.

MADRID - TOLEDO					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
2006	58.8	1,741	37.37	-	-
2007	58.8	2,770	59.46	1.591	1.591
2008	58.8	2,861	61.41	1.033	1.033
2009	58.8	2,364	50.74	0.826	0.826
2010	58.8	1,974	42.37	0.835	0.835
2011	58.8	1,828	39.24	0.926	0.926

MADRID - TOLEDO					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i) / ((veh-km) _(i-1))
2012	58.8	1,424	30.57	0.779	0.779
2013	58.8	1,316	28.25	0.924	0.924
2014	49.7	755	13.70	0.574	0.485

Source: Author.

Figure 74: Annual Average Daily Traffic of the Madrid - Toledo Motorway.

Source: Author.

Figure 75: Traffic Growth Rate of the Madrid - Toledo Motorway.

Source: Author.

Figure 76: Cartagena - Vera Motorway.

Table 26: Traffic Evolution of the Cartagena - Vera Motorway.

CARTAGENA - VERA					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
2007	112.6	3,179	130.68	-	-
2008	112.6	3,285	135.03	1.033	1.033
2009	112.6	3,174	130.47	0.966	0.966
2010	112.6	3,288	135.16	1.036	1.036
2011	112.6	3,142	129.16	0.956	0.956
2012	112.6	2,820	115.92	0.898	0.898
2013	112.6	2,737	112.51	0.971	0.971
2014	112.6	2,828	116.25	1.033	1.033

Source: Author.

Figure 77: Annual Average Daily Traffic of the Cartagena - Vera Motorway.

Source: Author.

Figure 78: Traffic Growth Rate of the Cartagena - Vera Motorway.

Source: Author.

Figure 79: Circunvalación de Alicante Motorway.

Table 27: Traffic Evolution of the Circunvalación de Alicante Motorway.

CIRCUNVALACIÓN DE ALICANTE					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
2007	33.2	8,427	102.12	-	-
2008	33.2	9,990	121.06	1.185	1.185
2009	33.2	7,985	96.76	0.799	0.799
2010	33.2	7,256	87.93	0.909	0.909
2011	33.2	6,533	79.17	0.900	0.900
2012	33.2	5,715	69.25	0.875	0.875
2013	33.2	5,298	64.20	0.927	0.927
2014	33.2	5,303	64.26	1.001	1.001

Source: Author.

Figure 80: Annual Average Daily Traffic of the Circunvalación de Alicante Motorway.

Source: Author.

Figure 81: Traffic Growth Rate of the Circunvalación de Alicante Motorway.

Source: Author.

Figure 82: Alto de las Pedrizas - Málaga Motorway.

Table 28: Traffic Evolution of the Alto de las Pedrizas - Málaga Motorway.

ALTO DE LAS PEDRIZAS - MÁLAGA					
Period	Length (Kms)	AADTi	(veh-km) _i	AADTi/AADT(i-1)	((veh-km) _i / (veh-km) _(i-1))
2011	28.0	8,159	83.50	-	-
2012	28.0	8,227	84.20	1.008	1.008
2013	28.0	8,150	83.41	0.991	0.991
2014	28.0	9,384	96.03	1.151	1.151

Source: Author.

Figure 83: Annual Average Daily Traffic of the Alto de las Pedrizas - Málaga Motorway.

Source: Author.

Figure 84: Traffic Growth Rate of the Alto de las Pedrizas - Málaga Motorway.

Source: Author.

Table 29: Average Traffic in All Toll Motorways.

AVERAGE TRAFFIC IN ALL TOLL MOTORWAYS					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / ((veh-km)(i-1))
1974	506	2,006	370		
1975	528	1,987	383	0.990	1.033
1976	724	2,420	640	1.218	1.672
1977	877	2,635	843	1.089	1.318
1978	1,141	3,722	1,550	1.412	1.839
1979	1,288	4,031	1,896	1.083	1.223
1980	1,410	4,093	2,107	1.015	1.111
1981	1,442	4,117	2,167	1.006	1.029
1982	1,442	4,109	2,163	0.998	0.998
1983	1,529	4,109	2,293	1.000	1.060
1984	1,540	4,129	2,321	1.005	1.012
1985	1,576	4,352	2,503	1.054	1.078
1986	1,576	5,575	3,207	1.281	1.281
1987	1,576	6,306	3,627	1.131	1.131
1988	1,584	7,447	4,305	1.181	1.187
1989	1,584	8,594	4,968	1.154	1.154
1990	1,602	9,004	5,264	1.048	1.060
1991	1,619	9,483	5,603	1.053	1.064
1992	1,642	9,354	5,605	0.986	1.000
1993	1,642	9,035	5,414	0.966	0.966
1994	1,642	9,198	5,511	1.018	1.018
1995	1,628	9,488	5,639	1.032	1.023

AVERAGE TRAFFIC IN ALL TOLL MOTORWAYS					
Period	Length (Kms)	AADTi	(veh-km)i	AADTi/AADT(i-1)	((veh-km)i) / (veh-km)(i-1))
1996	1,628	9,649	5,734	1.017	1.017
1997	1,638	10,671	6,380	1.106	1.113
1998	1,647	11,355	6,825	1.064	1.070
1999	1,739	13,366	8,484	1.177	1.243
2000	1,739	14,893	9,453	1.114	1.114
2001	1,816	16,541	10,961	1.111	1.160
2002	1,865	18,772	12,780	1.135	1.166
2003	2,040	18,956	14,116	1.010	1.105
2004	2,176	20,869	16,573	1.101	1.174
2005	2,197	22,563	18,092	1.081	1.092
2006	2,197	24,417	19,578	1.082	1.082
2007	2,197	25,713	20,615	1.053	1.053
2008	2,197	24,350	19,524	0.947	0.947
2009	2,199	23,022	18,482	0.945	0.947
2010	2,199	22,585	18,132	0.981	0.981
2011	2,199	21,426	17,201	0.949	0.949
2012	2,199	19,622	15,752	0.916	0.916
2013	2,199	18,836	15,121	0.960	0.960
2014	2,200	19,251	15,459	1.022	1.022

Source: Author.

Figure 85: Annual Average Daily Traffic in All Toll Motorways.

Source: Author.

Figure 86: Traffic Growth Rate in All Toll Motorways.

Source: Author.

Figure 87: Annual Average Daily Traffic of Each Toll Motorway and for the Whole Network.

Source: Author.

Figure 88: Traffic Growth of Each Toll Motorway and for the Whole Network.

Source: Author.

**ANNEX V: TRAFFIC TIME SERIES AT AUTOMATIC TRAFFIC
RECORDERS ON THE A-1 MOTORWAY.**

Table 1: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 32.00 on A-1 Motorway.

(K.P. 32.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1975	12.756			
1976	13.781	8.04%	1.0804	0.0773
1977	14.974	8.66%	1.0866	0.0830
1978	15.507	3.56%	1.0356	0.0350
1979	15.784	1.79%	1.0179	0.0177
1980	16.151	2.33%	1.0233	0.0230
1981	16.300	0.92%	1.0092	0.0092
1982	17.292	6.09%	1.0609	0.0591
1983	16.986	-1.77%	0.9823	-0.0179
1984	10.864	-36.04%	0.6396	-0.4469
1985	16.670	53.44%	1.5344	0.4282
1986	18.069	8.39%	1.0839	0.0806
1987	18.501	2.39%	1.0239	0.0236
1988	22.053	19.20%	1.1920	0.1756
1989	23.861	8.20%	1.0820	0.0788
1990	27.806	16.53%	1.1653	0.1530
1991	26.823	-3.54%	0.9646	-0.0360
1992	31.312	16.74%	1.1674	0.1547
1993	31.900	1.88%	1.0188	0.0186
1994	37.100	16.30%	1.1630	0.1510
1995	38.980	5.07%	1.0507	0.0494
1996	39.846	2.22%	1.0222	0.0220
1997	36.915	-7.36%	0.9264	-0.0764
1998	38.602	4.57%	1.0457	0.0447
1999	43.995	13.97%	1.1397	0.1308
2000	46.408	5.48%	1.0548	0.0534
2001	48.289	4.05%	1.0405	0.0397
2002	51.385	6.41%	1.0641	0.0621
2003	53.300	3.73%	1.0373	0.0366
2004	53.582	0.53%	1.0053	0.0053
2005	54.621	1.94%	1.0194	0.0192
2006	60.229	10.27%	1.1027	0.0977
2007	61.873	2.73%	1.0273	0.0269
2008	62.688	1.32%	1.0132	0.0131
2009	61.724	-1.54%	0.9846	-0.0155
2010	61.049	-1.09%	0.9891	-0.0110
2011	60.317	-1.20%	0.9880	-0.0121
2012	58.345	-3.27%	0.9673	-0.0332

(K.P. 32.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2013	56.909	-2.46%	0.9754	-0.0249
2014	57.890	1.72%	1.0172	0.0171

Figure 1: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 32.00 on the A-1 Motorway.

Table 2: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 98.40 on A-1 Motorway.

(K.P. 98.40)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1960	1.152			
1961	1.357	17.80%	1.1780	0.1638
1962	1.540	13.49%	1.1349	0.1265
1963	1.721	11.75%	1.1175	0.1111
1964	2.025	17.66%	1.1766	0.1627
1965	2.235	10.37%	1.1037	0.0987
1966	2.615	17.00%	1.1700	0.1570
1967	3.070	17.40%	1.1740	0.1604
1968	2.967	-3.36%	0.9664	-0.0341
1969	3.624	22.14%	1.2214	0.2000
1970	4.130	13.96%	1.1396	0.1307
1971	5.005	21.19%	1.2119	0.1922
1972	5.500	9.89%	1.0989	0.0943

(K.P. 98.40)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1973	5.894	7.16%	1.0716	0.0692
1974	6.989	18.58%	1.1858	0.1704
1975	5.913	-15.40%	0.8460	-0.1672
1976	6.685	13.06%	1.1306	0.1227
1977	6.867	2.72%	1.0272	0.0269
1978	6.800	-0.98%	0.9902	-0.0098
1979	8.085	18.90%	1.1890	0.1731
1980	6.306	-22.00%	0.7800	-0.2485
1981	7.095	12.51%	1.1251	0.1179
1982	7.337	3.41%	1.0341	0.0335
1983	8.343	13.71%	1.1371	0.1285
1984	7.785	-6.69%	0.9331	-0.0692
1985	6.523	-16.21%	0.8379	-0.1769
1986	7.169	9.90%	1.0990	0.0944
1987	7.928	10.59%	1.1059	0.1006
1988	9.578	20.81%	1.2081	0.1891
1989	9.110	-4.89%	0.9511	-0.0501
1990	9.401	3.19%	1.0319	0.0314
1991	10.935	16.32%	1.1632	0.1512
1992	10.846	-0.81%	0.9919	-0.0082
1993	11.060	1.97%	1.0197	0.0195
1994	13.356	20.76%	1.2076	0.1886
1995	15.789	18.22%	1.1822	0.1673
1996	15.088	-4.44%	0.9556	-0.0454
1997	15.679	3.92%	1.0392	0.0384
1998	13.983	-10.82%	0.8918	-0.1145
1999	18.127	29.64%	1.2964	0.2596
2000	21.770	20.10%	1.2010	0.1831
2001	21.957	0.86%	1.0086	0.0086
2002	23.263	5.95%	1.0595	0.0578
2003	24.262	4.29%	1.0429	0.0420
2004	23.176	-4.48%	0.9552	-0.0458
2005	24.074	3.87%	1.0387	0.0380
2006	26.624	10.59%	1.1059	0.1007
2007	26.434	-0.71%	0.9929	-0.0072
2008	26.176	-0.98%	0.9902	-0.0098
2009	23.287	-11.04%	0.8896	-0.1169
2010	20.766	-10.83%	0.8917	-0.1146
2011	21.203	2.10%	1.0210	0.0208
2012	19.613	-7.50%	0.9250	-0.0780
2013	16.825	-14.22%	0.8578	-0.1533
2014	18.451	9.66%	1.0966	0.0923

Figure 2: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 98.40 on the A-1 Motorway.

Table 3: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 101.03 on A-1 Motorway.

(K.P. 101.00)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	7.349			
1989	7.498	2.03%	1.0203	0.0201
1990	7.698	2.67%	1.0267	0.0263
1991	9.498	23.38%	1.2338	0.2101
1992	8.833	-7.00%	0.9300	-0.0726
1993	10.100	14.34%	1.1434	0.1340
1994	11.183	10.72%	1.1072	0.1019
1995	13.012	16.36%	1.1636	0.1515
1996	13.452	3.38%	1.0338	0.0333
1997	14.319	6.45%	1.0645	0.0625
1998	15.625	9.12%	1.0912	0.0873
1999	15.712	0.56%	1.0056	0.0056
2000	16.177	2.96%	1.0296	0.0292
2001	16.738	3.47%	1.0347	0.0341
2002	21.149	26.35%	1.2635	0.2339
2003	21.748	2.83%	1.0283	0.0279
2004	21.860	0.51%	1.0051	0.0051
2005	22.730	3.98%	1.0398	0.0390
2006	22.900	0.75%	1.0075	0.0075

(K.P. 101.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	21.283	-7.06%	0.9294	-0.0732
2008	20.773	-2.40%	0.9760	-0.0243
2009	21.254	2.32%	1.0232	0.0229
2010	20.426	-3.90%	0.9610	-0.0397
2011	18.657	-8.66%	0.9134	-0.0906
2012	19.774	5.99%	1.0599	0.0581
2013	18.393	-6.98%	0.9302	-0.0724
2014	19.286	4.86%	1.0486	0.0474

Figure 3: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 101.03 on the A-1 Motorway.

Table 4: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 108.00 on A-1 Motorway.

(K.P. 108.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	8.531			
1989	8.698	1.96%	1.0196	0.0194
1990	8.897	2.29%	1.0229	0.0226
1991	9.598	7.88%	1.0788	0.0758
1992	9.198	-4.17%	0.9583	-0.0426
1993	10.500	14.16%	1.1416	0.1324
1994	11.540	9.90%	1.0990	0.0944

(K.P. 108.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1995	12.477	8.12%	1.0812	0.0781
1996	12.550	0.59%	1.0059	0.0058
1997	13.384	6.65%	1.0665	0.0643
1998	14.229	6.31%	1.0631	0.0612
1999	14.347	0.83%	1.0083	0.0083
2000	14.817	3.28%	1.0328	0.0322
2001	17.688	19.38%	1.1938	0.1771
2002	18.097	2.31%	1.0231	0.0229
2003	18.500	2.23%	1.0223	0.0220
2004	18.650	0.81%	1.0081	0.0081
2005	19.396	4.00%	1.0400	0.0392
2006	19.560	0.85%	1.0085	0.0084
2007	19.650	0.46%	1.0046	0.0046
2008	19.523	-0.65%	0.9935	-0.0065
2009	19.887	1.86%	1.0186	0.0185
2010	20.559	3.38%	1.0338	0.0332
2011	15.588	-24.18%	0.7582	-0.2768
2012	16.562	6.25%	1.0625	0.0606
2013	16.697	0.82%	1.0082	0.0081
2014	17.062	2.19%	1.0219	0.0216

Figure 4: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 108.00 on the A-1 Motorway.

Table 5: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 135.90 on A-1 Motorway.

(K.P. 135.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1975	5.968			
1976	6.806	14.04%	1.1404	0.1314
1977	9.012	32.41%	1.3241	0.2808
1978	9.035	0.26%	1.0026	0.0025
1979	8.285	-8.30%	0.9170	-0.0867
1980	8.094	-2.31%	0.9769	-0.0233
1981	7.536	-6.89%	0.9311	-0.0714
1982	7.349	-2.48%	0.9752	-0.0251
1983	6.924	-5.78%	0.9422	-0.0596
1984	5.759	-16.83%	0.8317	-0.1842
1985	5.809	0.87%	1.0087	0.0086
1986	6.267	7.88%	1.0788	0.0759
1987	6.532	4.23%	1.0423	0.0414
1988	7.447	14.01%	1.1401	0.1311
1989	8.521	14.42%	1.1442	0.1347
1990	8.983	5.42%	1.0542	0.0528
1991	9.500	5.76%	1.0576	0.0560
1992	9.800	3.16%	1.0316	0.0311
1993	10.000	2.04%	1.0204	0.0202
1994	15.483	54.83%	1.5483	0.4372
1995	17.040	10.06%	1.1006	0.0958
1996	16.272	-4.51%	0.9549	-0.0461
1997	16.094	-1.09%	0.9891	-0.0110
1998	14.019	-12.89%	0.8711	-0.1380
1999	14.031	0.09%	1.0009	0.0009
2000	16.107	14.80%	1.1480	0.1380
2001	16.707	3.73%	1.0373	0.0366
2002	18.596	11.31%	1.1131	0.1071
2003	18.832	1.27%	1.0127	0.0126
2004	16.561	-12.06%	0.8794	-0.1285
2005	17.961	8.45%	1.0845	0.0812
2006	19.619	9.23%	1.0923	0.0883
2007	19.101	-2.64%	0.9736	-0.0268
2008	19.115	0.07%	1.0007	0.0007
2009	18.794	-1.68%	0.9832	-0.0169
2010	15.008	-20.14%	0.7986	-0.2250
2011	15.588	3.86%	1.0386	0.0379
2012	15.302	-1.83%	0.9817	-0.0185

(K.P. 135.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2013	15.100	-1.32%	0.9868	-0.0133
2014	15.775	4.47%	1.0447	0.0437

Figure 5: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 135.90 on the A-1 Motorway.

Table 6: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 199.00 on A-1 Motorway.

(K.P. 199.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1989	13.731			
1990	14.627	6.53%	1.0653	0.0632
1991	14.698	0.49%	1.0049	0.0048
1992	15.257	3.80%	1.0380	0.0373
1993	16.327	7.01%	1.0701	0.0678
1994	15.411	-5.61%	0.9439	-0.0577
1995	16.099	4.46%	1.0446	0.0437
1996	19.771	22.81%	1.2281	0.2055
1997	16.456	-16.77%	0.8323	-0.1835
1998	16.629	1.05%	1.0105	0.0105
1999	17.098	2.82%	1.0282	0.0278
2000	19.734	15.42%	1.1542	0.1434
2001	20.280	2.77%	1.0277	0.0273

(K.P. 199.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2002	19.150	-5.57%	0.9443	-0.0573
2003	21.652	13.07%	1.1307	0.1228
2004	22.150	2.30%	1.0230	0.0227
2005	24.436	10.32%	1.1032	0.0982
2006	18.583	-23.95%	0.7605	-0.2738
2007	19.195	3.29%	1.0329	0.0324
2008	20.964	9.22%	1.0922	0.0882
2009	18.762	-10.50%	0.8950	-0.1110
2010	20.050	6.86%	1.0686	0.0664
2011	13.847	-30.94%	0.6906	-0.3702
2012	14.678	6.00%	1.0600	0.0583
2013	18.286	24.58%	1.2458	0.2198
2014	18.328	0.23%	1.0023	0.0023

Figure 6: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 199.00 on the A-1 Motorway.

Table 7: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 205.60 on A-1 Motorway.

(K.P. 205.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	12.298			
1989	13.285	8.03%	1.0803	0.0772

(K.P. 205.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1990	13.116	-1.27%	0.9873	-0.0128
1991	14.484	10.43%	1.1043	0.0992
1992	14.999	3.56%	1.0356	0.0349
1993	13.038	-13.07%	0.8693	-0.1401
1994	16.417	25.92%	1.2592	0.2304
1995	16.549	0.80%	1.0080	0.0080
1996	17.388	5.07%	1.0507	0.0495
1997	15.909	-8.51%	0.9149	-0.0889
1998	16.848	5.90%	1.0590	0.0573
1999	17.144	1.76%	1.0176	0.0174
2000	19.770	15.32%	1.1532	0.1425
2001	19.846	0.38%	1.0038	0.0038
2002	19.908	0.31%	1.0031	0.0031
2003	22.680	13.92%	1.1392	0.1304
2004	23.592	4.02%	1.0402	0.0394
2005	22.560	-4.37%	0.9563	-0.0447
2006	20.180	-10.55%	0.8945	-0.1115
2007	20.596	2.06%	1.0206	0.0204
2008	24.916	20.97%	1.2097	0.1904
2009	17.139	-31.21%	0.6879	-0.3742
2010	20.240	18.09%	1.1809	0.1663
2011	17.660	-12.75%	0.8725	-0.1364
2012	18.027	2.08%	1.0208	0.0206
2013	18.814	4.37%	1.0437	0.0427
2014	18.829	0.08%	1.0008	0.0008

Figure 7: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 205.60 on the A-1 Motorway.

Table 8: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 230.90 on A-1 Motorway.

(K.P. 230.90)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	13.097			
1989	13.398	2.30%	1.0230	0.0227
1990	10.632	-20.64%	0.7936	-0.2312
1991	10.086	-5.14%	0.9486	-0.0527
1992	10.220	1.33%	1.0133	0.0132
1993	11.000	7.63%	1.0763	0.0735
1994	19.642	78.56%	1.7856	0.5798
1995	20.397	3.84%	1.0384	0.0377
1996	16.349	-19.85%	0.8015	-0.2212
1997	16.500	0.92%	1.0092	0.0092
1998	18.075	9.55%	1.0955	0.0912
1999	22.005	21.74%	1.2174	0.1967
2000	22.843	3.81%	1.0381	0.0374
2001	25.428	11.32%	1.1132	0.1072
2002	25.998	2.24%	1.0224	0.0222
2003	32.640	25.55%	1.2555	0.2275
2004	32.750	0.34%	1.0034	0.0034
2005	32.900	0.46%	1.0046	0.0046

(K.P. 230.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	33.709	2.46%	1.0246	0.0243
2007	36.601	8.58%	1.0858	0.0823
2008	32.128	-12.22%	0.8778	-0.1303
2009	23.548	-26.71%	0.7329	-0.3107
2010	25.708	9.17%	1.0917	0.0878
2011	28.993	12.78%	1.1278	0.1203
2012	25.661	-11.49%	0.8851	-0.1221
2013	25.540	-0.47%	0.9953	-0.0047
2014	27.387	7.23%	1.0723	0.0698

Figure 8: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 230.90 on the A-1 Motorway.

Table 9: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 235.10 on A-1 Motorway.

(K.P. 235.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	14.498			
1989	14.698	1.38%	1.0138	0.0137
1990	15.098	2.72%	1.0272	0.0269
1991	15.098	0.00%	1.0000	0.0000
1992	15.430	2.20%	1.0220	0.0218
1993	9.471	-38.62%	0.6138	-0.4881

(K.P. 235.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1994	25.831	172.74%	2.7274	1.0033
1995	26.679	3.28%	1.0328	0.0323
1996	26.854	0.66%	1.0066	0.0065
1997	15.635	-41.78%	0.5822	-0.5409
1998	18.128	15.94%	1.1594	0.1479
1999	22.302	23.03%	1.2303	0.2072
2000	23.503	5.39%	1.0539	0.0525
2001	24.322	3.48%	1.0348	0.0343
2002	26.996	10.99%	1.1099	0.1043
2003	35.052	29.84%	1.2984	0.2611
2004	35.100	0.14%	1.0014	0.0014
2005	35.560	1.31%	1.0131	0.0130
2006	35.750	0.53%	1.0053	0.0053
2007	35.860	0.31%	1.0031	0.0031
2008	28.634	-20.15%	0.7985	-0.2250
2009	37.362	30.48%	1.3048	0.2661
2010	33.995	-9.01%	0.9099	-0.0944
2011	32.128	-5.49%	0.9451	-0.0565
2012	35.113	9.29%	1.0929	0.0888
2013	36.768	4.71%	1.0471	0.0461
2014	37.986	3.31%	1.0331	0.0326

Figure 9: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 235.10 on the A-1 Motorway.

Table 10: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 277.90 on A-1 Motorway.

(K.P. 277.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.852			
1989	8.543	8.80%	1.0880	0.0843
1990	9.071	6.18%	1.0618	0.0600
1991	12.013	32.43%	1.3243	0.2809
1992	12.651	5.31%	1.0531	0.0517
1993	12.281	-2.92%	0.9708	-0.0297
1994	8.979	-26.89%	0.7311	-0.3132
1995	9.708	8.12%	1.0812	0.0781
1996	9.825	1.21%	1.0121	0.0120
1997	9.980	1.58%	1.0158	0.0157
1998	15.650	56.81%	1.5681	0.4499
1999	10.120	-35.34%	0.6466	-0.4360
2000	11.536	13.99%	1.1399	0.1310
2001	10.657	-7.62%	0.9238	-0.0793
2002	10.259	-3.73%	0.9627	-0.0381
2003	9.753	-4.93%	0.9507	-0.0506
2004	9.880	1.30%	1.0130	0.0129
2005	9.486	-3.99%	0.9601	-0.0407
2006	9.677	2.01%	1.0201	0.0199
2007	9.731	0.56%	1.0056	0.0056
2008	9.562	-1.74%	0.9826	-0.0175
2009	7.930	-17.07%	0.8293	-0.1871
2010	7.727	-2.56%	0.9744	-0.0259
2011	9.251	19.72%	1.1972	0.1800
2012	9.186	-0.70%	0.9930	-0.0071
2013	8.506	-7.40%	0.9260	-0.0769
2014	8.810	3.57%	1.0357	0.0351

Figure 10: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 277.90 on the A-1 Motorway.

Table 11: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 295.50 on A-1 Motorway.

(K.P. 295.50)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1975	9.287			
1976	9.938	7.01%	1.0701	0.0678
1977	12.102	21.78%	1.2178	0.1970
1978	13.259	9.56%	1.0956	0.0913
1979	9.405	-29.07%	0.7093	-0.3434
1980	8.319	-11.55%	0.8845	-0.1227
1981	7.796	-6.29%	0.9371	-0.0649
1982	7.776	-0.26%	0.9974	-0.0026
1983	9.549	22.80%	1.2280	0.2054
1984	6.530	-31.62%	0.6838	-0.3800
1985	6.941	6.29%	1.0629	0.0610
1986	6.826	-1.66%	0.9834	-0.0167
1987	7.044	3.19%	1.0319	0.0314
1988	8.023	13.90%	1.1390	0.1301
1989	8.525	6.26%	1.0626	0.0607
1990	9.173	7.60%	1.0760	0.0733
1991	9.199	0.28%	1.0028	0.0028
1992	9.553	3.85%	1.0385	0.0378

(K.P. 295.50)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1993	9.358	-2.04%	0.9796	-0.0206
1994	9.224	-1.43%	0.9857	-0.0144
1995	9.227	0.03%	1.0003	0.0003
1996	8.941	-3.10%	0.9690	-0.0315
1997	9.178	2.65%	1.0265	0.0262
1998	9.408	2.51%	1.0251	0.0248
1999	8.836	-6.08%	0.9392	-0.0627
2000	8.807	-0.33%	0.9967	-0.0033
2001	8.896	1.01%	1.0101	0.0101
2002	7.853	-11.72%	0.8828	-0.1247
2003	8.082	2.92%	1.0292	0.0287
2004	8.655	7.09%	1.0709	0.0685
2005	8.625	-0.35%	0.9965	-0.0035
2006	8.857	2.69%	1.0269	0.0265
2007	8.679	-2.01%	0.9799	-0.0203
2008	8.262	-4.80%	0.9520	-0.0492
2009	8.830	6.87%	1.0687	0.0665
2010	8.799	-0.35%	0.9965	-0.0035
2011	8.547	-2.86%	0.9714	-0.0291
2012	8.042	-5.91%	0.9409	-0.0609
2013	8.061	0.24%	1.0024	0.0024
2014	8.668	7.53%	1.0753	0.0726

Figure 11: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 295.50 on the A-1 Motorway.

**ANNEX VI: STATIONARITY ANALYSIS. CORRELOGRAMS OF
AUTOMATIC TRAFFIC RECORDERS ON A-1 MOTORWAY.**

Figure 1: Kilometre Point 32.00.

Sample: 1975 2014
Included observations: 40

Figure 2: Kilometre Point 98.40.

Sample: 1960 2014
Included observations: 55

Figure 3: Kilometre Point 101.00.

Sample: 1988 2014
Included observations: 27

Figure 4: Kilometre Point 108.00.

Sample: 1988 2014
Included observations: 27

Figure 5: Kilometre Point 135.90.

Sample: 1975 2014
Included observations: 40

Figure 6: Kilometre Point 199.00.

Sample: 1989 2014
Included observations: 26

Figure 7: Kilometre Point 205.60.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	1	0.717	0.717	15.481	0.000
2	0.668	0.318	29.475	0.000	
3	0.550	-0.010	39.353	0.000	
4	0.469	-0.025	46.828	0.000	
5	0.367	-0.066	51.628	0.000	
6	0.173	-0.306	52.747	0.000	
7	0.088	-0.068	53.053	0.000	
8	0.015	0.061	53.063	0.000	
9	-0.045	0.016	53.150	0.000	
10	-0.161	-0.148	54.339	0.000	
11	-0.275	-0.187	58.027	0.000	
12	-0.319	-0.078	63.352	0.000	

Figure 10: Kilometre Point 277.90.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	1	0.406	0.406	4.9563	0.026
2	0.200	0.042	6.2098	0.045	
3	-0.036	-0.158	6.2532	0.100	
4	-0.051	0.008	6.3433	0.175	
5	0.146	0.245	7.1026	0.213	
6	0.217	0.103	8.8645	0.181	
7	0.169	-0.038	9.9826	0.190	
8	-0.019	-0.129	9.9969	0.265	
9	-0.104	-0.017	10.470	0.314	
10	-0.252	-0.201	13.404	0.202	
11	-0.238	-0.164	16.188	0.134	
12	-0.316	-0.276	21.401	0.045	

Figure 8: Kilometre Point 230.90.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	1	0.879	0.879	23.267	0.000
2	0.741	-0.139	40.465	0.000	
3	0.622	0.008	53.069	0.000	
4	0.498	-0.104	61.509	0.000	
5	0.379	-0.051	66.627	0.000	
6	0.255	-0.120	69.045	0.000	
7	0.173	0.108	70.220	0.000	
8	0.084	-0.152	70.507	0.000	
9	-0.028	-0.148	70.542	0.000	
10	-0.148	-0.163	71.550	0.000	
11	-0.244	-0.009	74.458	0.000	
12	-0.307	-0.011	79.383	0.000	

Figure 11: Kilometre Point 295.50.

Sample: 1975 2014
Included observations: 40

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	1	0.654	0.654	18.447	0.000
2	0.366	-0.109	24.376	0.000	
3	0.130	-0.114	25.146	0.000	
4	-0.038	-0.085	25.215	0.000	
5	-0.025	0.145	25.246	0.000	
6	-0.225	-0.420	27.749	0.000	
7	-0.381	-0.166	35.135	0.000	
8	-0.444	-0.072	45.481	0.000	
9	-0.433	-0.046	55.629	0.000	
10	-0.337	-0.183	61.972	0.000	
11	-0.228	0.058	64.989	0.000	
12	-0.111	0.025	65.730	0.000	
13	-0.033	-0.121	65.799	0.000	
14	0.043	-0.068	65.920	0.000	
15	0.113	0.031	66.780	0.000	
16	0.117	-0.173	67.735	0.000	
17	0.117	-0.121	68.738	0.000	
18	0.120	0.057	69.835	0.000	
19	0.070	-0.121	70.228	0.000	
20	0.077	-0.035	70.723	0.000	

Figure 9: Kilometre Point 235.10.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	1	0.713	0.713	15.293	0.000
2	0.569	0.125	25.447	0.000	
3	0.456	0.024	32.227	0.000	
4	0.479	0.240	40.034	0.000	
5	0.378	-0.120	45.113	0.000	
6	0.186	-0.291	46.400	0.000	
7	0.192	0.258	47.838	0.000	
8	0.177	-0.028	49.128	0.000	
9	0.148	-0.117	50.079	0.000	
10	-0.002	-0.074	50.079	0.000	
11	-0.110	-0.181	50.677	0.000	
12	-0.234	-0.353	53.546	0.000	

**ANNEX VII: TRAFFIC TIME SERIES AT AUTOMATIC TRAFFIC
RECORDERS ON THE A-2 MOTORWAY.**

Table 1: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 35.90 on A-2 Motorway.

(K.P. 35.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1975	4.865			
1976	16.246	9.29%	1.0929	0.0888
1977	16.647	2.47%	1.0247	0.0244
1978	17.185	3.23%	1.0323	0.0318
1979	17.419	1.36%	1.0136	0.0135
1980	17.256	-0.94%	0.9906	-0.0094
1981	19.561	13.36%	1.1336	0.1254
1982	20.534	4.97%	1.0497	0.0485
1983	20.644	0.54%	1.0054	0.0053
1984	17.008	-17.61%	0.8239	-0.1937
1985	19.426	14.22%	1.1422	0.1329
1986	22.347	15.04%	1.1504	0.1401
1987	23.863	6.78%	1.0678	0.0656
1988	24.934	4.49%	1.0449	0.0439
1989	30.564	22.58%	1.2258	0.2036
1990	32.271	5.59%	1.0559	0.0543
1991	35.300	9.39%	1.0939	0.0897
1992	38.909	10.22%	1.1022	0.0973
1993	38.608	-0.77%	0.9923	-0.0078
1994	40.724	5.48%	1.0548	0.0534
1995	41.981	3.09%	1.0309	0.0304
1996	45.692	8.84%	1.0884	0.0847
1997	48.239	5.57%	1.0557	0.0542
1998	53.970	11.88%	1.1188	0.1123
1999	55.164	2.21%	1.0221	0.0219
2000	56.338	2.13%	1.0213	0.0211
2001	62.601	11.12%	1.1112	0.1054
2002	70.100	11.98%	1.1198	0.1131
2003	63.172	-9.88%	0.9012	-0.1041
2004	63.850	1.07%	1.0107	0.0107
2005	66.120	3.56%	1.0356	0.0349
2006	67.150	1.56%	1.0156	0.0155
2007	95.930	42.86%	1.4286	0.3567
2008	91.323	-4.80%	0.9520	-0.0492
2009	87.332	-4.37%	0.9563	-0.0447
2010	87.398	0.08%	1.0008	0.0008
2011	91.285	4.45%	1.0445	0.0435
2012	87.855	-3.76%	0.9624	-0.0383

(K.P. 35.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2013	89.345	1.70%	1.0170	0.0168
2014	91.476	2.39%	1.0239	0.0236

Figure 1: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 35.90 on the A-2 Motorway.

Table 2: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 47.00 on A-2 Motorway.

