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I. Personal and study details

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PPP in Highway Construction: A Lesson to Be Learned from Latin America?

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PPP v dálniční výstavbě: Model Latinské Ameriky

Guidelines:

The thesis is focused on highway construction in Latin America. It includes an evaluation and practical implications of estimated results. Also, the study covers data collection, an analysis of the current state of the discussed issue and the construction of the model for the evaluation of observed phenomena.

Bibliography / sources:

WOOLDRIDGE Jeffrey, M. Introductory Econometrics: A Modern Approach. 5th ed. Mason: South-Western CENGAGE Learning. 2012. ISBN: 978-1-111-53104-1.
The World Bank. Public-Private Partnerships: Reference Guide. 3rd ed. Washington: World Bank Publications. 2017.

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III. Assignment receipt

The student acknowledges that the bachelor’s thesis is an individual work. The student must produce his thesis without the assistance of others, with the exception of provided consultations. Within the bachelor’s thesis, the author must state the names of consultants and include a list of references.

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PPP in Highway Construction:

A Lesson to Be Learned from Latin America?

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PPP v dálniční výstavbě: Model Latinské Ameriky

Declaration of authorship

I, Jakub Pešek, hereby declare that the thesis “PPP in Highway Construction: A Lesson to Be Learned from Latin America?” was written by myself, and that all presented results are my own, unless stated otherwise. The literature sources are listed in the References section.

Prague, December 20th, 2018

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Signature

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Abstract

This paper investigates whether Public-Private Partnership projects in highway construction in Latin America have lower cost overruns and delays than their counterparts of public procurement. The economic rationale supported by behavioural and public sector economics shows that Public-Private Partnerships should be more efficient in terms of cost overruns and delays than public procurement. This hypothesis was tested with an econometric analysis. The linkage between the use of Public-Private Partnerships and a decrease in cost overruns and delays seems to be present in the data. The results show a statistically and economically significant effect of the use of Public-Private Partnerships on both tested variables. Furthermore, the thesis serves as an example of the possibility to use econometrics in the research on construction management issues.

Keywords: Public-Private Partnership, highways, Latin America, public procurement, cost overruns, delays

JEL Classification: H40, L33, R42

Abstrakt

Tato práce zkoumá, jestli projekty partnerství veřejného a soukromého sektoru dálniční výstavby v Latinské Americe mají nižší vícepráce a kratší zpoždění než stejné projekty řešené pomocí klasických veřejných zakázek. Ekonomické opodstatnění, které je podpořené ekonomií veřejného sektoru a behaviorální ekonomií, ukazuje, že partnerství veřejného a soukromého sektoru by mělo být efektivnější z hlediska víceprací a zpoždění výstavby než tradiční veřejné zakázky. Tato hypotéza je pak testována pomocí ekonometrické analýzy. Korelace mezi využitím partnerství veřejného a soukromého sektoru a poklesem obou zkoumaných proměnných (vícepráce a zpoždění) se zdá být v datech přítomná, jelikož tento efekt je statisticky i ekonomicky významný. Dále práce slouží jako příklad možnosti využití ekonometrie ve výzkumu stavebního managementu.

Klíčová slova: partnerství veřejného a soukromého sektoru, dálnice, Latinská Amerika, veřejné zakázky, vícepráce, zpoždění

JEL klasifikace: H40, L33, R42

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Introduction

Public-private partnership (PPP) has radically transformed the traditional way of a procurement process for public infrastructure and shifted the cooperation between the private and public sector to a new level. Although the history of PPP goes back to 17^{th} century when the private sector was authorised to construct and manage public works by the French government, it has been merely used until the 1990s when its popularity started to increase, and the trend continues until the present time (Jackson, 2010; Klein, 2015).

In the European Union, this approach may become even more important in highway construction after 2020 when the funding framework for investment in transport in EU, Connecting Europe Facility, will terminate together with the transport operational programmes for member countries (European Commission, 2018, Česká televize, 2018). Nonetheless, some EU countries such as Croatia, the Czech Republic, Slovakia or Slovenia seem not to have acquired much experience in PPP and rarely have these member countries successfully used PPP in general, not to mention highway construction (Brenck et al., 2005; European Commission, 2016; European Investment Bank, 2018). The fact must be inevitably treated as a missed opportunity if certain projects might be more advantageous under PPP. This could be illustrated by a positive experience from the United Kingdom where PPP has become a convenient alternative to the traditional approach (Spackman, 2002). Thus, not using PPP at all does not appear much productive even though PPP might contain various disadvantages and potential risks. Considering the post-communist countries had to undergo a painful transformation from centrally planned economies to market-based, the loss should probably be multiplied. The transition was characteristic of the lack of capital and knowledge about how to handle projects of public infrastructure when a choice of contractor was based on competition and the free market. Indeed, these issues could have been partly solved by PPP which would have brought highly sought-after foreign investment and know-how.

However, this would be just one side of the coin. A different perspective could suggest experience from many developing countries in the 1990s where the hasty approach to highway privatisation might have done more harm than good. At the outset of the boom, some governments underestimated the contract phase of the partnerships and tried to use them even for projects which were not suitable to PPP by their nature. Then, subsequent financial guarantees and contract renegotiations brought considerable governmental subsidies to the contracted projects (Engel, Fischer & Galetovic, 2003). Undoubtedly, above stated examples say little about the advantages and disadvantages of PPP or its evaluation, but they illustrate the complexity of the problem and potential extremes of which none leads to efficiency. The arising question is how to evaluate PPP.

Extensive research has been done to investigate the different types of PPP contracts and their pros and cons (Song, Zhang & Dong, 2016). There are indisputably distinct views to when, where or how to use PPP contracts, let alone the relevance for each type of project. Also, diverse approaches are taken with respect to the respective field of study. Construction management aims to see what differences PPPs bring to planning, scheduling or controlling. Economics may investigate the determinants of successful application of PPP or examine the impact of partnerships in infrastructure on economic growth. Law tries to resolve the possible future disputes and establish legally clear consequences when PPP contract is employed. Finance could question the return on investment and risk of entering the partnership. A long line of studies has already discussed these issues from sundry perspectives. However, little has the literature focused on the fact that PPP projects may actually alter cost overrun or delay of a project, thus influence the project efficiency. Is it possible that public projects could have been performed closer to a deadline or with lower cost overruns, had they been performed under PPP?

Firstly, the behavioural economics and simple logic might suggest so. Human behaviour and generally free markets are built on rationality[1] and incentives which lead agents to their final outcome. The final payoff in perfect competition is either in an efficient equilibrium or at least in a Nash equilibrium which presents the most efficient

[1] Rationality of agents does not have to be necessarily perfect to allow a model application. As long as the irrationality is predictable a market modelling is possible. Empirical evidence shows that humans and therefore companies have limited rationality with certain amount predictable irrationality which allows economic models to hold (Thaler, 2015).

reactions[2] to the behaviour of the other agents in the market. Using these assumptions, one may derive the behaviour of the construction company performing a contract as a standard public procurement project and as a PPP project. When a contract is carried out traditionally construction companies have fewer incentives to use the best value-for-money materials and procedures. They can try to save up on their cost and increase their profit margin by using cheaper materials which have lower quality, or they might claim additional expenses in form of overpriced works due to unexpected situations. In either case, the public sector suffers from disadvantages concerning availability of information since the construction companies will always possess more information than public entities. Thus, the private sector can take advantage of the principle called asymmetric information[3]. In addition, civil servants have generally lower incentives to inspect whether the cost and prices are measured appropriately since they have fixed wages and are not awarded for efficiency but for avoiding mistakes (Stiglitz, 2000). This does not benefit the public sector either. One could argue that the company is held responsible for the quality of the project and that warranty applies, which is undoubtedly true, however, guarantees apply only during a certain period and the process to prove claims is often lengthy and tedious once the contract is financially cleared.

Also, construction companies need not push too much to meet deadlines in case something unexpected happens since they are most likely paid anyway because contracts often include *force majeure* clauses. Nonetheless, the problem is also given by the status of the public body. Economically speaking, when a public good (highway) is paid by public sector there are low incentives to spend the money efficiently since the agents (government) spend money which is not theirs (taxpayers' money) on something which they personally will not use and therefore have no utility from the outcome and do not care substantially about it[4] (Friedman and Friedman, 1980). Overall, the simplified example illustrates the least efficient way of allocating resources especially when the counterparty is a private sector which has the right incentives to

[2] Final outcome might be Pareto-inefficient allocation even under perfect competition since there are often problems of cooperation or coordination. Such typical example is prisoner’s dilemma (Nicholson and Snyder, 2010).
[3] *A situation in which different agents possess different information is said to be one of asymmetric information.* (Jehle and Reny, 2011, p. 379)
[4] This is an application of Milton Friedman’s four ways to spend money.

perform well for its own benefit. Such asymmetry between the two parties is clearly logical. One side of the contract which cares less will end up worse-off and the other which needs to make a profit will be pushing on results. In contrast, PPP may delete the asymmetry because it limits the role of the public sector. Considering Build-Operate-Transfer[5] partnership, a private company is responsible for financing and constructing the project as well as operating the highway for a number of years, commonly between 20 and 30 years and then transfers it to the hands of governmental or local authorities (Yescombe, 2007). The fact implies that private sector is on both sides of the equation, hence they try to minimise costs and delays but also aim to construct the project with high quality, so it would last without much refurbishment 30 years while the company will be operating it. Furthermore, the high quality is important for it attracts prospective customers. If the fees are high and the quality of the road unsatisfactory, drivers may search for alternatives in a form of local non-paid roads. The stated simplified idea illustrates the logical reasoning why in theory PPPs might involve shorter delays, lower cost overruns of construction projects. Whether the theory comes true or not, it must, however, be answered by emphasising the experience from the real world. That brings the paper to its second part which is very much empirical in focus.

The first research question of the paper (Q1) is whether PPP projects might be more advantageous than standard public procurement project in terms of cost overruns and delays. To highlight, it focuses on the effect of PPP only during the construction phase of the project and leaves out other aspects, advantages and disadvantages of PPP. To answer the research question, the thesis employs econometric analysis. To use the method, it is necessary to have enough observations which are homogenous enough to be distinguished only by several variables on which data is available. Highways were chosen for the research since they are more alike to each other than any other type of construction. That helps to limit the number of variables and more easily compare projects to others in the group. Also, highways are often constructed as PPP for their high costs, a significant length of the construction and easy way of charging the customers during the operating phase. Yet the costs may differ

[5] Build-Operate-Transfer (BOT) - *An agreement where a facility is designed, financed, operated and maintained by the concessionaire for the period of the concession. Legal ownership of the facility may or may not rest with the concession company* (Grimsey and Lewis, 2004, p. *x*). Also, see chapter 1.1.2. of this thesis.

considerably among countries due to unequal purchasing power parity, diverse legal frameworks or different cost proportion between labour, material and capital. Thus, the selected region should be homogenous enough to overcome these variances but also adequately large to provide sufficient observations. One option would be to select developed countries which can be characterised by efficient and well-functioning institutional framework in general. They could be presented to show how PPPs work without any serious problems. Countries such as the United Kingdom, Germany, Norway, the United States or Canada may show well-functioning PPP projects with ease. Nevertheless, this approach would say little about the benefits of these partnerships since such countries have generally efficient policies. In other words, the countries may work efficiently in many aspects hence it could be expected that both public and private investment are solved in a way which improves the countries' development, economic growth and prosperity. Thus, the actual effect of PPPs might be less significant. Also, the governments would carefully select the particular projects which should be built under public procurement and which would be left to private sector. The results would, therefore, be biased. The second alternative is to choose a region which does not have such developed institutions and might suffer from problems regarding public investment. The example which fulfils all above-mentioned conditions is Latin America. Many Latin American countries are notorious for the great gap in their fight against corruption and problems with publicly funded projects. Consequently, it provides an opportunity to test whether PPP projects could give better results than public procurement and help to avoid the drawbacks of public investment (World Economic Forum, 2017).

Additionally, the thesis has one more aim apart from contrasting standard procurement process and PPP. The second goal of the thesis (Q2) is to propound arguments for use of econometric analysis in construction management research. Construction management covers diverse career areas such as project management, law, accounting and finance or IT and therefore its research should not be left behind and use the currents methods for investigating each area appropriately. For some time, econometrics has been a method which examines relationships which are not exclusively based on economics (Wooldridge, 2012). Econometrics and generally statistical methods have been increasingly used across sciences and there is no reason to believe that construction management should be an exception. Therefore, the paper advocates the use of econometric methods in research on certain construction management issues. In other words, the thesis provides arguments why econometric analysis might be a useful component of construction management research focusing on broader questions, similar to the one in this paper. To begin with, the thesis serves as an example of the technique.

To summarise, the objective of this study is two-fold. First, it seeks to establish whether a mere application of PPP on highway construction in Latin America might decrease delays or lower cost overruns of the highway construction as the economic theory suggests (Q1). Importantly, it focuses only on the efficiency of the construction phase of the project and it does not evaluate whether PPP is more efficient and better form of procurement on the whole. Second, the study argues that econometric analysis could be used to investigate effects related to construction management and should then be considered as a relevant method for future research (Q2). In other words, the research questions are; whether PPP projects in highway construction in Latin America have lower cost overruns and delays than their counterparts of public procurement (Q1) and if it is possible to use econometric analysis in the research on construction management (Q2). In case PPP is more advantageous than public procurement in terms of cost overrun and delays, many countries which do not use PPP contracts could and suffer similar problems of the public sector could learn from this experience. The data for the empirical part is taken predominantly from World Bank, involved construction companies, investment banks which lent funds for the projects, government official documents or independent agencies investigating construction businesses.

1. Theoretical background

1.1. Public-private partnership

This chapter discusses the issue of public-private partnerships to set the foundations for the analysis and introduce main arguments of the work. It lists various definitions of PPP and clarifies the meaning in this thesis. A section on types of PPP contracts follows to show how conditions may change depending on different types of PPP. The thesis then investigates the use of PPP in highway construction and behavioural aspects of the partnerships on which are built main arguments of the work. The chapter closes with the literature review of the current research related to the discussed issue.

1.1.1. Public-private partnership – definition

The term Public-Private Partnership although widely used might be blurry and often misunderstood due to many possible types of cooperation between public and private sector. The Chartered Institute of Building (2014) defines PPP as any cooperation between the private company and public entity to perform a project which has following characteristics. It should be of a long-standing character (at least five years), largely financed by sizeable loans which are repaid over the lifespan of the project. Moreover, the specific features of the long-term contract need to take into account the possible risk and payment issues. To that, Yescombe (2007) adds that the object of the contract should remain in the ownership of the public authority or be returned to its hands at the end of the contract. Similarly, Clough et al. (2015a) highlight the importance of ownership for PPP definition. They basically define PPP only on such basis where the partnership is distinctive from the classical public or private ownership. Then, PPP is a publicly owned project and financed by the private sector. Nevertheless, PPP arrangement might have narrower specifications which delimit the number of parties, their accountability, risk allocation, key performance indicators, duration of commitments, services specification and financial terms (Cooper et al., 2005).

On the other hand, such conditions might not be necessary as it is shown by Jackson (2017, p. 72) using following definition for PPP: *"A business venture approach whereby a public sector authority and a private enterprise join forces and combine resources to deliver government projects aimed at serving the public good."* A similar perspective is suggested by Clough et al. (2015b) who see the partnerships through the difficulty to distinguish between private and public construction projects and therefore the term is understood very broadly as well.

Furthermore, the source of disunity in definitions of PPP in the literature on construction management comes from countries' legislations which cannot have a vague definition of the term and therefore, countries use precise specifications regarding project size, contract types and sector which may use the partnerships (World Bank, 2017a). Then, PPP is understood distinctively depending on each country. For this reason, the World Bank uses a broad definition which is the most similar to the understanding of PPP in the thesis: *"A long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility and remuneration is linked to performance."* (World Bank, 2017a, p. 5).

1.1.2. Types of PPP contracts and other partnerships

Types of PPP contracts will be listed in order to understand their economic specifications and to see why the paper primarily selected BOT schemes for the econometric analysis and what might be consequences of using that particular type of PPP contract. The types could be recognised by different methodologies such as suitability for each type of infrastructure, complexity of the contract or use for existing and new facilities, however, academic literature mostly distinguishes PPPs by the degree to which private sector participates in the project, starting from basic outsourcing through classical concessions towards privatisation (Guash, 2004). The thesis uses such method as well. Even with such basic specification, many different types of PPP contracts can be recognised, some differing only minimally, while others could be challenged whether they still belong among the PPP contracts. Hence, only the most important ones will be listed below.

A Franchise, Affermage and Lease Contracts are the weakest forms of partnership with the private sector and some literature (such as World Bank, 2017a) does not even consider them as PPPs. The cooperation is usually based on middle-term contracts (10-15 years) where ownership and capital investment are strictly public (Asian Development Bank, 2008). Commercial risk is generally shared by both parties and private sector is not exposed to a high level of risk. The compensation is usually made by fix payment or tariff revenues. It may be paid by the government, directly by users or a mix of the two (World Bank, 2017a). The contracts are predominantly used for already existing infrastructure. The advantages of the contracts are increased operational and commercial efficiency which public body often lacks (Asian Development Bank, 2008). Disadvantages lie in possible disputes caused by the fact that the public sector is responsible for the investment which is then operated by a private body.

Design-Build-Finance-Operate[6] (DBFO) is a scheme based upon a long-term contract (25-30 years) for a new infrastructure (Grimsey, 2004). The content of the contract is clearly depicted in its name. Ownership remains in the hands of government while design, construction, funding and operation (and possibly maintenance) are responsibilities of the private sector (Yescombe, 2007). The projects are mostly financed by loans which are then repaid by fees levied either on government or users (Asian Development Bank, 2008). Though both options are possible, DBFO is mostly used for projects which do not enable user fees hence payments are levied on the government (Yescombe, 2007). The private funding is the major advantage of the contract because it enables government to develop new infrastructure under its ownership even if it lacks enough finances at that moment. The drawback might be that the facility remains in public ownership and then the private sector might not have right incentives to perform the work of the highest quality. Consequently, the claim management and legal guarantees are crucial for successful execution of the works.

Build-Transfer-Operate[7] (BTO) is a model similar to DBFO system with the difference that a private company is the owner during the construction phase and after the completion of the works the ownership is transferred to the public authority. However, the difference is absolutely crucial for the correct management of the facility until the property rights are transferred. The rights given to private entity may establish the right incentives for the private sector to perform work in required quality (Delmon, 2015). Nevertheless, it implies that companies bear the commercial risk. As before government or users pay for the facility.