(K.P. 47.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	20.204			
1989	27.177	34.51%	1.3451	0.2965
1990	26.710	-1.72%	0.9828	-0.0173
1991	29.611	10.86%	1.1086	0.1031
1992	31.235	5.48%	1.0548	0.0534
1993	34.294	9.79%	1.0979	0.0934
1994	34.534	0.70%	1.0070	0.0070
1995	41.461	20.06%	1.2006	0.1828
1996	44.951	8.42%	1.0842	0.0808
1997	48.559	8.03%	1.0803	0.0772
1998	57.552	18.52%	1.1852	0.1699
1999	47.401	-17.64%	0.8236	-0.1940
2000	49.430	4.28%	1.0428	0.0419

(K.P. 47.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2001	54.449	10.15%	1.1015	0.0967
2002	58.246	6.97%	1.0697	0.0674
2003	63.312	8.70%	1.0870	0.0834
2004	69.798	10.24%	1.1024	0.0975
2005	73.549	5.37%	1.0537	0.0523
2006	73.778	0.31%	1.0031	0.0031
2007	76.089	3.13%	1.0313	0.0308
2008	64.340	-15.44%	0.8456	-0.1677
2009	65.685	2.09%	1.0209	0.0207
2010	65.805	0.18%	1.0018	0.0018
2011	65.683	-0.19%	0.9981	-0.0019
2012	56.900	-13.37%	0.8663	-0.1435
2013	61.000	7.21%	1.0721	0.0696
2014	64.326	5.45%	1.0545	0.0531

Figure 2: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 47.00 on the A-2 Motorway.

Table 3: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 116.20 on A-2 Motorway.

(K.P. 116.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1975	6.138			

(K.P. 116.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1976	7.251	18.13%	1.1813	0.1666
1977	7.429	2.45%	1.0245	0.0243
1978	8.862	19.29%	1.1929	0.1764
1979	9.381	5.86%	1.0586	0.0569
1980	8.747	-6.76%	0.9324	-0.0700
1981	8.223	-5.99%	0.9401	-0.0618
1982	8.545	3.92%	1.0392	0.0384
1983	7.429	-13.06%	0.8694	-0.1400
1984	8.685	16.91%	1.1691	0.1562
1985	6.454	-25.69%	0.7431	-0.2969
1986	6.986	8.24%	1.0824	0.0792
1987	7.381	5.65%	1.0565	0.0550
1988	8.392	13.70%	1.1370	0.1284
1989	9.372	11.68%	1.1168	0.1104
1990	10.053	7.27%	1.0727	0.0701
1991	11.506	14.45%	1.1445	0.1350
1992	12.100	5.16%	1.0516	0.0503
1993	12.858	6.26%	1.0626	0.0608
1994	13.110	1.96%	1.0196	0.0194
1995	13.738	4.79%	1.0479	0.0468
1996	13.640	-0.71%	0.9929	-0.0072
1997	14.097	3.35%	1.0335	0.0330
1998	14.435	2.40%	1.0240	0.0237
1999	16.654	15.37%	1.1537	0.1430
2000	17.367	4.28%	1.0428	0.0419
2001	17.813	2.57%	1.0257	0.0254
2002	18.521	3.97%	1.0397	0.0390
2003	19.030	2.75%	1.0275	0.0271
2004	19.645	3.23%	1.0323	0.0318
2005	19.929	1.45%	1.0145	0.0144
2006	20.728	4.01%	1.0401	0.0393
2007	20.640	-0.42%	0.9958	-0.0043
2008	19.548	-5.29%	0.9471	-0.0544
2009	18.235	-6.72%	0.9328	-0.0695
2010	18.003	-1.27%	0.9873	-0.0128
2011	17.522	-2.67%	0.9733	-0.0271
2012	16.144	-7.86%	0.9214	-0.0819
2013	15.620	-3.25%	0.9675	-0.0330
2014	16.239	3.96%	1.0396	0.0389

Figure 3: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 116.20 on the A-2 Motorway.

Table 4: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 148.10 on A-2 Motorway.

(K.P. 148.10)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	6.654			
1989	7.753	16.52%	1.1652	0.1529
1990	8.692	12.11%	1.1211	0.1143
1991	10.636	22.37%	1.2237	0.2018
1992	12.690	19.31%	1.1931	0.1766
1993	9.549	-24.75%	0.7525	-0.2844
1994	9.402	-1.54%	0.9846	-0.0155
1995	10.046	6.85%	1.0685	0.0663
1996	11.238	11.87%	1.1187	0.1121
1997	11.788	4.89%	1.0489	0.0478
1998	11.040	-6.35%	0.9365	-0.0656
1999	11.570	4.80%	1.0480	0.0469
2000	14.337	23.92%	1.2392	0.2144
2001	14.083	-1.77%	0.9823	-0.0179
2002	13.905	-1.26%	0.9874	-0.0127
2003	14.968	7.64%	1.0764	0.0737
2004	15.396	2.86%	1.0286	0.0282
2005	15.524	0.83%	1.0083	0.0083
2006	17.131	10.35%	1.1035	0.0985

(K.P. 148.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	17.342	1.23%	1.0123	0.0122
2008	16.682	-3.81%	0.9619	-0.0388
2009	15.675	-6.04%	0.9396	-0.0623
2010	15.759	0.54%	1.0054	0.0053
2011	14.230	-9.70%	0.9030	-0.1021
2012	14.003	-1.60%	0.9840	-0.0161
2013	12.939	-7.60%	0.9240	-0.0790
2014	14.038	8.49%	1.0849	0.0815

Figure 4: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 148.10 on the A-2 Motorway.

Table 5: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 190.60 on A-2 Motorway.

(K.P. 190.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	5.301			
1989	5.983	12.87%	1.1287	0.1210
1990	6.006	0.38%	1.0038	0.0038
1991	7.298	21.51%	1.2151	0.1948
1992	10.587	45.07%	1.4507	0.3720
1993	8.049	-23.97%	0.7603	-0.2741
1994	8.913	10.73%	1.1073	0.1020

(K.P. 190.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1995	8.669	-2.74%	0.9726	-0.0278
1996	8.826	1.81%	1.0181	0.0179
1997	10.110	14.55%	1.1455	0.1358
1998	10.368	2.55%	1.0255	0.0252
1999	11.248	8.49%	1.0849	0.0815
2000	12.044	7.08%	1.0708	0.0684
2001	12.578	4.43%	1.0443	0.0434
2002	12.587	0.07%	1.0007	0.0007
2003	13.643	8.39%	1.0839	0.0806
2004	14.510	6.35%	1.0635	0.0616
2005	14.941	2.97%	1.0297	0.0293
2006	15.353	2.76%	1.0276	0.0272
2007	15.523	1.11%	1.0111	0.0110
2008	13.268	-14.53%	0.8547	-0.1570
2009	13.778	3.84%	1.0384	0.0377
2010	14.547	5.58%	1.0558	0.0543
2011	13.469	-7.41%	0.9259	-0.0770
2012	11.277	-16.27%	0.8373	-0.1776
2013	11.477	1.77%	1.0177	0.0176
2014	12.160	5.95%	1.0595	0.0578

Figure 5: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 190.60 on the A-2 Motorway.

Table 6: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 229.00 on A-2 Motorway.

(K.P. 229.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1960	1.042			
1961	1.208	15.93%	1.1593	0.1478
1962	1.447	19.78%	1.1978	0.1805
1963	1.761	21.70%	1.2170	0.1964
1964	2.113	19.99%	1.1999	0.1822
1965	2.226	5.35%	1.0535	0.0521
1966	2.513	12.89%	1.1289	0.1213
1967	2.769	10.19%	1.1019	0.0970
1968	3.105	12.13%	1.1213	0.1145
1969	3.359	8.18%	1.0818	0.0786
1970	4.106	22.24%	1.2224	0.2008
1971	4.147	1.00%	1.0100	0.0099
1972	4.772	15.07%	1.1507	0.1404
1973	5.294	10.94%	1.1094	0.1038
1974	6.369	20.31%	1.2031	0.1849
1975	5.015	-21.26%	0.7874	-0.2390
1976	5.629	12.24%	1.1224	0.1155
1977	5.569	-1.07%	0.9893	-0.0107
1978	6.467	16.12%	1.1612	0.1495
1979	6.070	-6.14%	0.9386	-0.0634
1980	6.477	6.71%	1.0671	0.0649
1981	6.671	3.00%	1.0300	0.0295
1982	6.300	-5.56%	0.9444	-0.0572
1983	6.020	-4.44%	0.9556	-0.0455
1984	7.287	21.05%	1.2105	0.1910
1985	5.904	-18.98%	0.8102	-0.2105
1986	6.423	8.79%	1.0879	0.0843
1987	6.531	1.68%	1.0168	0.0167
1988	6.995	7.10%	1.0710	0.0686
1989	8.150	16.51%	1.1651	0.1528
1990	7.760	-4.79%	0.9521	-0.0490
1991	10.629	36.97%	1.3697	0.3146
1992	11.355	6.83%	1.0683	0.0661
1993	11.204	-1.33%	0.9867	-0.0134
1994	10.019	-10.58%	0.8942	-0.1118
1995	10.203	1.84%	1.0184	0.0182
1996	10.430	2.22%	1.0222	0.0220
1997	11.352	8.84%	1.0884	0.0847

(K.P. 229.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1998	12.478	9.92%	1.0992	0.0946
1999	13.012	4.28%	1.0428	0.0419
2000	14.691	12.90%	1.1290	0.1214
2001	14.323	-2.50%	0.9750	-0.0254
2002	16.379	14.35%	1.1435	0.1341
2003	16.322	-0.35%	0.9965	-0.0035
2004	17.045	4.43%	1.0443	0.0433
2005	17.410	2.14%	1.0214	0.0212
2006	17.654	1.40%	1.0140	0.0139
2007	17.372	-1.60%	0.9840	-0.0161
2008	17.462	0.52%	1.0052	0.0052
2009	16.111	-7.74%	0.9226	-0.0805
2010	15.482	-3.90%	0.9610	-0.0398
2011	14.535	-6.12%	0.9388	-0.0631
2012	13.688	-5.83%	0.9417	-0.0600
2013	13.209	-3.50%	0.9650	-0.0356
2014	13.793	4.42%	1.0442	0.0433

Figure 6: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 229.00 on the A-2 Motorway.

Table 7: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 258.15 on A-2 Motorway.

(K.P. 258.15)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	8.605			
1989	9.748	13.28%	1.1328	0.1247
1990	10.901	11.83%	1.1183	0.1118
1991	12.998	19.24%	1.1924	0.1759
1992	13.504	3.89%	1.0389	0.0382
1993	13.998	3.66%	1.0366	0.0359
1994	17.219	23.01%	1.2301	0.2071
1995	15.923	-7.53%	0.9247	-0.0782
1996	16.785	5.41%	1.0541	0.0527
1997	16.009	-4.62%	0.9538	-0.0473
1998	15.947	-0.39%	0.9961	-0.0039
1999	17.184	7.76%	1.0776	0.0747
2000	19.958	16.14%	1.1614	0.1497
2001	20.276	1.59%	1.0159	0.0158
2002	23.232	14.58%	1.1458	0.1361
2003	23.470	1.02%	1.0102	0.0102
2004	21.085	-10.16%	0.8984	-0.1072
2005	21.160	0.36%	1.0036	0.0036
2006	25.552	20.76%	1.2076	0.1886
2007	22.927	-10.27%	0.8973	-0.1084
2008	21.344	-6.90%	0.9310	-0.0715
2009	19.161	-10.23%	0.8977	-0.1079
2010	19.488	1.71%	1.0171	0.0169
2011	18.370	-5.74%	0.9426	-0.0591
2012	17.736	-3.45%	0.9655	-0.0351
2013	17.047	-3.88%	0.9612	-0.0396
2014	17.821	4.54%	1.0454	0.0444

Figure 7: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 258.15 on the A-2 Motorway.

Table 8: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 307.02 on A-2 Motorway.

(K.P. 307.20)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1993	18.035			
1994	18.152	0.65%	1.0065	0.0065
1995	17.907	-1.35%	0.9865	-0.0136
1996	17.282	-3.49%	0.9651	-0.0355
1997	20.700	19.78%	1.1978	0.1805
1998	21.060	1.74%	1.0174	0.0172
1999	25.216	19.73%	1.1973	0.1801
2000	27.042	7.24%	1.0724	0.0699
2001	26.550	-1.82%	0.9818	-0.0184
2002	27.338	2.97%	1.0297	0.0292
2003	25.422	-7.01%	0.9299	-0.0727
2004	26.277	3.36%	1.0336	0.0331
2005	16.139	-38.58%	0.6142	-0.4875
2006	27.978	73.36%	1.7336	0.5502
2007	33.260	18.88%	1.1888	0.1729
2008	36.522	9.81%	1.0981	0.0936
2009	33.824	-7.39%	0.9261	-0.0767
2010	32.868	-2.83%	0.9717	-0.0287
2011	32.942	0.23%	1.0023	0.0022

(K.P. 307.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2012	30.398	-7.72%	0.9228	-0.0804
2013	29.732	-2.19%	0.9781	-0.0222
2014	30.709	3.29%	1.0329	0.0323

Figure 8: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 307.20 on the A-2 Motorway.

Table 9: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 317.20 on A-2 Motorway.

(K.P. 317.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	29.497			
1989	25.977	-11.93%	0.8807	-0.1271
1990	18.825	-27.53%	0.7247	-0.3220
1991	26.233	39.35%	1.3935	0.3318
1992	28.325	7.97%	1.0797	0.0767
1993	61.606	117.50%	2.1750	0.7770
1994	55.620	-9.72%	0.9028	-0.1022
1995	69.158	24.34%	1.2434	0.2179
1996	44.239	-36.03%	0.6397	-0.4468
1997	52.848	19.46%	1.1946	0.1778
1998	59.865	13.28%	1.1328	0.1247
1999	62.488	4.38%	1.0438	0.0429

(K.P. 317.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2000	65.774	5.26%	1.0526	0.0513
2001	73.220	11.32%	1.1132	0.1072
2002	78.056	6.60%	1.0660	0.0640
2003	78.156	0.13%	1.0013	0.0013
2004	78.560	0.52%	1.0052	0.0052
2005	78.690	0.17%	1.0017	0.0017
2006	78.950	0.33%	1.0033	0.0033
2007	79.148	0.25%	1.0025	0.0025
2008	71.400	-9.79%	0.9021	-0.1030
2009	71.643	0.34%	1.0034	0.0034
2010	68.779	-4.00%	0.9600	-0.0408
2011	55.217	-19.72%	0.8028	-0.2196
2012	50.203	-9.08%	0.9092	-0.0952
2013	58.473	16.47%	1.1647	0.1525
2014	62.113	6.23%	1.0623	0.0604

Figure 9: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 317.20 on the A-2 Motorway.

Table 10: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 334.70 on A-2 Motorway.

(K.P. 334.70)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	13.707			
1989	15.675	14.36%	1.1436	0.1342
1990	17.015	8.55%	1.0855	0.0820
1991	18.188	6.89%	1.0689	0.0667
1992	19.291	6.06%	1.0606	0.0589
1993	17.031	-11.72%	0.8828	-0.1246
1994	18.863	10.76%	1.1076	0.1022
1995	20.225	7.22%	1.0722	0.0697
1996	20.168	-0.28%	0.9972	-0.0028
1997	20.991	4.08%	1.0408	0.0400
1998	22.849	8.85%	1.0885	0.0848
1999	23.701	3.73%	1.0373	0.0366
2000	25.521	7.68%	1.0768	0.0740
2001	26.339	3.21%	1.0321	0.0315
2002	27.286	3.60%	1.0360	0.0353
2003	27.892	2.22%	1.0222	0.0220
2004	28.547	2.35%	1.0235	0.0232
2005	28.370	-0.62%	0.9938	-0.0062
2006	28.466	0.34%	1.0034	0.0034
2007	29.823	4.77%	1.0477	0.0466
2008	23.306	-21.85%	0.7815	-0.2466
2009	29.452	26.37%	1.2637	0.2341
2010	28.391	-3.60%	0.9640	-0.0367
2011	27.071	-4.65%	0.9535	-0.0476
2012	25.355	-6.34%	0.9366	-0.0655
2013	24.368	-3.89%	0.9611	-0.0397
2014	25.062	2.85%	1.0285	0.0281

Figure 10: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 334.70 on the A-2 Motorway.

Table 11: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 373.85 on A-2 Motorway.

(K.P. 373.85)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1960	1.449			
1961	1.687	16.43%	1.1643	0.1521
1962	1.957	16.00%	1.1600	0.1485
1963	2.203	12.57%	1.1257	0.1184
1964	2.340	6.22%	1.0622	0.0603
1965	3.143	34.32%	1.3432	0.2950
1966	3.656	16.32%	1.1632	0.1512
1967	4.183	14.41%	1.1441	0.1347
1968	4.433	5.98%	1.0598	0.0580
1969	4.641	4.69%	1.0469	0.0459
1970	6.117	31.80%	1.3180	0.2761
1971	6.572	7.44%	1.0744	0.0717
1972	7.386	12.39%	1.1239	0.1168
1973	8.801	19.16%	1.1916	0.1753
1974	9.140	3.85%	1.0385	0.0378
1975	9.508	4.03%	1.0403	0.0395
1976	10.395	9.33%	1.0933	0.0892
1977	8.199	-21.13%	0.7887	-0.2373
1978	6.318	-22.94%	0.7706	-0.2606

(K.P. 373.85)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1979	8.024	27.00%	1.2700	0.2390
1980	7.470	-6.90%	0.9310	-0.0715
1981	6.866	-8.09%	0.9191	-0.0843
1982	7.204	4.92%	1.0492	0.0481
1983	7.028	-2.44%	0.9756	-0.0247
1984	5.259	-25.17%	0.7483	-0.2900
1985	4.024	-23.48%	0.7652	-0.2677
1986	4.725	17.42%	1.1742	0.1606
1987	5.342	13.06%	1.1306	0.1227
1988	5.912	10.67%	1.1067	0.1014
1989	5.438	-8.02%	0.9198	-0.0836
1990	5.891	8.33%	1.0833	0.0800
1991	5.817	-1.26%	0.9874	-0.0126
1992	5.645	-2.96%	0.9704	-0.0300
1993	6.357	12.61%	1.1261	0.1188
1994	6.599	3.81%	1.0381	0.0374
1995	6.276	-4.89%	0.9511	-0.0502
1996	6.544	4.27%	1.0427	0.0418
1997	7.253	10.83%	1.1083	0.1029
1998	7.487	3.23%	1.0323	0.0318
1999	7.534	0.63%	1.0063	0.0063
2000	7.733	2.64%	1.0264	0.0261
2001	7.865	1.71%	1.0171	0.0169
2002	7.081	-9.97%	0.9003	-0.1050
2003	8.627	21.83%	1.2183	0.1975
2004	9.158	6.16%	1.0616	0.0597
2005	9.491	3.64%	1.0364	0.0357
2006	9.926	4.58%	1.0458	0.0448
2007	10.152	2.28%	1.0228	0.0225
2008	9.593	-5.51%	0.9449	-0.0566
2009	8.620	-10.14%	0.8986	-0.1069
2010	9.119	5.79%	1.0579	0.0563
2011	9.087	-0.35%	0.9965	-0.0035
2012	8.549	-5.92%	0.9408	-0.0610
2013	8.221	-3.84%	0.9616	-0.0391
2014	7.991	-2.80%	0.9720	-0.0284

Figure 11: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 373.85 on the A-2 Motorway.

Table 12: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 402.00 on A-2 Motorway.

(K.P. 402.00)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	10.308			
1989	10.598	2.81%	1.0281	0.0277
1990	10.899	2.84%	1.0284	0.0280
1991	12.952	18.84%	1.1884	0.1726
1992	14.486	11.84%	1.1184	0.1119
1993	12.717	-12.21%	0.8779	-0.1302
1994	10.161	-20.10%	0.7990	-0.2244
1995	12.531	23.32%	1.2332	0.2096
1996	12.608	0.61%	1.0061	0.0061
1997	9.600	-23.86%	0.7614	-0.2726
1998	9.370	-2.40%	0.9760	-0.0243
1999	9.447	0.82%	1.0082	0.0082
2000	10.676	13.01%	1.1301	0.1223
2001	11.700	9.59%	1.0959	0.0916
2002	9.134	-21.93%	0.7807	-0.2476
2003	9.247	1.24%	1.0124	0.0123
2004	10.134	9.59%	1.0959	0.0916
2005	10.149	0.15%	1.0015	0.0015
2006	10.604	4.48%	1.0448	0.0439

(K.P. 402.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	10.498	-1.00%	0.9900	-0.0100
2008	10.300	-1.89%	0.9811	-0.0190
2009	9.053	-12.11%	0.8789	-0.1290
2010	9.346	3.24%	1.0324	0.0319
2011	8.568	-8.32%	0.9168	-0.0869
2012	8.516	-0.61%	0.9939	-0.0061
2013	8.239	-3.25%	0.9675	-0.0331
2014	8.212	-0.33%	0.9967	-0.0033

Figure 13: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 402.00 on the A-2 Motorway.

Table 14: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 460.10 on A-2 Motorway.

(K.P. 460.1)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1998	13.630			
1999	14.106	3.49%	1.0349	0.0343
2000	14.316	1.49%	1.0149	0.0148
2001	14.816	3.49%	1.0349	0.0343
2002	22.226	50.01%	1.5001	0.4056
2003	23.303	4.85%	1.0485	0.0473
2004	28.164	20.86%	1.2086	0.1895

(K.P. 460.1)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2005	27.614	-1.95%	0.9805	-0.0197
2006	29.581	7.12%	1.0712	0.0688
2007	32.735	10.66%	1.1066	0.1013
2008	31.240	-4.57%	0.9543	-0.0467
2009	29.453	-5.72%	0.9428	-0.0589
2010	30.782	4.51%	1.0451	0.0441
2011	28.827	-6.35%	0.9365	-0.0656
2012	28.239	-2.04%	0.9796	-0.0206
2013	27.855	-1.36%	0.9864	-0.0137
2014	28.914	3.80%	1.0380	0.0373

Figure 14: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 460.10 on the A-2 Motorway.

Table 15: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 501.10 on A-2 Motorway.

(K.P. 501.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1993	8.999			
1994	15.200	68.91%	1.6891	0.5242
1995	15.899	4.60%	1.0460	0.0450
1996	16.800	5.67%	1.0567	0.0551
1997	17.000	1.19%	1.0119	0.0118

(K.P. 501.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1998	13.349	-21.48%	0.7852	-0.2418
1999	22.510	68.63%	1.6863	0.5225
2000	22.748	1.06%	1.0106	0.0105
2001	23.540	3.48%	1.0348	0.0342
2002	23.795	1.08%	1.0108	0.0108
2003	25.999	9.26%	1.0926	0.0886
2004	23.712	-8.80%	0.9120	-0.0921
2005	31.685	33.62%	1.3362	0.2899
2006	33.452	5.58%	1.0558	0.0543
2007	34.258	2.41%	1.0241	0.0238
2008	31.763	-7.28%	0.9272	-0.0756
2009	30.948	-2.57%	0.9743	-0.0260
2010	31.221	0.88%	1.0088	0.0088
2011	31.594	1.19%	1.0119	0.0119
2012	33.736	6.78%	1.0678	0.0656
2013	29.913	-11.33%	0.8867	-0.1203
2014	29.979	0.22%	1.0022	0.0022

Figure 15: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 501.10 on the A-2 Motorway.

Table 16: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 563.70 on A-2 Motorway.

(K.P. 563.70)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1990	19.065			
1991	20.999	10.14%	1.1014	0.0966
1992	21.022	0.11%	1.0011	0.0011
1993	20.179	-4.01%	0.9599	-0.0409
1994	22.500	11.50%	1.1150	0.1089
1995	29.871	32.76%	1.3276	0.2834
1996	31.858	6.65%	1.0665	0.0644
1997	28.757	-9.73%	0.9027	-0.1024
1998	31.600	9.89%	1.0989	0.0943
1999	31.790	0.60%	1.0060	0.0060
2000	21.996	-30.81%	0.6919	-0.3683
2001	31.506	43.24%	1.4324	0.3593
2002	32.716	3.84%	1.0384	0.0377
2003	34.112	4.27%	1.0427	0.0418
2004	34.500	1.14%	1.0114	0.0113
2005	34.670	0.49%	1.0049	0.0049
2006	35.150	1.38%	1.0138	0.0137
2007	43.886	24.85%	1.2485	0.2220
2008	42.906	-2.23%	0.9777	-0.0226
2009	40.176	-6.36%	0.9364	-0.0657
2010	39.057	-2.79%	0.9721	-0.0282
2011	42.908	9.86%	1.0986	0.0940
2012	38.446	-10.40%	0.8960	-0.1098
2013	39.316	2.26%	1.0226	0.0224
2014	38.763	-1.41%	0.9859	-0.0142

Figure 16: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 563.70 on the A-2 Motorway.

Table 17: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 608.30 on A-2 Motorway.

(K.P. 608.30)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	53.411			
1989	69.899	30.87%	1.3087	0.2690
1990	69.900	0.00%	1.0000	0.0000
1991	78.375	12.12%	1.1212	0.1144
1992	88.490	12.91%	1.1291	0.1214
1993	76.909	-13.09%	0.8691	-0.1403
1994	82.281	6.98%	1.0698	0.0675
1995	83.890	1.96%	1.0196	0.0194
1996	88.288	5.24%	1.0524	0.0511
1997	85.543	-3.11%	0.9689	-0.0316
1998	86.051	0.59%	1.0059	0.0059
1999	88.818	3.22%	1.0322	0.0316
2000	98.837	11.28%	1.1128	0.1069
2001	93.652	-5.25%	0.9475	-0.0539
2002	98.960	5.67%	1.0567	0.0551
2003	93.180	-5.84%	0.9416	-0.0602
2004	93.560	0.41%	1.0041	0.0041
2005	129.192	38.08%	1.3808	0.3227
2006	145.362	12.52%	1.1252	0.1179

(K.P. 608.30)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	150.380	3.45%	1.0345	0.0339
2008	142.468	-5.26%	0.9474	-0.0540
2009	129.114	-9.37%	0.9063	-0.0984
2010	126.983	-1.65%	0.9835	-0.0166
2011	131.672	3.69%	1.0369	0.0363
2012	132.354	0.52%	1.0052	0.0052
2013	136.984	3.50%	1.0350	0.0344
2014	143.095	4.46%	1.0446	0.0436

Figure 17: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 608.30 on the A-2 Motorway.

**ANNEX VIII: STATIONARITY ANALYSIS. CORRELOGRAMS OF
AUTOMATIC TRAFFIC RECORDERS ON A-2 MOTORWAY.**

Figure 1: Kilometre Point 35.90.

Figure 2: Kilometre Point 47.00.

Figure 3: Kilometre Point 148.10.

Figure 4: Kilometre Point 190.60.

Figure 5: Kilometre Point 229.00.

Figure 6: Kilometre Point 258.15.

Figure 7: Kilometre Point 307.20.

Figure 8: Kilometre Point 317.20.

Figure 9: Kilometre Point 334.70.

Figure 10: Kilometre Point 373.85.

Figure 11: Kilometre Point 402.00.

Figure 12: Kilometre Point 460.10.

Figure 13: Kilometre Point 501.10.

Sample: 1993 2014
Included observations: 22

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.686	0.686	11.844	0.001
2	0.600	0.244	21.348	0.000
3	0.497	0.036	28.204	0.000
4	0.419	0.012	33.354	0.000
5	0.364	0.028	37.472	0.000
6	0.145	-0.328	38.166	0.000
7	0.040	-0.126	38.221	0.000
8	-0.065	-0.073	38.381	0.000
		9	-0.143	-0.063	39.217	0.000
		10	-0.225	-0.080	41.438	0.000
		11	-0.236	0.141	44.116	0.000
		12	-0.349	-0.208	50.530	0.000

Figure 15: Kilometre Point 608.30.

Sample: 1988 2014
Included observations: 27

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.793	0.793	18.941	0.000
2	0.666	0.099	32.820	0.000
3	0.539	-0.042	42.285	0.000
4	0.446	0.017	49.057	0.000
5	0.434	0.183	55.752	0.000
6	0.351	-0.136	60.334	0.000
7	0.249	-0.148	62.753	0.000
8	0.136	-0.095	63.521	0.000	
		9	0.035	-0.052	63.575	0.000	
		10	-0.061	-0.147	63.746	0.000	
		11	-0.106	0.019	64.300	0.000	
		12	-0.170	-0.068	65.809	0.000	

Figure 14: Kilometre Point 563.70.

Sample: 1990 2014
Included observations: 25

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.762	0.762	16.346	0.000
2	0.618	0.087	27.539	0.000
3	0.523	0.064	35.926	0.000
4	0.349	-0.211	39.839	0.000
5	0.211	-0.076	41.346	0.000
6	0.214	0.226	42.978	0.000
7	0.150	-0.052	43.825	0.000
8	0.064	-0.117	43.987	0.000
		9	0.042	-0.032	44.061	0.000
		10	0.021	0.043	44.081	0.000
		11	-0.145	-0.309	45.100	0.000
		12	-0.164	0.087	46.505	0.000

**ANNEX IX: TRAFFIC TIME SERIES AT AUTOMATIC TRAFFIC
RECORDERS ON THE A-3 MOTORWAY.**

Table 1: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 18.80 on A-3 Motorway.

(K.P. 18.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1992	41.033			
1993	43.754	6.63%	1.0663	0.0642
1994	50.939	16.42%	1.1642	0.1520
1995	52.071	2.22%	1.0222	0.0220
1996	53.939	3.59%	1.0359	0.0352
1997	54.149	0.39%	1.0039	0.0039
1998	57.438	6.07%	1.0607	0.0590
1999	62.497	8.81%	1.0881	0.0844
2000	62.266	-0.37%	0.9963	-0.0037
2001	68.639	10.24%	1.1024	0.0974
2002	73.945	7.73%	1.0773	0.0745
2003	74.150	0.28%	1.0028	0.0028
2004	74.650	0.67%	1.0067	0.0067
2005	75.150	0.67%	1.0067	0.0067
2006	54.185	-27.90%	0.7210	-0.3271
2007	54.376	0.35%	1.0035	0.0035
2008	85.922	58.01%	1.5801	0.4575
2009	86.124	0.24%	1.0024	0.0023
2010	86.782	0.76%	1.0076	0.0076
2011	84.759	-2.33%	0.9767	-0.0236
2012	80.531	-4.99%	0.9501	-0.0512
2013	75.700	-6.00%	0.9400	-0.0619
2014	81.632	7.84%	1.0784	0.0754

Figure 1: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 18.80 on the A-3 Motorway.

Table 2: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 30.10 on A-3 Motorway.

(K.P. 30.10)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	18.860			
1989	18.897	0.20%	1.0020	0.0020
1990	11.858	-37.25%	0.6275	-0.4660
1991	13.339	12.49%	1.1249	0.1177
1992	14.976	12.27%	1.1227	0.1158
1993	19.100	27.54%	1.2754	0.2432
1994	19.500	2.09%	1.0209	0.0207
1995	19.900	2.05%	1.0205	0.0203
1996	21.200	6.53%	1.0653	0.0633
1997	21.280	0.38%	1.0038	0.0038
1998	22.500	5.73%	1.0573	0.0557
1999	23.584	4.82%	1.0482	0.0471
2000	24.281	2.96%	1.0296	0.0291
2001	25.128	3.49%	1.0349	0.0343
2002	25.964	3.33%	1.0333	0.0327
2003	26.232	1.03%	1.0103	0.0103
2004	27.580	5.14%	1.0514	0.0501
2005	31.950	15.84%	1.1584	0.1471

(K.P. 30.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	31.802	-0.46%	0.9954	-0.0046
2007	35.142	10.50%	1.1050	0.0999
2008	33.558	-4.51%	0.9549	-0.0461
2009	36.763	9.55%	1.0955	0.0912
2010	36.273	-1.33%	0.9867	-0.0134
2011	34.534	-4.79%	0.9521	-0.0491
2012	33.708	-2.39%	0.9761	-0.0242
2013	32.696	-3.00%	0.9700	-0.0305
2014	34.165	4.49%	1.0449	0.0439

Figure 2: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 30.10 on the A-3 Motorway.

Table 3: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 48.50 on A-3 Motorway.

(K.P. 48.50)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1991	11.260			
1992	12.808	13.75%	1.1375	0.1288
1993	16.419	28.19%	1.2819	0.2484
1994	19.193	16.90%	1.1690	0.1561
1995	18.453	-3.86%	0.9614	-0.0393
1996	19.743	6.99%	1.0699	0.0676

(K.P. 48.50)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1997	20.847	5.59%	1.0559	0.0544
1998	23.603	13.22%	1.1322	0.1242
1999	25.692	8.85%	1.0885	0.0848
2000	27.603	7.44%	1.0744	0.0717
2001	29.612	7.28%	1.0728	0.0703
2002	30.846	4.17%	1.0417	0.0408
2003	31.394	1.78%	1.0178	0.0176
2004	28.519	-9.16%	0.9084	-0.0960
2005	28.950	1.51%	1.0151	0.0150
2006	34.150	17.96%	1.1796	0.1652
2007	34.913	2.23%	1.0223	0.0221
2008	31.462	-9.88%	0.9012	-0.1041
2009	34.287	8.98%	1.0898	0.0860
2010	33.735	-1.61%	0.9839	-0.0162
2011	31.024	-8.04%	0.9196	-0.0838
2012	29.125	-6.12%	0.9388	-0.0632
2013	28.189	-3.21%	0.9679	-0.0327
2014	28.189	0.00%	1.0000	0.0000

Figure 3: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 48.50 on the A-3 Motorway.

Table 4: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 60.20 on A-3 Motorway.

(K.P. 60.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.598			
1989	9.676	27.35%	1.2735	0.2418
1990	8.531	-11.83%	0.8817	-0.1259
1991	9.198	7.82%	1.0782	0.0753
1992	10.359	12.62%	1.1262	0.1189
1993	13.200	27.43%	1.2743	0.2424
1994	15.366	16.41%	1.1641	0.1519
1995	15.100	-1.73%	0.9827	-0.0175
1996	16.099	6.62%	1.0662	0.0641
1997	16.999	5.59%	1.0559	0.0544
1998	19.001	11.78%	1.1178	0.1113
1999	19.778	4.09%	1.0409	0.0401
2000	20.364	2.96%	1.0296	0.0292
2001	21.070	3.47%	1.0347	0.0341
2002	22.208	5.40%	1.0540	0.0526
2003	31.626	42.41%	1.4241	0.3535
2004	29.279	-7.42%	0.9258	-0.0771
2005	27.572	-5.83%	0.9417	-0.0601
2006	34.536	25.26%	1.2526	0.2252
2007	34.250	-0.83%	0.9917	-0.0083
2008	28.226	-17.59%	0.8241	-0.1934
2009	29.868	5.82%	1.0582	0.0565
2010	28.578	-4.32%	0.9568	-0.0442
2011	28.935	1.25%	1.0125	0.0124
2012	28.849	-0.30%	0.9970	-0.0030
2013	25.632	-11.15%	0.8885	-0.1182
2014	26.928	5.06%	1.0506	0.0493

Figure 4: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 60.20 on the A-3 Motorway.