Build-Operate-Transfer (BOT) or Build-Own-Operate-Transfer (BOOT) is another variation of PPP which involves private ownership of a public facility. The private possession is stronger than in BTO because the property rights are transferred to the public body after the concession period (Yescombe, 2007). It means the private

[6]Similar forms are Design-Build-Finance-Operate-Maintain (DBFOM) and Design-Construct-Manage-Finance (DCMF).
[7]Build-Transfer-Lease (BTL) is an alternative to BTO with the difference that ownership remains to private company and the facility is leased to the government (Yescombe, 2007).

sector designs, builds, finances, operates and maintains the facility until the end of the contract. Thus, overall responsibility is shifted to the private sector. It might be beneficial since the company is more likely to care about spending and quality but also problematic if issues occur and the private company wants to withdraw from the contract. It may not happen on a rare occasion since the private sector is exposed to a high level of risk. Hence, the private developer might require guarantees about future income or payments if tariffs paid by users do not bring enough revenues (Asian Development Bank, 2008). For this reason, the private partner prefers an agreement based upon fixed payments by the government. Moreover, if there is a desirability to maintain at least a certain public ownership over the project, BTO model would be preferred to BOT (Grimsey, 2004).

Next, an extreme example of PPP with respect to legal ownership of the facility is Build-Own-Operate (BOO). BOO contracts do not contain any clause about transferring the ownership rights to the government. When the contract terminates it might be re-negotiated or government might purchase the object from the developer (Grimsey, 2004). BOO model is clearly a form of privatisation of public services or infrastructure (Guash, 2004). It implies that the financial responsibility lies with the employer so the debt from construction of the facility is usually repaid by the fees levied on users and the role of government is minimal in the financial terms of the contract. Overall, characteristics are high risks of the private sector and weak role of the government (Yescombe, 2007).

Since full privatisation is rare in public infrastructure, an alternative to that is Joint Venture which is a legal form of PPP which enables public and private bodies to jointly finance and operate the object (Grimsey, 2004). Public and private sector are both equity shareholders. Then, they share the potential revenues or financial losses. However, maximisation of revenues is not the main interest of public authorities. This might lead to a conflict of interests between the two parties (Yescombe, 2007). Nonetheless, the problem of private sector’ excess profits on public infrastructure is reduced thanks to lower information deficiency. The drawback remains the obvious difficulty to maintain the long-run relationship between the two parties which both have different interests.

To summarise, each type has its pros and cons and they might be used depending on project, preferences and development of the country or local legislation. BOT and BTO schemes are popular in developing countries since they are not administratively complicated and may be easily added to existed infrastructure because of transferred ownership (Grimsey, 2004). It may also help if regulation is poorly defined and capital markets are not very strong because it brings foreign capital and does not demand strong legislation. A drawback is that the government needs to pay attention to contract condition especially to prices and payments provisions. Affermage and Lease Contracts are mostly used for services and management of public infrastructure and by definition they can barely be used for new infrastructure projects. DBFO helps to mobilise finances for publicly owned projects and distribute risks between both parties. Therefore, they appear attractive to public and private sectors. However, DBFO contracts seem to be rather complex and strong institutional framework is needed to ensure efficiency for both sides of the agreement. As a result, they are more likely to be used in developed countries. Moreover, DBFO structure allows it to be used for projects which do not enable consumers payments, which gets a bit problematic in BTO when the ownership is private. BOO has major disadvantages for both sides. Private sector faces enormous risks and public body is left with little rights over the project and it is unclear what happens to the infrastructure after the contract ends. To make BOO work, government would have to provide companies with strong guarantees or high-risk premium and that might be costly.

1.1.3. PPP in highway construction

Highway construction is for many reasons ideal business for PPP. The primary motive why governments started to cooperate with the private sector has been that highway construction is an expensive and risky investment which creates a large burden on government’s budget (International Road Federation, 2018). Furthermore, highways easily enable to charge user fees or measure the usage. Popular are mixed payments where both government and users are charged (Yescombe, 2007). Regular payment from government ensures the service of the debt which the private company has towards the third party. Consumers fees serve, in an ideal case, as an incentive to maintain the quality of the road to attract demand. Furthermore, today’s complex models, easily attainable information about prospects of a new highway and accuracy of traffic estimations lower risks for private investors and increase the attractiveness of PPP in highway construction.

All these attributes appeal to the private sector whose participation brings expertise and efficiency, which is otherwise not achievable by public bodies. Also, even less developed countries might attract investment into highway construction with ease thanks to a variety of incentives such as tax exemptions and duty-free import of machinery and equipment necessary for highway construction (Rekhi, 2018). Because of high risks, the private sector is less willing to enter complete privatisation of highway structures, which would have to be secured by strong guarantees of the government and that is not always possible. Therefore, PPP is a feasible solution for highway construction since it distributes the risks and benefits between all involved parties (e.g. employer, constructor, supplier and government). Moreover, related technology does not change fast which allows parties to commit to a long-term relationship. Otherwise, if technology needs to be renewed often and frequent additional investment is required, sustainable long-run commitment may be too costly or not attainable (Yescombe, 2007).

As mentioned before, the fees might be easily levied on direct consumers, in this case, drivers who use the particular part of the highway. Services are provided through toll management. Toll may be charge at toll booths at the entrance or exit to the highway (fixed fee per entrance or exit) or via electronic toll collection technology. In such case, there are no toll booths and vehicles are charged per driven kilometre. An alternative to classical toll system is so-called “shadow toll”. Shadow toll system is based upon negotiated payment paid by public entity per driven kilometre and user (Yescombe, 2007). A common approach is a combination of the two when users are charged but government provides subsidies.

A disadvantage of many contracts which are based on user fees is a non-compete clause in the contract (Yescombe, 2007). To mitigate potential commercial risk, a private company may request such clause preventing further infrastructure development in the area to eliminate future competition. A government might be easily willing to agree since it is more interested in current problems than issues which their decision will cause in future. However, such behaviour is rather myopic and creates monopoly position which distorts competition.

Turning to data on PPP globally, there is no continuous information on PPP for developed countries since the World Bank and other development banks do not cover developed countries although they closely watch developing countries. Hammami, Ruhashyankiko & Yehoue (2006) state that transportation is the second most used sector of construction with PPP application after energy structures in terms of the number of started projects. Among transport PPP contracts, roads and highways dominate (Klein, 2015; OECD, 2012). Nevertheless, a study by Ernst & Young (2015) claims that transportation and social infrastructure are the two leading sectors in developed countries. Looking at emerging and developing economies, the energy sector has been prevailing sector until 2014 when transport took over, but the trend reverted to the dominance of energy sector in 2016 (World Bank, 2017b). Other sectors apart from transport and energy are marginal. Focusing on regional patterns, Latin America and the Caribbean has been receiving the highest amount of investment in long-run followed by East Asia and Pacific (World Bank, 2016).

To conclude, it is important to state that a company which is awarded the contract does not have to perform all the activities (designing, construction, operation and maintenance) (Yescombe, 2007). As a matter of fact, it does not have to perform any of the of them. The company may subcontract the works; however, this should not influence the efficiency since the incentives of the primary contractor do not change. Thus, for purpose of the thesis, the impact of the choice between one contractor only and one contractor with many subcontractors is irrelevant.

1.1.4. Behavioural economics of PPP

Warren Buffett's long-time business partner Charlie Munger once said: *"Show me the incentive and I will show you the outcome."* (Financial Times, 2013). The quote from the successful investor illustrates the economic truth that human actions are led by incentives. This holds even if one forgets *homo economicus* and acknowledge behavioural economics and the fact that humans are predictably irrational. Since incentives work for people, and both a government and a private company are formed by people, incentives must then lead to the behaviour of the two sectors as well. Thus, if one manages to see the correct incentives and to use common sense, then the path of their most likely actions might be established. In other words, if the triggers are revealed, the final outcome should not be difficult to find. Then, one could shape the behaviour of government and construction company by varying the incentives which the players would face. Following paragraphs should illustrate incentives, which play a role in conventional procurement and PPP contracts.

Starting from the private sector, a primary objective of a construction company is to make a profit for its shareholders. Even though its employees might often have other desires than achieving the goal, the managers make sure the company would do its best to pursue the objective since they are held responsible for achieving it. Thus, it becomes their goal. For instance, the salaries of top managers might be frequently based upon achieving given targets. Then, they form incentives for employees, so the company would profit. However, the situation is more complicated with a government. Governments might have many different objectives, but they should generally talk about economic growth, increased quality and effectiveness of public services, higher welfare, full employment, stable prices, the balanced state budget in long-run or fair redistribution of income. Admittedly, some of them are rather blurry and others are unrealistic. It makes the goal complicated to follow and the efficiency difficult to measure. Moreover, the accountability of the "state managers" – government ministers is questionable. The civil servants are usually employed longer in the government than the ministers and therefore know how the system "works". Then, it is difficult for ministers to hold the officers responsible for the possible inefficiency. On top of that, ministers are often replaced which does not increase the efficiency either. Besides, a government needs to maintain its political capital and appeal to voters in order to be re-elected, which may sometimes prevent it from choosing the most efficient long-term decisions.

A standard public procurement contract suffers from stated asymmetries of the public and private sector. The construction company needs to earn a profit but a profit margin in a contract price might be too low if the company had to lower it in order to win the contract against its competitors. So, it might search the sources of profit somewhere else. It can save on its cost by using lower quality materials and work methods or it could perform additional overpriced works which were unexpected when the contract was signed. Since construction business actually faces many unanticipated problems, such results are rather frequent. Obviously, the government employs clerks of works to supervise the construction process, but it does not have means to monitor every aspect of the construction project and often it cannot afford the best people in the field. Civil servants have low incentives to inspect the works in detail because their wage is fixed, and their efficiency is difficult to measure and therefore seldom controlled. Also, if delays occur (most likely due to unexpected circumstances), the company has low interest to rush since more additional needs mean more overpriced works and higher profit. Overall, there is no reason trying to catch up and finish on time because profit is being realised. As described in the introduction to the thesis, the government suffers from asymmetric information because the public sector will always have less information about the ongoing construction process than the construction company will. The public good theory also describes how government officials lack the incentives to spend money efficiently since they spend someone else's money (Friedman and Friedman, 1980). Inefficacy might happen even if due diligence clause is applied because it can be caused by lack of information thus the government behaves efficiently for the (low) amount of information it has.