Table 5: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 86.90 on A-3 Motorway.

(K.P. 86.90)				
Year	AADTi	Variation (%)	AADTi / AADTi(i-1)	ln(AADTi / AADTi(i-1))
1988	6.095			
1989	5.229	-14.21%	0.8579	-0.1532
1990	5.493	5.05%	1.0505	0.0493
1991	9.737	77.26%	1.7726	0.5725
1992	10.630	9.17%	1.0917	0.0877
1993	14.001	31.71%	1.3171	0.2754
1994	11.484	-17.98%	0.8202	-0.1982
1995	11.800	2.75%	1.0275	0.0271
1996	12.700	7.63%	1.0763	0.0735
1997	12.950	1.97%	1.0197	0.0195
1998	13.329	2.93%	1.0293	0.0288
1999	15.008	12.60%	1.1260	0.1186
2000	15.452	2.96%	1.0296	0.0292
2001	15.990	3.48%	1.0348	0.0342
2002	20.813	30.16%	1.3016	0.2636
2003	21.832	4.90%	1.0490	0.0478
2004	21.930	0.45%	1.0045	0.0045
2005	26.484	20.77%	1.2077	0.1887

(K.P. 86.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	28.956	9.33%	1.0933	0.0892
2007	30.553	5.52%	1.0552	0.0537
2008	27.208	-10.95%	0.8905	-0.1160
2009	22.252	-18.22%	0.8178	-0.2011
2010	25.066	12.65%	1.1265	0.1191
2011	23.290	-7.09%	0.9291	-0.0735
2012	24.669	5.92%	1.0592	0.0575
2013	20.947	-15.09%	0.8491	-0.1636
2014	22.819	8.94%	1.0894	0.0856

Figure 5: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 86.90 on the A-3 Motorway.

Table 6: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 130.10 on A-3 Motorway.

(K.P. 130.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	5.995			
1989	6.099	1.73%	1.0173	0.0172
1990	7.098	16.38%	1.1638	0.1517
1991	9.022	27.11%	1.2711	0.2399
1992	10.146	12.46%	1.1246	0.1174
1993	14.001	38.00%	1.3800	0.3220

(K.P. 130.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1994	12.931	-7.64%	0.9236	-0.0795
1995	13.301	2.86%	1.0286	0.0282
1996	14.200	6.76%	1.0676	0.0654
1997	14.479	1.96%	1.0196	0.0195
1998	14.909	2.97%	1.0297	0.0293
1999	15.122	1.43%	1.0143	0.0142
2000	15.573	2.98%	1.0298	0.0294
2001	16.116	3.49%	1.0349	0.0343
2002	19.383	20.27%	1.2027	0.1846
2003	20.462	5.57%	1.0557	0.0542
2004	21.216	3.68%	1.0368	0.0362
2005	23.828	12.31%	1.1231	0.1161
2006	31.227	31.05%	1.3105	0.2704
2007	28.562	-8.53%	0.9147	-0.0892
2008	25.526	-10.63%	0.8937	-0.1124
2009	25.992	1.83%	1.0183	0.0181
2010	23.153	-10.92%	0.8908	-0.1157
2011	21.014	-9.24%	0.9076	-0.0969
2012	18.024	-14.23%	0.8577	-0.1535
2013	19.130	6.14%	1.0614	0.0596
2014	25.510	33.35%	1.3335	0.2878

Figure 6: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 130.10 on the A-3 Motorway.

Table 7: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 150.80 on A-3 Motorway.

(K.P. 150.80)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	5.295			
1989	7.761	46.57%	1.4657	0.3823
1990	7.798	0.48%	1.0048	0.0048
1991	8.008	2.69%	1.0269	0.0266
1992	10.652	33.02%	1.3302	0.2853
1993	14.001	31.44%	1.3144	0.2734
1994	11.242	-19.71%	0.8029	-0.2195
1995	11.899	5.84%	1.0584	0.0568
1996	14.811	24.47%	1.2447	0.2189
1997	14.850	0.26%	1.0026	0.0026
1998	14.860	0.07%	1.0007	0.0007
1999	15.148	1.94%	1.0194	0.0192
2000	15.600	2.98%	1.0298	0.0294
2001	16.144	3.49%	1.0349	0.0343
2002	19.520	20.91%	1.2091	0.1899
2003	19.594	0.38%	1.0038	0.0038
2004	22.774	16.23%	1.1623	0.1504
2005	26.188	14.99%	1.1499	0.1397
2006	29.513	12.70%	1.1270	0.1195
2007	29.682	0.57%	1.0057	0.0057
2008	25.703	-13.41%	0.8659	-0.1439
2009	25.815	0.44%	1.0044	0.0043
2010	22.302	-13.61%	0.8639	-0.1463
2011	19.079	-14.45%	0.8555	-0.1561
2012	20.850	9.28%	1.0928	0.0888
2013	20.068	-3.75%	0.9625	-0.0382
2014	20.602	2.66%	1.0266	0.0263

Figure 7: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 150.80 on the A-3 Motorway.

Table 8: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 278.80 on A-3 Motorway.

(K.P. 278.80)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	14.456			
1989	14.498	0.29%	1.0029	0.0029
1990	16.280	12.29%	1.1229	0.1159
1991	15.997	-1.74%	0.9826	-0.0175
1992	16.273	1.73%	1.0173	0.0171
1993	17.988	10.54%	1.1054	0.1002
1994	18.000	0.07%	1.0007	0.0007
1995	18.100	0.56%	1.0056	0.0055
1996	19.000	4.97%	1.0497	0.0485
1997	16.856	-11.28%	0.8872	-0.1197
1998	17.453	3.54%	1.0354	0.0348
1999	18.099	3.70%	1.0370	0.0363
2000	18.636	2.97%	1.0297	0.0292
2001	16.498	-11.47%	0.8853	-0.1219
2002	23.236	40.84%	1.4084	0.3425
2003	25.782	10.96%	1.1096	0.1040
2004	26.393	2.37%	1.0237	0.0234
2005	28.143	6.63%	1.0663	0.0642

(K.P. 278.80)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	27.659	-1.72%	0.9828	-0.0173
2007	27.660	0.00%	1.0000	0.0000
2008	24.585	-11.12%	0.8888	-0.1179
2009	24.450	-0.55%	0.9945	-0.0055
2010	25.591	4.67%	1.0467	0.0456
2011	25.952	1.41%	1.0141	0.0140
2012	25.623	-1.27%	0.9873	-0.0128
2013	23.979	-6.42%	0.9358	-0.0663
2014	23.636	-1.43%	0.9857	-0.0144

Figure 8: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 278.80 on the A-3 Motorway.

Table 9: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 306.30 on A-3 Motorway.

(K.P. 306.30)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	10.797			
1989	11.498	6.49%	1.0649	0.0629
1990	11.748	2.17%	1.0217	0.0215
1991	15.583	32.64%	1.3264	0.2825
1992	15.502	-0.52%	0.9948	-0.0052
1993	16.400	5.79%	1.0579	0.0563

(K.P. 306.30)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1994	17.000	3.66%	1.0366	0.0359
1995	17.400	2.35%	1.0235	0.0233
1996	16.819	-3.34%	0.9666	-0.0340
1997	29.306	74.24%	1.7424	0.5553
1998	30.436	3.86%	1.0386	0.0378
1999	20.098	-33.97%	0.6603	-0.4150
2000	20.696	2.98%	1.0298	0.0293
2001	21.596	4.35%	1.0435	0.0426
2002	21.778	0.84%	1.0084	0.0084
2003	25.518	17.17%	1.1717	0.1585
2004	27.934	9.47%	1.0947	0.0905
2005	27.639	-1.06%	0.9894	-0.0106
2006	26.563	-3.89%	0.9611	-0.0397
2007	28.150	5.97%	1.0597	0.0580
2008	27.148	-3.56%	0.9644	-0.0362
2009	28.517	5.04%	1.0504	0.0492
2010	27.481	-3.63%	0.9637	-0.0370
2011	28.158	2.46%	1.0246	0.0243
2012	27.925	-0.83%	0.9917	-0.0083
2013	28.300	1.34%	1.0134	0.0133
2014	26.011	-8.09%	0.9191	-0.0843

Figure 9: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 306.30 on the A-3 Motorway.

Table 10: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 317.80 on A-3 Motorway.

(K.P. 317.80)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	10.798			
1989	11.498	6.48%	1.0648	0.0628
1990	10.035	-12.72%	0.8728	-0.1361
1991	15.774	57.19%	1.5719	0.4523
1992	15.791	0.11%	1.0011	0.0011
1993	17.552	11.15%	1.1115	0.1057
1994	18.000	2.55%	1.0255	0.0252
1995	18.200	1.11%	1.0111	0.0110
1996	17.179	-5.61%	0.9439	-0.0577
1997	29.499	71.72%	1.7172	0.5407
1998	30.399	3.05%	1.0305	0.0301
1999	20.508	-32.54%	0.6746	-0.3936
2000	21.117	2.97%	1.0297	0.0293
2001	21.678	2.66%	1.0266	0.0262
2002	29.928	38.06%	1.3806	0.3225
2003	26.434	-11.67%	0.8833	-0.1241
2004	26.002	-1.63%	0.9837	-0.0165
2005	25.414	-2.26%	0.9774	-0.0229
2006	31.150	22.57%	1.2257	0.2035
2007	42.987	38.00%	1.3800	0.3221
2008	41.604	-3.22%	0.9678	-0.0327
2009	41.770	0.40%	1.0040	0.0040
2010	41.865	0.23%	1.0023	0.0023
2011	41.546	-0.76%	0.9924	-0.0076
2012	37.889	-8.80%	0.9120	-0.0921
2013	34.009	-10.24%	0.8976	-0.1080
2014	34.525	1.52%	1.0152	0.0151

Figure 10: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 317.80 on the A-3 Motorway.

Table 11: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 334.70 on A-3 Motorway.

(K.P. 334.70)				
Year	AADTi	Variation (%)	AADTi / AADTi(i-1)	ln(AADTi / AADTi(i-1))
1988	39.768			
1989	42.497	6.86%	1.0686	0.0664
1990	41.162	-3.14%	0.9686	-0.0319
1991	36.199	-12.06%	0.8794	-0.1285
1992	34.199	-5.53%	0.9447	-0.0568
1993	43.220	26.38%	1.2638	0.2341
1994	43.299	0.18%	1.0018	0.0018
1995	41.999	-3.00%	0.9700	-0.0305
1996	51.999	23.81%	1.2381	0.2136
1997	54.649	5.10%	1.0510	0.0497
1998	55.999	2.47%	1.0247	0.0244
1999	58.116	3.78%	1.0378	0.0371
2000	59.858	3.00%	1.0300	0.0295
2001	62.900	5.08%	1.0508	0.0496
2002	60.992	-3.03%	0.9697	-0.0308
2003	62.964	3.23%	1.0323	0.0318
2004	65.161	3.49%	1.0349	0.0343
2005	67.781	4.02%	1.0402	0.0394

(K.P. 334.70)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	66.890	-1.31%	0.9869	-0.0132
2007	67.120	0.34%	1.0034	0.0034
2008	68.274	1.72%	1.0172	0.0170
2009	68.357	0.12%	1.0012	0.0012
2010	68.101	-0.37%	0.9963	-0.0038
2011	67.047	-1.55%	0.9845	-0.0156
2012	60.069	-10.41%	0.8959	-0.1099
2013	54.271	-9.65%	0.9035	-0.1015
2014	54.240	-0.06%	0.9994	-0.0006

Figure 11: Traffic Evolution in the Automatic Traffic Recorder Located at the K.P. 334.70 on the A-3 Motorway.

**ANNEX X: STATIONARITY ANALYSIS. CORRELOGRAMS OF
AUTOMATIC TRAFFIC RECORDERS ON A-3 MOTORWAY.**

Figure 1: Kilometre Point 18.90.

Sample: 1992 2014
Included observations: 23

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.715	0.715	13.364	0.000
		2 0.449	-0.127	18.891	0.000
		3 0.350	0.164	22.416	0.000
		4 0.242	-0.103	24.194	0.000
		5 0.171	0.060	25.125	0.000
		6 0.129	-0.024	25.684	0.000
		7 0.025	-0.132	25.707	0.001
		8 -0.000	0.097	25.707	0.001
		9 -0.002	-0.056	25.707	0.002
		10 -0.067	-0.077	25.905	0.004
		11 -0.110	-0.029	26.480	0.006
		12 -0.139	-0.071	27.489	0.007

Figure 5: Kilometre Point 86.90.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.863	0.863	22.443	0.000
		2 0.701	-0.172	37.848	0.000
		3 0.523	-0.153	46.778	0.000
		4 0.442	0.291	53.419	0.000
		5 0.365	-0.119	58.158	0.000
		6 0.319	0.012	61.950	0.000
		7 0.229	-0.126	64.008	0.000
		8 0.138	-0.086	64.791	0.000
		9 0.055	0.057	64.922	0.000
		10 -0.033	-0.224	64.973	0.000
		11 -0.112	-0.020	65.583	0.000
		12 -0.186	-0.047	67.391	0.000

Figure 2: Kilometre Point 30.10.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.895	0.895	24.129	0.000
		2 0.797	-0.022	44.018	0.000
		3 0.641	-0.343	57.435	0.000
		4 0.527	0.110	66.880	0.000
		5 0.410	0.002	72.874	0.000
		6 0.305	-0.137	76.343	0.000
		7 0.216	0.036	78.178	0.000
		8 0.112	-0.154	78.699	0.000
		9 0.029	-0.033	78.737	0.000
		10 -0.059	-0.024	78.896	0.000
		11 -0.123	-0.043	79.642	0.000
		12 -0.182	-0.022	81.363	0.000

Figure 6: Kilometre Point 130.10.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.841	0.841	21.302	0.000
		2 0.682	-0.087	35.860	0.000
		3 0.544	-0.021	45.509	0.000
		4 0.423	-0.030	51.613	0.000
		5 0.310	-0.058	55.043	0.000
		6 0.247	0.090	57.320	0.000
		7 0.184	-0.058	58.648	0.000
		8 0.117	-0.057	59.216	0.000
		9 0.041	-0.085	59.291	0.000
		10 -0.023	-0.033	59.315	0.000
		11 -0.080	-0.029	59.628	0.000
		12 -0.146	-0.104	60.735	0.000

Figure 3: Kilometre Point 48.50.

Sample: 1991 2014
Included observations: 24

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.804	0.804	17.554	0.000
		2 0.612	-0.100	28.174	0.000
		3 0.501	0.113	35.624	0.000
		4 0.420	0.009	41.140	0.000
		5 0.293	-0.162	43.955	0.000
		6 0.170	-0.049	44.961	0.000
		7 0.055	-0.117	45.070	0.000
		8 -0.044	-0.068	45.144	0.000
		9 -0.133	-0.071	45.879	0.000
		10 -0.203	-0.049	47.717	0.000
		11 -0.243	0.000	50.550	0.000
		12 -0.258	-0.003	54.024	0.000

Figure 7: Kilometre Point 150.80.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.819	0.819	20.219	0.000
		2 0.707	0.108	35.871	0.000
		3 0.598	-0.022	47.542	0.000
		4 0.456	-0.162	54.609	0.000
		5 0.337	-0.054	58.657	0.000
		6 0.288	0.144	61.754	0.000
		7 0.191	-0.118	63.179	0.000
		8 0.082	-0.163	63.457	0.000
		9 0.023	0.008	63.480	0.000
		10 -0.042	-0.002	63.562	0.000
		11 -0.115	-0.059	64.210	0.000
		12 -0.181	-0.143	65.920	0.000

Figure 4: Kilometre Point 60.20.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.869	0.869	22.727	0.000
		2 0.780	0.102	41.771	0.000
		3 0.664	-0.138	56.137	0.000
		4 0.532	-0.161	65.788	0.000
		5 0.405	-0.086	71.624	0.000
		6 0.301	0.025	74.993	0.000
		7 0.218	0.052	76.860	0.000
		8 0.121	-0.124	77.462	0.000
		9 0.025	-0.141	77.488	0.000
		10 -0.067	-0.094	77.696	0.000
		11 -0.150	-0.031	78.803	0.000
		12 -0.235	-0.068	81.690	0.000

Figure 8: Kilometre Point 278.80.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.859	0.859	22.243	0.000
		2 0.727	-0.043	38.814	0.000
		3 0.620	0.019	51.355	0.000
		4 0.482	-0.180	59.258	0.000
		5 0.346	-0.082	63.515	0.000
		6 0.273	0.133	66.297	0.000
		7 0.215	0.016	68.104	0.000
		8 0.136	-0.108	68.862	0.000
		9 0.074	-0.046	69.100	0.000
		10 -0.048	-0.338	69.208	0.000
		11 -0.158	-0.017	70.435	0.000
		12 -0.238	0.003	73.389	0.000

Figure 9: Kilometre Point 306.30.

Figure 11: Kilometre Point 334.70.

Figure 10: Kilometre Point 317.80.

**ANNEX XI: TRAFFIC TIME SERIES AT AUTOMATIC TRAFFIC
RECORDERS ON THE A-4 MOTORWAY.**

Table 1: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 19.00 on A-4 Motorway.

(K.P. 19.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1975	27.975			
1976	28.524	1.96%	1.0196	0.0194
1977	33.326	16.83%	1.1683	0.1556
1978	36.009	8.05%	1.0805	0.0774
1979	38.537	7.02%	1.0702	0.0678
1980	40.014	3.83%	1.0383	0.0376
1981	40.542	1.32%	1.0132	0.0131
1982	41.569	2.53%	1.0253	0.0250
1983	18.129	-56.39%	0.4361	-0.8298
1984	33.469	84.62%	1.8462	0.6131
1985	34.265	2.38%	1.0238	0.0235
1986	35.447	3.45%	1.0345	0.0339
1987	38.669	9.09%	1.0909	0.0870
1988	41.577	7.52%	1.0752	0.0725
1989	46.801	12.56%	1.1256	0.1184
1990	53.506	14.33%	1.1433	0.1339
1991	56.127	4.90%	1.0490	0.0478
1992	73.848	31.57%	1.3157	0.2744
1993	75.500	2.24%	1.0224	0.0221
1994	76.200	0.93%	1.0093	0.0092
1995	80.632	5.82%	1.0582	0.0565
1996	89.720	11.27%	1.1127	0.1068
1997	63.358	-29.38%	0.7062	-0.3479
1998	77.379	22.13%	1.2213	0.1999
1999	83.545	7.97%	1.0797	0.0767
2000	94.639	13.28%	1.1328	0.1247
2001	90.370	-4.51%	0.9549	-0.0462
2002	91.086	0.79%	1.0079	0.0079
2003	91.558	0.52%	1.0052	0.0052
2004	93.250	1.85%	1.0185	0.0183
2005	101.950	9.33%	1.0933	0.0892
2006	102.150	0.20%	1.0020	0.0020
2007	149.332	46.19%	1.4619	0.3797
2008	143.083	-4.18%	0.9582	-0.0427
2009	147.484	3.08%	1.0308	0.0303
2010	145.915	-1.06%	0.9894	-0.0107
2011	145.630	-0.20%	0.9980	-0.0020
2012	140.729	-3.37%	0.9663	-0.0342

(K.P. 19.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2013	138.439	-1.63%	0.9837	-0.0164
2014	147.992	6.90%	1.0690	0.0667

Figure 1: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 19.00 on the A-4 Motorway.

Table 2: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 65.00 on A-4 Motorway.

(K.P. 65.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	12.698			
1989	14.036	10.54%	1.1054	0.1002
1990	15.997	13.97%	1.1397	0.1308
1991	17.499	9.39%	1.0939	0.0897
1992	16.196	-7.45%	0.9255	-0.0774
1993	16.851	4.04%	1.0404	0.0396
1994	17.699	5.03%	1.0503	0.0491
1995	20.163	13.92%	1.1392	0.1303
1996	20.200	0.18%	1.0018	0.0018
1997	23.641	17.03%	1.1703	0.1573
1998	20.423	-13.61%	0.8639	-0.1463
1999	22.948	12.36%	1.1236	0.1166
2000	23.630	2.97%	1.0297	0.0293

(K.P. 65.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2001	24.448	3.46%	1.0346	0.0340
2002	24.846	1.63%	1.0163	0.0161
2003	27.244	9.65%	1.0965	0.0921
2004	36.510	34.01%	1.3401	0.2928
2005	36.899	1.07%	1.0107	0.0106
2006	31.689	-14.12%	0.8588	-0.1522
2007	32.162	1.49%	1.0149	0.0148
2008	28.252	-12.16%	0.8784	-0.1296
2009	24.752	-12.39%	0.8761	-0.1323
2010	26.098	5.44%	1.0544	0.0530
2011	27.512	5.42%	1.0542	0.0528
2012	26.287	-4.45%	0.9555	-0.0455
2013	26.241	-0.17%	0.9983	-0.0018
2014	28.737	9.51%	1.0951	0.0909

Figure 2: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 65.00 on the A-4 Motorway.

Table 3: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 80.21 on A-4 Motorway.

(K.P. 80.21)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	12.498			

(K.P. 80.21)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1989	12.234	-2.11%	0.9789	-0.0213
1990	13.998	14.42%	1.1442	0.1347
1991	15.998	14.29%	1.1429	0.1335
1992	14.846	-7.20%	0.9280	-0.0747
1993	15.600	5.08%	1.0508	0.0495
1994	16.799	7.69%	1.0769	0.0740
1995	20.049	19.35%	1.1935	0.1769
1996	20.100	0.25%	1.0025	0.0025
1997	22.869	13.78%	1.1378	0.1291
1998	22.870	0.00%	1.0000	0.0000
1999	23.147	1.21%	1.0121	0.0120
2000	23.834	2.97%	1.0297	0.0292
2001	24.660	3.47%	1.0347	0.0341
2002	24.975	1.28%	1.0128	0.0127
2003	33.078	32.44%	1.3244	0.2810
2004	35.757	8.10%	1.0810	0.0779
2005	35.372	-1.08%	0.9892	-0.0108
2006	35.447	0.21%	1.0021	0.0021
2007	33.484	-5.54%	0.9446	-0.0570
2008	30.837	-7.91%	0.9209	-0.0824
2009	29.741	-3.55%	0.9645	-0.0362
2010	26.938	-9.42%	0.9058	-0.0990
2011	25.256	-6.24%	0.9376	-0.0645
2012	24.516	-2.93%	0.9707	-0.0297
2013	23.775	-3.02%	0.9698	-0.0307
2014	23.261	-2.16%	0.9784	-0.0219

Figure 3: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 80.21 on the A-4 Motorway.

Table 4: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 96.60 on A-4 Motorway.

(K.P. 96.60)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1960	1.390			
1961	1.516	9.06%	1.0906	0.0868
1962	1.693	11.68%	1.1168	0.1104
1963	2.243	32.49%	1.3249	0.2813
1964	2.438	8.69%	1.0869	0.0834
1965	3.138	28.71%	1.2871	0.2524
1966	3.582	14.15%	1.1415	0.1323
1967	3.874	8.15%	1.0815	0.0784
1968	4.183	7.98%	1.0798	0.0767
1969	4.386	4.85%	1.0485	0.0474
1970	4.749	8.28%	1.0828	0.0795
1971	4.894	3.05%	1.0305	0.0301
1972	6.151	25.68%	1.2568	0.2286
1973	6.237	1.40%	1.0140	0.0139
1974	6.794	8.93%	1.0893	0.0855
1975	6.855	0.90%	1.0090	0.0089
1976	7.046	2.79%	1.0279	0.0275
1977	7.274	3.24%	1.0324	0.0318
1978	6.603	-9.22%	0.9078	-0.0968

(K.P. 96.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1979	6.792	2.86%	1.0286	0.0282
1980	6.732	-0.88%	0.9912	-0.0089
1981	7.293	8.33%	1.0833	0.0800
1982	7.900	8.32%	1.0832	0.0799
1983	8.551	8.24%	1.0824	0.0792
1984	7.619	-10.90%	0.8910	-0.1154
1985	8.265	8.48%	1.0848	0.0814
1986	9.886	19.61%	1.1961	0.1791
1987	11.186	13.15%	1.1315	0.1235
1988	10.825	-3.23%	0.9677	-0.0328
1989	11.527	6.48%	1.0648	0.0628
1990	13.231	14.78%	1.1478	0.1379
1991	16.762	26.69%	1.2669	0.2366
1992	16.027	-4.38%	0.9562	-0.0448
1993	16.791	4.77%	1.0477	0.0466
1994	17.700	5.41%	1.0541	0.0527
1995	15.666	-11.49%	0.8851	-0.1221
1996	17.297	10.41%	1.1041	0.0990
1997	18.265	5.60%	1.0560	0.0545
1998	17.782	-2.64%	0.9736	-0.0268
1999	20.514	15.36%	1.1536	0.1429
2000	21.453	4.58%	1.0458	0.0448
2001	21.846	1.83%	1.0183	0.0182
2002	26.068	19.33%	1.1933	0.1767
2003	27.534	5.62%	1.0562	0.0547
2004	30.080	9.25%	1.0925	0.0884
2005	29.996	-0.28%	0.9972	-0.0028
2006	29.368	-2.09%	0.9791	-0.0212
2007	30.868	5.11%	1.0511	0.0498
2008	27.824	-9.86%	0.9014	-0.1038
2009	27.109	-2.57%	0.9743	-0.0260
2010	24.089	-11.14%	0.8886	-0.1181
2011	24.980	3.70%	1.0370	0.0363
2012	22.496	-9.94%	0.9006	-0.1047
2013	21.903	-2.64%	0.9736	-0.0267
2014	21.701	-0.92%	0.9908	-0.0093

Figure 4: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 96.60 on the A-4 Motorway.

Table 5: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 122.60 on A-4 Motorway.

(K.P. 122.60)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1960	1.392			
1961	1.376	-1.15%	0.9885	-0.0116
1962	1.739	26.38%	1.2638	0.2341
1963	1.896	9.03%	1.0903	0.0864
1964	2.111	11.34%	1.1134	0.1074
1965	2.335	10.61%	1.1061	0.1009
1966	2.583	10.62%	1.1062	0.1009
1967	2.988	15.68%	1.1568	0.1457
1968	3.662	22.56%	1.2256	0.2034
1969	5.363	46.45%	1.4645	0.3815
1970	5.822	8.56%	1.0856	0.0821
1971	6.243	7.23%	1.0723	0.0698
1972	6.644	6.42%	1.0642	0.0623
1973	7.206	8.46%	1.0846	0.0812
1974	7.826	8.60%	1.0860	0.0825
1975	7.282	-6.95%	0.9305	-0.0720
1976	8.211	12.76%	1.1276	0.1201
1977	8.955	9.06%	1.0906	0.0867
1978	9.595	7.15%	1.0715	0.0690

(K.P. 122.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1979	10.101	5.27%	1.0527	0.0514
1980	10.281	1.78%	1.0178	0.0177
1981	9.501	-7.59%	0.9241	-0.0789
1982	10.149	6.82%	1.0682	0.0660
1983	9.704	-4.38%	0.9562	-0.0448
1984	7.286	-24.92%	0.7508	-0.2866
1985	8.590	17.90%	1.1790	0.1646
1986	9.536	11.01%	1.1101	0.1045
1987	10.035	5.23%	1.0523	0.0510
1988	10.838	8.00%	1.0800	0.0770
1989	12.597	16.23%	1.1623	0.1504
1990	12.893	2.35%	1.0235	0.0232
1991	14.000	8.59%	1.0859	0.0824
1992	15.600	11.43%	1.1143	0.1082
1993	15.700	0.64%	1.0064	0.0064
1994	16.500	5.10%	1.0510	0.0497
1995	17.500	6.06%	1.0606	0.0588
1996	17.700	1.14%	1.0114	0.0114
1997	19.660	11.07%	1.1107	0.1050
1998	19.124	-2.73%	0.9727	-0.0276
1999	22.521	17.76%	1.1776	0.1635
2000	22.691	0.75%	1.0075	0.0075
2001	23.003	1.37%	1.0137	0.0137
2002	25.349	10.20%	1.1020	0.0971
2003	26.664	5.19%	1.0519	0.0506
2004	28.024	5.10%	1.0510	0.0497
2005	29.662	5.84%	1.0584	0.0568
2006	30.337	2.28%	1.0228	0.0225
2007	30.960	2.05%	1.0205	0.0203
2008	20.273	-34.52%	0.6548	-0.4234
2009	24.634	21.51%	1.2151	0.1948
2010	23.332	-5.29%	0.9471	-0.0543
2011	21.839	-6.40%	0.9360	-0.0661
2012	21.023	-3.74%	0.9626	-0.0381
2013	19.834	-5.66%	0.9434	-0.0582
2014	21.693	9.37%	1.0937	0.0896

Figure 5: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 122.60 on the A-4 Motorway.

Table 6: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 130.00 on A-4 Motorway.

(K.P. 130.00)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	10.498			
1989	10.998	4.76%	1.0476	0.0465
1990	11.198	1.82%	1.0182	0.0180
1991	11.998	7.14%	1.0714	0.0690
1992	12.824	6.88%	1.0688	0.0666
1993	13.500	5.27%	1.0527	0.0514
1994	14.000	3.70%	1.0370	0.0364
1995	14.800	5.71%	1.0571	0.0556
1996	16.999	14.86%	1.1486	0.1385
1997	18.999	11.77%	1.1177	0.1112
1998	19.101	0.54%	1.0054	0.0054
1999	20.849	9.15%	1.0915	0.0876
2000	21.470	2.98%	1.0298	0.0294
2001	22.216	3.47%	1.0347	0.0342
2002	22.606	1.76%	1.0176	0.0174
2003	23.524	4.06%	1.0406	0.0398
2004	22.350	-4.99%	0.9501	-0.0512
2005	27.500	23.04%	1.2304	0.2074
2006	31.720	15.35%	1.1535	0.1428

(K.P. 130.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	30.120	-5.04%	0.9496	-0.0518
2008	25.160	-16.47%	0.8353	-0.1799
2009	21.890	-13.00%	0.8700	-0.1392
2010	22.089	0.91%	1.0091	0.0090
2011	20.738	-6.12%	0.9388	-0.0631
2012	20.800	0.30%	1.0030	0.0030
2013	20.578	-1.07%	0.9893	-0.0107
2014	22.387	8.79%	1.0879	0.0843

Figure 6: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 130.00 on the A-4 Motorway.

Table 7: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 196.90 on A-4 Motorway.

(K.P. 196.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.998			
1989	7.998	0.00%	1.0000	0.0000
1990	8.498	6.25%	1.0625	0.0606
1991	8.498	0.00%	1.0000	0.0000
1992	9.642	13.46%	1.1346	0.1263
1993	8.599	-10.82%	0.8918	-0.1145
1994	11.253	30.86%	1.3086	0.2690

(K.P. 196.90)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1995	11.604	3.12%	1.0312	0.0307
1996	12.063	3.96%	1.0396	0.0388
1997	11.752	-2.58%	0.9742	-0.0261
1998	11.445	-2.61%	0.9739	-0.0265
1999	12.207	6.66%	1.0666	0.0645
2000	14.791	21.17%	1.2117	0.1920
2001	14.792	0.01%	1.0001	0.0001
2002	15.888	7.41%	1.0741	0.0715
2003	16.704	5.14%	1.0514	0.0501
2004	18.857	12.89%	1.1289	0.1212
2005	17.718	-6.04%	0.9396	-0.0623
2006	17.411	-1.73%	0.9827	-0.0175
2007	19.552	12.30%	1.1230	0.1160
2008	19.305	-1.26%	0.9874	-0.0127
2009	16.609	-13.97%	0.8603	-0.1504
2010	19.342	16.45%	1.1645	0.1523
2011	14.523	-24.91%	0.7509	-0.2865
2012	14.172	-2.42%	0.9758	-0.0245
2013	13.264	-6.41%	0.9359	-0.0662
2014	16.500	24.40%	1.2440	0.2183

Figure 7: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 196.90 on the A-4 Motorway.

Table 8: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 265.91 on A-4 Motorway.

(K.P. 265.91)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1974	7.588			
1975	8.832	16.39%	1.1639	0.1518
1976	9.455	7.05%	1.0705	0.0682
1977	9.842	4.09%	1.0409	0.0401
1978	9.883	0.42%	1.0042	0.0042
1979	10.148	2.68%	1.0268	0.0265
1980	9.905	-2.39%	0.9761	-0.0242
1981	10.180	2.78%	1.0278	0.0274
1982	10.430	2.46%	1.0246	0.0243
1983	9.979	-4.32%	0.9568	-0.0442
1984	9.444	-5.36%	0.9464	-0.0551
1985	8.071	-14.54%	0.8546	-0.1571
1986	9.436	16.91%	1.1691	0.1563
1987	9.888	4.79%	1.0479	0.0468
1988	11.845	19.79%	1.1979	0.1806
1989	12.846	8.45%	1.0845	0.0811
1990	13.253	3.17%	1.0317	0.0312
1991	12.472	-5.89%	0.9411	-0.0607
1992	12.444	-0.22%	0.9978	-0.0022
1993	13.500	8.49%	1.0849	0.0815
1994	17.986	33.23%	1.3323	0.2869
1995	17.636	-1.95%	0.9805	-0.0197
1996	18.332	3.95%	1.0395	0.0387
1997	16.752	-8.62%	0.9138	-0.0901
1998	18.268	9.05%	1.0905	0.0866
1999	20.552	12.50%	1.1250	0.1178
2000	22.720	10.55%	1.1055	0.1003
2001	22.032	-3.03%	0.9697	-0.0307
2002	24.277	10.19%	1.1019	0.0970
2003	25.528	5.15%	1.0515	0.0502
2004	27.112	6.20%	1.0620	0.0602
2005	26.896	-0.80%	0.9920	-0.0080
2006	26.082	-3.03%	0.9697	-0.0307
2007	25.438	-2.47%	0.9753	-0.0250
2008	23.111	-9.15%	0.9085	-0.0959
2009	22.097	-4.39%	0.9561	-0.0449
2010	21.365	-3.31%	0.9669	-0.0337
2011	20.545	-3.84%	0.9616	-0.0391

(K.P. 265.91)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2012	19.287	-6.12%	0.9388	-0.0632
2013	19.608	1.66%	1.0166	0.0165
2014	19.608	0.00%	1.0000	0.0000

Figure 8: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 265.91 on the A-4 Motorway.

Table 9: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 283.10 on A-4 Motorway.

(K.P. 283.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	11.199			
1989	11.497	2.66%	1.0266	0.0263
1990	11.999	4.37%	1.0437	0.0427
1991	11.998	-0.01%	0.9999	-0.0001
1992	11.664	-2.78%	0.9722	-0.0282
1993	13.500	15.74%	1.1574	0.1462
1994	15.000	11.11%	1.1111	0.1054
1995	17.299	15.33%	1.1533	0.1426
1996	17.799	2.89%	1.0289	0.0285
1997	16.500	-7.30%	0.9270	-0.0758
1998	20.047	21.50%	1.2150	0.1947
1999	20.545	2.48%	1.0248	0.0245

(K.P. 283.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2000	23.069	12.29%	1.1229	0.1159
2001	25.894	12.25%	1.1225	0.1155
2002	24.572	-5.11%	0.9489	-0.0524
2003	27.134	10.43%	1.1043	0.0992
2004	23.266	-14.26%	0.8574	-0.1538
2005	27.381	17.69%	1.1769	0.1629
2006	27.607	0.83%	1.0083	0.0082
2007	27.356	-0.91%	0.9909	-0.0091
2008	28.255	3.29%	1.0329	0.0323
2009	22.033	-22.02%	0.7798	-0.2487
2010	24.362	10.57%	1.1057	0.1005
2011	22.548	-7.45%	0.9255	-0.0774
2012	22.081	-2.07%	0.9793	-0.0209
2013	20.310	-8.02%	0.9198	-0.0836
2014	21.480	5.76%	1.0576	0.0560

Figure 9: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 283.10 on the A-4 Motorway.

Table 10: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 290.64 on A-4 Motorway.

(K.P. 290.64)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	10.551			
1989	12.719	20.55%	1.2055	0.1869
1990	14.058	10.53%	1.1053	0.1001
1991	13.562	-3.53%	0.9647	-0.0359
1992	13.700	1.02%	1.0102	0.0101
1993	6.789	-50.45%	0.4955	-0.7021
1994	14.271	110.21%	2.1021	0.7429
1995	16.549	15.96%	1.1596	0.1481
1996	17.250	4.24%	1.0424	0.0415
1997	19.604	13.65%	1.1365	0.1279
1998	20.168	2.88%	1.0288	0.0284
1999	23.426	16.15%	1.1615	0.1497
2000	23.322	-0.44%	0.9956	-0.0044
2001	24.730	6.04%	1.0604	0.0586
2002	27.704	12.03%	1.1203	0.1136
2003	24.600	-11.20%	0.8880	-0.1188
2004	26.567	8.00%	1.0800	0.0769
2005	28.672	7.92%	1.0792	0.0763
2006	26.273	-8.37%	0.9163	-0.0874
2007	29.389	11.86%	1.1186	0.1121
2008	25.677	-12.63%	0.8737	-0.1350
2009	23.345	-9.08%	0.9092	-0.0952
2010	26.764	14.65%	1.1465	0.1367
2011	23.821	-11.00%	0.8900	-0.1165
2012	23.388	-1.82%	0.9818	-0.0183
2013	23.085	-1.30%	0.9870	-0.0130
2014	20.963	-9.19%	0.9081	-0.0964

Figure 10: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 290.64 on the A-4 Motorway.

Table 11: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 308.60 on A-4 Motorway.

(K.P. 308.60)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	9.998			
1989	12.498	25.01%	1.2501	0.2232
1990	12.997	3.99%	1.0399	0.0391
1991	13.325	2.52%	1.0252	0.0249
1992	12.787	-4.04%	0.9596	-0.0412
1993	14.500	13.40%	1.1340	0.1257
1994	15.500	6.90%	1.0690	0.0667
1995	17.000	9.68%	1.0968	0.0924
1996	17.046	0.27%	1.0027	0.0027
1997	17.000	-0.27%	0.9973	-0.0027
1998	17.000	0.00%	1.0000	0.0000
1999	18.344	7.91%	1.0791	0.0761
2000	18.232	-0.61%	0.9939	-0.0061
2001	19.532	7.13%	1.0713	0.0689
2002	21.464	9.89%	1.0989	0.0943
2003	21.748	1.32%	1.0132	0.0131
2004	22.149	1.84%	1.0184	0.0183
2005	22.100	-0.22%	0.9978	-0.0022
2006	17.745	-19.71%	0.8029	-0.2195

(K.P. 308.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	17.950	1.16%	1.0116	0.0115
2008	16.683	-7.06%	0.9294	-0.0732
2009	16.062	-3.72%	0.9628	-0.0379
2010	15.803	-1.61%	0.9839	-0.0163
2011	14.504	-8.22%	0.9178	-0.0858
2012	13.634	-6.00%	0.9400	-0.0619
2013	13.554	-0.59%	0.9941	-0.0059
2014	13.207	-2.56%	0.9744	-0.0259

Figure 11: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 308.60 on the A-4 Motorway.

Table 12: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 356.77 on A-4 Motorway.

(K.P. 356.77)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.798			
1989	8.298	6.41%	1.0641	0.0621
1990	8.998	8.44%	1.0844	0.0810
1991	9.997	11.10%	1.1110	0.1053
1992	9.610	-3.87%	0.9613	-0.0395
1993	12.999	35.27%	1.3527	0.3021
1994	12.999	0.00%	1.0000	0.0000

(K.P. 356.77)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1995	13.500	3.85%	1.0385	0.0378
1996	13.999	3.70%	1.0370	0.0363
1997	14.500	3.58%	1.0358	0.0352
1998	15.800	8.97%	1.0897	0.0859
1999	16.420	3.92%	1.0392	0.0385
2000	17.630	7.37%	1.0737	0.0711
2001	17.988	2.03%	1.0203	0.0201
2002	17.680	-1.71%	0.9829	-0.0173
2003	18.146	2.64%	1.0264	0.0260
2004	19.125	5.40%	1.0540	0.0525
2005	17.249	-9.81%	0.9019	-0.1032
2006	17.276	0.16%	1.0016	0.0016
2007	18.907	9.44%	1.0944	0.0902
2008	19.283	1.99%	1.0199	0.0197
2009	17.043	-11.62%	0.8838	-0.1235
2010	15.908	-6.66%	0.9334	-0.0689
2011	16.438	3.33%	1.0333	0.0328
2012	14.678	-10.71%	0.8929	-0.1132
2013	15.371	4.72%	1.0472	0.0461
2014	14.639	-4.76%	0.9524	-0.0488

Figure 12: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 356.77 on the A-4 Motorway.

Table 13: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 369.80 on A-4 Motorway.

(K.P. 369.80)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	8.598			
1989	8.998	4.65%	1.0465	0.0455
1990	9.999	11.12%	1.1112	0.1055
1991	10.998	9.99%	1.0999	0.0952
1992	10.645	-3.21%	0.9679	-0.0326
1993	11.433	7.40%	1.0740	0.0714
1994	11.700	2.34%	1.0234	0.0231
1995	11.999	2.56%	1.0256	0.0252
1996	14.000	16.68%	1.1668	0.1542
1997	14.500	3.57%	1.0357	0.0351
1998	15.800	8.97%	1.0897	0.0859
1999	15.905	0.66%	1.0066	0.0066
2000	17.099	7.51%	1.0751	0.0724
2001	17.496	2.32%	1.0232	0.0230
2002	17.645	0.85%	1.0085	0.0085
2003	18.898	7.10%	1.0710	0.0686
2004	19.380	2.55%	1.0255	0.0252
2005	19.169	-1.09%	0.9891	-0.0109
2006	21.742	13.42%	1.1342	0.1260
2007	21.901	0.73%	1.0073	0.0073
2008	20.716	-5.41%	0.9459	-0.0556
2009	18.336	-11.49%	0.8851	-0.1220
2010	18.078	-1.41%	0.9859	-0.0142
2011	17.290	-4.36%	0.9564	-0.0446
2012	16.560	-4.22%	0.9578	-0.0431
2013	15.630	-5.62%	0.9438	-0.0578
2014	15.985	2.27%	1.0227	0.0225

Figure 13: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 369.80 on the A-4 Motorway.

Table 14: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 408.80 on A-4 Motorway.

(K.P. 408.80)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	16.998			
1989	18.498	8.82%	1.0882	0.0846
1990	19.897	7.56%	1.0756	0.0729
1991	23.998	20.61%	1.2061	0.1874
1992	24.353	1.48%	1.0148	0.0147
1993	25.000	2.66%	1.0266	0.0262
1994	24.999	0.00%	1.0000	0.0000
1995	30.000	20.00%	1.2000	0.1824
1996	32.500	8.33%	1.0833	0.0800
1997	34.000	4.62%	1.0462	0.0451
1998	35.700	5.00%	1.0500	0.0488
1999	29.753	-16.66%	0.8334	-0.1822
2000	30.386	2.13%	1.0213	0.0211
2001	34.840	14.66%	1.1466	0.1368
2002	35.496	1.88%	1.0188	0.0187
2003	27.236	-23.27%	0.7673	-0.2649
2004	41.750	53.29%	1.5329	0.4272
2005	31.598	-24.32%	0.7568	-0.2786
2006	34.334	8.66%	1.0866	0.0830

(K.P. 408.80)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	28.577	-16.77%	0.8323	-0.1835
2008	25.927	-9.27%	0.9073	-0.0973
2009	27.152	4.72%	1.0472	0.0462
2010	24.105	-11.22%	0.8878	-0.1190
2011	21.510	-10.77%	0.8923	-0.1139
2012	20.176	-6.20%	0.9380	-0.0640
2013	18.392	-8.84%	0.9116	-0.0926
2014	17.318	-5.84%	0.9416	-0.0602

Figure 14: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 408.80 on the A-4 Motorway.

Table 15: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 427.00 on A-4 Motorway.

(K.P. 427.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.998			
1989	8.398	5.00%	1.0500	0.0488
1990	8.898	5.95%	1.0595	0.0578
1991	9.998	12.36%	1.1236	0.1166
1992	10.253	2.55%	1.0255	0.0252
1993	10.499	2.40%	1.0240	0.0237
1994	10.500	0.01%	1.0001	0.0001

(K.P. 427.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1995	12.552	19.54%	1.1954	0.1785
1996	13.400	6.76%	1.0676	0.0654
1997	13.750	2.61%	1.0261	0.0258
1998	14.400	4.73%	1.0473	0.0462
1999	13.239	-8.06%	0.9194	-0.0841
2000	18.506	39.78%	1.3978	0.3349
2001	21.634	16.90%	1.1690	0.1562
2002	21.746	0.52%	1.0052	0.0052
2003	22.449	3.23%	1.0323	0.0318
2004	22.506	0.25%	1.0025	0.0025
2005	25.682	14.11%	1.1411	0.1320
2006	23.755	-7.50%	0.9250	-0.0780
2007	20.026	-15.70%	0.8430	-0.1708
2008	18.570	-7.27%	0.9273	-0.0755
2009	19.247	3.65%	1.0365	0.0358
2010	20.837	8.26%	1.0826	0.0794
2011	19.893	-4.53%	0.9547	-0.0464
2012	18.986	-4.56%	0.9544	-0.0467
2013	18.495	-2.59%	0.9741	-0.0262
2014	18.191	-1.64%	0.9836	-0.0166

Figure 15: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 427.00 on the A-4 Motorway.

Table 16: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 435.10 on A-4 Motorway.

(K.P. 435.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.498			
1989	7.798	4.00%	1.0400	0.0392
1990	7.999	2.58%	1.0258	0.0254
1991	8.499	6.25%	1.0625	0.0606
1992	8.626	1.49%	1.0149	0.0148
1993	9.000	4.34%	1.0434	0.0424
1994	10.000	11.11%	1.1111	0.1054
1995	12.000	20.00%	1.2000	0.1823
1996	12.800	6.67%	1.0667	0.0645
1997	12.899	0.77%	1.0077	0.0077
1998	13.545	5.01%	1.0501	0.0489
1999	13.945	2.95%	1.0295	0.0291
2000	17.699	26.92%	1.2692	0.2384
2001	18.100	2.27%	1.0227	0.0224
2002	18.548	2.48%	1.0248	0.0245
2003	18.645	0.52%	1.0052	0.0052
2004	18.700	0.29%	1.0029	0.0029
2005	20.950	12.03%	1.1203	0.1136
2006	19.466	-7.08%	0.9292	-0.0735
2007	18.174	-6.64%	0.9336	-0.0687
2008	14.654	-19.37%	0.8063	-0.2153
2009	17.252	17.73%	1.1773	0.1632
2010	15.594	-9.61%	0.9039	-0.1010
2011	15.443	-0.97%	0.9903	-0.0097
2012	14.103	-8.68%	0.9132	-0.0908
2013	13.463	-4.54%	0.9546	-0.0464
2014	14.095	4.69%	1.0469	0.0459

Figure 16: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 435.10 on the A-4 Motorway.

Table 17: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 456.00 on A-4 Motorway.

(K.P. 456.00)				
Year	AADTi	Variation (%)	AADTi / AADTi(i-1)	ln(AADTi / AADTi(i-1))
1988	11.498			
1989	13.398	16.52%	1.1652	0.1529
1990	14.498	8.21%	1.0821	0.0789
1991	14.561	0.43%	1.0043	0.0043
1992	14.816	1.75%	1.0175	0.0174
1993	12.000	-19.01%	0.8099	-0.2108
1994	13.499	12.49%	1.1249	0.1177
1995	13.500	0.01%	1.0001	0.0001
1996	13.000	-3.70%	0.9630	-0.0377
1997	14.175	9.04%	1.0904	0.0865
1998	15.849	11.81%	1.1181	0.1116
1999	15.918	0.44%	1.0044	0.0043
2000	16.146	1.43%	1.0143	0.0142
2001	17.096	5.88%	1.0588	0.0572
2002	22.126	29.42%	1.2942	0.2579
2003	22.748	2.81%	1.0281	0.0277
2004	21.566	-5.20%	0.9480	-0.0534
2005	26.968	25.05%	1.2505	0.2235

(K.P. 456.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	20.722	-23.16%	0.7684	-0.2635
2007	23.184	11.88%	1.1188	0.1123
2008	24.605	6.13%	1.0613	0.0595
2009	23.203	-5.70%	0.9430	-0.0587
2010	21.982	-5.26%	0.9474	-0.0541
2011	23.592	7.32%	1.0732	0.0707
2012	20.447	-13.33%	0.8667	-0.1431
2013	19.809	-3.12%	0.9688	-0.0317
2014	19.957	0.75%	1.0075	0.0074

Figure 17: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 456.00 on the A-4 Motorway.

Table 18: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 505.00 on A-4 Motorway.

(K.P. 505.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	9.498			
1989	9.798	3.16%	1.0316	0.0311
1990	10.017	2.24%	1.0224	0.0221
1991	11.808	17.88%	1.1788	0.1645
1992	11.951	1.21%	1.0121	0.0120
1993	12.000	0.41%	1.0041	0.0041

(K.P. 505.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1994	14.649	22.08%	1.2208	0.1995
1995	15.000	2.40%	1.0240	0.0237
1996	12.894	-14.04%	0.8596	-0.1513
1997	13.050	1.21%	1.0121	0.0120
1998	13.699	4.97%	1.0497	0.0485
1999	15.119	10.37%	1.1037	0.0986
2000	18.049	19.38%	1.1938	0.1771
2001	18.148	0.55%	1.0055	0.0055
2002	15.594	-14.07%	0.8593	-0.1517
2003	16.370	4.98%	1.0498	0.0486
2004	20.544	25.50%	1.2550	0.2271
2005	22.100	7.57%	1.0757	0.0730
2006	22.510	1.86%	1.0186	0.0184
2007	17.896	-20.50%	0.7950	-0.2294
2008	18.987	6.10%	1.0610	0.0592
2009	17.672	-6.93%	0.9307	-0.0718
2010	17.439	-1.32%	0.9868	-0.0133
2011	17.067	-2.13%	0.9787	-0.0216
2012	15.771	-7.59%	0.9241	-0.0790
2013	15.797	0.16%	1.0016	0.0016
2014	15.857	0.38%	1.0038	0.0038

Figure 18: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 505.00 on the A-4 Motorway.

Table 19: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 525.00 on A-4 Motorway.

(K.P. 525.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	11.998			
1989	12.498	4.17%	1.0417	0.0408
1990	13.998	12.00%	1.1200	0.1133
1991	18.542	32.46%	1.3246	0.2811
1992	18.765	1.20%	1.0120	0.0120
1993	17.000	-9.41%	0.9059	-0.0988
1994	21.481	26.36%	1.2636	0.2340
1995	21.000	-2.24%	0.9776	-0.0226
1996	21.250	1.19%	1.0119	0.0118
1997	23.150	8.94%	1.0894	0.0856
1998	24.687	6.64%	1.0664	0.0643
1999	25.451	3.09%	1.0309	0.0305
2000	25.845	1.55%	1.0155	0.0154
2001	27.140	5.01%	1.0501	0.0489
2002	31.608	16.46%	1.1646	0.1524
2003	33.098	4.71%	1.0471	0.0461
2004	34.591	4.51%	1.0451	0.0441
2005	35.055	1.34%	1.0134	0.0133
2006	35.350	0.84%	1.0084	0.0084
2007	49.190	39.15%	1.3915	0.3304
2008	44.561	-9.41%	0.9059	-0.0988
2009	40.990	-8.01%	0.9199	-0.0835
2010	43.973	7.28%	1.0728	0.0702
2011	39.493	-10.19%	0.8981	-0.1075
2012	38.756	-1.87%	0.9813	-0.0188
2013	38.501	-0.66%	0.9934	-0.0066
2014	38.535	0.09%	1.0009	0.0009

Figure 19: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 525.00 on the A-4 Motorway.

Table 17: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 531.00 on A-4 Motorway.

(K.P. 531.00)				
Year	AADTi	Variation (%)	AADTi / AADTi(i-1)	ln(AADTi / AADTi(i-1))
1988	20.788			
1989	23.740	14.20%	1.1420	0.1328
1990	27.322	15.09%	1.1509	0.1405
1991	27.294	-0.10%	0.9990	-0.0010
1992	28.200	3.32%	1.0332	0.0327
1993	22.372	-20.67%	0.7933	-0.2315
1994	26.048	16.43%	1.1643	0.1521
1995	24.080	-7.56%	0.9244	-0.0786
1996	24.400	1.33%	1.0133	0.0132
1997	26.574	8.91%	1.0891	0.0854
1998	29.330	10.37%	1.1037	0.0987
1999	33.191	13.16%	1.1316	0.1237
2000	35.639	7.38%	1.0738	0.0712
2001	40.072	12.44%	1.1244	0.1172
2002	41.556	3.70%	1.0370	0.0364
2003	43.211	3.98%	1.0398	0.0391
2004	46.733	8.15%	1.0815	0.0784
2005	52.538	12.42%	1.1242	0.1171
2006	53.837	2.47%	1.0247	0.0244

(K.P. 531.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	54.650	1.51%	1.0151	0.0150
2008	56.450	3.29%	1.0329	0.0324
2009	55.801	-1.15%	0.9885	-0.0116
2010	54.921	-1.58%	0.9842	-0.0159
2011	53.292	-2.97%	0.9703	-0.0301
2012	50.309	-5.60%	0.9440	-0.0576
2013	48.548	-3.50%	0.9650	-0.0356
2014	48.917	0.76%	1.0076	0.0076

Figure 17: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 531.00 on the A-4 Motorway.

Table 18: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 667.33 on A-4 Motorway.

(K.P. 667.33)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	11.549			
1989	11.511	-0.33%	0.9967	-0.0033
1990	15.297	32.89%	1.3289	0.2844
1991	15.776	3.13%	1.0313	0.0308
1992	16.983	7.65%	1.0765	0.0737
1993	18.500	8.93%	1.0893	0.0856
1994	19.000	2.70%	1.0270	0.0267

(K.P. 667.33)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1995	19.000	0.00%	1.0000	0.0000
1996	19.199	1.05%	1.0105	0.0104
1997	20.000	4.17%	1.0417	0.0409
1998	21.200	6.00%	1.0600	0.0583
1999	21.493	1.38%	1.0138	0.0137
2000	22.130	2.96%	1.0296	0.0292
2001	22.902	3.49%	1.0349	0.0343
2002	28.628	25.00%	1.2500	0.2232
2003	33.310	16.35%	1.1635	0.1515
2004	34.721	4.24%	1.0424	0.0415
2005	34.338	-1.10%	0.9890	-0.0111
2006	34.550	0.62%	1.0062	0.0062
2007	45.469	31.60%	1.3160	0.2746
2008	42.854	-5.75%	0.9425	-0.0592
2009	38.453	-10.27%	0.8973	-0.1084
2010	40.096	4.27%	1.0427	0.0418
2011	40.084	-0.03%	0.9997	-0.0003
2012	35.893	-10.46%	0.8954	-0.1104
2013	34.189	-4.75%	0.9525	-0.0486
2014	33.881	-0.90%	0.9910	-0.0090

Figure 18: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 667.33 on the A-4 Motorway.

**ANNEX XII: STATIONARITY ANALYSIS. CORRELOGRAMS OF
AUTOMATIC TRAFFIC RECORDERS ON A-4 MOTORWAY.**

Figure 1: Kilometre Point 19.00.

Sample: 1975 2014
Included observations: 40

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.886	0.886	33.813	0.000
2	0.818	0.153	63.379	0.000
3	0.748	-0.004	88.810	0.000
4	0.678	-0.038	110.27	0.000
5	0.609	-0.038	128.07	0.000
6	0.545	-0.017	142.74	0.000
7	0.486	-0.006	154.79	0.000
8	0.419	-0.071	164.01	0.000
9	0.306	-0.280	169.07	0.000
10	0.239	0.061	172.28	0.000
11	0.187	0.083	174.31	0.000
12	0.127	-0.045	175.27	0.000
13	0.066	-0.074	175.54	0.000
14	0.027	0.037	175.59	0.000
15	-0.043	-0.164	175.72	0.000
16	-0.101	-0.019	176.43	0.000
17	-0.156	0.005	178.20	0.000
18	-0.173	0.057	180.50	0.000
19	-0.219	-0.151	184.32	0.000
20	-0.259	-0.037	189.98	0.000

Figure 2: Kilometre Point 65.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.827	0.827	20.621	0.000
		2	0.682	-0.008	35.200	0.000
		3	0.573	0.034	45.924	0.000
		4	0.481	-0.001	53.813	0.000
		5	0.361	-0.134	58.464	0.000
		6	0.278	0.032	61.349	0.000
		7	0.187	-0.092	62.721	0.000
		8	0.098	-0.065	63.113	0.000
		9	0.002	-0.089	63.113	0.000
		10	-0.062	-0.012	63.290	0.000
		11	-0.204	-0.315	65.325	0.000
		12	-0.283	0.049	69.497	0.000

Figure 3: Kilometre Point 80.21.

Sample: 1988 2014
Included observations: 27

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob	
1		1		1	0.893	0.893	24.033	0.000
2		2		2	0.757	-0.204	41.971	0.000
3		3		3	0.632	0.001	54.997	0.000
4		4		4	0.520	-0.025	64.219	0.000
5		5		5	0.378	-0.249	69.293	0.000
6		6		6	0.245	0.004	71.522	0.000
7		7		7	0.112	-0.142	72.013	0.000
8		8		8	0.019	0.092	72.028	0.000
9		9		9	-0.082	-0.173	72.320	0.000
10		10		10	-0.162	0.026	73.532	0.000
11		11		11	-0.243	-0.123	76.427	0.000
12		12		12	-0.308	-0.079	81.387	0.000

Figure 4: Kilometre Point 96.60.

Sample: 1960 2014
Included observations: 55

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob	
			1	0.934	0.934	50.695	0.000
			2	0.868	-0.043	95.241	0.000
			3	0.800	-0.047	133.80	0.000
			4	0.738	0.015	167.30	0.000
			5	0.677	-0.035	196.03	0.000
			6	0.621	0.008	220.74	0.000
			7	0.569	-0.006	241.90	0.000
			8	0.517	-0.040	259.70	0.000
			9	0.466	-0.013	274.51	0.000
			10	0.414	-0.045	286.46	0.000
			11	0.364	-0.022	295.90	0.000
			12	0.314	-0.036	303.07	0.000
			13	0.275	0.055	308.71	0.000
			14	0.239	-0.014	313.07	0.000
			15	0.204	-0.019	316.34	0.000
			16	0.170	-0.027	318.66	0.000
			17	0.137	-0.014	320.21	0.000
			18	0.102	-0.043	321.09	0.000
			19	0.061	-0.076	321.42	0.000
			20	0.022	-0.023	321.46	0.000
			21	-0.023	-0.084	321.51	0.000
			22	-0.065	-0.021	321.91	0.000
			23	-0.104	-0.019	322.96	0.000
			24	-0.140	-0.038	324.95	0.000

Figure 5: Kilometre Point 122.60.

Sample: 1960 2014
Included observations: 55

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.931	0.931		50.358	0.000		
2	0.860	-0.056		94.101	0.000		
3	0.793	-0.003		132.03	0.000		
4	0.723	-0.066		164.15	0.000		
5	0.652	-0.044		190.78	0.000		
6	0.580	-0.053		212.26	0.000		
7	0.514	0.003		229.49	0.000		
8	0.442	-0.090		242.53	0.000		
9	0.379	0.020		252.31	0.000		
10	0.333	0.076		260.01	0.000		
11	0.288	-0.026		265.90	0.000		
12	0.246	-0.004		270.32	0.000		
13	0.207	-0.030		273.51	0.000		
14	0.172	-0.002		275.78	0.000		
15	0.140	-0.014		277.32	0.000		
16	0.105	-0.052		278.21	0.000		
17	0.079	0.025		278.73	0.000		
18	0.055	-0.012		278.99	0.000		
19	0.034	0.015		279.09	0.000		
20	0.016	-0.004		279.11	0.000		
21	-0.002	-0.028		279.11	0.000		
22	-0.025	-0.063		279.17	0.000		
23	-0.045	0.011		279.37	0.000		
24	-0.068	-0.063		279.84	0.000		

Figure 6: Kilometre Point 130.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1 0.888	0.888	23.729	0.000
		2 0.759	-0.139	41.748	0.000
		3 0.625	-0.088	54.503	0.000
		4 0.509	0.003	63.325	0.000
		5 0.392	-0.094	68.784	0.000
		6 0.279	-0.064	71.681	0.000
		7 0.160	-0.113	72.686	0.000
		8 0.034	-0.139	72.733	0.000
		9 -0.074	-0.023	72.974	0.000
		10 -0.166	-0.047	74.241	0.000
		11 -0.247	-0.083	77.237	0.000
		12 -0.309	-0.014	82.234	0.000

Figure 7: Kilometre Point 196.90.

Figure 11: Kilometre Point 356.77.

Figure 8: Kilometre Point 265.91.

Figure 12: Kilometre Point 369.80.

Figure 9: Kilometre Point 283.10.

Figure 13: Kilometre Point 408.80.

Figure 10: Kilometre Point 308.60.

Figure 14: Kilometre Point 427.00.

Figure 15: Kilometre Point 435.10.

Figure 19: Kilometre Point 531.00.

Figure 16: Kilometre Point 465.00.

Figure 20: Kilometre Point 667.33.

Figure 17: Kilometre Point 505.00.

Figure 18: Kilometre Point 525.00.

**ANNEX XIII: TRAFFIC TIME SERIES AT AUTOMATIC TRAFFIC
RECORDERS ON THE A-5 MOTORWAY.**

Table 1: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 37.00 on A-5 Motorway.

(K.P. 37.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	11.598			
1989	12.251	5.63%	1.0563	0.0548
1990	12.897	5.27%	1.0527	0.0514
1991	13.198	2.33%	1.0233	0.0231
1992	12.563	-4.81%	0.9519	-0.0493
1993	13.349	6.26%	1.0626	0.0607
1994	13.914	4.23%	1.0423	0.0415
1995	12.730	-8.51%	0.9149	-0.0889
1996	13.499	6.04%	1.0604	0.0587
1997	21.378	58.37%	1.5837	0.4597
1998	23.153	8.30%	1.0830	0.0798
1999	25.711	11.05%	1.1105	0.1048
2000	26.475	2.97%	1.0297	0.0293
2001	27.394	3.47%	1.0347	0.0341
2002	27.526	0.48%	1.0048	0.0048
2003	37.202	35.15%	1.3515	0.3012
2004	37.087	-0.31%	0.9969	-0.0031
2005	36.047	-2.80%	0.9720	-0.0284
2006	50.574	40.30%	1.4030	0.3386
2007	50.508	-0.13%	0.9987	-0.0013
2008	52.562	4.07%	1.0407	0.0399
2009	60.059	14.26%	1.1426	0.1333
2010	50.612	-15.73%	0.8427	-0.1711
2011	52.993	4.70%	1.0470	0.0460
2012	49.994	-5.66%	0.9434	-0.0583
2013	48.646	-2.70%	0.9730	-0.0273
2014	48.984	0.69%	1.0069	0.0069

Figure 1: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 37.00 on the A-5 Motorway.

Table 2: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 62.70 on A-5 Motorway.

(K.P. 62.70)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1975	6.544			
1976	8.946	36.71%	1.3671	0.3127
1977	7.915	-11.52%	0.8848	-0.1224
1978	8.772	10.83%	1.1083	0.1028
1979	7.953	-9.34%	0.9066	-0.0980
1980	10.483	31.81%	1.3181	0.2762
1981	9.439	-9.96%	0.9004	-0.1049
1982	8.219	-12.93%	0.8707	-0.1384
1983	8.990	9.38%	1.0938	0.0897
1984	7.755	-13.74%	0.8626	-0.1478
1985	10.980	41.59%	1.4159	0.3477
1986	9.740	-11.29%	0.8871	-0.1198
1987	10.158	4.29%	1.0429	0.0420
1988	11.477	12.98%	1.1298	0.1221
1989	11.844	3.20%	1.0320	0.0315
1990	12.708	7.29%	1.0729	0.0704
1991	13.165	3.60%	1.0360	0.0353
1992	13.200	0.27%	1.0027	0.0027
1993	13.300	0.76%	1.0076	0.0075

(K.P. 62.70)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1994	13.500	1.50%	1.0150	0.0149
1995	13.600	0.74%	1.0074	0.0074
1996	14.200	4.41%	1.0441	0.0432
1997	21.489	51.33%	1.5133	0.4143
1998	22.094	2.82%	1.0282	0.0278
1999	24.327	10.11%	1.1011	0.0963
2000	24.916	2.42%	1.0242	0.0239
2001	26.055	4.57%	1.0457	0.0447
2002	27.346	4.95%	1.0495	0.0484
2003	28.593	4.56%	1.0456	0.0446
2004	30.435	6.44%	1.0644	0.0624
2005	31.257	2.70%	1.0270	0.0267
2006	33.116	5.95%	1.0595	0.0578
2007	33.949	2.52%	1.0252	0.0248
2008	32.969	-2.89%	0.9711	-0.0293
2009	32.369	-1.82%	0.9818	-0.0184
2010	31.415	-2.95%	0.9705	-0.0299
2011	30.653	-2.43%	0.9757	-0.0246
2012	29.139	-4.94%	0.9506	-0.0507
2013	26.862	-7.81%	0.9219	-0.0814
2014	28.368	5.61%	1.0561	0.0545

Figure 2: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 62.70 on the A-4 Motorway.

Table 3: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 73.00 on A-5 Motorway.

(K.P. 73.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	12.399			
1989	14.893	20.11%	1.2011	0.1833
1990	13.998	-6.01%	0.9399	-0.0620
1991	14.498	3.57%	1.0357	0.0351
1992	13.791	-4.88%	0.9512	-0.0500
1993	14.599	5.86%	1.0586	0.0569
1994	14.921	2.21%	1.0221	0.0218
1995	14.950	0.19%	1.0019	0.0019
1996	14.980	0.20%	1.0020	0.0020
1997	21.883	46.08%	1.4608	0.3790
1998	20.962	-4.21%	0.9579	-0.0430
1999	23.280	11.06%	1.1106	0.1049
2000	23.971	2.97%	1.0297	0.0293
2001	24.804	3.48%	1.0348	0.0342
2002	24.956	0.61%	1.0061	0.0061
2003	25.748	3.17%	1.0317	0.0312
2004	58.500	127.20%	2.2720	0.8207
2005	29.335	-49.85%	0.5015	-0.6902
2006	31.756	8.25%	1.0825	0.0793
2007	30.886	-2.74%	0.9726	-0.0278
2008	29.753	-3.67%	0.9633	-0.0374
2009	19.532	-34.35%	0.6565	-0.4209
2010	24.929	27.63%	1.2763	0.2440
2011	27.316	9.58%	1.0958	0.0914
2012	25.983	-4.88%	0.9512	-0.0500
2013	25.454	-2.04%	0.9796	-0.0206
2014	26.373	3.61%	1.0361	0.0355

Figure 3: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 73.00 on the A-5 Motorway.

Table 4: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 82.00 on A-5 Motorway.

(K.P. 82.00)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	11.198			
1989	12.953	15.67%	1.1567	0.1456
1990	12.897	-0.43%	0.9957	-0.0043
1991	13.198	2.33%	1.0233	0.0231
1992	12.563	-4.81%	0.9519	-0.0493
1993	13.349	6.26%	1.0626	0.0607
1994	15.600	16.86%	1.1686	0.1558
1995	15.699	0.63%	1.0063	0.0063
1996	16.400	4.47%	1.0447	0.0437
1997	17.162	4.65%	1.0465	0.0454
1998	17.658	2.89%	1.0289	0.0285
1999	19.450	10.15%	1.1015	0.0967
2000	20.027	2.97%	1.0297	0.0292
2001	20.724	3.48%	1.0348	0.0342
2002	21.148	2.05%	1.0205	0.0203
2003	22.228	5.11%	1.0511	0.0498
2004	24.727	11.24%	1.1124	0.1065
2005	24.395	-1.34%	0.9866	-0.0135
2006	28.890	18.43%	1.1843	0.1691

(K.P. 82.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	28.086	-2.78%	0.9722	-0.0282
2008	29.291	4.29%	1.0429	0.0420
2009	27.770	-5.19%	0.9481	-0.0533
2010	29.615	6.64%	1.0664	0.0643
2011	28.795	-2.77%	0.9723	-0.0281
2012	27.214	-5.49%	0.9451	-0.0565
2013	26.549	-2.44%	0.9756	-0.0247
2014	29.060	9.46%	1.0946	0.0904

Figure 4: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 82.00 on the A-5 Motorway.

Table 5: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 109.59 on A-5 Motorway.