In contrast, public-private partnerships eliminate[8] the asymmetry and lack of incentives to perform the works efficiently because the role of government during the construction phase is minimal. The private sector must typically finance, build, operate and maintain the facility for some time. It implies that if a company wants to make a profit, it needs to function efficiently. It establishes the right impetus in all activities during the life-span of the facility. The company aims to minimise the costs since it is responsible for financing it. However, it cannot afford to use cheap and low-quality materials because such attitude would increase the costs of maintenance for which the company is also responsible. In other words, it uses best value-for-money approaches and materials. Also, it needs to maintain it in decent quality, otherwise the drivers would consider other roads or form of transportation rather than the highway in question. The reason for such efficiency is simple, the profit lies on the path of efficient construction. In other words, the company's incentive to perform best value-for-money works is pure desire to achieve profit which is also its primary objective. Both examples are of course

[8] It holds for the forms of PPP where the private sector is responsible for building, financing and operating the facility, the effect is even stronger if the legal ownership belongs to the company for a particular period.

simplified and do not aim to thoroughly describe all the relevant aspects. But it illustrates the possible and likely behaviour of both sectors.

This could also be described as principal-agent problem which is caused by the information asymmetry. Principal (government) gives a task to the agent (construction company) whose action (effort) is to certain degree hidden (Nicholson and Snyder, 2010). The issue is that effort is difficult to include in a contract as one can hardly oversee it and enforce it. However, the problem is eliminated once the agent becomes principal and has an interest on the results (as it is the case of PPP).

An objection could be that the construction company is unlikely to do all the activities during the life-cycle alone and it would probably hire subcontractors or that the construction company could be only subcontracted by a private employer to perform the works. That is all true, nevertheless, when two private companies negotiate, they both want to make a profit and therefore they are more likely to care about results and supervise the other party. Then, the business between two private companies is still more efficient than the outcome where a private sector faces a government.

Lastly, construction business is prone to corruption by its size and nature. So, it is reasonable to ask whether corruption can influence above described processes and consequences. Corruption per se has probably little effect on the efficiency of the highway construction. In both cases, bribes might need to be paid to the government officials for awarding the contract to a particular company or approving higher price of the project. Nevertheless, two small implications might be derived contrasting PPP with public procurement. Primarily, costs of the project might be higher in public procurement than PPP as a consequence of corruption. One could imagine bribes are a part of the costs for the company and then the construction company reflects the bribes in the project price, which is paid by the government (taxpayers). But in the PPP to reflect the bribes in the project price would not help much since the price only shows the expenses of the private sector and the project is financed by a loan which the company needs to repay. Thus, the overall costs might be slightly lower in PPP as the private company would try to limit bribes as part of its expenses. It also implies that, in case of PPP, the burden of bribes would be levied on costumers of the highway and therefore the user fees would be higher which is not much desirable even for the private company since higher prices decrease consumption. Different result would take place in case the government would pay for the usage of the highway. Furthermore, one could assume the second implication of PPP in corruption environment would be lower bribes. Nonetheless, the effect is likely to be negligible.

In conclusion, it is necessary to remind that the thesis focuses only on the efficiency of the construction phase of the project and under no circumstance does it judge whether PPP is more efficient and better form of procurement on the whole.

1.1.5. Current state of the discussed issue

PPP is a frequent and vastly-discussed topic both in academia as well as in business. The topic is addressed by many research areas and advisory sectors such as construction management, finance, law, risk management or economics nevertheless, there is little literature which would investigate whether PPP projects may lower cost overrun and delay of the project. The literature does not question the efficiency of the construction phase caused by PPP application.

Seldom has econometrics or regression analysis been used for research on PPP or highway construction. Some studies were made regarding determinants of the number of PPP projects (Hammami, Ruhashyankiko and Yehoue, 2006), internal rates of return of PPP projects (Bitsch, Buchner and Kaserer, 2010), determinants of public-private partnership contractual choice (Albalate, Bel and Geddes), PPP contract types for roadway construction (Anastasopoulos, et al., 2015), influence of budget constraints of the use of PPP (Buso, Marty and Tran, 2017), PPP renegotiations and the bargaining power rate (Sarmento and Renneboog, 2017), contractual flexibility or rigidity for PPP (Athias and Saussier, 2010), impact on public service effectiveness, efficiency, and equity (Andrews and Entwistle, 2010), key factors that facilitate PPP development in transition countries (Hou, Yang & Wang, 2013), the economic and political factors influencing performance of PPP projects (Emirullah and Azam, 2014) or determinants of PPP debt spreads (Blanc-Brude and Strange, 2007). Regarding highways, econometrics was applied on factors of correct estimation of maintenance and rehabilitation costs (Anastasopoulos, Haddock & Peeta. 2014) and multidimensional auctions of PPP transport-sector projects (Estache et al., 2008).

Notably, a majority of the studies is focused on the determinants of PPP use or its conditions. However, little concern is devoted to the impact of PPP which it has on the construction phase if used instead of the conventional public procurement. As far as highway construction is concerned, there is only one empirical study which aims to investigate the cost of PPP in comparison to public procurement and uses econometric analysis. The study by Blanc-Brude, Goldsmith & Välilä (2009) discusses the contract prices for roads in Europe. It compares the portfolio of European roads built as PPP and through public procurement. They found the projects under PPP had ex-ante higher construction costs than public procurement projects. Authors continue *"… [it] suggested that this difference can represent a higher construction-phase investment to achieve cost savings in the operations phase and the pricing of the construction risk that is transferred to the private-sector partner."* (Blanc-Brude, Goldsmith and Välilä, 2009, p.36). In other words, the higher ex-ante price could have been caused by the risk premium for the transferred risk from the public sector to the private company. Also, it implies that the private company behave efficiently because of the higher initial investment provided in order to save on the operation and maintenance cost. That is clearly desired effect. More importantly, the study concludes that delays and ex-post cost overruns were limited and almost eliminated under PPP while common in traditional public procurement. This goes along with the theory proposed and described here that projects are more likely to be finished on budget and without delay.

Lastly, omitting the ex-ante costs, an in-depth analysis focused on ten PPP projects published by European Investment Bank (2005, p. 4) found that the PPP projects *"… were largely completed on-time, on-budget and to specification."* which is rarely the case of traditional public procurement.

1.2. Latin America

The thesis is focused on the region of Latin America, whose specifics, however, impact results of the investigated issue. For this reason, the local context of public policy and highway construction are briefly discussed with respect to the topic of the thesis. The boom and popularity of PPP is also reviewed.

1.2.1. Public policy background

To shortly illustrate the background of public policy in Latin America, hard data may provide a clear illustration to governance issues occurring in the region. Therefore, the work lists data from Global Competitiveness Report published by World Economic Forum (2017). Latin-American economies generally suffer from weak, undeveloped and poorly functioning institutions which deliver the worst results from all reported sections for Latin-American countries. Also, in contrast to other factors influencing competitiveness and economic growth institutions in Latin America have been worsening recently. Following factors were among the worst in the section of institutions: diversion of public funds, efficiency of government spending, efficiency of legal framework, favouritism in decisions of government officials, irregular payments and bribes, judicial independence, public trust in politicians. In summary, they all point to one problem which is a weak legal framework characteristic by poor law enforcement against government officials or interest groups. That, in turn, supports the corruption environment and boosts problems with public infrastructure projects.

On the other hand, there are differences among Latin-American countries. For instance, Chile, Costa Rica and Uruguay performed better than the rest of the region. Also, inefficient public institutions are not exclusively problem of Latin America or developing countries. If contrasted to EU member states, 14 of them (Bulgaria, Croatia, Cyprus, the Czech Republic, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia and Spain) has worse institutions than the trio above mentioned Latin-American countries (World Economic Forum, 2017).

1.2.2. Highway construction in Latin America

Since the thesis is focused on highway construction in Latin America, it is necessary to look closer at the term highway (*autovía*, *autopista* or sometimes simply *carretera* in Spanish)[9] which may have a slightly different meaning in the Latin-American context in contrast to European understanding of a term *highway* or *motorway*. Highways in Latin America need not comply with such strong standards for

[9] The terms *autovía*, *autopista* and *carretera* might refer, to certain degree, to specifics of the road however in Latin America, the usage of the words depends mostly on the local context and differences of Spanish language.

safety as the European highway and do not share the same technical parameters (Abarca, Mendoza and Saucedo, 2011; Foro Internacional de Transporte, 2017). For instance, they may not have the side lane or sometimes might be in a form of a simple two-lane road which connects large cities. To understand the context, it is crucial to take into account the urbanisation structure of the countries. Countries commonly do not apply any regional policies and, in contrast to Europe, a welfare state is minimal with low social security and social policy (Huber, 1995). Economies are mostly capital-based[10] and economic growth is profit-led rather than wage-led as it is in Europe (Onaran and Galanis, 2011). As a consequence, agglomeration forces are strong while dispersion forces low which results in large and heavily populated cities and a lower proportion of the population living in small towns and villages (Baldwin and Wyplosz, 2009). Highways, therefore, connect large cities which are commonly far from each other. Saying that, the intercity traffic is generally sparse since the traffic is mostly concentrated around the cities and people tend to travel less across the country (Engel, Fischer & Galetovic, 2003). Overall, the features and regulations of the highways are different which is necessary to bear in mind while discussing it. Nonetheless, the differences should have no impact on the investigated issue.