(K.P. 109.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1960	1.241			
1961	1.648	32.80%	1.3280	0.2836
1962	1.286	-21.97%	0.7803	-0.2480
1963	1.550	20.53%	1.2053	0.1867
1964	1.643	6.00%	1.0600	0.0583
1965	1.900	15.64%	1.1564	0.1453
1966	2.712	42.74%	1.4274	0.3558

(K.P. 109.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1967	2.710	-0.07%	0.9993	-0.0007
1968	3.854	42.21%	1.4221	0.3522
1969	4.376	13.54%	1.1354	0.1270
1970	4.521	3.31%	1.0331	0.0326
1971	4.837	6.99%	1.0699	0.0676
1972	5.407	11.78%	1.1178	0.1114
1973	6.126	13.30%	1.1330	0.1248
1974	7.130	16.39%	1.1639	0.1518
1975	7.003	-1.78%	0.9822	-0.0180
1976	7.780	11.10%	1.1110	0.1052
1977	8.176	5.09%	1.0509	0.0496
1978	9.581	17.18%	1.1718	0.1586
1979	9.579	-0.02%	0.9998	-0.0002
1980	10.209	6.58%	1.0658	0.0637
1981	10.096	-1.11%	0.9889	-0.0111
1982	9.942	-1.53%	0.9847	-0.0154
1983	10.196	2.55%	1.0255	0.0252
1984	9.740	-4.47%	0.9553	-0.0458
1985	10.031	2.99%	1.0299	0.0294
1986	10.381	3.49%	1.0349	0.0343
1987	12.220	17.72%	1.1772	0.1631
1988	12.456	1.93%	1.0193	0.0191
1989	12.997	4.34%	1.0434	0.0425
1990	10.072	-22.51%	0.7749	-0.2550
1991	9.885	-1.86%	0.9814	-0.0187
1992	9.095	-7.99%	0.9201	-0.0833
1993	10.135	11.43%	1.1143	0.1083
1994	10.019	-1.14%	0.9886	-0.0115
1995	12.535	25.11%	1.2511	0.2240
1996	12.660	1.00%	1.0100	0.0099
1997	13.292	4.99%	1.0499	0.0487
1998	13.297	0.04%	1.0004	0.0004
1999	13.584	2.16%	1.0216	0.0214
2000	13.535	-0.36%	0.9964	-0.0036
2001	13.850	2.33%	1.0233	0.0230
2002	17.978	29.81%	1.2981	0.2609
2003	19.445	8.16%	1.0816	0.0784
2004	20.986	7.92%	1.0792	0.0763
2005	20.384	-2.87%	0.9713	-0.0291
2006	22.382	9.80%	1.0980	0.0935
2007	23.656	5.69%	1.0569	0.0554
2008	22.440	-5.14%	0.9486	-0.0528

(K.P. 109.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2009	22.465	0.11%	1.0011	0.0011
2010	23.643	5.24%	1.0524	0.0511
2011	23.528	-0.49%	0.9951	-0.0049
2012	20.557	-12.63%	0.8737	-0.1350
2013	20.584	0.13%	1.0013	0.0013
2014	21.372	3.83%	1.0383	0.0376

Figure 5: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 109.59 on the A-4 Motorway.

Table 6: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 127.00 on A-5 Motorway.

(K.P. 127.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	8.798			
1989	9.498	7.96%	1.0796	0.0766
1990	10.448	10.00%	1.1000	0.0953
1991	9.779	-6.40%	0.9360	-0.0662
1992	9.681	-1.00%	0.9900	-0.0101
1993	10.260	5.98%	1.0598	0.0581
1994	10.846	5.71%	1.0571	0.0555
1995	10.999	1.41%	1.0141	0.0140
1996	11.199	1.82%	1.0182	0.0180

(K.P. 127.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1997	12.000	7.15%	1.0715	0.0691
1998	10.289	-14.26%	0.8574	-0.1538
1999	12.094	17.54%	1.1754	0.1616
2000	12.453	2.97%	1.0297	0.0293
2001	12.888	3.49%	1.0349	0.0343
2002	11.242	-12.77%	0.8723	-0.1366
2003	15.268	35.81%	1.3581	0.3061
2004	15.360	0.60%	1.0060	0.0060
2005	16.100	4.82%	1.0482	0.0471
2006	19.964	24.00%	1.2400	0.2151
2007	19.980	0.08%	1.0008	0.0008
2008	19.341	-3.20%	0.9680	-0.0325
2009	19.769	2.21%	1.0221	0.0219
2010	19.292	-2.41%	0.9759	-0.0244
2011	20.298	5.21%	1.0521	0.0508
2012	19.156	-5.63%	0.9437	-0.0579
2013	19.810	3.41%	1.0341	0.0336
2014	19.818	0.04%	1.0004	0.0004

Figure 6: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 127.00 on the A-4 Motorway.

Table 7: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 153.00 on A-5 Motorway.

(K.P. 153.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.598			
1989	7.462	-1.79%	0.9821	-0.0181
1990	8.198	9.86%	1.0986	0.0941
1991	8.498	3.66%	1.0366	0.0359
1992	8.453	-0.53%	0.9947	-0.0053
1993	8.980	6.23%	1.0623	0.0605
1994	8.908	-0.80%	0.9920	-0.0081
1995	8.950	0.47%	1.0047	0.0047
1996	10.500	17.32%	1.1732	0.1597
1997	11.400	8.57%	1.0857	0.0822
1998	11.995	5.22%	1.0522	0.0509
1999	14.099	17.54%	1.1754	0.1616
2000	14.517	2.96%	1.0296	0.0292
2001	15.022	3.48%	1.0348	0.0342
2002	13.098	-12.81%	0.8719	-0.1371
2003	13.748	4.96%	1.0496	0.0484
2004	13.765	0.12%	1.0012	0.0012
2005	15.217	10.55%	1.1055	0.1003
2006	15.187	-0.20%	0.9980	-0.0020
2007	15.084	-0.68%	0.9932	-0.0068
2008	14.969	-0.76%	0.9924	-0.0077
2009	16.116	7.66%	1.0766	0.0738
2010	16.240	0.77%	1.0077	0.0077
2011	16.429	1.16%	1.0116	0.0116
2012	15.915	-3.13%	0.9687	-0.0318
2013	16.136	1.39%	1.0139	0.0138
2014	15.925	-1.31%	0.9869	-0.0132

Figure 7: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 153.00 on the A-5 Motorway.

Table 8: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 190.10 on A-5 Motorway.

(K.P. 190.10)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	7.499			
1989	8.098	7.99%	1.0799	0.0768
1990	8.298	2.47%	1.0247	0.0244
1991	9.497	14.45%	1.1445	0.1350
1992	6.528	-31.26%	0.6874	-0.3749
1993	7.225	10.68%	1.1068	0.1014
1994	7.275	0.69%	1.0069	0.0069
1995	8.342	14.67%	1.1467	0.1369
1996	7.999	-4.11%	0.9589	-0.0420
1997	8.999	12.50%	1.1250	0.1178
1998	9.450	5.01%	1.0501	0.0489
1999	10.526	11.39%	1.1139	0.1078
2000	10.750	2.13%	1.0213	0.0211
2001	11.864	10.36%	1.1036	0.0986
2002	10.646	-10.27%	0.8973	-0.1083
2003	10.346	-2.82%	0.9718	-0.0286
2004	11.390	10.09%	1.1009	0.0961
2005	11.007	-3.36%	0.9664	-0.0342

(K.P. 190.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	11.510	4.57%	1.0457	0.0447
2007	10.467	-9.06%	0.9094	-0.0950
2008	12.919	23.43%	1.2343	0.2105
2009	10.526	-18.52%	0.8148	-0.2049
2010	14.032	33.31%	1.3331	0.2875
2011	13.431	-4.28%	0.9572	-0.0438
2012	12.993	-3.26%	0.9674	-0.0332
2013	12.033	-7.39%	0.9261	-0.0768
2014	13.094	8.82%	1.0882	0.0845

Figure 8: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 190.10 on the A-5 Motorway.

Table 9: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 233.10 on A-5 Motorway.

(K.P. 233.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1967	1.037			
1968	1.151	10.99%	1.1099	0.1043
1969	1.246	8.25%	1.0825	0.0793
1970	1.290	3.53%	1.0353	0.0347
1971	1.536	19.07%	1.1907	0.1745
1972	1.756	14.32%	1.1432	0.1339

(K.P. 233.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1973	2.054	16.97%	1.1697	0.1568
1974	2.393	16.50%	1.1650	0.1528
1975	2.469	3.18%	1.0318	0.0313
1976	2.671	8.18%	1.0818	0.0786
1977	3.400	27.29%	1.2729	0.2413
1978	3.436	1.06%	1.0106	0.0105
1979	3.700	7.68%	1.0768	0.0740
1980	4.050	9.46%	1.0946	0.0904
1981	5.127	26.59%	1.2659	0.2358
1982	4.947	-3.51%	0.9649	-0.0357
1983	5.125	3.60%	1.0360	0.0353
1984	5.113	-0.23%	0.9977	-0.0023
1985	3.688	-27.87%	0.7213	-0.3267
1986	3.809	3.28%	1.0328	0.0323
1987	4.310	13.15%	1.1315	0.1236
1988	4.862	12.81%	1.1281	0.1205
1989	5.151	5.94%	1.0594	0.0577
1990	5.731	11.26%	1.1126	0.1067
1991	5.909	3.11%	1.0311	0.0306
1992	6.096	3.16%	1.0316	0.0312
1993	6.407	5.10%	1.0510	0.0498
1994	7.202	12.41%	1.1241	0.1170
1995	7.004	-2.75%	0.9725	-0.0279
1996	6.865	-1.98%	0.9802	-0.0200
1997	8.423	22.69%	1.2269	0.2045
1998	9.300	10.41%	1.1041	0.0990
1999	10.094	8.54%	1.0854	0.0819
2000	10.449	3.52%	1.0352	0.0346
2001	10.610	1.54%	1.0154	0.0153
2002	11.217	5.72%	1.0572	0.0556
2003	11.663	3.98%	1.0398	0.0390
2004	11.807	1.23%	1.0123	0.0123
2005	12.029	1.88%	1.0188	0.0186
2006	11.947	-0.68%	0.9932	-0.0068
2007	11.812	-1.13%	0.9887	-0.0114
2008	11.635	-1.50%	0.9850	-0.0151
2009	12.121	4.18%	1.0418	0.0409
2010	12.801	5.61%	1.0561	0.0546
2011	12.462	-2.65%	0.9735	-0.0268
2012	11.590	-7.00%	0.9300	-0.0725
2013	11.037	-4.77%	0.9523	-0.0489
2014	11.369	3.01%	1.0301	0.0296

Figure 9: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 233.10 on the A-5 Motorway.

Table 10: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 267.00 on A-5 Motorway.

(K.P. 267.00)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	4.378			
1989	4.076	-6.90%	0.9310	-0.0715
1990	4.298	5.45%	1.0545	0.0530
1991	4.598	6.98%	1.0698	0.0675
1992	4.677	1.72%	1.0172	0.0170
1993	4.700	0.49%	1.0049	0.0049
1994	5.053	7.51%	1.0751	0.0724
1995	5.271	4.31%	1.0431	0.0422
1996	5.399	2.43%	1.0243	0.0240
1997	5.575	3.26%	1.0326	0.0321
1998	6.096	9.35%	1.0935	0.0893
1999	7.098	16.44%	1.1644	0.1522
2000	7.248	2.11%	1.0211	0.0209
2001	7.234	-0.19%	0.9981	-0.0019
2002	7.268	0.47%	1.0047	0.0047
2003	7.494	3.11%	1.0311	0.0306
2004	7.790	3.95%	1.0395	0.0387
2005	6.878	-11.71%	0.8829	-0.1245

(K.P. 267.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	7.761	12.84%	1.1284	0.1208
2007	8.973	15.62%	1.1562	0.1451
2008	9.800	9.22%	1.0922	0.0882
2009	8.552	-12.73%	0.8727	-0.1362
2010	9.133	6.79%	1.0679	0.0657
2011	10.386	13.72%	1.1372	0.1286
2012	9.628	-7.30%	0.9270	-0.0758
2013	9.243	-4.00%	0.9600	-0.0408
2014	9.325	0.89%	1.0089	0.0088

Figure 10: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 267.00 on the A-4 Motorway.

Table 11: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 295.00 on A-5 Motorway.

(K.P. 295.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	4.403			
1989	4.254	-3.38%	0.9662	-0.0344
1990	4.498	5.74%	1.0574	0.0558
1991	4.564	1.47%	1.0147	0.0146
1992	4.578	0.31%	1.0031	0.0031
1993	3.699	-19.20%	0.8080	-0.2132

(K.P. 295.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1994	4.960	34.09%	1.3409	0.2933
1995	5.293	6.71%	1.0671	0.0650
1996	5.062	-4.36%	0.9564	-0.0446
1997	5.249	3.69%	1.0369	0.0363
1998	6.081	15.85%	1.1585	0.1471
1999	6.449	6.05%	1.0605	0.0588
2000	6.539	1.40%	1.0140	0.0139
2001	6.630	1.39%	1.0139	0.0138
2002	6.652	0.33%	1.0033	0.0033
2003	7.696	15.69%	1.1569	0.1458
2004	7.733	0.48%	1.0048	0.0048
2005	6.777	-12.36%	0.8764	-0.1320
2006	7.768	14.62%	1.1462	0.1365
2007	8.357	7.58%	1.0758	0.0731
2008	9.258	10.78%	1.1078	0.1024
2009	8.237	-11.03%	0.8897	-0.1169
2010	8.066	-2.08%	0.9792	-0.0210
2011	9.468	17.38%	1.1738	0.1603
2012	8.730	-7.79%	0.9221	-0.0812
2013	8.392	-3.87%	0.9613	-0.0395
2014	8.631	2.85%	1.0285	0.0281

Figure 11: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 295.00 on the A-4 Motorway.

Table 12: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 329.20 on A-5 Motorway.

(K.P. 329.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	5.098			
1989	6.638	30.21%	1.3021	0.2640
1990	6.698	0.90%	1.0090	0.0090
1991	8.721	30.20%	1.3020	0.2639
1992	8.775	0.62%	1.0062	0.0062
1993	9.000	2.56%	1.0256	0.0253
1994	9.923	10.26%	1.1026	0.0976
1995	10.849	9.33%	1.0933	0.0892
1996	10.667	-1.68%	0.9832	-0.0169
1997	11.244	5.41%	1.0541	0.0527
1998	11.594	3.11%	1.0311	0.0307
1999	11.616	0.19%	1.0019	0.0019
2000	12.348	6.30%	1.0630	0.0611
2001	12.734	3.13%	1.0313	0.0308
2002	12.952	1.71%	1.0171	0.0170
2003	13.916	7.44%	1.0744	0.0718
2004	14.495	4.16%	1.0416	0.0408
2005	14.972	3.29%	1.0329	0.0324
2006	14.754	-1.46%	0.9854	-0.0147
2007	15.042	1.95%	1.0195	0.0193
2008	15.039	-0.02%	0.9998	-0.0002
2009	16.604	10.41%	1.1041	0.0990
2010	16.246	-2.16%	0.9784	-0.0218
2011	17.140	5.50%	1.0550	0.0536
2012	15.488	-9.64%	0.9036	-0.1013
2013	14.175	-8.48%	0.9152	-0.0886
2014	14.266	0.64%	1.0064	0.0064

Figure 12: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 329.20 on the A-5 Motorway.

Table 13: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 346.70 on A-5 Motorway.

(K.P. 346.70)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	8.014			
1989	9.378	17.02%	1.1702	0.1572
1990	8.148	-13.12%	0.8688	-0.1406
1991	10.298	26.39%	1.2639	0.2342
1992	9.727	-5.54%	0.9446	-0.0570
1993	10.844	11.48%	1.1148	0.1087
1994	10.497	-3.20%	0.9680	-0.0325
1995	10.841	3.28%	1.0328	0.0322
1996	11.304	4.27%	1.0427	0.0418
1997	12.016	6.30%	1.0630	0.0611
1998	13.780	14.68%	1.1468	0.1370
1999	13.911	0.95%	1.0095	0.0095
2000	14.229	2.29%	1.0229	0.0226
2001	14.848	4.35%	1.0435	0.0426
2002	16.431	10.66%	1.1066	0.1013
2003	17.765	8.12%	1.0812	0.0781
2004	18.505	4.17%	1.0417	0.0408
2005	19.245	4.00%	1.0400	0.0392
2006	21.043	9.34%	1.0934	0.0893

(K.P. 346.70)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2007	21.431	1.84%	1.0184	0.0183
2008	20.049	-6.45%	0.9355	-0.0667
2009	18.820	-6.13%	0.9387	-0.0633
2010	20.755	10.28%	1.1028	0.0979
2011	18.152	-12.54%	0.8746	-0.1340
2012	16.682	-8.10%	0.9190	-0.0845
2013	16.415	-1.60%	0.9840	-0.0161
2014	16.328	-0.53%	0.9947	-0.0053

Figure 13: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 346.70 on the A-5 Motorway.

Table 14: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 377.00 on A-5 Motorway.

(K.P. 377.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1975	3.585			
1976	3.729	4.02%	1.0402	0.0394
1977	4.619	23.87%	1.2387	0.2140
1978	5.048	9.29%	1.0929	0.0888
1979	4.624	-8.40%	0.9160	-0.0877
1980	5.336	15.40%	1.1540	0.1432
1981	5.110	-4.24%	0.9576	-0.0433

(K.P. 377.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1982	4.847	-5.15%	0.9485	-0.0528
1983	4.639	-4.29%	0.9571	-0.0439
1984	4.783	3.10%	1.0310	0.0306
1985	4.853	1.46%	1.0146	0.0145
1986	4.945	1.90%	1.0190	0.0188
1987	5.455	10.31%	1.1031	0.0982
1988	6.706	22.93%	1.2293	0.2065
1989	7.189	7.20%	1.0720	0.0695
1990	8.163	13.55%	1.1355	0.1271
1991	8.445	3.45%	1.0345	0.0340
1992	7.538	-10.74%	0.8926	-0.1136
1993	9.396	24.65%	1.2465	0.2203
1994	10.106	7.56%	1.0756	0.0728
1995	10.366	2.57%	1.0257	0.0254
1996	11.213	8.17%	1.0817	0.0785
1997	11.947	6.55%	1.0655	0.0634
1998	12.758	6.79%	1.0679	0.0657
1999	13.538	6.11%	1.0611	0.0593
2000	14.594	7.80%	1.0780	0.0751
2001	15.315	4.94%	1.0494	0.0482
2002	16.020	4.60%	1.0460	0.0450
2003	16.492	2.95%	1.0295	0.0290
2004	17.078	3.55%	1.0355	0.0349
2005	17.791	4.17%	1.0417	0.0409
2006	18.430	3.59%	1.0359	0.0353
2007	19.628	6.50%	1.0650	0.0630
2008	19.835	1.05%	1.0105	0.0105
2009	20.020	0.93%	1.0093	0.0093
2010	20.036	0.08%	1.0008	0.0008
2011	19.065	-4.85%	0.9515	-0.0497
2012	17.895	-6.14%	0.9386	-0.0633
2013	17.557	-1.89%	0.9811	-0.0191
2014	17.932	2.14%	1.0214	0.0211

Figure 14: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 377.00 on the A-5 Motorway.

**ANNEX XIV: STATIONARITY ANALYSIS. CORRELOGRAMS OF
AUTOMATIC TRAFFIC RECORDERS ON A-5 MOTORWAY.**

Figure 1: Kilometre Point 37.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1 0.913	0.913	25.127	0.000
		2 0.829	-0.034	46.634	0.000
		3 0.743	-0.052	64.642	0.000
		4 0.634	-0.192	78.315	0.000
		5 0.523	-0.083	88.042	0.000
		6 0.400	-0.149	94.011	0.000
		7 0.271	-0.119	96.885	0.000
		8 0.134	-0.157	97.629	0.000
		9 -0.002	-0.112	97.629	0.000
		10 -0.091	0.180	98.007	0.000
		11 -0.180	-0.062	99.594	0.000
		12 -0.257	-0.003	103.04	0.000

Figure 2: Kilometre Point 62.70.

Sample: 1975 2014
Included observations: 40

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.922	0.922	36.656	0.000
2	0.887	0.239	71.402	0.000
3	0.822	-0.151	102.04	0.000
4	0.762	-0.075	129.17	0.000
5	0.691	-0.100	152.09	0.000
6	0.625	-0.037	171.40	0.000
7	0.560	-0.003	187.35	0.000
8	0.469	-0.222	198.92	0.000
9	0.391	-0.066	207.20	0.000
10	0.287	-0.188	211.82	0.000
11	0.211	0.045	214.39	0.000
12	0.131	0.048	215.42	0.000
13	0.041	-0.184	215.53	0.000
14	-0.031	0.003	215.59	0.000
15	-0.105	-0.014	216.33	0.000
16	-0.167	0.007	218.27	0.000
17	-0.217	0.119	221.72	0.000
18	-0.278	-0.202	227.61	0.000
19	-0.315	0.049	235.56	0.000
20	-0.356	-0.007	246.18	0.000

Figure 3: Kilometre Point 73.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.702	0.702	14.844	0.000
2	0.649	0.308	28.047	0.000
3	0.564	0.071	38.435	0.000
4	0.478	-0.024	46.225	0.000
5	0.286	-0.289	49.128	0.000
6	0.259	0.051	51.622	0.000
7	0.196	0.066	53.126	0.000
8	0.001	-0.310	53.126	0.000
9	-0.128	-0.228	53.838	0.000
10	-0.177	-0.028	55.288	0.000
11	-0.282	-0.031	59.179	0.000
12	-0.340	0.066	65.204	0.000

Figure 4: Kilometre Point 82.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1 0.886	0.886	23.640	0.000
		2 0.814	0.134	44.385	0.000
		3 0.722	-0.101	61.382	0.000
		4 0.623	-0.112	74.588	0.000
		5 0.491	-0.231	83.173	0.000
		6 0.365	-0.117	88.145	0.000
		7 0.258	0.021	90.751	0.000
		8 0.148	-0.042	91.659	0.000
		9 0.034	-0.103	91.709	0.000
		10 -0.053	0.011	91.839	0.000
		11 -0.152	-0.141	92.975	0.000
		12 -0.221	0.009	95.522	0.000

Figure 5: Kilometre Point 109.60.

Sample: 1960 2014
Included observations: 55

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.924	0.924	49.528 0.000
2	0.862	0.058	93.436 0.000
3	0.776	-0.187	129.72 0.000
4	0.693	-0.054	159.25 0.000
5	0.609	-0.032	182.53 0.000
6	0.528	-0.034	200.40 0.000
7	0.464	0.069	214.48 0.000
8	0.392	-0.086	224.75 0.000
9	0.334	0.004	232.37 0.000
10	0.281	0.019	237.88 0.000
11	0.227	-0.067	241.55 0.000
12	0.176	-0.037	243.79 0.000
13	0.132	0.028	245.10 0.000
14	0.100	0.030	245.86 0.000
15	0.076	0.043	246.32 0.000
16	0.047	-0.081	246.50 0.000
17	0.026	-0.012	246.55 0.000
18	0.005	0.002	246.56 0.000
19	-0.005	0.046	246.56 0.000
20	-0.018	-0.029	246.59 0.000
21	-0.023	0.022	246.64 0.000
22	-0.031	-0.034	246.73 0.000
23	-0.039	-0.012	246.88 0.000
24	-0.048	-0.032	247.11 0.000

Figure 6: Kilometre Point 127.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.871	22.864	0.000	
		2	0.786	0.112	42.220	0.000
		3	0.716	0.041	58.926	0.000
		4	0.601	-0.202	71.229	0.000
		5	0.471	-0.193	79.116	0.000
		6	0.367	-0.029	84.130	0.000
		7	0.258	-0.054	86.732	0.000
		8	0.127	-0.146	87.393	0.000
		9	0.013	-0.084	87.400	0.000
		10	-0.051	0.112	87.520	0.000
		11	-0.166	-0.201	88.864	0.000
		12	-0.249	-0.023	92.107	0.000

Figure 7: Kilometre Point 153.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.896	0.896	24.180	0.000
2	0.776	-0.138	43.027	0.000
3	0.664	-0.017	57.416	0.000
4	0.554	-0.068	67.851	0.000
5	0.432	-0.128	74.487	0.000
6	0.322	-0.015	78.341	0.000
7	0.203	-0.140	79.958	0.000
8	0.082	-0.102	80.236	0.000
9	-0.013	0.031	80.243	0.000
10	-0.098	-0.075	80.686	0.000
11	-0.168	-0.004	82.072	0.000
12	-0.198	0.118	84.116	0.000

Figure 10: Kilometre Point 267.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.900	0.900	24.377	0.000			
2	0.779	-0.159	43.395	0.000			
3	0.680	0.057	58.488	0.000			
4	0.570	-0.141	69.565	0.000			
5	0.448	-0.110	76.719	0.000			
6	0.334	-0.046	80.871	0.000			
7	0.230	-0.041	82.944	0.000			
8	0.133	-0.046	83.672	0.000			
9	0.038	-0.074	83.733	0.000			
10	-0.046	-0.029	83.829	0.000			
11	-0.123	-0.075	84.569	0.000			
12	-0.167	0.101	86.021	0.000			

Figure 8: Kilometre Point 190.10.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.743	0.743	16.641	0.000
2	0.722	0.378	32.946	0.000
3	0.565	-0.130	43.349	0.000
4	0.562	0.142	54.093	0.000
5	0.334	-0.365	58.074	0.000
6	0.280	-0.055	60.999	0.000
7	0.130	-0.042	61.660	0.000
8	0.071	-0.098	61.867	0.000
9	0.011	0.237	61.872	0.000
10	-0.026	-0.067	61.903	0.000
11	-0.097	-0.087	62.365	0.000
12	-0.177	-0.181	64.007	0.000

Figure 11: Kilometre Point 295.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.871	0.871	22.823	0.000
2	0.768	0.043	41.307	0.000
3	0.709	0.129	57.689	0.000
4	0.617	-0.135	70.656	0.000
5	0.500	-0.161	79.538	0.000
6	0.326	-0.382	83.505	0.000
7	0.218	0.076	85.373	0.000
8	0.140	0.035	86.178	0.000
9	0.031	-0.018	86.220	0.000
10	-0.076	-0.069	86.486	0.000
11	-0.157	-0.013	87.689	0.000
12	-0.205	-0.054	89.878	0.000

Figure 9: Kilometre Point 233.10.

Sample: 1967 2014
Included observations: 48

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
	1	0.927	0.927	43.894	0.000
	2	0.854	-0.040	81.947	0.000
	3	0.780	-0.048	114.37	0.000
	4	0.699	-0.089	141.00	0.000
	5	0.624	-0.007	162.70	0.000
	6	0.555	-0.000	180.28	0.000
	7	0.491	-0.003	194.40	0.000
	8	0.431	-0.024	205.55	0.000
	9	0.371	-0.049	214.00	0.000
	10	0.311	-0.039	220.11	0.000
	11	0.262	0.029	224.55	0.000
	12	0.210	-0.051	227.49	0.000
	13	0.164	-0.000	229.34	0.000
	14	0.124	-0.010	230.43	0.000
	15	0.100	0.081	231.15	0.000
	16	0.073	-0.053	231.55	0.000
	17	0.046	-0.028	231.71	0.000
	18	0.019	-0.045	231.74	0.000
	19	-0.026	-0.152	231.80	0.000
	20	-0.073	-0.047	232.25	0.000

Figure 12: Kilometre Point 329.20.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1 0.809	0.809	19.718	0.000
		2 0.699	0.127	35.002	0.000
		3 0.546	-0.148	44.726	0.000
		4 0.460	0.067	51.936	0.000
		5 0.366	-0.022	56.697	0.000
		6 0.264	-0.115	59.299	0.000
		7 0.180	-0.018	60.563	0.000
		8 0.120	0.027	61.154	0.000
		9 0.046	-0.099	61.246	0.000
		10 -0.023	-0.073	61.271	0.000
		11 -0.085	-0.017	61.622	0.000
		12 -0.153	-0.102	62.837	0.000

Figure 13: Kilometre Point 346.70.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.883	0.883	23.504	0.000
2	0.823	0.194	44.717	0.000
3	0.690	-0.320	60.236	0.000
4	0.605	0.038	72.715	0.000
5	0.472	-0.160	80.629	0.000
6	0.360	-0.121	85.469	0.000
7	0.236	-0.036	87.641	0.000
8	0.100	-0.223	88.056	0.000
9	-0.025	-0.073	88.083	0.000
10	-0.140	-0.015	88.987	0.000
11	-0.217	0.047	91.298	0.000
12	-0.291	-0.008	95.726	0.000

Figure 14: Kilometre Point 377.00.

**ANNEX XV: TRAFFIC TIME SERIES AT AUTOMATIC TRAFFIC
RECORDERS ON THE A-6 MOTORWAY.**

Table 1: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 21.00 on A-6 Motorway.

(K.P. 21.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1966	13.021			
1967	14.800	13.66%	1.1366	0.1281
1968	17.004	14.89%	1.1489	0.1388
1969	18.828	10.73%	1.1073	0.1019
1970	21.386	13.59%	1.1359	0.1274
1971	23.289	8.90%	1.0890	0.0852
1972	26.992	15.90%	1.1590	0.1476
1973	28.814	6.75%	1.0675	0.0653
1974	28.873	0.20%	1.0020	0.0020
1975	32.057	11.03%	1.1103	0.1046
1976	33.628	4.90%	1.0490	0.0478
1977	33.672	0.13%	1.0013	0.0013
1978	35.692	6.00%	1.0600	0.0583
1979	36.737	2.93%	1.0293	0.0289
1980	37.348	1.66%	1.0166	0.0165
1981	38.101	2.02%	1.0202	0.0200
1982	41.169	8.05%	1.0805	0.0774
1983	40.651	-1.26%	0.9874	-0.0127
1984	35.512	-12.64%	0.8736	-0.1352
1985	43.436	22.31%	1.2231	0.2014
1986	41.342	-4.82%	0.9518	-0.0494
1987	41.493	0.37%	1.0037	0.0036
1988	50.456	21.60%	1.2160	0.1956
1989	55.547	10.09%	1.1009	0.0961
1990	58.971	6.16%	1.0616	0.0598
1991	61.195	3.77%	1.0377	0.0370
1992	65.612	7.22%	1.0722	0.0697
1993	62.635	-4.54%	0.9546	-0.0464
1994	56.720	-9.44%	0.9056	-0.0992
1995	58.037	2.32%	1.0232	0.0230
1996	57.312	-1.25%	0.9875	-0.0126
1997	80.366	40.23%	1.4023	0.3381
1998	81.964	1.99%	1.0199	0.0197
1999	90.001	9.81%	1.0981	0.0935
2000	94.054	4.50%	1.0450	0.0440
2001	98.453	4.68%	1.0468	0.0457
2002	88.100	-10.52%	0.8948	-0.1111
2003	88.936	0.95%	1.0095	0.0094

(K.P. 21.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2004	92.312	3.80%	1.0380	0.0373
2005	99.931	8.25%	1.0825	0.0793
2006	100.489	0.56%	1.0056	0.0056
2007	101.508	1.01%	1.0101	0.0101
2008	101.642	0.13%	1.0013	0.0013
2009	87.029	-14.38%	0.8562	-0.1552
2010	92.203	5.95%	1.0595	0.0578
2011	92.203	0.00%	1.0000	0.0000
2012	92.733	0.57%	1.0057	0.0057
2013	90.861	-2.02%	0.9798	-0.0204
2014	90.548	-0.34%	0.9966	-0.0035

Figure 1: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 21.00 on the A-6 Motorway.

Table 2: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 112.20 on A-6 Motorway.

(K.P. 112.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	6.723			
1989	6.798	1.12%	1.0112	0.0111
1990	9.309	36.94%	1.3694	0.3144
1991	9.498	2.03%	1.0203	0.0201

(K.P. 112.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1992	10.349	8.96%	1.0896	0.0858
1993	11.001	6.30%	1.0630	0.0611
1994	11.639	5.80%	1.0580	0.0564
1995	11.013	-5.38%	0.9462	-0.0553
1996	13.168	19.57%	1.1957	0.1787
1997	14.094	7.03%	1.0703	0.0680
1998	14.628	3.79%	1.0379	0.0372
1999	16.571	13.28%	1.1328	0.1247
2000	17.909	8.07%	1.0807	0.0776
2001	18.292	2.14%	1.0214	0.0212
2002	18.212	-0.44%	0.9956	-0.0044
2003	19.538	7.28%	1.0728	0.0703
2004	24.016	22.92%	1.2292	0.2064
2005	21.512	-10.43%	0.8957	-0.1101
2006	21.750	1.11%	1.0111	0.0110
2007	22.184	2.00%	1.0200	0.0198
2008	21.246	-4.23%	0.9577	-0.0432
2009	18.050	-15.04%	0.8496	-0.1630
2010	20.851	15.52%	1.1552	0.1443
2011	19.528	-6.35%	0.9365	-0.0656
2012	18.145	-7.08%	0.9292	-0.0735
2013	17.931	-1.18%	0.9882	-0.0119
2014	18.034	0.57%	1.0057	0.0057

Figure 2: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 112.20 on the A-6 Motorway.

Table 3: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 131.00 on A-6 Motorway.

(K.P. 131.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1975	4.310			
1976	4.782	10.95%	1.1095	0.1039
1977	5.410	13.13%	1.1313	0.1234
1978	5.887	8.82%	1.0882	0.0845
1979	6.313	7.24%	1.0724	0.0699
1980	6.096	-3.44%	0.9656	-0.0350
1981	6.990	14.67%	1.1467	0.1368
1982	7.743	10.77%	1.1077	0.1023
1983	7.679	-0.83%	0.9917	-0.0083
1984	5.203	-32.24%	0.6776	-0.3893
1985	5.371	3.23%	1.0323	0.0318
1986	5.936	10.52%	1.1052	0.1000
1987	6.189	4.26%	1.0426	0.0417
1988	6.586	6.41%	1.0641	0.0622
1989	7.613	15.59%	1.1559	0.1449
1990	8.610	13.10%	1.1310	0.1231
1991	8.700	1.05%	1.0105	0.0104
1992	9.300	6.90%	1.0690	0.0667
1993	9.200	-1.08%	0.9892	-0.0108
1994	12.987	41.16%	1.4116	0.3447
1995	13.728	5.71%	1.0571	0.0555
1996	13.766	0.28%	1.0028	0.0028
1997	14.071	2.22%	1.0222	0.0219
1998	14.969	6.38%	1.0638	0.0619
1999	17.100	14.24%	1.1424	0.1331
2000	18.109	5.90%	1.0590	0.0573
2001	18.589	2.65%	1.0265	0.0262
2002	19.333	4.00%	1.0400	0.0392
2003	19.671	1.75%	1.0175	0.0173
2004	21.176	7.65%	1.0765	0.0737
2005	21.719	2.56%	1.0256	0.0253
2006	23.433	7.89%	1.0789	0.0760
2007	23.957	2.24%	1.0224	0.0221
2008	22.655	-5.43%	0.9457	-0.0559
2009	20.820	-8.10%	0.9190	-0.0845
2010	19.366	-6.98%	0.9302	-0.0724
2011	19.264	-0.53%	0.9947	-0.0053
2012	18.414	-4.41%	0.9559	-0.0451

(K.P. 131.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2013	17.842	-3.11%	0.9689	-0.0316
2014	18.166	1.82%	1.0182	0.0180

Figure 3: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 131.00 on the A-6 Motorway.