1.2.3. PPP contracts in Latin America

PPP contracts gained enormous popularity in Latin America, however, the trend was accompanied by many controversies. The countries took advantage of PPP especially because of the lack of resources and expertise (Engel, Fischer & Galetovic, 2003). PPP brought vast investment into public infrastructure which was hardly affordable by the public sector. The investment helped the governments to overcome the infrastructure deficit from previous years. Nevertheless, as PPP contracts were a novelty, governments underestimated the contract and regulation stage of the project in the 1990s (Guash, Laffont & Straub, 2005). The contracts carried two main drawbacks as Engel, Fischer & Galetovic (2003) point. The first issue was so-called *"privatize now, regulate later approach"* while the second problem resided in the fact that contracts were created in the form *"fixed-term franchise".* That lead to many renegotiations and excessive government guarantees. Authors state that approximately 60% of the highway PPP contracts were substantially renegotiated

[10] Exceptions are Cuba and Venezuela.

within the period of three years. It prevented the realisation of the full potential of the benefit given by PPP. As the process was rather painful for the involved countries, governments have learned from that experience and the outcome after new millennium is better (Economist Intelligence Unit, 2014).

Speaking in numbers, PPP projects form 40% of infrastructure investment in Latin-American countries and that accounts for approximately one percent of regional GDP (Fay et al., 2017). To conclude, Latin America is leading region with respect to the amount of PPP contracts with overall 38% world share.

2. Practical section

The empirical part of the thesis employs econometric analysis, specifically the method of ordinary least square (OLS). Econometric analysis is not a frequent tool in the construction industry and therefore its general aspects are discussed in brief. Thus, the proposed models, variables and data are explained. Finally, results and possible implications are presented and evaluated. A discussion about the use of econometric analysis in the field of construction management closes the chapter.

2.1. Econometric analysis

Econometric analysis is an empirical method, mostly applied in economics, which uses mathematical and statistical tools to analyse given phenomena based upon economic theory (Gujarati, 2004). Nonetheless, it is not an exclusive method destined for social sciences, but it might be used in other fields as well. The literature review (chapter 1.1.5. – Current state of the discussed issue) illustrates that PPP contracts or highways are not exceptions although the use is sporadic.

The first step of the analysis is a formation of investigated hypotheses and related questions (Wooldridge, 2012). An econometric model, simplifying the phenomenon, follows. However, the formulation of the model is dependent on the type of data on which relationships should be estimated. The observed, non-experimental data may have different forms, out of which three main types are commonly recognised: cross-sectional data, time series data and panel data. *A cross-sectional data set consists of a sample of individuals, households, firms, cities, states, countries, or a variety of other units, taken at a given point in time* (Wooldridge, 2012, p. 5). *A time series data set consists of observations on a variable or several variables over time* (Wooldridge, 2012, p. 8). Panel data is the combination of the previous two. As the model in the thesis uses the cross-sectional data set, which is also the most frequently used data set, the following description is strictly related to this type of data.

Once the hypothesis and type of data are determined, a creation of a model may come. The model consists of an equation which describes a relationship between variables. Two types of variables appear in the equation: dependent and independent.

The dependent (explained, response or predicted) variable is the main object of the analysis which should be influenced and explained by independent (explanatory, control or predictor) variables (Wooldridge, 2012). There is also an error term (disturbance or stochastic variable) which presents all the other factors which affect the dependent variable but are not explicitly considered (Gujarati, 2004).

The most common model is the general multiple regression model (adapted from Wooldridge, 2012, p. 71):

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ \dots + \beta_k x_k + u \tag{1}$$

where

y is the dependent variable;

β_0 is the intercept;

$\beta_{1,2,\dots k}$ are parameters associated with $x_{1,2,\dots k}$;

$x_{1,2,\dots k}$ are independent variables;

u is the error term.

Econometrics recognises several methods to estimate the intercept and parameters of the model. The analysis in this thesis applies the most widely used method: ordinary least square (OLS) which is "*a method for estimating the parameters of a multiple linear regression model. The ordinary least squares estimates are obtained by minimizing the sum of squared residuals"* (Wooldridge, 2012, p. 854).

However, for the OLS to be efficient, the estimators must fulfil so-called Gauss-Markov assumptions. The OLS estimators are the best linear unbiased estimators if they satisfy five main assumptions (for cross-sectional regression) (adapted from Wooldridge, 2012, p. 105):

1) The population model is linear in parameters;
2) The sample of n observations, $\{(x_{i1}, x_{i2}, \dots, x_{ik}, y_i): i = 1,2, \dots, n\}$ is random and follows the population model;
3) None of the independent variables is constant, and there is no perfect collinearity among the independent variables;
4) The expected value of the error u is zero given any values of the independent variables: $E(u|x_1, x_2 \dots, x_k) = 0$;

5) The variance of error u is constant given any value of the independent variables: $Var(u|x_1, x_2, \dots, x_k) = \sigma^2$.

Nevertheless, there is not yet any assumption about the distribution of u which is necessary to draw the statistical interference (Gujarati, 2004). Thus, one more condition is commonly added to the Gauss-Markov assumptions to use hypothesis testing (adapted from Gujarati, 2004, p. 108):

6) The error term u follows the normal distribution: $u \sim N(0, \sigma^2)$.

Once the variables are estimated and the procedure satisfies above-stated assumptions, the model and coefficients should be tested for statistical significance, the relevance of the model and the importance of the estimates. To verify this, econometricians might use the t-test, the F-test and the coefficient of determination.

The coefficient of determination (R-squared) represents how well the regression line fits the set of data, also known as "goodness of fit" (Wooldridge, 2012). It is a fraction of how much of the variation of the dependent variable is explained by the independent variables (adapted from Wooldridge, 2012, p. 38):

$$R^2 \equiv \frac{SSE}{SST} = 1 - \frac{SSR}{SST} \tag{2}$$

where

R^2	is the coefficient of determination;
SSE	is the explained sum of squares;
SST	is the total sum of squares;
SSR	is the residual sum of squares.

As it may be noticed in (2),

$$SST = SSE + SSR. \tag{3}$$

Hence, R^2 must always lie between zero and one. The closer to one the better the fit to the data is. However, even very low R^2 (which is not rare in social science) does not have to mean the model is useless (Wooldridge, 2012). Though R^2 is a useful indicator, the size of R^2 should not be seen as a primary instrument for measuring the success of the model. Also, adding more variables will never decrease R^2 even if the variables are insignificant. Thus, it may be misleading. *Adjusted* R^2 solves the problem because it takes into account the number of independent variables and therefore it is often used for comparing models.

Additionally, there is a criterion to determine if a model follows the theory with statistical significance: hypotheses testing, also known as statistical interference (Gujarati, 2004). For testing any hypothesis about a single population parameter, one may use so-called t-test (t-statistics) (Wooldridge, 2012). In the classical basic form, the t-test is used to detect whether the parameter is different from zero. In other words, the null hypothesis is that the parameter is equal to zero ($H_0: \beta_k = 0$). If the null hypothesis is rejected in favour of the alternative hypothesis, it is assumed the parameter is statistically significant in the model. The rejection depends on the chosen significance level. The most frequently used levels are 10%, 5% or 1%. In order words, to decide about the rejection of the hypothesis, one compares the value of the t-test with the value of the significance level given by statistical tables for the respective number of degrees of freedom. The second option to ascertain whether the null hypothesis should be rejected is a calculation of a p-value (probability value). *"P-value is defined as the lowest significance level at which a null hypothesis can be rejected"* (Gujarati, 2004, p. 137). If the p-value is higher than the significance level, then the null hypothesis cannot be rejected.

Nevertheless, t-statistics determines the significance of one parameter only and it does not reveal whether all the variables are jointly statistically significant. For joint significance, one must use so-called F-statistic, which generally tests multiple hypotheses about the parameters in the regression model (thus hypothesis that all the parameters are jointly equal to zero) (Wooldridge, 2012). The procedure of selection the significance level and comparing it to the calculated p-value follows the same manner as in the t-test. If the null hypothesis ($H_0: \beta_1 = 0, \dots, \beta_k = 0$) is rejected, it means that all variables are jointly statistically significant at the given significance level.

Furthermore, the parameters may be tested from the perspective other problems such as heteroskedasticity or autocorrelation. For instance, autocorrelation should not take place in this analysis as it is mostly related to time series data. In contrast, heteroskedasticity (non-constant variance) might occur. Therefore, the analysis should employ the Breusch-Pagan test or the White test. Breusch-Pagan test is *"... a test for heteroskedasticity where the squared OLS residuals are regressed on the explanatory variables in the model."* (Wooldridge, 2012, p. 845) while White test *"…involves regressing the squared OLS residuals on the OLS fitted values and on the squares of the fitted values; in its most general form, the squared OLS residuals are regressed on the explanatory variables, the squares of the explanatory variables, and all the nonredundant interactions of the explanatory variables."* (Wooldridge, 2012, p. 860-861). To put it differently, the Breusch-Pagan test examines only the linear form of heteroskedasticity, but White test looks also at squares and cross products of all independent variables (Wooldridge, 2012). However, adding the square and cross products causes a loss of many degrees of freedom and therefore it is applicable only on large data sets. Thus, it cannot be employed here, and the analysis uses Breusch-Pagan test instead.