Table 4: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 138.40 on A-6 Motorway.

(K.P. 138.40)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	6.896			
1989	6.382	-7.45%	0.9255	-0.0775
1990	9.219	44.45%	1.4445	0.3678
1991	9.800	6.30%	1.0630	0.0611
1992	8.603	-12.21%	0.8779	-0.1303
1993	9.377	9.00%	1.0900	0.0861
1994	11.134	18.74%	1.1874	0.1717
1995	11.015	-1.07%	0.9893	-0.0107
1996	11.949	8.48%	1.0848	0.0814
1997	12.369	3.51%	1.0351	0.0345
1998	13.525	9.35%	1.0935	0.0893
1999	15.232	12.62%	1.1262	0.1189
2000	15.775	3.56%	1.0356	0.0350

(K.P. 138.40)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2001	14.519	-7.96%	0.9204	-0.0830
2002	16.778	15.56%	1.1556	0.1446
2003	17.399	3.70%	1.0370	0.0363
2004	19.220	10.47%	1.1047	0.0995
2005	19.181	-0.20%	0.9980	-0.0020
2006	18.098	-5.65%	0.9435	-0.0581
2007	18.064	-0.19%	0.9981	-0.0019
2008	20.692	14.55%	1.1455	0.1358
2009	19.310	-6.68%	0.9332	-0.0691
2010	21.751	12.64%	1.1264	0.1190
2011	20.235	-6.97%	0.9303	-0.0722
2012	18.757	-7.30%	0.9270	-0.0758
2013	17.726	-5.50%	0.9450	-0.0565
2014	19.793	11.66%	1.1166	0.1103

Figure 4: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 138.40 on the A-6 Motorway.

Table 5: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 156.20 on A-6 Motorway.

(K.P. 156.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.381			

(K.P. 156.20)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1989	7.498	1.59%	1.0159	0.0157
1990	8.998	20.01%	1.2001	0.1824
1991	9.748	8.34%	1.0834	0.0801
1992	8.444	-13.38%	0.8662	-0.1436
1993	12.558	48.72%	1.4872	0.3969
1994	11.279	-10.18%	0.8982	-0.1074
1995	11.500	1.96%	1.0196	0.0194
1996	13.628	18.50%	1.1850	0.1698
1997	14.194	4.15%	1.0415	0.0407
1998	13.233	-6.77%	0.9323	-0.0701
1999	15.443	16.70%	1.1670	0.1544
2000	15.577	0.87%	1.0087	0.0086
2001	16.120	3.49%	1.0349	0.0343
2002	16.812	4.29%	1.0429	0.0420
2003	16.566	-1.46%	0.9854	-0.0147
2004	19.394	17.07%	1.1707	0.1576
2005	17.634	-9.07%	0.9093	-0.0951
2006	18.120	2.76%	1.0276	0.0272
2007	19.554	7.91%	1.0791	0.0762
2008	18.577	-5.00%	0.9500	-0.0513
2009	15.851	-14.67%	0.8533	-0.1587
2010	21.399	35.00%	1.3500	0.3001
2011	17.530	-18.08%	0.8192	-0.1994
2012	17.733	1.16%	1.0116	0.0115
2013	17.819	0.48%	1.0048	0.0048
2014	17.724	-0.53%	0.9947	-0.0053

Figure 5: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 156.20 on the A-6 Motorway.

Table 6: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 173.10 on A-6 Motorway.

(K.P. 173.10)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	6.998			
1989	7.498	7.14%	1.0714	0.0690
1990	9.098	21.34%	1.2134	0.1934
1991	9.998	9.89%	1.0989	0.0943
1992	11.043	10.45%	1.1045	0.0994
1993	12.809	15.99%	1.1599	0.1484
1994	13.500	5.39%	1.0539	0.0525
1995	17.521	29.79%	1.2979	0.2607
1996	15.905	-9.22%	0.9078	-0.0968
1997	16.699	4.99%	1.0499	0.0487
1998	17.070	2.22%	1.0222	0.0220
1999	18.171	6.45%	1.0645	0.0625
2000	18.709	2.96%	1.0296	0.0292
2001	19.358	3.47%	1.0347	0.0341
2002	20.016	3.40%	1.0340	0.0334
2003	20.474	2.29%	1.0229	0.0226
2004	23.457	14.57%	1.1457	0.1360
2005	21.188	-9.67%	0.9033	-0.1017

(K.P. 173.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	20.844	-1.62%	0.9838	-0.0164
2007	22.008	5.58%	1.0558	0.0543
2008	27.289	24.00%	1.2400	0.2151
2009	26.038	-4.58%	0.9542	-0.0469
2010	26.343	1.17%	1.0117	0.0116
2011	24.819	-5.79%	0.9421	-0.0596
2012	22.369	-9.87%	0.9013	-0.1039
2013	21.656	-3.19%	0.9681	-0.0324
2014	22.443	3.63%	1.0363	0.0357

Figure 6: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 173.10 on the A-6 Motorway.

Table 7: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 217.10 on A-6 Motorway.

(K.P. 217.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.540			
1989	7.747	2.75%	1.0275	0.0271
1990	8.069	4.16%	1.0416	0.0407
1991	8.497	5.30%	1.0530	0.0517
1992	9.585	12.80%	1.1280	0.1205
1993	8.499	-11.33%	0.8867	-0.1203

(K.P. 217.10)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1994	12.749	50.01%	1.5001	0.4055
1995	12.185	-4.42%	0.9558	-0.0452
1996	12.799	5.04%	1.0504	0.0492
1997	12.800	0.01%	1.0001	0.0001
1998	11.358	-11.27%	0.8873	-0.1195
1999	11.729	3.27%	1.0327	0.0321
2000	11.789	0.51%	1.0051	0.0051
2001	15.572	32.09%	1.3209	0.2783
2002	16.824	8.04%	1.0804	0.0773
2003	16.950	0.75%	1.0075	0.0075
2004	17.959	5.95%	1.0595	0.0578
2005	16.745	-6.76%	0.9324	-0.0700
2006	17.560	4.87%	1.0487	0.0475
2007	19.626	11.77%	1.1177	0.1112
2008	15.573	-20.65%	0.7935	-0.2313
2009	16.534	6.17%	1.0617	0.0599
2010	17.640	6.69%	1.0669	0.0648
2011	16.276	-7.73%	0.9227	-0.0805
2012	18.691	14.84%	1.1484	0.1384
2013	18.187	-2.70%	0.9730	-0.0273
2014	15.723	-13.55%	0.8645	-0.1456

Figure 7: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 217.10 on the A-6 Motorway.

Table 8: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 226.00 on A-6 Motorway.

(K.P. 226.00)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.998			
1989	7.998	0.00%	1.0000	0.0000
1990	8.498	6.25%	1.0625	0.0606
1991	8.498	0.00%	1.0000	0.0000
1992	9.642	13.46%	1.1346	0.1263
1993	8.599	-10.82%	0.8918	-0.1145
1994	11.253	30.86%	1.3086	0.2690
1995	11.604	3.12%	1.0312	0.0307
1996	12.063	3.96%	1.0396	0.0388
1997	11.752	-2.58%	0.9742	-0.0261
1998	11.445	-2.61%	0.9739	-0.0265
1999	12.207	6.66%	1.0666	0.0645
2000	14.791	21.17%	1.2117	0.1920
2001	14.792	0.01%	1.0001	0.0001
2002	15.888	7.41%	1.0741	0.0715
2003	16.704	5.14%	1.0514	0.0501
2004	18.857	12.89%	1.1289	0.1212
2005	17.718	-6.04%	0.9396	-0.0623
2006	17.411	-1.73%	0.9827	-0.0175
2007	19.552	12.30%	1.1230	0.1160
2008	19.305	-1.26%	0.9874	-0.0127
2009	16.609	-13.97%	0.8603	-0.1504
2010	19.342	16.45%	1.1645	0.1523
2011	14.523	-24.91%	0.7509	-0.2865
2012	14.172	-2.42%	0.9758	-0.0245
2013	13.264	-6.41%	0.9359	-0.0662
2014	16.500	24.40%	1.2440	0.2183

Figure 8: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 226.00 on the A-6 Motorway.

Table 9: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 255.30 on A-6 Motorway.

(K.P. 255.30)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1970	3.969			
1971	3.040	-23.41%	0.7659	-0.2667
1972	3.282	7.96%	1.0796	0.0766
1973	4.267	30.01%	1.3001	0.2625
1974	4.694	10.01%	1.1001	0.0954
1975	5.806	23.69%	1.2369	0.2126
1976	6.517	12.25%	1.1225	0.1155
1977	6.940	6.49%	1.0649	0.0629
1978	7.641	10.10%	1.1010	0.0962
1979	8.087	5.84%	1.0584	0.0567
1980	8.004	-1.03%	0.9897	-0.0103
1981	8.966	12.02%	1.1202	0.1135
1982	8.768	-2.21%	0.9779	-0.0223
1983	7.034	-19.78%	0.8022	-0.2204
1984	5.316	-24.42%	0.7558	-0.2800
1985	6.150	15.69%	1.1569	0.1457
1986	6.408	4.20%	1.0420	0.0411
1987	7.779	21.40%	1.2140	0.1939

(K.P. 255.30)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
1988	7.707	-0.93%	0.9907	-0.0093
1989	8.184	6.19%	1.0619	0.0601
1990	8.774	7.21%	1.0721	0.0696
1991	9.805	11.75%	1.1175	0.1111
1992	10.254	4.58%	1.0458	0.0448
1993	9.767	-4.75%	0.9525	-0.0487
1994	9.850	0.85%	1.0085	0.0085
1995	11.516	16.91%	1.1691	0.1563
1996	12.036	4.52%	1.0452	0.0442
1997	12.836	6.65%	1.0665	0.0644
1998	13.353	4.03%	1.0403	0.0395
1999	14.413	7.94%	1.0794	0.0764
2000	16.525	14.65%	1.1465	0.1367
2001	16.843	1.92%	1.0192	0.0191
2002	18.159	7.81%	1.0781	0.0752
2003	19.377	6.71%	1.0671	0.0649
2004	21.162	9.21%	1.0921	0.0881
2005	21.532	1.75%	1.0175	0.0173
2006	22.337	3.74%	1.0374	0.0367
2007	23.166	3.71%	1.0371	0.0364
2008	20.848	-10.01%	0.8999	-0.1054
2009	20.165	-3.28%	0.9672	-0.0333
2010	19.526	-3.17%	0.9683	-0.0322
2011	18.475	-5.38%	0.9462	-0.0553
2012	16.840	-8.85%	0.9115	-0.0927
2013	16.555	-1.69%	0.9831	-0.0171
2014	17.093	3.25%	1.0325	0.0320

Figure 9: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 255.30 on the A-6 Motorway.

Table 10: Traffic Evolution at the Automatic Traffic Recorder Located at the Kilometre Point 262.60 on A-6 Motorway.

(K.P. 262.60)				
Year	AADTi	Variation (%)	AADTi / AADT(i-1)	ln(AADTi / AADT(i-1))
1988	13.553			
1989	14.895	9.90%	1.0990	0.0944
1990	14.898	0.02%	1.0002	0.0002
1991	14.898	0.00%	1.0000	0.0000
1992	15.449	3.70%	1.0370	0.0363
1993	11.375	-26.37%	0.7363	-0.3061
1994	11.697	2.83%	1.0283	0.0279
1995	11.506	-1.63%	0.9837	-0.0165
1996	12.169	5.76%	1.0576	0.0560
1997	12.762	4.87%	1.0487	0.0476
1998	12.922	1.25%	1.0125	0.0125
1999	13.557	4.91%	1.0491	0.0480
2000	15.097	11.36%	1.1136	0.1076
2001	21.632	43.29%	1.4329	0.3597
2002	23.326	7.83%	1.0783	0.0754
2003	24.042	3.07%	1.0307	0.0302
2004	23.477	-2.35%	0.9765	-0.0238
2005	25.573	8.93%	1.0893	0.0855

(K.P. 262.60)				
Year	AADTi	Variation (%)	AADTi /AADT(i-1)	ln(AADTi /AADT(i-1))
2006	26.666	4.27%	1.0427	0.0419
2007	25.520	-4.30%	0.9570	-0.0439
2008	23.486	-7.97%	0.9203	-0.0831
2009	20.739	-11.70%	0.8830	-0.1244
2010	19.797	-4.54%	0.9546	-0.0465
2011	20.039	1.22%	1.0122	0.0121
2012	17.607	-12.14%	0.8786	-0.1294
2013	17.358	-1.41%	0.9859	-0.0142
2014	17.330	-0.16%	0.9984	-0.0016

Figure 10: Traffic Evolution in the Automatic Traffic Recorder Located at the Kilometre Point 262.60 on the A-6 Motorway.

**ANNEX XVI: STATIONARITY ANALYSIS. CORRELOGRAMS OF
AUTOMATIC TRAFFIC RECORDERS ON A-6 MOTORWAY.**

Figure 1: Kilometre Point 21.00.

Sample: 1966 2014
Included observations: 49

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.918	0.918	43.876	0.000
2	0.842	-0.005	81.563	0.000
3	0.770	-0.013	113.78	0.000
4	0.701	-0.022	141.05	0.000
5	0.639	0.011	164.28	0.000
6	0.587	0.022	184.29	0.000
7	0.538	-0.004	201.51	0.000
8	0.487	-0.041	215.97	0.000
9	0.432	-0.059	227.61	0.000
10	0.379	-0.015	236.83	0.000
11	0.329	-0.022	243.95	0.000
12	0.279	-0.030	249.21	0.000
13	0.232	-0.022	252.96	0.000
14	0.182	-0.063	255.32	0.000
15	0.134	-0.025	256.64	0.000
16	0.084	-0.051	257.18	0.000
17	0.041	-0.002	257.31	0.000
18	-0.004	-0.058	257.31	0.000
19	-0.055	-0.077	257.56	0.000
20	-0.092	0.030	258.29	0.000

Figure 2: Kilometre Point 112.20.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1 0.855	0.855	22.002	0.000
		2 0.710	-0.075	37.805	0.000
		3 0.629	0.150	50.702	0.000
		4 0.521	-0.154	59.955	0.000
		5 0.406	-0.053	65.811	0.000
		6 0.322	0.005	69.679	0.000
		7 0.216	-0.157	71.499	0.000
		8 0.073	-0.186	71.718	0.000
		9 -0.034	-0.024	71.767	0.000
		10 -0.122	-0.080	72.449	0.000
		11 -0.218	-0.077	74.778	0.000
		12 -0.282	0.006	78.917	0.000

Figure 3: Kilometre Point 131.00.

Sample: 1975 2014
Included observations: 40

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.933	0.933	37.483	0.000
2	0.865	-0.041	70.549	0.000
3	0.804	0.018	99.890	0.000
4	0.747	-0.007	125.90	0.000
5	0.684	-0.068	148.38	0.000
6	0.610	-0.129	166.76	0.000
7	0.543	0.013	181.78	0.000
8	0.480	-0.024	193.90	0.000
9	0.414	-0.068	203.19	0.000
10	0.313	-0.312	208.68	0.000
11	0.220	-0.008	211.49	0.000
12	0.135	-0.052	212.58	0.000
13	0.045	-0.136	212.71	0.000
14	-0.048	-0.093	212.85	0.000
15	-0.127	0.059	213.93	0.000
16	-0.191	-0.013	216.48	0.000
17	-0.251	-0.050	221.08	0.000
18	-0.309	-0.022	228.36	0.000
19	-0.370	-0.029	239.29	0.000
20	-0.402	0.107	252.89	0.000

Figure 4: Kilometre Point 138.40.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1 0.852	0.852	21.839	0.000
		2 0.704	-0.077	37.366	0.000
		3 0.645	0.236	50.929	0.000
		4 0.572	-0.098	62.078	0.000
		5 0.436	-0.203	68.855	0.000
		6 0.327	-0.003	72.841	0.000
		7 0.215	-0.199	74.659	0.000
		8 0.127	0.068	75.328	0.000
		9 0.037	-0.108	75.389	0.000
		10 -0.066	-0.110	75.592	0.000
		11 -0.153	-0.006	76.735	0.000
		12 -0.200	-0.032	78.827	0.000

Figure 5: Kilometre Point 156.20.

Sample: 1988 2014
Included observations: 27

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.799	0.799	19.219	0.000			
2	0.693	0.151	34.251	0.000			
3	0.628	0.106	47.110	0.000			
4	0.503	-0.148	55.739	0.000			
5	0.329	-0.271	59.587	0.000			
6	0.312	0.244	63.226	0.000			
7	0.187	-0.215	64.601	0.000			
8	0.083	-0.006	64.882	0.000			
9	0.010	-0.090	64.886	0.000			
10	-0.057	-0.089	65.035	0.000			
11	-0.134	0.089	65.914	0.000			
12	-0.218	-0.298	68.392	0.000			

Figure 6: Kilometre Point 173.10.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1 0.847	0.847	21.604	0.000
		2 0.699	-0.066	36.901	0.000
		3 0.571	-0.013	47.554	0.000
		4 0.449	-0.061	54.430	0.000
		5 0.328	-0.079	58.253	0.000
		6 0.228	-0.011	60.193	0.000
		7 0.126	-0.091	60.817	0.000
		8 0.092	0.158	61.162	0.000
		9 0.036	-0.129	61.218	0.000
		10 -0.029	-0.070	61.255	0.000
		11 -0.096	-0.090	61.709	0.000
		12 -0.146	-0.025	62.817	0.000

Figure 7: Kilometre Point 217.10.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.835	0.835	21.012	0.000
2	0.712	0.048	36.903	0.000
3	0.578	-0.094	47.813	0.000
4	0.439	-0.109	54.375	0.000
5	0.375	0.152	59.368	0.000
6	0.252	-0.203	61.730	0.000
7	0.219	0.179	63.601	0.000
8	0.147	-0.146	64.494	0.000
9	0.087	0.015	64.827	0.000
10	0.022	-0.168	64.850	0.000
11	-0.102	-0.147	65.362	0.000
12	-0.221	-0.260	67.917	0.000

Figure 8: Kilometre Point 226.00.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.849	0.849	21.727	0.000
2	0.764	0.152	39.995	0.000
3	0.648	-0.116	53.675	0.000
4	0.546	-0.047	63.841	0.000
5	0.413	-0.166	69.919	0.000
6	0.284	-0.125	72.928	0.000
7	0.177	-0.006	74.156	0.000
8	0.076	-0.037	74.396	0.000
9	-0.026	-0.088	74.425	0.000
10	-0.107	-0.020	74.952	0.000
11	-0.237	-0.277	77.707	0.000
		12	-0.316	-0.044	82.930	0.000

Figure 9: Kilometre Point 255.30.

Sample: 1970 2014
Included observations: 45

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.937	0.937	42.165	0.000
2	0.842	-0.288	77.018	0.000
3	0.747	0.014	105.14	0.000
4	0.665	0.038	127.97	0.000
5	0.584	-0.090	146.01	0.000
6	0.515	0.063	160.38	0.000
7	0.451	-0.036	171.71	0.000
8	0.393	-0.016	180.54	0.000
9	0.346	0.059	187.57	0.000
10	0.304	-0.042	193.16	0.000
11	0.262	-0.030	197.44	0.000
12	0.236	0.120	200.99	0.000
13	0.202	-0.170	203.68	0.000
14	0.146	-0.167	205.14	0.000
15	0.067	-0.135	205.45	0.000
16	0.000	0.086	205.45	0.000
17	-0.058	-0.047	205.71	0.000	
		18	-0.104	0.019	206.56	0.000	
		19	-0.150	-0.093	208.39	0.000	
		20	-0.191	-0.019	211.49	0.000	

Figure 10: Kilometre Point 262.60.

Sample: 1988 2014
Included observations: 27

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.908	0.908	24.834	0.000
2	0.790	-0.196	44.390	0.000
3	0.645	-0.206	57.984	0.000
4	0.494	-0.095	66.306	0.000
5	0.340	-0.101	70.425	0.000
6	0.126	-0.492	71.015	0.000
7	-0.069	-0.026	71.203	0.000
8	-0.232	0.083	73.417	0.000
9	-0.311	0.349	77.630	0.000
10	-0.366	-0.099	83.793	0.000
11	-0.408	-0.021	91.931	0.000
		12	-0.426	-0.103	101.42	0.000

ANNEX XVII: FINANCIAL MODEL (CASE STUDY).

Financial Statements							Ramp-up Period										
							Construction Flag	1	1	1	0	0	0	0	0	0	0
							Operation Flag	0	0	0	1	1	1	1	1	1	1
							Period	0	1	2	3	4	5	6	7	8	9
							Beginning of the Period	01-ene-04	01-ene-05	01-ene-06	01-ene-07	01-ene-08	01-ene-09	01-ene-10	01-ene-11	01-ene-12	01-ene-13
Units	End of the Period	31-dic-04	31-dic-05	31-dic-06	31-dic-07	31-dic-08	31-dic-09	31-dic-10	31-dic-11	31-dic-12	31-dic-13						
1.- Profit & Loses																	
Traffic Incomes (Light-Duty Vehicles)	Eur'000	3,747,206	-	-	-	28,656	31,929	35,142	38,561	42,104	45,898	50,677					
Traffic Incomes (Heavy-Duty Vehicles)	Eur'000	1,851,482	-	-	-	11,743	13,808	15,874	18,056	20,317	22,724	24,992					
Other Incomes	Eur'000	167,961	-	-	-	1,212	1,372	1,530	1,699	1,873	2,059	2,270					
Total incomes	Eur'000	5,766,649	-	-	-	41,611	47,109	52,546	58,315	64,294	70,681	77,939					
Operational Expenses	Eur'000	- 75,696	-	-	-	- 471	- 480	- 580	- 910	- 642	- 756	- 646					
Total Expenses	Eur'000	- 75,696	-	-	-	- 471	- 480	- 580	- 910	- 642	- 756	- 646					
EBITDA	Eur'000	5,690,953	-	-	-	41,140	46,629	51,967	57,406	63,652	69,925	77,293					
Depreciation	Linear	Eur'000	- 404,571	-	-	- 9,586	- 9,586	- 9,586	- 9,586	- 9,586	- 9,586	- 9,586					
EBIT	Eur'000	5,286,381	-	-	-	31,554	37,043	42,381	47,820	54,066	60,339	67,707					
Net Financial Costs	Eur'000	- 258,011	-	-	-	- 16,300	- 15,887	- 15,656	- 15,336	- 14,963	- 14,541	- 14,092					
Earnings Before Taxes	Eur'000	5,028,371	-	-	-	15,254	21,156	26,725	32,484	39,104	45,798	53,615					
Corporate Tax Rate	35.00%																
Corporate Taxes	Eur'000	- 1,759,930	-	-	-	- 5,339	- 7,405	- 9,354	- 11,370	- 13,686	- 16,029	- 18,765					
Earnings After Taxes	Eur'000	3,268,441	-	-	-	9,915	13,752	17,371	21,115	25,417	29,769	34,850					
2.- Balance Sheet																	
Assets																	
Intangible Asset	Eur'000	15,616,254	84,033	244,125	414,749	414,749	414,749	414,749	414,749	414,749	414,749	414,749					
Acc. Depreciation	Eur'000	6,320,899	-	-	-	9,586	19,171	28,757	38,342	47,928	57,514	67,099					

Financial Statements						Ramp-up Period										
						Construction Flag	1	1	1	0	0	0	0	0	0	0
						Operation Flag	0	0	0	1	1	1	1	1	1	1
						Period	0	1	2	3	4	5	6	7	8	9
						Beginning of the Period	01-ene-04	01-ene-05	01-ene-06	01-ene-07	01-ene-08	01-ene-09	01-ene-10	01-ene-11	01-ene-12	01-ene-13
Units	End of the Period	31-dic-04	31-dic-05	31-dic-06	31-dic-07	31-dic-08	31-dic-09	31-dic-10	31-dic-11	31-dic-12	31-dic-13					
Activo Inmovilizado Neto	Eur'000	9,295,356	84,033	244,125	414,749	405,163	395,578	385,992	376,407	366,821	357,235	347,650				
Commercial Debtors	Eur'000	949,835	-	-	-	6,859	7,744	8,661	9,612	10,598	11,619	12,847				
Tax Receivables	Eur'000	11,958	2,389	5,079	4,491	-	-	-	-	-	-	-				
Cash	Eur'000	36,178,159	-	-	-	770	11,299	25,425	43,287	65,351	91,773	123,044				
S/T Assets	Eur'000	37,139,952	2,389	5,079	4,491	7,629	19,043	34,087	52,899	75,949	103,391	135,891				
ASSETS	Eur'000	46,435,307	86,422	249,204	419,240	412,792	414,620	420,079	429,306	442,770	460,627	483,541				
Liabilities																
Equity	Eur'000	2,894,652	16,386	47,604	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80,876				
Earnings After Taxes	Eur'000	38,415,061	-	-	-	9,915	23,667	41,038	62,153	87,570	117,339	152,189				
Equity	Eur'000	41,309,713	16,386	47,604	80,876	90,791	104,543	121,914	143,029	168,447	198,215	233,065				
VAT Loan	Eur'000	11,958	2,389	5,079	4,491	-	-	-	-	-	-	-				
Senior Debt Loan	Eur'000		67,647	196,521	333,873	321,949	310,025	298,101	286,177	274,253	262,329	250,405				
I/t Senior Loan	Eur'000	4,771,451	67,647	196,521	321,949	310,025	298,101	286,177	274,253	262,329	250,405	238,481				
s/t Senior Loan	Eur'000	333,873	-	-	11,924	11,924	11,924	11,924	11,924	11,924	11,924	11,924				
Financial Liabilities	Eur'000	5,117,282	70,036	201,599	338,364	321,949	310,025	298,101	286,177	274,253	262,329	250,405				
Commercial Creditors (Operational Period)	Eur'000	8,312	-	-	-	52	53	64	100	71	83	71				
Commercial Creditors (Construction Period)	Eur'000	-	-	-	-	-	-	-	-	-	-	-				
Income Tax Payable (Corporate Tax)	Eur'000	-	-	-	-	-	-	-	-	-	-	-				
Non financial Liabilities	Eur'000	8,312	-	-	-	52	53	64	100	71	83	71				

Financial Statements						Ramp-up Period						
						0	0	0	0	0	0	0
						1	1	1	1	1	1	1
						3	4	5	6	7	8	9
						01-ene-07	01-ene-08	01-ene-09	01-ene-10	01-ene-11	01-ene-12	01-ene-13
Units						31-dic-07	31-dic-08	31-dic-09	31-dic-10	31-dic-11	31-dic-12	31-dic-13
LIABILITIES	Eur'000		46,435,307	86,422	249,204	412,792	414,620	420,079	429,306	442,770	460,627	483,541
				ok	ok	ok	ok	ok	ok	ok	ok	ok
				-	-	-	-	-	-	-	-	-
3.- Cash Flow												
Operational Incomes	Eur'000	p/V Proy,	5,713,117	-	-	34,752	46,224	51,629	57,364	63,308	69,660	76,711
Construction Expenses	Eur'000	p/V Proy,	- 392,541	- 77,823	- 155,229	-	-	-	-	-	-	-
Investment During Operation	Eur'000	p/V Proy,	- 55,959	-	-	-	-	-	-	-	-	-
Operational Expenses	Eur'000	p/V Proy,	- 75,696	-	-	- 419	- 480	- 568	- 873	- 671	- 744	- 658
Construction and Operation Cash Flow	Eur'000		5,188,920	- 77,823	- 155,229	34,333	45,744	51,060	56,491	62,637	68,916	76,053
VAT Recovered by the Treasury	Eur'000	p/V Proy,	47,834	7,168	17,625	4,491	-	-	-	-	-	-
VAT Paid to Suppliers	Eur'000	p/V Proy,	- 47,834	- 9,557	- 20,314	-	-	-	-	-	-	-
Corporate Taxes	Eur'000	p/V Proy,	- 1,759,930	-	-	- 5,339	- 7,405	- 9,354	- 11,370	- 13,686	- 16,029	- 18,765
Taxes Cash Flows	Eur'000		- 1,759,930	- 2,389	- 2,689	- 848	- 7,405	- 9,354	- 11,370	- 13,686	- 16,029	- 18,765
Equity Additions	Eur'000	p/V Proy,	80,876	16,386	31,218	-	-	-	-	-	-	-
VAT loan Additions	Eur'000	p/V Proy,	47,834	9,557	20,314	-	-	-	-	-	-	-
Senior Loan Additions	Eur'000	p/V Proy,	333,873	67,647	128,874	-	-	-	-	-	-	-
Senior Debt Fees	Eur'000	p/V Proy,	- 8,066	- 6,210	- 1,225	-	-	-	-	-	-	-
Senior Debt Interests	Eur'000	p/V Proy,	- 271,715	-	- 3,551	- 16,136	- 15,887	- 15,656	- 15,336	- 14,963	- 14,541	- 14,092

Financial Statements										Ramp-up Period										
										Construction Flag	1	1	1	0	0	0	0	0	0	0
										Operation Flag	0	0	0	1	1	1	1	1	1	1
										Period	0	1	2	3	4	5	6	7	8	9
										Beginning of the Period	01-ene-04	01-ene-05	01-ene-06	01-ene-07	01-ene-08	01-ene-09	01-ene-10	01-ene-11	01-ene-12	01-ene-13
Units	End of the Period	31-dic-04	31-dic-05	31-dic-06	31-dic-07	31-dic-08	31-dic-09	31-dic-10	31-dic-11	31-dic-12	31-dic-13									
VAT Loan Interests and Fees	Eur'000	p/V Proy,	-	436	-	-	87	-	185	-	164	-	-	-	-					
VAT Loan Repayments	Eur'000	p/V Proy,	-	47,834	-	7,168	-	17,625	-	18,551	-	4,491	-	-	-					
Senior Debt Repayments	Eur'000	p/V Proy,	-	333,873	-	-	-	-	-	-	11,924	-	11,924	-	11,924					
Financial Cash Flows	Eur'000		-	199,342	80,212	157,918	158,901	-	32,715	-	27,811	-	27,580	-	27,260					
Variation of Cash	Eur'000			3,229,648	-	-	-		770	10,529	14,126		17,862	22,064	26,422					
Opening Cash Balance	Eur'000			32,948,510	-	-	-		-	770	11,299		25,425	43,287	65,351					
Variation of Cash	Eur'000			3,229,648	-	-	-		770	10,529	14,126		17,862	22,064	26,422					
Final Cash Balance	Eur'000	p/Bal		36,178,159	-	-	-		770	11,299	25,425		43,287	65,351	91,773					

Financial Statements											
Units	Construction Flag	0	0	0	0	0	0	0	0	0	0
	Operation Flag	1	1	1	1	1	1	1	1	1	1
	Period	10	11	12	13	14	15	16	17	18	19
	Beginning of the Period	01-ene-14	01-ene-15	01-ene-16	01-ene-17	01-ene-18	01-ene-19	01-ene-20	01-ene-21	01-ene-22	01-ene-23
	End of the Period	31-dic-14	31-dic-15	31-dic-16	31-dic-17	31-dic-18	31-dic-19	31-dic-20	31-dic-21	31-dic-22	31-dic-23

1.- Profit & Loses

Traffic Incomes (Light-Duty Vehicles)	Eur'000	55,759	61,024	66,660	72,124	77,970	84,022	90,532	94,877	99,609	104,483
Traffic Incomes (Heavy-Duty Vehicles)	Eur'000	27,406	29,906	32,584	35,174	37,948	40,818	43,908	46,209	48,696	51,250
Other Incomes	Eur'000	2,495	2,728	2,977	3,219	3,478	3,745	4,033	4,233	4,449	4,672
Total incomes	Eur'000	85,660	93,658	102,221	110,517	119,396	128,585	138,473	145,318	152,754	160,404

Financial Statements			Construction Flag		0	0	0	0	0	0	0	0	0	0	0	0	0					
			Operation Flag		1	1	1	1	1	1	1	1	1	1	1	1	1					
			Period		10	11	12	13	14	15	16	17	18	19								
			Beginning of the Period		01-ene-14	01-ene-15	01-ene-16	01-ene-17	01-ene-18	01-ene-19	01-ene-20	01-ene-21	01-ene-22	01-ene-23								
			End of the Period		31-dic-14	31-dic-15	31-dic-16	31-dic-17	31-dic-18	31-dic-19	31-dic-20	31-dic-21	31-dic-22	31-dic-23								
Units																						
Operational Expenses	Eur'000		-	1,572	-	688	-	1,203	-	574	-	1,882	-	597	-	626	-	9,503	-	1,841	-	647
Total Expenses	Eur'000		-	1,572	-	688	-	1,203	-	574	-	1,882	-	597	-	626	-	9,503	-	1,841	-	647
EBITDA	Eur'000			84,088		92,969		101,018		109,943		117,513		127,987		137,847		135,815		150,913		159,758
Depreciation	Lineal	Eur'000	-	9,586	-	9,586	-	10,279	-	10,279	-	10,279	-	10,279	-	10,279	-	10,279	-	10,279	-	10,279
EBIT	Eur'000			74,503		83,384		90,739		99,664		107,234		117,708		127,567		125,535		140,633		149,478
Net Financial Costs	Eur'000		-	13,574	-	13,003	-	12,353	-	11,846	-	11,088	-	10,536	-	9,959	-	9,131	-	8,533	-	7,922
Earnings Before Taxes	Eur'000			60,928		70,381		78,386		87,818		96,146		107,172		117,609		116,404		132,100		141,556
Corporate Tax Rate	35.00%																					
Corporate Taxes	Eur'000		-	21,325	-	24,633	-	27,435	-	30,736	-	33,651	-	37,510	-	41,163	-	40,741	-	46,235	-	49,545
Earnings After Taxes	Eur'000			39,603		45,747		50,951		57,082		62,495		69,662		76,446		75,663		85,865		92,011
				191,792		237,540		288,491		345,572		408,067		477,729		554,174		629,837		715,702		807,713
2.- Balance Sheet																						

2.- Balance Sheet

Assets

Intangible Asset	Eur'000	414,749	414,749	424,745	424,745	424,745	424,745	424,745	424,745	424,745	424,745	424,745	424,745
Acc. Depreciation	Eur'000	76,685	86,270	96,550	106,829	117,109	127,388	137,668	147,947	158,226	168,506		
Activo Inmovilizado Neto	Eur'000	338,064	328,479	328,196	317,916	307,637	297,357	287,078	276,798	266,519	256,239		
Commercial Debtors	Eur'000	14,120	15,438	16,803	18,217	19,681	21,195	22,763	23,954	25,179	26,440		
Tax Receivables	Eur'000	-	-	-	-	-	-	-	-	-	-		
Cash	Eur'000	159,138	201,131	239,132	293,087	352,617	418,978	492,215	566,018	648,170	737,145		
S/T Assets	Eur'000	173,258	216,570	255,935	311,304	372,298	440,174	514,978	589,971	673,350	763,585		

Financial Statements		Construction Flag	0	0	0	0	0	0	0	0	0	0
		Operation Flag	1	1	1	1	1	1	1	1	1	1
		Period	10	11	12	13	14	15	16	17	18	19
		Beginning of the Period	01-ene-14	01-ene-15	01-ene-16	01-ene-17	01-ene-18	01-ene-19	01-ene-20	01-ene-21	01-ene-22	01-ene-23
		End of the Period	31-dic-14	31-dic-15	31-dic-16	31-dic-17	31-dic-18	31-dic-19	31-dic-20	31-dic-21	31-dic-22	31-dic-23
Units												
ASSETS		Eur'000	511,322	545,048	584,131	629,220	679,934	737,531	802,055	866,770	939,869	1.019.825
Liabilities												
Equity	Eur'000	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80.876
Earnings After Taxes	Eur'000	191,792	237,540	288,491	345,572	408,067	477,729	554,174	629,837	715,702	807,713	
Equity	Eur'000	272,668	318,416	369,367	426,448	488,943	558,605	635,050	710,713	796,578	888.589	
VAT Loan	Eur'000	-	-	-	-	-	-	-	-	-	-	-
Senior Debt Loan	Eur'000	238,481	226,557	214,633	202,709	190,784	178,860	166,936	155,012	143,088	131.164	
l/t Senior Loan	Eur'000	226,557	214,633	202,709	190,784	178,860	166,936	155,012	143,088	131.164	119.240	
s/t Senior Loan	Eur'000	11,924	11,924	11,924	11,924	11,924	11,924	11,924	11,924	11.924	11.924	
Financial Liabilities	Eur'000	238,481	226,557	214,633	202,709	190,784	178,860	166,936	155,012	143,088	131.164	
Commercial Creditors (Operational Period)	Eur'000	173	76	132	63	207	66	69	1,044	202	71	
Commercial Creditors (Construction Period)	Eur'000	-	-	-	-	-	-	-	-	-	-	
Income Tax Payable (Corporate Tax)	Eur'000	-	-	-	-	-	-	-	-	-	-	
Non financial Liabilities	Eur'000	173	76	132	63	207	66	69	1,044	202	71	
LIABILITIES		Eur'000	511,322	545,048	584,131	629,220	679,934	737,531	802,055	866,770	939,869	1,019,825
			ok	ok	ok	ok	ok	ok	ok	ok	ok	ok
			-	-	-	-	-	-	-	-	-	-
3,- Cash Flow												
Operational Incomes	Eur'000	p/V Proy,	84,387	92,339	100,856	109,104	117,932	127,070	136,905	144,127	151,529	159,143
Construction Expenses	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-

Financial Statements			Units		Construction Flag		0		0		0		0		0		0		0		0		0	
Period		Beginning of the Period		01-ene-14		01-ene-15		01-ene-16		01-ene-17		01-ene-18		01-ene-19		01-ene-20		01-ene-21		01-ene-22		01-ene-23		
End of the Period		31-dic-14		31-dic-15		31-dic-16		31-dic-17		31-dic-18		31-dic-19		31-dic-20		31-dic-21		31-dic-22		31-dic-23				
Investment During Operation	Eur'000	p/V Proy,	-	-	-	9,996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Operational Expenses	Eur'000	p/V Proy,	-	1,470	-	785	-	1,147	-	643	-	1,739	-	739	-	623	-	8,528	-	2,683	-	778		
Construction and Operation Cash Flow			Eur'000			82,917	91,554	89,712	108,461	116,194	126,332	136,283	135,600	148,845	158,365									
VAT Recovered by the Treasury	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
VAT Paid to Suppliers	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Corporate Taxes	Eur'000	p/V Proy,	-	21,325	-	24,633	-	27,435	-	30,736	-	33,651	-	37,510	-	41,163	-	40,741	-	46,235	-	49,545		
Taxes Cash Flows			Eur'000	-	21,325	-	24,633	-	27,435	-	30,736	-	33,651	-	37,510	-	41,163	-	40,741	-	46,235	-	49,545	
Equity Additions	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
VAT loan Additions	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Senior Loan Additions	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Senior Debt Fees	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Senior Debt Interests	Eur'000	p/V Proy,	-	13,574	-	13,003	-	12,353	-	11,846	-	11,088	-	10,536	-	9,959	-	9,131	-	8,533	-	7,922		
VAT Loan Interests and Fees	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
VAT Loan Repayments	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Senior Debt Repayments	Eur'000	p/V Proy,	-	11,924	-	11,924	-	11,924	-	11,924	-	11,924	-	11,924	-	11,924	-	11,924	-	11,924	-	11,924		
Financial Cash Flows			Eur'000	-	25,498	-	24,927	-	24,277	-	23,770	-	23,012	-	22,460	-	21,883	-	21,055	-	20,457	-	19,846	
Variation of Cash			Eur'000	36,094	41,994	38,000	53,955	59,530	66,361	73,237	73,803	82,153	88,975											
Opening Cash Balance			Eur'000	123,044	159,138	201,131	239,132	293,087	352,617	418,978	492,215	566,018	648,170											

Financial Statements	Units	Construction Flag	0	0	0	0	0	0	0	0	0	0
		Operation Flag	1	1	1	1	1	1	1	1	1	1
		Period	10	11	12	13	14	15	16	17	18	19
		Beginning of the Period	01-ene-14	01-ene-15	01-ene-16	01-ene-17	01-ene-18	01-ene-19	01-ene-20	01-ene-21	01-ene-22	01-ene-23
		End of the Period	31-dic-14	31-dic-15	31-dic-16	31-dic-17	31-dic-18	31-dic-19	31-dic-20	31-dic-21	31-dic-22	31-dic-23
Variation of Cash	Eur'000		36,094	41,994	38,000	53,955	59,530	66,361	73,237	73,803	82,153	88,975
Final Cash Balance	Eur'000	p/Bal	159,138	201,131	239,132	293,087	352,617	418,978	492,215	566,018	648,170	737,145

Financial Statements				Construction Flag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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Financial Statements		Construction Flag	0	0	0	0	0	0	0	0	0	0
		Operation Flag	1	1	1	1	1	1	1	1	1	1
		Period	20	21	22	23	24	25	26	27	28	29
		Beginning of the Period	01-ene-24	01-ene-25	01-ene-26	01-ene-27	01-ene-28	01-ene-29	01-ene-30	01-ene-31	01-ene-32	01-ene-33
		End of the Period	31-dic-24	31-dic-25	31-dic-26	31-dic-27	31-dic-28	31-dic-29	31-dic-30	31-dic-31	31-dic-32	31-dic-33
Units												
Earnings Before Taxes		Eur'000	150,275	158,716	162,464	173,784	183,739	192,938	200,488	196,580	223,892	233,551
Corporate Tax Rate	35,00%											
Corporate Taxes		Eur'000	- 52,596	- 55,551	- 56,862	- 60,825	- 64,309	- 67,528	- 70,171	- 68,803	- 78,362	- 81,743
Earnings After Taxes		Eur'000	97,678	103,165	105,602	112,960	119,430	125,410	130,317	127,777	145,530	151,808
			905,392	1,008,557	1,114,159	1,227,119	1,346,549	1,471,959	1,602,276	1,730,053	1,875,583	2,027,391
2,- Balance Sheet												
Assets												
Intangible Asset		Eur'000	424,745	424,745	436,931	455,854	455,854	455,854	455,854	455,854	455,854	455,854
Acc, Depreciation		Eur'000	178,785	189,065	200,515	213,873	227,232	240,590	253,949	267,307	280,666	294,024
Activo Inmovilizado Neto		Eur'000	245,960	235,681	236,416	241,980	228,622	215,263	201,905	188,547	175,188	161,830
Commercial Debtors		Eur'000	27,737	29,070	30,440	31,846	33,291	34,773	36,295	37,852	39,445	41,074
Tax Receivables		Eur'000	-	-	-	-	-	-	-	-	-	-
Cash		Eur'000	831,907	932,073	1,024,111	1,117,729	1,237,149	1,362,498	1,492,983	1,622,184	1,765,758	1,917,395
S/T Assets		Eur'000	859,644	961,143	1,054,550	1,149,576	1,270,440	1,397,271	1,529,278	1,660,036	1,805,203	1,958,469
ASSETS												
		Eur'000	1,105,604	1,196,823	1,290,966	1,391,556	1,499,062	1,612,535	1,731,183	1,848,582	1,980,392	2,120,299
Liabilities												
Equity		Eur'000	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80,876	80,876
Earnings After Taxes		Eur'000	905,392	1,008,557	1,114,159	1,227,119	1,346,549	1,471,959	1,602,276	1,730,053	1,875,583	2,027,391
Equity		Eur'000	986,268	1,089,433	1,195,035	1,307,995	1,427,425	1,552,835	1,683,152	1,810,929	1,956,459	2,108,267
VAT Loan		Eur'000	-	-	-	-	-	-	-	-	-	-

Financial Statements		Construction Flag	0	0	0	0	0	0	0	0	0	0	0
		Operation Flag	1	1	1	1	1	1	1	1	1	1	1
		Period	20	21	22	23	24	25	26	27	28	29	29
		Beginning of the Period	01-ene-24	01-ene-25	01-ene-26	01-ene-27	01-ene-28	01-ene-29	01-ene-30	01-ene-31	01-ene-32	01-ene-33	01-ene-33
		End of the Period	31-dic-24	31-dic-25	31-dic-26	31-dic-27	31-dic-28	31-dic-29	31-dic-30	31-dic-31	31-dic-32	31-dic-33	31-dic-33
Units													
Senior Debt Loan	Eur'000		119,240	107,316	95,392	83,468	71,544	59,620	47,696	35,772	23,848	11,924	11,924
l/t Senior Loan	Eur'000		107,316	95,392	83,468	71,544	59,620	47,696	35,772	23,848	11,924	0	0
s/t Senior Loan	Eur'000		11,924	11,924	11,924	11,924	11,924	11,924	11,924	11,924	11,924	11,924	11,924
Financial Liabilities	Eur'000		119,240	107,316	95,392	83,468	71,544	59,620	47,696	35,772	23,848	11,924	11,924
Commercial Creditors (Operational Period)	Eur'000		96	74	539	93	93	80	335	1,881	85	108	108
Commercial Creditors (Construction Period)	Eur'000		-	-	-	-	-	-	-	-	-	-	-
Income Tax Payable (Corporate Tax)	Eur'000		-	-	-	-	-	-	-	-	-	-	-
Non financial Liabilities	Eur'000		96	74	539	93	93	80	335	1,881	85	108	108
LIABILITIES	Eur'000		1,105,604	1,196,823	1,290,966	1,391,556	1,499,062	1,612,535	1,731,183	1,848,582	1,980,392	2,120,299	2,120,299
			ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok
			-	-	-	-	-	-	-	-	-	-	-
3,- Cash Flow													
Operational Incomes	Eur'000	p/V Proy,	167,437	175,025	183,297	191,794	201,074	209,476	218,667	228,077	238,363	247,554	247,554
Construction Expenses	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-
Investment During Operation	Eur'000	p/V Proy,	-	-	- 12,186	- 18,923	-	-	-	-	-	-	-
Operational Expenses	Eur'000	p/V Proy,	- 851	- 695	- 4,443	- 1,293	- 850	- 741	- 2,796	- 15,574	- 2,569	- 960	- 960
Construction and Operation Cash Flow	Eur'000		166,585	174,330	166,668	171,578	200,224	208,734	215,871	212,503	235,794	246,595	246,595
VAT Recovered by the Treasury	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-
VAT Paid to Suppliers	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-

Financial Statements		Units	Construction Flag								0			
			Operation Flag								0			
			Period								1			
			Beginning of the Period								20			
			End of the Period								26			
			01-ene-24	01-ene-25	01-ene-26	01-ene-27	01-ene-28	01-ene-29			01-ene-30	01-ene-31	01-ene-32	01-ene-33
			31-dic-24	31-dic-25	31-dic-26	31-dic-27	31-dic-28	31-dic-29			31-dic-30	31-dic-31	31-dic-32	31-dic-33
Corporate Taxes	Eur'000	p/V Proy,	- 52,596	- 55,551	- 56,862	- 60,825	- 64,309	- 67,528	-	-	- 70,171	- 68,803	- 78,362	- 81,743
Taxes Cash Flows	Eur'000		- 52,596	- 55,551	- 56,862	- 60,825	- 64,309	- 67,528	-	-	- 70,171	- 68,803	- 78,362	- 81,743
Equity Additions	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-
VAT loan Additions	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-
Senior Loan Additions	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-
Senior Debt Fees	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-
Senior Debt Interests	Eur'000	p/V Proy,	- 7,303	- 6,689	- 5,844	- 5,211	- 4,572	- 3,933	-	-	- 3,290	- 2,576	- 1,933	- 1,291
VAT Loan Interests and Fees	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-
VAT Loan Repayments	Eur'000	p/V Proy,	-	-	-	-	-	-	-	-	-	-	-	-
Senior Debt Repayments	Eur'000	p/V Proy,	- 11,924	- 11,924	- 11,924	- 11,924	- 11,924	- 11,924	-	-	- 11,924	- 11,924	- 11,924	- 11,924
Financial Cash Flows	Eur'000		- 19,227	- 18,613	- 17,768	- 17,135	- 16,496	- 15,858	-	-	- 15,214	- 14,500	- 13,857	- 13,215
Variation of Cash	Eur'000		94,762	100,166	92,038	93,618	119,420	125,349			130,485	129,201	143,575	151,637
Opening Cash Balance	Eur'000		737,145	831,907	932,073	1,024,111	1,117,729	1,237,149			1,362,498	1,492,983	1,622,184	1,765,758
Variation of Cash	Eur'000		94,762	100,166	92,038	93,618	119,420	125,349			130,485	129,201	143,575	151,637
Final Cash Balance	Eur'000	p/Bal	831,907	932,073	1,024,111	1,117,729	1,237,149	1,362,498			1,492,983	1,622,184	1,765,758	1,917,395

Financial Statements		Construction Flag	0	0	0	0	0	0	0
		Operation Flag	1	1	1	1	1	1	1
		Period	30	31	32	33	34	35	36
		Beginning of the Period	01-ene-34	01-ene-35	01-ene-36	01-ene-37	01-ene-38	01-ene-39	01-ene-40
		End of the Period	31-dic-34	31-dic-35	31-dic-36	31-dic-37	31-dic-38	31-dic-39	31-dic-40
		Units							
1.- Profit & Losses									
Traffic Incomes (Light-Duty Vehicles)	Eur'000		167,864	174,501	181,783	188,216	195,298	202,531	210,495
Traffic Incomes (Heavy-Duty Vehicles)	Eur'000		83,875	87,271	90,990	94,286	97,908	101,607	105,674
Other Incomes	Eur'000		7,552	7,853	8,183	8,475	8,796	9,124	9,485
Total incomes	Eur'000		259,292	269,625	280,956	290,978	302,002	313,263	325,654
Operational Expenses	Eur'000		- 1,485	- 820	- 14,532	- 853	- 2,528	- 1,050	- 0
Total Expenses	Eur'000		- 1,485	- 820	- 14,532	- 853	- 2,528	- 1,050	- 0
EBITDA	Eur'000		257,807	268,805	266,424	290,124	299,475	312,213	325.654
Depreciation	Lineal Eur'000		- 13,358	- 13,358	- 16,766	- 16,766	- 16,766	- 16,766	- 16,766
EBIT	Eur'000		244,449	255,446	249,658	273,358	282,708	295,447	308.888
Net Financial Costs	Eur'000		- 647	-	-	-	-	-	-
Earnings Before Taxes	Eur'000		243,802	255,446	249,658	273,358	282,708	295,447	308,888
Corporate Tax Rate	35.00%								
Corporate Taxes	Eur'000		- 85,331	- 89,406	- 87,380	- 95,675	- 98,948	- 103,406	- 108,111
Earnings After Taxes	Eur'000		158,471	166,040	162,278	177,683	183,760	192,041	200,777
			2,185,862	2,351,902	2,514,180	2,691,863	2,875,623	3,067.664	3.268.441
2.- Balance Sheet									
Assets									
Intangible Asset	Eur'000		455,854	455,854	470,708	470,708	470,708	470,708	470.708
Acc. Depreciation	Eur'000		307,382	320,741	337,507	354,273	371,039	387,805	404.571

Financial Statements		Construction Flag	0	0	0	0	0	0	0
		Operation Flag	1	1	1	1	1	1	1
		Period	30	31	32	33	34	35	36
		Beginning of the Period	01-ene-34	01-ene-35	01-ene-36	01-ene-37	01-ene-38	01-ene-39	01-ene-40
		End of the Period	31-dic-34	31-dic-35	31-dic-36	31-dic-37	31-dic-38	31-dic-39	31-dic-40
		Units							
Activo Inmovilizado Neto	Eur'000		148,471	135,113	133,201	116,435	99,669	82,903	66.136
Commercial Debtors	Eur'000		42,740	44,444	46,185	47,963	49,781	51,637	53.532
Tax Receivables	Eur'000		-	-	-	-	-	-	-
Cash	Eur'000		2,075,690	2,253,312	2,417,263	2,608,434	2,807,328	3,014,116	3.229.648
S/T Assets	Eur'000		2,118,430	2,297,755	2,463,447	2,656,398	2,857,108	3,065,753	3.283.180
ASSETS	Eur'000		2,266,901	2,432,868	2,596,648	2,772,833	2,956,777	3,148,655	3.349.317
Liabilities									
Equity	Eur'000		80,876	80,876	80,876	80,876	80,876	80,876	80.876
Earnings After Taxes	Eur'000		2,185,862	2,351,902	2,514,180	2,691,863	2,875,623	3,067,664	3.268.441
Equity	Eur'000		2,266,738	2,432,778	2,595,056	2,772,739	2,956,499	3,148,540	3.349.317
VAT Loan	Eur'000		-	-	-	-	-	-	-
Senior Debt Loan	Eur'000		0	-	-	-	-	-	-
I/t Senior Loan	Eur'000		0	-	-	-	-	-	-
s/t Senior Loan	Eur'000		-	-	-	-	-	-	-
Financial Liabilities	Eur'000		0	-	-	-	-	-	-
Commercial Creditors (Operational Period)	Eur'000		163	90	1,593	94	278	115	0
Commercial Creditors (Construction Period)	Eur'000		-	-	-	-	-	-	-
Income Tax Payable (Corporate Tax)	Eur'000		-	-	-	-	-	-	-
Non financial Liabilities	Eur'000		163	90	1,593	94	278	115	0
LIABILITIES	Eur'000		2,266,901	2,432,868	2,596,648	2,772,833	2,956,777	3,148,655	3.349.317
			ok	ok	ok	ok	ok	ok	ok
			-	-	-	-	-	-	-

Financial Statements			Construction Flag	0	0	0	0	0	0	0
			Operation Flag	1	1	1	1	1	1	1
			Period	30	31	32	33	34	35	36
			Beginning of the Period	01-ene-34	01-ene-35	01-ene-36	01-ene-37	01-ene-38	01-ene-39	01-ene-40
			End of the Period	31-dic-34	31-dic-35	31-dic-36	31-dic-37	31-dic-38	31-dic-39	31-dic-40
Units										
3.- Cash Flow										
Operational Incomes	Eur'000	p/V Proy,		257,626	267,922	279,215	289,199	300,185	311,407	323,759
Construction Expenses	Eur'000	p/V Proy,		-	-	-	-	-	-	-
Investment During Operation	Eur'000	p/V Proy,		-	-	14,854	-	-	-	-
Operational Expenses	Eur'000	p/V Proy,		- 1,430	- 893	- 13,030	- 2,352	- 2,344	- 1,212	- 116
Construction and Operation Cash Flow	Eur'000			256,196	267,029	251,331	286,847	297,841	310,195	323,643
VAT Recovered by the Treasury	Eur'000	p/V Proy,		-	-	-	-	-	-	-
VAT Paid to Suppliers	Eur'000	p/V Proy,		-	-	-	-	-	-	-
Corporate Taxes	Eur'000	p/V Proy,		- 85,331	- 89,406	- 87,380	- 95,675	- 98,948	- 103,406	- 108,111
Taxes Cash Flows	Eur'000			- 85,331	- 89,406	- 87,380	- 95,675	- 98,948	- 103,406	- 108,111
Equity Additions	Eur'000	p/V Proy,		-	-	-	-	-	-	-
VAT loan Additions	Eur'000	p/V Proy,		-	-	-	-	-	-	-
Senior Loan Additions	Eur'000	p/V Proy,		-	-	-	-	-	-	-
Senior Debt Fees	Eur'000	p/V Proy,		-	-	-	-	-	-	-
Senior Debt Interests	Eur'000	p/V Proy,		- 647	-	-	-	-	-	-
VAT Loan Interests and Fees	Eur'000	p/V Proy,		-	-	-	-	-	-	-
VAT Loan Repayments	Eur'000	p/V Proy,		-	-	-	-	-	-	-
Senior Debt Repayments	Eur'000	p/V Proy,		- 11,924	-	-	-	-	-	-
Financial Cash Flows	Eur'000			- 12,571	-	-	-	-	-	-
Variation of Cash	Eur'000			158,294	177,622	163,951	191,171	198,893	206,788	215,532
Opening Cash Balance	Eur'000			1,917,395	2,075,690	2,253,312	2,417,263	2,608,434	2,807,328	3,014,116
Variation of Cash	Eur'000			158,294	177,622	163,951	191,171	198,893	206,788	215,532
Final Cash Balance	Eur'000	p/Bal		2,075,690	2,253,312	2,417,263	2,608,434	2,807,328	3,014,116	3,229,648

ANNEX XVIII: RPA CALCULATIONS (CASE STUDY).

Administration`s Patrimonial Liability Calculations

Construction Flag	1	1	1	0	0	0	0	0	0	0	0
Operation Flag	0	0	0	1	1	1	1	1	1	1	1
Period	0	1	2	3	4	5	6	7	8	9	
Beginning of the Period	01-ene-04	01-ene-05	01-ene-06	01-ene-07	01-ene-08	01-ene-09	01-ene-10	01-ene-11	01-ene-12	01-ene-13	
Units	End of the Period	31-dic-04	31-dic-05	31-dic-06	31-dic-07	31-dic-08	31-dic-09	31-dic-10	31-dic-11	31-dic-12	31-dic-13

1.- Calculation of the RPA Amount

1.1.- Construction Phase Expenses Adding up the RPA

		Total										
Expropriation of Land	Eur'000	88,839	17,500	26,250	45,089	-	-	-	-	-	-	-
Civil Construction Works	Eur'000	271,669	53,871	122,176	95,622	-	-	-	-	-	-	-
Investments During Operation Phase	Eur'000	55,959	-	-	-	-	-	-	-	-	-	-
Real properties incorporated into the concession	Eur'000	21,555	572	4,663	16,320	-	-	-	-	-	-	-
RPA at the Beginning of the Operation Phase	Eur'000	438,022	71,943	153,089	157,031	-	-	-	-	-	-	-
Accumulated RPA	Eur'000		71,943	225,032	382,063	382,063	382,063	382,063	382,063	382,063	382,063	382,063

1.2.- Linear Amortization Criterion

	Linear											
Amortization Period	34	Years										
Total Investment	Eur'000	423,168	71,943	153,089	157,031	-	-	-	-	-	-	-
Accumulated Investment	Eur'000	9,711,948	71,943	225,032	382,063	382,063	382,063	382,063	382,063	382,063	382,063	382,063
Annual Amortization	Eur'000	278,576	-	-	-	11,237	11,237	11,237	11,237	11,237	11,237	11,237
Accumulated Amortization	Eur'000	3,197,466	-	-	-	11,237	22,474	33,711	44,949	56,186	67,423	78,660
			71,943	225,032	382,063	370,826	359,589	348,352	337,114	325,877	314,640	303,403
Net Value	Eur'000	6,514,482	71,943	225,032	382,063	370,826	359,589	348,352	337,114	325,877	314,640	303,403

1.3.- Calculo de Amortización (En función del tráfico)

	Traffic											
% AADT Year "i" / Total AADT	%	100.00%	0.00%	0.00%	0.00%	1.11%	1.22%	1.33%	1.44%	1.55%	1.67%	1.81%
Total Investment	Eur'000	423,168	71,943	153,089	157,031	-	-	-	-	-	-	-
Accumulated Investment	Eur'000	9,711,948	71,943	225,032	382,063	382,063	382,063	382,063	382,063	382,063	382,063	382,063
Annual Amortization	Eur'000	231,850	-	-	-	4,226	4,653	5,081	5,508	5,935	6,362	6,900
Accumulated Amortization	Eur'000	2,188,376	-	-	-	4,226	8,879	13,960	19,468	25,403	31,765	38,664
			71,943	225,032	382,063	377,837	373,184	368,103	362,595	356,660	350,298	343,399
Net Value	Eur'000	7,523,572	71,943	225,032	382,063	377,837	373,184	368,103	362,595	356,660	350,298	343,399

Administration`s Patrimonial Liability Calculations

Construction Flag	0	0	0	0	0	0	0	0	0	0	0
Operation Flag	1	1	1	1	1	1	1	1	1	1	1
Period	10	11	12	13	14	15	16	17	18	19	
Beginning of the Period	01-ene-14	01-ene-15	01-ene-16	01-ene-17	01-ene-18	01-ene-19	01-ene-20	01-ene-21	01-ene-22	01-ene-23	
Units	End of the Period	31-dic-14	31-dic-15	31-dic-16	31-dic-17	31-dic-18	31-dic-19	31-dic-20	31-dic-21	31-dic-22	31-dic-23

1,- Calculation of the RPA Amount

1,1,- Construction Phase Expenses Adding up the RPA

Expropriation of Land	Eur'000	-	-	-	-	-	-	-	-	-	-
Civil Construction Works	Eur'000	-	-	-	-	-	-	-	-	-	-
Investments During Operation Phase	Eur'000	-	-	9,996	-	-	-	-	-	-	-
Real properties incorporated into the concession	Eur'000	-	-	-	-	-	-	-	-	-	-
RPA at the Beginning of the Operation Phase	Eur'000	-	-	9,996	-	-	-	-	-	-	-
Accumulated RPA	Eur'000	382,063	382,063	392,059	392,059	392,059	392,059	392,059	392,059	392,059	392,059

1,2,- Linear Amortization Criterion

Linear

Amortization Period	34	Years									
Total Investment	Eur'000	-	-	9,996	-	-	-	-	-	-	-
Accumulated Investment	Eur'000	382,063	382,063	392,059	392,059	392,059	392,059	392,059	392,059	392,059	392,059
Annual Amortization	Eur'000	11,237	11,237	11,931	11,931	11,931	11,931	11,931	11,931	11,931	11,931
Accumulated Amortization	Eur'000	89,897	101,134	113,065	124,996	136,927	148,858	160,789	172,720	184,651	196,582
		292,166	280,929	278,994	267,063	255,132	243,201	231,270	219,339	207,408	195,477
Net Value	Eur'000	292,166	280,929	278,994	267,063	255,132	243,201	231,270	219,339	207,408	195,477

1.3.- Amortization Criterion with Respect to Traffic

Traffic

% AADT Year "i" / Total AADT	%	1.95%	2.09%	2.23%	2.37%	2.51%	2.65%	2.79%	2.88%	2.96%	3.05%
Total Investment	Eur'000	-	-	9,996	-	-	-	-	-	-	-
Accumulated Investment	Eur'000	382,063	382,063	392,059	392,059	392,059	392,059	392,059	392,059	392,059	392,059
Annual Amortization	Eur'000	7,437	7,974	8,994	9,562	10,129	10,697	11,265	11,617	11,967	12,315
Accumulated Amortization	Eur'000	46,101	54,076	63,069	72,631	82,760	93,457	104,722	116,338	128,305	140,621
		335,962	327,987	328,990	319,429	309,299	298,602	287,338	275,721	263,754	251,439
Net Value	Eur'000	335,962	327,987	328,990	319,429	309,299	298,602	287,338	275,721	263,754	251,439

Administration`s Patrimonial Liability Calculations

Construction Flag	0	0	0	0	0	0	0	0	0	0	0
Operation Flag	1	1	1	1	1	1	1	1	1	1	1
Period	20	21	22	23	24	25	26	27	28	29	
Beginning of the Period	01-ene-24	01-ene-25	01-ene-26	01-ene-27	01-ene-28	01-ene-29	01-ene-30	01-ene-31	01-ene-32	01-ene-33	
Units	End of the Period	31-dic-24	31-dic-25	31-dic-26	31-dic-27	31-dic-28	31-dic-29	31-dic-30	31-dic-31	31-dic-32	31-dic-33

1,- Calculation of the RPA Amount

1,1,- Construction Phase Expenses Adding up the RPA

Expropriation of Land	Eur'000	-	-	-	-	-	-	-	-	-	-
Civil Construction Works	Eur'000	-	-	-	-	-	-	-	-	-	-
Investments During Operation Phase	Eur'000	-	-	12,186	18,923	-	-	-	-	-	-
Real properties incorporated into the concession	Eur'000	-	-	-	-	-	-	-	-	-	-
RPA at the Beginning of the Operation Phase	Eur'000	-	-	12,186	18,923	-	-	-	-	-	-

Accumulated RPA	Eur'000	392,059	392,059	404,245	423,168	423,168	423,168	423,168	423,168	423,168	423,168
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1,2,- Linear Amortization Criterion

Linear

Amortization Period	34	Years									
Total Investment	Eur'000	-	-	12,186	18,923	-	-	-	-	-	-
Accumulated Investment	Eur'000	392,059	392,059	404,245	423,168	423,168	423,168	423,168	423,168	423,168	423,168
Annual Amortization	Eur'000	11,931	11,931	13,102	15,010	15,010	15,010	15,010	15,010	15,010	15,010
Accumulated Amortization	Eur'000	208,513	220,445	233,546	248,556	263,566	278,576	293,586	308,596	323,606	338,616
		183,546	171,615	170,699	174,612	159,602	144,592	129,582	114,572	99,562	84,552
Net Value	Eur'000	183,546	171,615	170,699	174,612	159,602	144,592	129,582	114,572	99,562	84,552

1.3.- Amortization Criterion with Respect to Traffic

Traffic

% AADT Year "i" / Total AADT	%	3.14%	3.22%	3.31%	3.39%	3.47%	3.56%	3.64%	3.72%	3.80%	3.88%
Total Investment	Eur'000	-	-	12,186	18,923	-	-	-	-	-	-
Accumulated Investment	Eur'000	392,059	392,059	404,245	423,168	423,168	423,168	423,168	423,168	423,168	423,168
Annual Amortization	Eur'000	12,662	13,007	14,447	16,629	17,039	17,446	17,850	18,249	18,642	19,029
Accumulated Amortization	Eur'000	153,283	166,290	180,737	197,365	214,404	231,850	249,700	267,949	286,591	305,620
		238,776	225,769	223,508	225,803	208,764	191,318	173,467	155,219	136,577	117,548
Net Value	Eur'000	238,776	225,769	223,508	225,803	208,764	191,318	173,467	155,219	136,577	117,548

Administration's Patrimonial Liability Calculations

Construction Flag	0	0	0	0	0	0	0
Operation Flag	1	1	1	1	1	1	1
Period	30	31	32	33	34	35	36
Beginning of the Period	01-ene-34	01-ene-35	01-ene-36	01-ene-37	01-ene-38	01-ene-39	01-ene-40
End of the Period	31-dic-34	31-dic-35	31-dic-36	31-dic-37	31-dic-38	31-dic-39	31-dic-40

1,- Calculation of the RPA Amount

1,1,- Construction Phase Expenses Adding up the RPA

Expropriation of Land	Eur'000	-	-	-	-	-	-	-
Civil Construction Works	Eur'000	-	-	-	-	-	-	-
Investments During Operation Phase	Eur'000	-	-	14,854	-	-	-	-
Real properties incorporated into the concession	Eur'000	-	-	-	-	-	-	-
RPA at the Beginning of the Operation Phase	Eur'000	-	-	14,854	-	-	-	-
Accumulated RPA	Eur'000	423,168	423,168	438,022	438,022	438,022	438,022	438,022

1,2,- Linear Amortization Criterion

Linear

Amortization Period	34	Years						
Total Investment		Eur'000	-	-	14,854	-	-	-
Accumulated Investment		Eur'000	423,168	423,168	438,022	438,022	438,022	438,022
Annual Amortization		Eur'000	15,010	15,010	18,418	18,418	18,418	18,418
Accumulated Amortization		Eur'000	353,626	368,636	387,054	405,471	423,889	442,307
			69,542	54,532	50,968	32,551	14,133	-
Net Value		Eur'000	69,542	54,532	50,968	32,551	14,133	-

1,3,- Amortization Criterion with Respect to Traffic

Traffic

% AADT Year "i" / Total AADT	%		3,96%	4,04%	4,11%	4,18%	4,26%	4,33%	4,40%
Total Investment	Eur'000		-	-	14,854	-	-	-	-
Accumulated Investment	Eur'000		423,168	423,168	438,022	438,022	438,022	438,022	438,022
Annual Amortization	Eur'000		19,411	19,787	23,636	24,063	24,483	24,896	25,302
Accumulated Amortization	Eur'000		325,030	344,817	368,453	392,516	416,999	441,896	467,198
			98,137	78,351	69,569	45,506	21,023	-	3,874
Net Value	Eur'000		98,137	78,351	69,569	45,506	21,023	-	-

ANNEX XIX: DIFFUSION PROCESS (CASE STUDY).