At the end of the analysis, the outcome must be critically evaluated. Results should be compared to the predicted theoretical relationships. In other words, the positive/negative sign and the size of the parameter estimated by the model are appraised whether they correspond with the stated theory. Then, possible causes of any discrepancy might be drawn, as well as further implications of the results.

Indisputably, a short chapter in this paper cannot include all extensive knowledge of econometrics which is covered on hundreds of pages of econometrics textbooks. Nevertheless, as the method is not very common in the field of construction management, it was necessary to shortly describe basics of the procedure which is used in this thesis. Although the methodology is applicable in general, some parts are not discussed due to their irrelevance for this specific analysis. Therefore, the extracts from Wooldridge (2012) and Gujarati (2004) which were used for the short synthesis aim to provide an overview of the methodology of this paper only.

2.2. Model

Following the theoretical background and general knowledge of the construction processes, the model tries to estimate whether the use of PPP instead of public procurement leads to lower cost overruns and shorter delays of the construction phase of the project (Q1). Assuming costs and time schedules are planned to be met, any variations of the variables should be simply random and cause of *force majeure*. It holds especially as an analysis compares the same type of structures, in this case, highways. Then, all possible non-random causes should be limited which supports the notion of *ceteris paribus*, "other things being equal". Therefore, only a limited number of factors apart from *force majeure* might have an impact on cost overruns and delays. The analysis consists of two models, one estimates the causes of delays and the other reasons for cost overruns. The independent and dependent variables of the regression are listed below.

Dependent variables are:

$delay$	is the delay of the construction phase of the project in months; it is the difference of planned duration ($plandur$) and final duration of the construction; negative value implies the project was finished earlier than planned;
$costover$	is the cost overrun of the construction; it is determined as a percentage value[11] of the expected costs ($expcost$) thus expected costs are subtracted from final costs and that is divided by expected costs; negative value implies the project was finished with lower costs than expected.

Independent variables are then:

$expcost$	stands for expected costs, thus estimated costs before construction works started; the values are in millions of U.S. dollars[12];

[11] In contrast to $delay$, the variable $costover$ is determined by relative values rather than absolute. To measure cost overruns in absolute terms would not make much economic sense. Clearly, a more expensive project could imply higher cost overruns, but it is more relevant to investigate whether the percentage of cost overruns also increases. It could be done similarly with $delay$ but Breusch-Pagan test (described on page 28) revealed that such regression suffered from heteroskedasticity so the variance in the error term was not constant (this was not the case with the regression for regression with $costover$). Therefore, the absolute values were used instead, and heteroscedasticity was eliminated. The problem was also that delays and planned durations are given by whole months, thus integers. Then, the values might be misleading for short projects. For instance, a one-week delay would be reported as a one-month delay which on a 12-month long project would create a delay of 8% instead of the actual 2%.

[12] Majority of construction projects in Latin America post prices in dollars due to the investment loans as well as the influence of dollar on local economies. Taking into account the low inflation of the dollar and the fact that all projects were conducted during a relatively similar period, nominal values are considered.

$plandur$ indicates the planned duration; which is the number of months that works should have lasted before the construction had begun;

ppp is a dummy (binary) variable to which is assigned value one if the contract was performed as PPP and value zero if the contract was conducted as public procurement;

$ppp \cdot expcost$ is an interaction term between ppp and $expcost$ which allows different slopes of the function of expected costs for PPP and public procurement projects; to put it another way, the term enables to see whether there is the additional effect of the expected costs on cost overruns in case PPP is used;

$ppp \cdot plandur$ is an interaction term between ppp and $plandur$ which shows the additional effect of planned duration on delay in case of PPP.

Then, these six regressions[13] should estimate the assumed effects:

$$costover = \beta_0 + \beta_1 expcost + \delta_0 ppp + \delta_1 ppp \cdot expcost + u \tag{4}$$

$$costover = \beta_0 + \beta_1 expcost + \delta_0 ppp + u \tag{5}$$

$$costover = \beta_0 + \beta_1 expcost + \delta_1 ppp \cdot expcost + u \tag{6}$$

$$delay = \alpha_0 + \alpha_1 plandur + \gamma_0 ppp + \gamma_1 ppp \cdot plandur + u \tag{7}$$

$$delay = \alpha_0 + \alpha_1 plandur + \gamma_0 ppp + u \tag{8}$$

$$delay = \alpha_0 + \alpha_1 plandur + \gamma_1 ppp \cdot plandur + u \tag{9}$$

[13] Parameters of the regressions are: β_0; β_1; δ_0; δ_1 for overrun costs and α_0; α_1; γ_0; γ_1 for delays. For equations (4), (5) and (6), β_0 is the intercept; β_1 is the slope parameter associated with expected costs; δ_0 is the parameter, which shifts the intercept, associated with the dummy for a PPP contract ; and δ_1 is the slope parameter associated with the interaction term between expected costs and the dummy for PPP contract. The intercept β_0 shows the value of dependent variable in case all independent variables are equal to 0. The parameter δ_0 changes the intercept for a PPP contract. In addition, both parameters β_1 ; δ_1 express how much the dependent variable changes in response to an increase in the particular independent variable by one unit if other variables remain unchanged. For instance, if expected costs increase by one million USD and other variables remained unchanged in equation (4), the costs overrun should change by β_1. Similarly, for equations (7), (8) and (9), α_0 is the intercept; α_1 is the slope parameter associated with planned duration; γ_0 is the parameter associated with the dummy for PPP contract; and γ_1 is the slope parameter associated with the interaction term between planned duration and the dummy for a PPP contract.

In the ideal case, there should be only random delays and cost overruns. Nevertheless, it is likely the inaccuracy of the cost plans and time schedules grows with the complexity and difficulty of the project. Variables $expcost$ and $plandur$ should capture these factors related to the intricacy of the project. The notion is that the higher the expected costs are, the large percentage of cost overruns might be since it is more difficult to provide an accurate estimation of a costlier project. The same is valid for delays because longer-term and more complex projects might simply be more delayed as the risks of conducting an accurate schedule are higher.

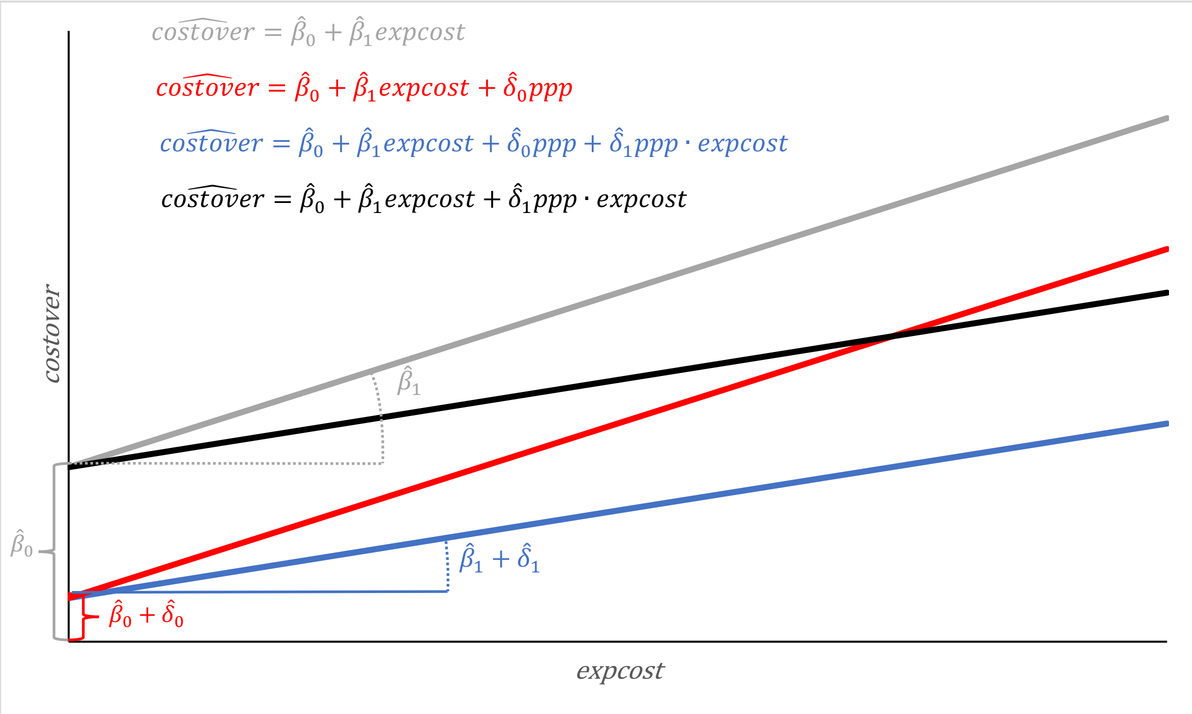
Then, there are three variables which the thesis is focused on and which should provide answers to the given questions. The variables are a dummy ppp and two interaction terms $ppp \cdot expcost$ and $ppp \cdot plandur$ (one term for each dependent variable). The terms ppp and $ppp \cdot expcost$ in (4) detect the difference in cost overrun between the PPP and public procurement projects. The terms $ppp \cdot plandur$ and ppp have a similar function in (7) for estimating the delay of a project.