Diffusion Process
$\frac{d\theta_i(t)}{\theta_i(0)} = \alpha_i \cdot dt + \sigma_i \cdot dz_i$ $\theta_i(t) = \theta_i(0) \cdot e^{\left[\left(\alpha_i - \frac{\sigma_i^2}{2}\right) \cdot t + \sigma_i \cdot \xi_i \cdot \sqrt{t}\right]}$

Simulation Variables			
<i>rf</i>	2.94%	<i>r</i>	2.89%
<i>α</i>	2.18%	<i>α (adjusted)</i>	0.95%
<i>σ</i>	8.00%	<i>δ</i>	0.020
<i>rm</i>	8.99%	WACC	3.66%
<i>β</i>	0.2038	Δt	1.000

Beginning of the Period	01-ene-04	01-ene-05	01-ene-06	01-ene-07	01-ene-08	01-ene-09	01-ene-10	01-ene-11	01-ene-12	01-ene-13
End of the Period	31-dic-04	31-dic-05	31-dic-06	31-dic-07	31-dic-08	31-dic-09	31-dic-10	31-dic-11	31-dic-12	31-dic-13
Period	0	1	2	3	4	5	6	7	8	9

Traffic Considered in the Tender	4,050,017	4,471,766	4,868,948	5,278,331	5,687,675	6,113,735	6,612,050			
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ξi	0.61995	-	0.61726	0.43964	1.53934	1.44325	0.18100			
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Traffic Obtained by Simulation	2,985,428	3,156,928	2,995,222	3,092,530	3,486,633	3,900,859	3,945,110			
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<i>Total AADT</i>	466,094	-	-	-	8,202	8,649	8,229	8,496	9,579	10,687	10,838
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Beginning of the Period	01-ene-14	01-ene-15	01-ene-16	01-ene-17	01-ene-18	01-ene-19	01-ene-20	01-ene-21	01-ene-22	01-ene-23
End of the Period	31-dic-14	31-dic-15	31-dic-16	31-dic-17	31-dic-18	31-dic-19	31-dic-20	31-dic-21	31-dic-22	31-dic-23
Period	10	11	12	13	14	15	16	17	18	19

Traffic Considered in the Tender	7,127,073	7,642,063	8,179,434	8,671,964	9,186,885	9,701,790	10,244,749	10,535,783	10,853,511	11,169,698
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ξi	1	1	0	2	0.40336	0.42706	0.61137	-	0.19303	0.23439	1.05272
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Traffic Obtained by Simulation	4,393,062	4,890,491	4,952,658	5,627,595	5,793,584	5,975,787	6,255,276	6,139,740	6,235,967	6,762,219
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<i>Total AADT</i>	466,094	12,069	13,435	13,569	15,460	15,916	16,417	17,138	16,867	17,132	18,578
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Beginning of the Period	01-ene-24	01-ene-25	01-ene-26	01-ene-27	01-ene-28	01-ene-29	01-ene-30	01-ene-31	01-ene-32	01-ene-33
End of the Period	31-dic-24	31-dic-25	31-dic-26	31-dic-27	31-dic-28	31-dic-29	31-dic-30	31-dic-31	31-dic-32	31-dic-33
Period	20	21	22	23	24	25	26	27	28	29

Traffic Considered in the Tender	11,515,741	11,796,844	12,107,523	12,416,103	12,757,421	13,026,515	13,328,142	13,625,720	13,957,407	14,208,416
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ξ_i	-	0 -	1 -	1	0	-	0.28445	-	0.21443	-	1.76300	0.72705	1.69902	0.27065
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Traffic Obtained by Simulation	6,649,513	6,075,376	5,764,483	5,851,400	5,701,473	5,586,596	4,836,204	5,109,460	5,834,655	5,943,317
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<i>Total AADT</i>	<i>18,218</i>	<i>16,691</i>	<i>15,836</i>	<i>16,075</i>	<i>15,620</i>	<i>15,348</i>	<i>13,286</i>	<i>14,037</i>	<i>15,985</i>	<i>16,328</i>
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Beginning of the Period	01-ene-34	01-ene-35	01-ene-36	01-ene-37	01-ene-38	01-ene-39	01-ene-40
End of the Period	31-dic-34	31-dic-35	31-dic-36	31-dic-37	31-dic-38	31-dic-39	31-dic-40
Period	30	31	32	33	34	35	36

Traffic Considered in the Tender	14,493,402	14,774,072	15,091,727	15,322,284	15,589,752	15,852,756	16,155,536
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ξ_i	-	2.03879	0.02457	0.10171	-	1.82373	-	0.64535	-	1.00455	2.10922
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Traffic Obtained by Simulation	5,032,736	5,026,527	5,051,402	4,351,704	4,119,531	3,789,276	4,471,450
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<i>Total AADT</i>	<i>13,826</i>	<i>13,809</i>	<i>13,839</i>	<i>11,955</i>	<i>11,317</i>	<i>10,410</i>	<i>12,251</i>
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**ANNEX XX: ABANDONMENT OPTION VALUE WITH RESPECT TO
INITIAL TRAFFIC VOLUME.**

Table a.: Abandonment Option Value (AOV) with Respect to Traffic

($\theta_0 = 4,050,017$)

Initial Traffic	4.050.017	vehicles																				
$\sigma =$	8,00%		Σ Present Value, T=0	3,285	Eur'000																	
Depreciation Criterion	Linear		Σ Abandonment Likelihood	6,28%	(%)																	
Abandonment Penalty	2,00%																					
	Year		<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")			141	228	283	310	357	272	262	345	412	370	311	322	221	294	215	231	309	168	29	19
Abandonment Likelihood in Year "i"			0,22%	0,32%	0,38%	0,43%	0,45%	0,38%	0,30%	0,39%	0,46%	0,45%	0,37%	0,39%	0,27%	0,36%	0,28%	0,30%	0,33%	0,15%	0,03%	0,02%
Present Value			115	181	218	232	260	192	180	230	267	233	190	191	127	165	117	122	159	84	14	9
Discount Rate	2,94%																					

($\theta_0 - 10\%$)

Initial Traffic	3.645.015	vehicles																				
$\sigma =$	8,00%		Σ Present Value, T=0	6,452	Eur'000																	
Depreciation Criterion	Linear		Σ Abandonment Likelihood	16,81%	(%)																	
Abandonment Penalty	2,00%																					
	Year		<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")			569	641	685	712	744	796	807	561	496	470	545	466	314	436	293	375	457	179	95	18
Abandonment Likelihood in Year "i"			1,25%	1,50%	1,61%	1,41%	1,45%	1,47%	1,31%	0,87%	0,77%	0,78%	0,83%	0,70%	0,45%	0,64%	0,39%	0,53%	0,54%	0,19%	0,10%	0,02%
Present Value			465	508	528	533	541	562	554	374	321	296	333	277	181	244	159	198	235	89	46	8
Discount Rate	2,94%																					

Table a.: Abandonment Option Value (AOV) with Respect to Initial Traffic Volume

(θ_0 -20%)

Initial Traffic	3,240,014	vehicles																				
$\sigma =$	8.00%	Σ Present Value, T=0	21,302	Eur'000																		
Depreciation Criterion	Linear	Σ Abandonment Likelihood	39.05%	(%)																		
Abandonment Penalty	2.00%																					
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>	
E(AOV, Year "i")		3,857	2,666	2,322	2,472	2,252	2,279	2,280	1,549	1,603	1,503	1,491	1,233	1,034	1,023	868	725	1,107	433	111	141	
Abandonment Likelihood in Year "i"		5.16%	4.39%	3.96%	3.45%	2.82%	2.67%	2.36%	1.68%	1.75%	1.65%	1.70%	1.45%	1.17%	1.18%	1.02%	0.85%	1.13%	0.40%	0.11%	0.15%	
Present Value		3,149	2,114	1,789	1,850	1,637	1,610	1,564	1,032	1,038	945	911	732	596	573	472	383	568	216	54	66	
Discount Rate	2.94%																					

(θ_0 -30%)

Initial Traffic	2,835,012	vehicles																				
$\sigma =$	8.00%	Σ Present Value, T=0	47,683	Eur'000	43458																	
Depreciation Criterion	Linear	Σ Abandonment Likelihood	74,84%	(%)																		
Abandonment Penalty	2.00%																					
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>	
E(AOV, Year "i")		13,263	9,596	7,133	5,595	4,134	4,049	3,412	2,909	2,619	2,280	2,035	2,095	1,420	1,311	1,098	1,000	1,199	667	224	135	
Abandonment Likelihood in Year "i"		12.68%	10.30%	8.62%	7.24%	5.46%	4.63%	4.58%	3.97%	2.82%	2.41%	2.23%	2.25%	1.59%	1.44%	1.25%	1.12%	1.26%	0.62%	0.23%	0.14%	
Present Value		10,828	7,611	5,496	4,188	3,006	2,860	2,341	1,939	1,696	1,434	1,243	1,244	819	734	597	529	616	333	65	105	
Discount Rate	2.94%																					

Table a.: Abandonment Option Value (AOV) with Respect to Traffic

(θo -40%)

Initial Traffic	2,430,010	vehicles																				
σ =	8.00%		ΣPresent Value, T=0	69,099	Eur'000																	
Depreciation Criterion	Linear		ΣAbandonment Likelihood	94,29%	(%)																	
Abandonment Penalty	2.00%																					
	Year		<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")			25,310	16,657	11,752	9,084	6,641	5,144	4,492	2,665	2,032	1,807	1,416	1,277	811	711	536	616	586	196	123	73
Abandonment Likelihood in Year "i"			27.77%	15.82%	11.76%	9.37%	6.69%	5.48%	4.30%	2.59%	2.05%	1.80%	1.52%	1.31%	0.82%	0.77%	0.61%	0.69%	0.57%	0.18%	0.12%	0.07%
Present Value			20,663	13,211	9,054	6,799	4,828	3,633	3,082	1,776	1,316	1,137	865	758	468	398	292	326	301	98	60	34
Discount Rate	2.94%																					

(θo -50%)

Initial Traffic	2,025,009	vehicles																				
σ =	8.00%		ΣPresent Value, T=0	86,486	Eur'000																	
Depreciation Criterion	Linear		ΣAbandonment Likelihood	99.86%	(%)																	
Abandonment Penalty	2.00%																					
	Year		<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")			56,217	26,833	11,653	6,454	3,248	1,826	1,248	703	228	219	169	70	31	81	29	28	-	-	-	-
Abandonment Likelihood in Year "i"			51.46%	24.34%	10.75%	5.98%	3.11%	1.69%	1.08%	0.64%	0.22%	0.21%	0.15%	0.08%	0.03%	0.07%	0.03%	0.02%	0.00%	0.00%	0.00%	0.00%
Present Value			45,896	21,281	8,978	4,830	2,362	1,290	856	469	148	138	103	42	18	45	16	15	-	-	-	-
Discount Rate	2.94%																					

Table a.: Abandonment Option Value (AOV) with Respect to Traffic

(θ_0 =Random)

Initial Traffic	Random	vehicles																			
$\sigma =$	8.00%	Σ Present Value, T=0		78,018	Eur'000																
Depreciation Criterion	Linear	Σ Abandonment Likelihood		85.30%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		18,848	15,915	12,788	9,432	8,586	7,150	6,694	5,040	4,510	4,040	3,074	2,112	2,111	1,795	1,258	1,391	1,541	748	418	528
Abandonment Likelihood in Year "i"		14.59%	12.19%	10.06%	7.37%	6.85%	5.68%	5.05%	3.93%	3.57%	3.21%	2.51%	1.84%	1.71%	1.54%	1.15%	1.32%	1.29%	0.60%	0.38%	0.46%
Present Value		15,388	12,622	9,852	7,059	6,243	5,050	4,593	3,359	2,920	2,541	1,878	1,254	1,217	1,005	685	735	791	373	203	249
Discount Rate	2.94%																				

ANNEX XXI: ABANDONMENT OPTION VALUE WITH RESPECT TO VOLATILITY.

Table a.: Abandonment Option Value (AOV) with Respect to Volatility																						
(σ = 5.00%)																						
Initial Traffic	Random																					
σ =	5.00%	ΣPresent Value, T=0		69,313	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood		75.41%	(%)																	
Abandonment Penalty	2.00%																					
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>	
E(AOV, Year "i")		16,234	13,627	10,790	9,550	7,362	6,281	6,376	4,366	3,790	3,515	2,482	2,986	1,711	1,577	1,193	1,394	1,151	972	462	440	
Abandonment Likelihood in Year "i"		12.64%	10.54%	8.48%	7.33%	5.96%	5.04%	4.72%	3.22%	2.90%	2.70%	2.06%	2.42%	1.41%	1.30%	1.06%	1.20%	0.97%	0.73%	0.37%	0.36%	
Present Value		13,254	10,808	8,313	7,148	5,353	4,436	4,375	2,910	2,454	2,211	1,517	1,772	987	883	649	737	591	485	224	207	
Discount Rate	2.94%																					
(σ = 10.00%)																						
Initial Traffic	Random																					
σ =	10.00%	ΣPresent Value, T=0		95,105	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood		95.15%	(%)																	
Abandonment Penalty	2.00%																					
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>	
E(AOV, Year "i")		27,544	21,261	17,439	12,803	10,228	8,658	6,941	4,621	3,812	3,558	2,486	2,068	1,688	1,297	1,229	981	810	476	411	320	
Abandonment Likelihood in Year "i"		19.61%	15.66%	12.65%	9.62%	7.62%	6.61%	4.81%	3.49%	2.83%	2.67%	1.98%	1.55%	1.38%	1.09%	1.04%	0.89%	0.67%	0.36%	0.34%	0.28%	
Present Value		22,487	16,862	13,436	9,582	7,436	6,115	4,762	3,080	2,468	2,238	1,519	1,228	973	727	669	519	416	237	199	151	
Discount Rate	2.94%																					

Table a.: Abandonment Option Value (AOV) with Respect to Volatility

(σ = 15.00%)																					
Initial Traffic	Random																				
σ =	15.00%	ΣPresent Value, T=0		118,746	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		99.67%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		48,801	31,660	22,382	15,760	11,208	6,889	5,723	3,943	2,420	1,815	1,194	890	597	572	351	247	209	129	46	83
Abandonment Likelihood in Year "i"		30.91%	20.54%	14.38%	10.18%	7.20%	4.66%	3.48%	2.48%	1.54%	1.19%	0.84%	0.62%	0.45%	0.41%	0.26%	0.19%	0.15%	0.08%	0.04%	0.07%
Present Value		39,842	25,109	17,244	11,795	8,149	4,866	3,927	2,628	1,567	1,142	730	528	344	320	191	131	107	64	22	39
Discount Rate	2.94%																				
(σ = 20.00%)																					
Initial Traffic	Random																				
σ =	20.00%	ΣPresent Value, T=0		140,982	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		99.96%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		71,580	44,015	26,233	16,250	8,638	5,247	3,605	1,459	1,243	665	475	266	95	81	66	41	-	-	-	-
Abandonment Likelihood in Year "i"		39.85%	24.52%	14.56%	8.71%	4.80%	3.02%	2.03%	0.81%	0.68%	0.38%	0.27%	0.15%	0.06%	0.06%	0.04%	0.02%	0.00%	0.00%	0.00%	0.00%
Present Value		58,439	34,908	20,211	12,162	6,280	3,706	2,473	972	805	418	290	158	55	45	36	22	-	-	-	-
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Volatility

(σ = 25.00%)																					
Initial Traffic	Random																				
σ =	25.00%	ΣPresent Value, T=0		160,844		Eur'000															
Depreciation Criterion	Linear	ΣAbandonment Likelihood		99.98%		(%)															
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		97,065	50,816	27,374	13,387	7,087	3,779	1,882	994	365	123	112	37	13	-	-	-	-	-	-	-
Abandonment Likelihood in Year "i"		47.66%	25.09%	13.59%	6.53%	3.55%	1.84%	0.87%	0.49%	0.20%	0.07%	0.06%	0.02%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Present Value		79,245	40,302	21,090	10,019	5,153	2,669	1,291	663	236	77	68	22	7	-	-	-	-	-	-	-
Discount Rate	2.94%																				
(σ = 30.00%)																					
Initial Traffic	Random																				
σ =	30.00%	ΣPresent Value, T=0		181,423		Eur'000															
Depreciation Criterion	Linear	ΣAbandonment Likelihood		100.00%		(%)															
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		127,488	55,200	24,822	11,389	4,952	1,715	984	354	172	109	17	-	-	-	-	-	-	-	-	-
Abandonment Likelihood in Year "i"		56.01%	24.35%	10.97%	4.99%	2.16%	0.79%	0.43%	0.14%	0.07%	0.05%	0.01%	0.00%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Present Value		104,083	43,779	19,124	8,524	3,600	1,211	675	236	111	69	10	-	-	-	-	-	-	-	-	-
Discount Rate	2.94%																				

ANNEX XXII: ABANDONMENT OPTION VALUE WITH RESPECT TO DEBT.

Table a.: Abandonment Option Value (AOV) with Respect to Debt

(Debt = 50%)

Initial Traffic	Random																				
$\sigma =$	8.00%	Σ Present Value, T=0	48,557	Eur'000																	
Depreciation Criterion	Linear	Σ Abandonment Likelihood	37.43%	(%)																	
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		6,814	6,957	5,638	5,330	4,870	5,336	4,847	4,008	3,449	3,074	3,390	2,948	2,340	2,542	2,202	2,086	2,189	1,747	930	697
Abandonment Likelihood in Year "i"		3.01%	3.14%	2.58%	2.57%	2.44%	2.69%	2.26%	2.00%	1.78%	1.68%	1.93%	1.76%	1.41%	1.57%	1.48%	1.44%	1.43%	1.11%	0.63%	0.52%
Present Value		5,563	5,518	4,344	3,989	3,541	3,769	3,326	2,671	2,233	1,934	2,071	1,750	1,349	1,424	1,198	1,103	1,124	872	451	328
Discount Rate	2.94%																				

(Debt = 60%)

Initial Traffic	Random																				
$\sigma =$	8.00%	Σ Present Value, T=0	70,191	Eur'000																	
Depreciation Criterion	Linear	Σ Abandonment Likelihood	59.27%	(%)																	
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		11,678	10,824	10,529	8,301	7,669	7,282	6,507	5,043	5,187	4,226	3,960	3,910	3,103	2,550	2,527	2,032	2,345	1,659	879	681
Abandonment Likelihood in Year "i"		6.05%	5.74%	5.74%	4.61%	4.36%	4.16%	3.62%	3.04%	3.06%	2.56%	2.48%	2.59%	2.07%	1.77%	1.86%	1.52%	1.69%	1.16%	0.65%	0.54%
Present Value		9,534	8,584	8,112	6,213	5,576	5,143	4,465	3,361	3,359	2,658	2,420	2,321	1,789	1,428	1,375	1,074	1,204	828	426	321
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Debt

(Debt = 70%)

Initial Traffic	Random																				
$\sigma =$	8.00%	Σ Present Value, T=0	77,261	Eur'000																	
Depreciation Criterion	Linear	Σ Abandonment Likelihood	73.39%	(%)																	
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		16,301	12,987	10,912	10,326	8,749	7,667	7,118	5,989	4,202	4,337	3,979	3,198	2,580	2,072	2,179	1,971	1,822	1,381	627	600
Abandonment Likelihood in Year "i"		10.03%	8.27%	7.20%	6.75%	5.82%	5.14%	4.63%	3.95%	2.97%	3.04%	2.81%	2.36%	1.98%	1.61%	1.73%	1.68%	1.43%	1.00%	0.50%	0.49%
Present Value		13,308	10,300	8,407	7,728	6,361	5,415	4,884	3,992	2,721	2,728	2,431	1,898	1,488	1,161	1,186	1,042	936	689	304	282
Discount Rate	2.94%																				

(Debt = 80%)

Initial Traffic	Random																				
$\sigma =$	8.00%	Σ Present Value, T=0	78,033	Eur'000																	
Depreciation Criterion	Linear	Σ Abandonment Likelihood	84.90%	(%)																	
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		18,708	15,334	12,529	10,805	9,072	7,018	6,151	5,004	4,610	3,636	2,802	2,417	1,985	1,766	1,532	1,485	1,099	1,051	540	485
Abandonment Likelihood in Year "i"		14.26%	11.90%	9.76%	8.58%	7.03%	5.75%	4.63%	3.70%	3.62%	2.84%	2.40%	2.02%	1.59%	1.44%	1.37%	1.32%	0.98%	0.83%	0.45%	0.43%
Present Value		15,273	12,161	9,653	8,087	6,596	4,957	4,220	3,335	2,985	2,287	1,712	1,435	1,145	989	834	785	564	524	235	254
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Debt

(Debt = 90%)

Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0	70,162	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood	92.47%	(%)																	
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		20,250	15,340	12,175	9,226	7,468	6,341	5,506	3,620	2,893	2,701	2,169	1,749	1,197	1,094	981	737	651	530	377	288
Abandonment Likelihood in Year "i"		20.05%	15.00%	12.07%	9.21%	7.44%	5.86%	4.84%	3.42%	2.77%	2.55%	1.95%	1.63%	1.26%	1.09%	1.00%	0.73%	0.57%	0.44%	0.32%	0.27%
Present Value		16,532	12,166	9,380	6,905	5,430	4,479	3,778	2,413	1,873	1,699	1,325	1,038	690	613	534	390	334	264	183	136
Discount Rate	2.94%																				

**ANNEX XXIII: ABANDONMENT OPTION VALUE WITH RESPECT
TO DIFFERENT FINES APPLIED BY THE PUBLIC ADMINISTRATION.**

Table a.: Abandonment Option Value (AOV) with Respect to Different Fines

(Penalty = 5%)

Initial Traffic	Random																				
$\sigma =$	8.00%	ΣPresent Value, T=0	79,155	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood	88.99%	(%)																	
Abandonment Penalty	5.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		22,227	15,908	13,483	10,426	8,515	6,785	6,095	4,406	3,688	2,999	2,999	2,585	1,870	1,505	1,231	1,146	1,044	898	257	322
Abandonment Likelihood in Year "i"		17.66%	13.03%	10.72%	8.55%	7.09%	5.78%	4.74%	3.70%	3.07%	2.51%	2.68%	2.12%	1.65%	1.39%	1.13%	1.09%	0.85%	0.70%	0.22%	0.31%
Present Value		18,146	12,617	10,388	7,803	6,191	4,792	4,182	2,937	2,388	1,886	1,833	1,534	1,078	843	670	606	536	448	125	152
Discount Rate	2.94%																				

(Penalty = 10%)

Initial Traffic	Random																				
$\sigma =$	8.00%	ΣPresent Value, T=0	67,306	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood	88.58%	(%)																	
Abandonment Penalty	10.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		16,545	14,264	11,403	8,937	7,449	6,572	5,744	4,177	3,380	2,813	2,004	2,003	1,599	1,122	1,147	909	1,070	620	375	343
Abandonment Likelihood in Year "i"		16.45%	13.54%	10.93%	8.62%	7.40%	6.27%	5.11%	3.71%	3.25%	2.53%	1.99%	1.82%	1.58%	1.17%	1.11%	0.89%	1.00%	0.54%	0.36%	0.31%
Present Value		13,508	11,313	8,785	6,689	5,416	4,642	3,941	2,784	2,189	1,769	1,225	1,189	922	629	624	481	549	309	182	161
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Different Fines

(Penalty = 15%)

Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0	58,490	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood	89.08%	(%)																	
Abandonment Penalty	15.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		14,739	11,735	9,305	7,838	6,589	5,371	5,152	3,622	2,850	2,447	2,116	1,840	1,279	1,451	1,188	813	1,054	675	334	309
Abandonment Likelihood in Year "i"		16.85%	13.25%	10.59%	8.79%	7.36%	5.80%	5.14%	3.71%	3.03%	2.74%	2.36%	2.04%	1.35%	1.57%	1.33%	0.91%	1.05%	0.58%	0.30%	0.33%
Present Value		12,033	9,307	7,169	5,866	4,791	3,794	3,535	2,414	1,845	1,539	1,293	1,092	738	813	646	430	541	337	162	145
Discount Rate	2.94%																				

(Penalty = 20%)

Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0	51,512	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood	87.86%	(%)																	
Abandonment Penalty	20.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		11,692	9,803	9,052	6,507	6,124	4,717	4,932	3,164	2,823	2,309	1,953	1,552	1,338	1,102	962	1,000	1,002	661	449	368
Abandonment Likelihood in Year "i"		13.96%	11.86%	10.92%	8.39%	7.46%	6.37%	5.49%	4.13%	3.56%	2.89%	2.57%	2.06%	1.72%	1.49%	1.21%	1.22%	1.08%	0.67%	0.41%	0.40%
Present Value		9,546	7,775	6,974	4,870	4,453	3,332	3,384	2,109	1,828	1,452	1,193	921	772	617	523	529	515	330	218	173
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Different Fines

(Penalty = 25%)

Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		45,635	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		86.24%	(%)																
Abandonment Penalty	25.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		9,332	8,244	7,295	5,684	5,392	4,705	4,253	3,261	2,848	2,259	2,049	1,754	1,526	1,098	1,157	848	828	646	445	369
Abandonment Likelihood in Year "i"		11.57%	10.67%	9.79%	7.48%	7.25%	6.56%	6.05%	4.52%	4.13%	3.53%	2.85%	2.54%	2.06%	1.67%	1.66%	1.18%	1.04%	0.73%	0.54%	0.42%
Present Value		7,619	6,538	5,620	4,254	3,920	3,323	2,918	2,174	1,844	1,421	1,252	1,041	880	615	630	448	425	322	216	174
Discount Rate	2.94%																				

(Penalty = 30%)

Initial Traffic	Random																					
σ =	8.00%	ΣPresent Value, T=0				39,813	Eur'000															
Depreciation Criterion	Linear	ΣAbandonment Likelihood				82.86%	(%)															
Abandonment Penalty	30.00%																					
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>	
E(AOV, Year "i")		7,391	6,723	5,655	5,012	4,803	4,184	4,020	2,837	2,560	2,158	1,979	1,881	1,509	1,155	1,122	944	1,060	750	404	341	
Abandonment Likelihood in Year "i"		9.57%	9.19%	7.97%	7.46%	6.60%	6.09%	5.47%	4.47%	3.98%	3.69%	3.41%	3.33%	2.73%	2.05%	1.81%	1.55%	1.51%	0.95%	0.56%	0.47%	
Present Value		6,034	5,332	4,357	3,751	3,492	2,955	2,758	1,891	1,658	1,357	1,209	1,117	870	647	611	499	544	374	196	161	
Discount Rate	2.94%																					

**ANNEX XXIV: ABANDONMENT OPTION VALUE WITH RESPECT TO
THE EXPROPRIATIONS OVERRUN.**

Table a.: Abandonment Option Value (AOV) with Respect to Expropriations Overrun

(Exp. Overrun = 10%)																					
Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		88,197	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		90.51%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		24,640	18,849	15,206	12,708	9,634	7,660	6,476	4,760	3,603	3,711	2,676	2,376	1,702	1,394	1,351	991	876	746	381	283
Abandonment Likelihood in Year "i"		17.84%	14.08%	11.35%	9.47%	7.17%	5.86%	4.85%	3.52%	2.87%	2.80%	2.12%	1.99%	1.47%	1.20%	1.20%	0.90%	0.73%	0.56%	0.29%	0.24%
Present Value		20,116	14,949	11,715	9,511	7,005	5,410	4,443	3,173	2,333	2,334	1,635	1,410	981	781	735	524	450	372	185	133
Discount Rate	2.94%																				
(Exp. Overrun = 20%)																					
Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		92,087	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		91.59%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		27,040	20,851	15,403	12,919	9,793	7,667	6,700	4,714	3,877	3,214	2,763	2,201	1,923	1,347	1,162	946	817	714	435	327
Abandonment Likelihood in Year "i"		19.31%	15.14%	11.08%	9.44%	7.14%	5.81%	4.86%	3.33%	2.95%	2.40%	2.11%	1.70%	1.57%	1.08%	1.01%	0.82%	0.67%	0.53%	0.36%	0.28%
Present Value		22,076	16,537	11,867	9,669	7,120	5,415	4,597	3,142	2,510	2,022	1,688	1,306	1,109	755	632	500	420	356	211	154
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Expropriations Overrun

(Exp. Overrun = 30%)																					
Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		95,234		Eur'000															
Depreciation Criterion	Linear	ΣAbandonment Likelihood		92.30%		(%)															
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		29,163	22,529	16,528	12,507	10,231	8,039	5,753	4,549	3,692	3,089	2,485	2,229	1,565	1,624	1,398	933	1,004	708	288	249
Abandonment Likelihood in Year "i"		20.20%	15.70%	11.64%	9.12%	7.52%	5.85%	4.12%	3.28%	2.74%	2.27%	1.84%	1.76%	1.26%	1.29%	1.14%	0.82%	0.76%	0.54%	0.24%	0.21%
Present Value		23,809	17,868	12,734	9,361	7,439	5,678	3,947	3,032	2,391	1,943	1,518	1,323	902	910	761	493	516	353	140	117
Discount Rate	2.94%																				
(Exp. Overrun = 40%)																					
Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		98,706		Eur'000															
Depreciation Criterion	Linear	ΣAbandonment Likelihood		93.58%		(%)															
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		30,655	22,648	17,675	13,685	10,561	7,907	6,352	4,687	3,903	3,431	2,206	2,173	1,585	1,661	979	1,058	592	573	323	224
Abandonment Likelihood in Year "i"		21.27%	15.34%	12.12%	9.76%	7.32%	5.75%	4.34%	3.46%	2.76%	2.45%	1.77%	1.63%	1.28%	1.27%	0.80%	0.93%	0.48%	0.42%	0.25%	0.18%
Present Value		25,027	17,962	13,618	10,242	7,679	5,585	4,358	3,124	2,527	2,158	1,348	1,290	914	930	533	559	304	286	157	105
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Expropriations Overrun

(Exp. Overrun = 50%)

Initial Traffic	Random																				
$\sigma =$	8.00%	ΣPresent Value, T=0	101,276	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood	94.36%	(%)																	
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		32,175	24,673	18,024	14,231	10,500	7,444	6,519	4,673	3,622	3,124	2,584	1,961	1,829	1,101	1,024	707	632	416	230	262
Abandonment Likelihood in Year "i"		21.96%	16.75%	12.50%	9.58%	7.20%	5.55%	4.34%	3.39%	2.58%	2.18%	1.91%	1.46%	1.45%	0.87%	0.85%	0.56%	0.50%	0.32%	0.19%	0.22%
Present Value		26,268	19,568	13,887	10,651	7,634	5,258	4,473	3,115	2,345	1,965	1,579	1,164	1,055	617	557	374	325	208	111	123
Discount Rate	2.94%																				

(Exp. Overrun = 60%)

Initial Traffic	Random																				
$\sigma =$	8.00%	ΣPresent Value, T=0	105,228	Eur'000																	
Depreciation Criterion	Linear	ΣAbandonment Likelihood	95.23%	(%)																	
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		34,994	25,377	18,434	13,886	10,870	8,345	7,179	4,773	3,857	3,195	2,073	1,848	1,336	1,002	985	880	756	446	298	156
Abandonment Likelihood in Year "i"		22.86%	16.97%	12.43%	9.37%	7.48%	5.99%	4.70%	3.16%	2.67%	2.25%	1.51%	1.40%	1.03%	0.78%	0.78%	0.65%	0.55%	0.30%	0.23%	0.12%
Present Value		28,570	20,126	14,202	10,393	7,903	5,894	4,926	3,181	2,497	2,010	1,267	1,097	770	561	536	465	388	222	144	73
Discount Rate	2.94%																				

Table a.: Abandonment Option Value (AOV) with Respect to Expropriations Overrun

(Exp. Overrun = 70%)

Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		108,571	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		95.96%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		37,301	28,578	19,276	14,670	10,581	8,135	6,297	4,174	3,551	2,569	2,021	1,403	1,482	1,005	796	756	781	475	266	171
Abandonment Likelihood in Year "i"		24.11%	18.74%	12.64%	9.87%	7.10%	5.55%	4.06%	2.94%	2.38%	1.75%	1.41%	1.08%	1.10%	0.78%	0.64%	0.57%	0.58%	0.34%	0.19%	0.13%
Present Value		30,453	22,665	14,851	10,980	7,693	5,746	4,321	2,782	2,299	1,616	1,235	833	855	563	433	400	401	237	129	81
Discount Rate	2.94%																				

(Exp. Overrun = 80%)

Initial Traffic	Random																					
σ =	8.00%	ΣPresent Value, T=0				111,151	Eur'000															
Depreciation Criterion	Linear	ΣAbandonment Likelihood				96.23%	(%)															
Abandonment Penalty	2.00%																					
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>	
E(AOV, Year "i")		40,599	28,059	19,538	15,188	10,366	8,560	5,605	4,599	3,416	2,698	2,166	1,612	1,101	751	970	545	564	594	167	234	
Abandonment Likelihood in Year "i"		25.56%	18.05%	12.55%	9.91%	6.92%	5.75%	3.75%	3.01%	2.32%	1.84%	1.61%	1.19%	0.88%	0.60%	0.74%	0.43%	0.42%	0.39%	0.13%	0.18%	
Present Value		33,146	22,254	15,053	11,367	7,537	6,046	3,846	3,065	2,212	1,697	1,324	957	635	421	528	288	290	296	81	110	
Discount Rate	2.94%																					

Table a.: Abandonment Option Value (AOV) with Respect to Expropriations Overrun

(Exp. Overrun = 90%)

Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		116,284	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		97.00%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		43,885	29,696	21,577	15,286	10,558	8,040	6,154	4,449	3,181	2,481	2,040	1,513	1,036	1,062	794	523	463	408	215	180
Abandonment Likelihood in Year "i"		27.07%	18.43%	13.63%	9.83%	6.79%	5.28%	3.81%	2.80%	2.05%	1.56%	1.40%	1.04%	0.75%	0.76%	0.54%	0.39%	0.32%	0.27%	0.14%	0.14%
Present Value		35,828	23,552	16,624	11,441	7,676	5,679	4,222	2,965	2,060	1,561	1,247	898	597	595	432	276	238	204	104	85
Discount Rate	2.94%																				

(Exp. Overrun = 100%)

Initial Traffic	Random																				
σ =	8.00%	ΣPresent Value, T=0		117,657	Eur'000																
Depreciation Criterion	Linear	ΣAbandonment Likelihood		97.43%	(%)																
Abandonment Penalty	2.00%																				
	Year	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023</u>	<u>2024</u>	<u>2025</u>	<u>2026</u>	<u>2027</u>	<u>2028</u>	<u>2029</u>
E(AOV, Year "i")		44,983	30,151	21,661	15,245	10,885	8,260	6,349	4,098	3,130	2,639	1,871	1,596	974	909	659	530	392	555	200	50
Abandonment Likelihood in Year "i"		27.46%	18.89%	13.37%	9.55%	7.04%	5.44%	3.92%	2.61%	2.07%	1.71%	1.30%	1.08%	0.71%	0.65%	0.45%	0.36%	0.26%	0.37%	0.15%	0.04%
Present Value		36,725	23,913	16,689	11,410	7,914	5,834	4,356	2,731	2,027	1,660	1,143	947	562	509	359	280	201	277	97	24
Discount Rate	2.94%																				