To illustrate better effects of interaction terms and the dummy variable, Figure 1 shows their impact on the regression function of cost overrun. Therefore, the effects of $expcost$, ppp and $ppp \cdot expcost$ on $costover$ are considered[14]. The grey line represents the estimated equation for cost overrun of public procurement project, therefore neither $\hat{\delta}_0$ nor $\hat{\delta}_1$ occur in the equation and $costover$ increases only as a result of higher $expcost$. Then there is not expected any effect of ppp. The red line depicts the estimate for a PPP project in case the interaction term is not taken into account. It would simply mean that the PPP projects have a static effect on the cost overrun regardless of the project size. Figuratively speaking, it would shift the intercept of the regression line, but the slope would remain the same. Thus, the intercept is $\hat{\beta}_0 + \hat{\delta}_0$ instead of $\hat{\beta}_0$, but the slope remains $\hat{\beta}_1$. The blue regression considered both dynamic and static effect of ppp on $expcost.$ Afterwards, the slope changes to $\hat{\beta}_1 + \hat{\delta}_1$ and the intercept becomes $\hat{\beta}_0 + \hat{\delta}_0$. That would happen if the use of PPP had an additional impact on cost overrun depending on expected costs of the project. The last regression (black line) shows the case when only the dynamic effect takes place, thus the intercept remains unchanged $\hat{\beta}_0$ while the slope changes to $\hat{\beta}_1 + \hat{\delta}_1$ for PPP contracts. The problem of using both

[14] The notation is $\hat{\beta}_0;\ \hat{\beta}_1;\ \hat{\delta}_0;\ \hat{\delta}_1$is used (instead of $\beta_0;\ \beta_1;\ \delta_0; \delta_1$) to depict that the values are estimates of population parameters $\beta_0;\ \beta_1;\ \delta_0; \delta_1$.

variables ppp and $ppp \cdot expcost$ together is that they are highly correlated, hence such regressions might suffer from high correlation of the variables. It may lead to results which are not accurate as it is problematic to estimate their partial effects (Wooldridge, 2012). Then, it is convenient to run all three regressions and contrast the results. Also, the theory predicts that $\hat{\delta}_0$ and $\hat{\delta}_2$ are negative, therefore the grey regression line is above the red one and steeper than the blue.

Figure 1 Effects of a standard variable, a dummy variable and an interaction term



Source: Own figure.

Note: $\hat{\beta}_0$; $\hat{\beta}_1$; $\hat{\delta}_0$; $\hat{\delta}_1$ are the predicted (and best linear unbiased) estimates for population parameters β_0; β_1; δ_0; δ_1. Then, $\hat{\beta}_0$ is the estimated intercept; $\hat{\beta}_1$ is the estimated parameter associated with expected costs; $\hat{\delta}_0$ is the estimated parameter associated with the dummy for PPP contract; $\hat{\delta}_1$ is the estimated parameter associated with the interaction term between expected costs and the dummy for PPP contract. Also, $\widehat{costover}$ is the estimate for the dependent variable of cost overruns depending on the values of independent variables; ppp is the dummy of a PPP contract; $expcost$ is variable for expected costs and $ppp \cdot expcost$ is the interaction term between the dummy variable of a PPP contract and independent variable of expected costs.

The vertical axis shows the predicted cost overrun depending on expected costs which are depicted on the horizontal axis. $\hat{\beta}_0$ and δ_0; determine the intercept while $\hat{\beta}_1$ and $\hat{\delta}_1$ change the slope of the curve.

The values for the variable $expcost$ are in millions of U.S. dollars; ppp is a binary variable, therefore it has only values of zero (for a public procurement project) or one (for a PPP project); $ppp \cdot expcost$ is the interaction term, thus it has a value of zero for a public procurement project and a value of $expcost$ for a PPP project (in millions of U.S. dollars). Cost overruns ($\widehat{costover}$) are determined as a percentage value of expected costs, thus it shows what the percentage of cost overruns were in comparison to 100% of expected costs. The curves are growing as it is assumed that the percentage of cost overruns could be increasing with expected costs.

Figure 1 is described in more detail in the preceding paragraph.

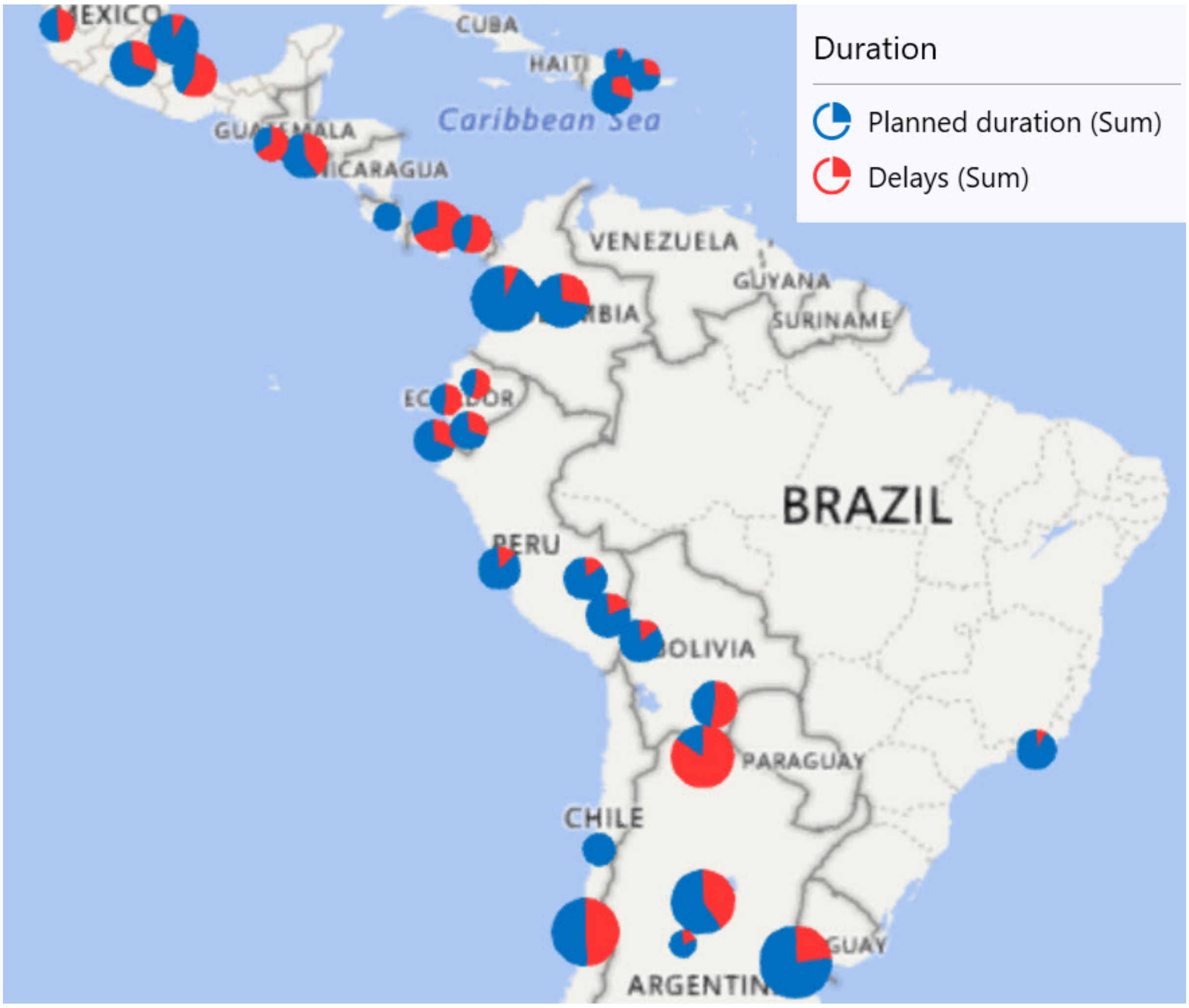
To conclude, the model mostly draws from the facts that delays and cost overrun should be simply random, especially when only one type of construction is used in the analysis. The assumption is strong but well-founded since quantitative surveying should provide the most accurate estimate given the available data. The implication of the assumptions is that the technical aspects of a highway are simply insignificant for delays and cost overrun and hence do not have to be considered. Indeed, it is possible because the model estimates cost overrun and delays rather than overall costs and construction period where such data would be needed but almost impossible to obtain in such extent. Even though the delays and cost overruns should be completely random, there might be a certain aspect of a risk of inaccurate estimation which is related to the complexity of the project. For this reason, the analysis employs two variables which may influence the dependent variables – $expcost$ and $plandur$ – each for one dependent variable. Most importantly, there are terms $ppp,$ $ppp \cdot expcost$ and $ppp \cdot plandur$ that should reveal whether the use of PPP might deliver lower cost overruns and shorter delays.

2.3. Data collection

Data on 30 highways across Latin-American countries was collected to investigate the impact of PPP. The data set contains 15 highways performed as PPP projects and 15 which were obtained in traditional procurement. In order to omit country effects, the data on highways was taken for 13 Latin-American countries and none of them delivered more than 4 highways: Argentina (4 highways), Brazil (1), Bolivia (2), Chile (2), Colombia (2), Costa Rica (1), Dominican Republic (3), Ecuador (4), El Salvador (1), Guatemala (1), Mexico (4), Panama (2), Peru (3). To consider the most recent highways, current conditions but also include longer constructions, none of the projects started earlier than 2003 and finished before 2008. Nevertheless, the accessibility of the data is more problematic than in developed countries, as local governments do not always disclose all financial information or the access to such data is complicated. It was especially problematic for highways contracted traditionally because the PPP projects are overseen and reported much more closely by development banks and international institutions. This fact prevented the research from obtaining a higher number of observations.

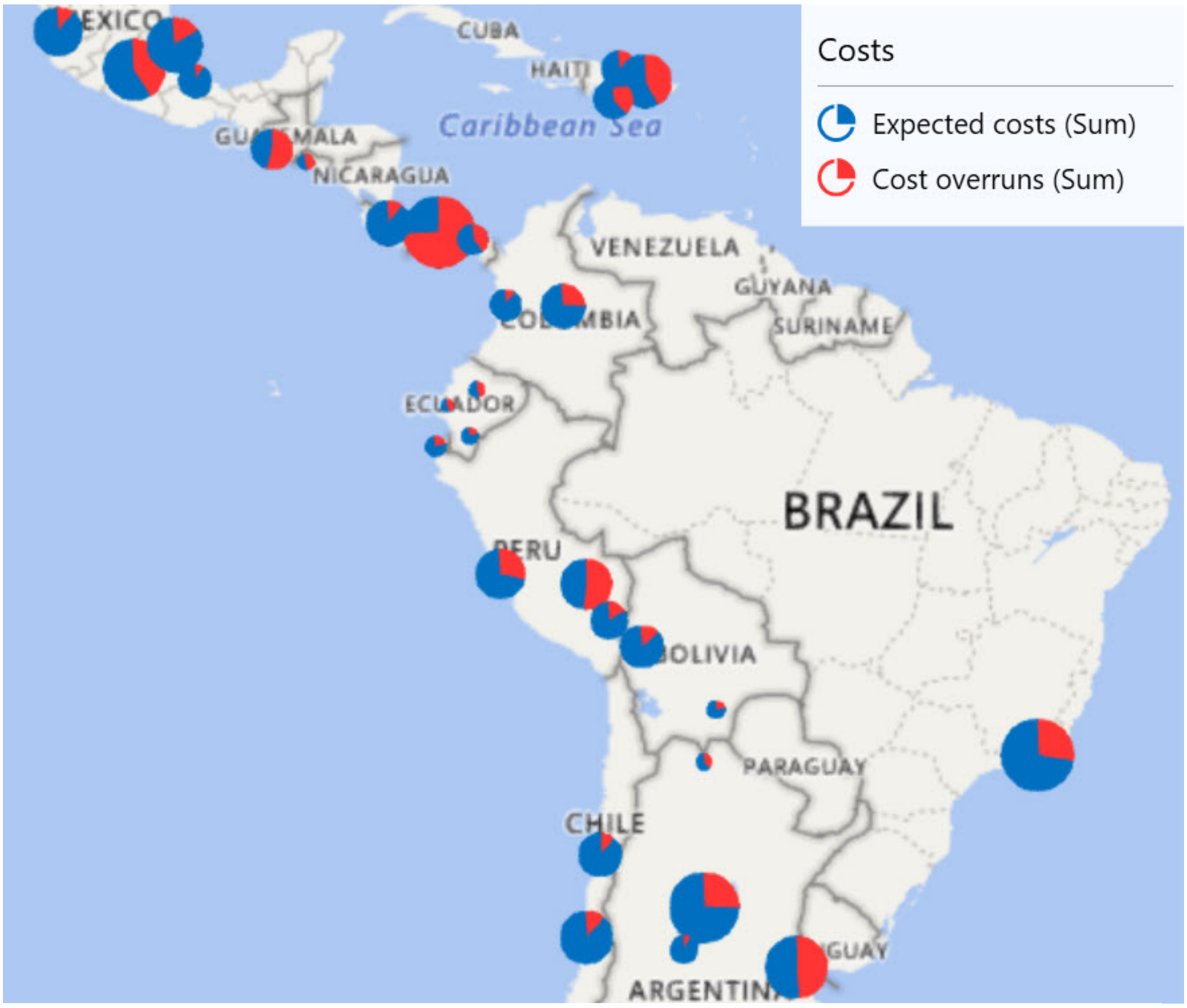
To illustrate the collected data set, Picture 1 displays the approximate location, expected costs and cost overruns of all observed highways. The size of the circle characterises the overall costs while the colours depict the proportion between expected costs and cost overruns. Similarly, Picture 2 displays the planned duration and delays of the projects.

Picture 1 Map of observed highways: Planned duration and delays



Source: Own picture.

Picture 2 Map of observed highways: Expected costs and cost overruns



Source: Own picture.

Overall, the data comes from the databases of the World Bank, investment financial institutions, development banks, other groups which provided financial resources for the highways, governments, governmental agencies, other state entities, non-governmental organization and construction companies. Summary statistics of particular variables is in Table 1. A brief insight into the data already reveals certain specifics described earlier in the thesis. Firstly, cost overruns reached on average almost 50% of the initial price. Although it might be inflated by a couple of problematic projects, median still remains rather high with 33%. Similarly, delays reached significant numbers; 21 months was the average while the median exceeded 15 months. Once again, it is necessary to remind that the data is only related to the construction phase of the project. Possible renegotiations of the contract with respect to the operation of the highway or additional fees from state to the operating company are not relevant for the analysis.

Table 1 Summary statistics

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
$costover$	49.24	33.14	57.14	-16.53	290.55
$delay$	21.30	15.50	21.96	-2.00	100.00
$expcost$	221.00	205.50	159.67	17.90	625.00
$plandur$	40.80	34.00	27.74	12.00	123.00
Number of observations: 30					

Source: Own calculations.

2.4. Results

The econometric results of the influence of PPP on cost overruns are depicted in Table 2 while the impact of PPP on delays is shown in Table 3. I run three regressions for each dependent variable: with a dummy and an interaction variable together and with each of them separately due to their high correlation.

Looking at the result for cost overrun, neither ppp nor $ppp \cdot expcost$ was statistically significant if both were considered together in the regression ((4) in Table 2). Nevertheless, both became statistically significant at least at 10% level when considered alone ((5) and (6)). There was an inverse relationship between ppp and cor which follows the theoretical prediction. The estimated effect was that PPP project had lower cost overrun by nearly 46 percentage points with statistical significance at the 5% level. Taking into account the constant (which is also statistically significant), the model estimates that a project of traditional procurement featured 68.4% of cost overrun (of the initial price) while a final price of PPP project increased only by 22.7%. When $ppp \cdot expcost$ is considered instead of ppp the estimated effect is that for every 10 million USD the cost overruns of the initial price decreased by 1.4 percentage points for PPP projects. Considering both statistical and economic significance (5) delivers better results than (6). Firstly, it gives higher statistical significance and secondly for a small project the effect would be negligible (50 million USD gives the difference of only 7 percentage points). This is confirmed if one looks at the R^2 which did not significantly decrease after $ppp \cdot expcost$ was removed from (4) and that was not the case of (6). Similarly, the *Adjusted* R^2 could be compared, as it is 0.05 for (4), 0.09 for (5) and 0.05

for (6). Considering high standard error of the term $ppp \cdot expcost$, it is possible to conclude that $ppp \cdot expcost$ caused harm in (4). Therefore, the model (5) giving constant cost overrun differential for PPP and traditional procurement project is preferred. The effect of expected costs on the percentage of cost overrun was not significant in any of the models. That also indicates why the interaction term was less significant than the dummy. As $expcost$ alone was statistically insignificant, the impact of the interaction term $ppp \cdot expcost$ was driven by the impact of ppp and $expcost$ only lower the effect.

Table 2 Results of the empirical model estimating cost overrun

Equation	Independent variables				Observations R^2
	$constant$	$expcost$	ppp	$ppp \cdot expcost$	
(4)	67.7** (20.0)	0.02 (0.09)	-42.7 (41.7)	-0.01 (0.15)	30 0.15
(5)	68.4*** (17.7)	0.02 (0.07)	-45.7* (22.1)	–	30 0.15
(6)	57.8** (17.6)	0.05 (0.09)	–	-0.14+ (0.08)	30 0.12

Source: Own calculations.

Note: Results with statistical significance 10% and the correct expected sign (-) for the impact of ppp or $ppp \cdot expcost$ are highlighted in yellow. Regression highlighted in blue is preferred.

Resulting effects are determined in percentage points.

*Significance codes: '***' for p<0.001; '**' for p<0.01; '*' for p<0.05' and '+' for p<0.1.*

Standard errors are in parentheses.

In contrast to cost overruns, the results for the impact of PPP on delays are much weaker. The interaction term $ppp \cdot plandur$ did not feature statistical significance in any of the models while ppp delivered results of statistical significance at 10% level when $ppp \cdot plandur$ was not present in the model – regression (8) which is thus the favoured model. Similarly to the model on cost overrun, reason for insignificance of $ppp \cdot plandur$ is due to the insignificance of the term $plandur$. The estimated effect for the sample is that the delay of the PPP project was shorter by 15 months than the public procurement project. Therefore, PPP should have been delayed only 10 months whilst the traditional projects would have been late by 25 months. Nevertheless, the results should be considered with caution since the significance of the results is not very strong. Also, it could have been more informative to estimate the delays as percentages of planned duration instead of absolute numbers (in the same manner as cost overruns). However, such procedure was not possible in this case because as the Breusch-Pagan test revealed the data suffered from heteroskedasticity (variance of the error term was not constant). Therefore, the standard errors of the estimated variables would not be valid. Also, using the absolute values instead of relative contributed to the lower significance of the model for delay in comparison to the one on cost overrun. Furthermore, the planned duration showed no significant impact on the length of the delay. This is more surprising than the situation with cost overruns because the delays were not considered in relative numbers. Therefore, one would expect that longer project might have more substantial delays.

Table 3 Results of the empirical model estimating delay

Equation	Independent variables				Observations
	$constant$	$plandur$	ppp	$ppp \cdot plandur$	R^2
(7)	25.1** (9.0)	0.09 (0.20)	-15.7 (14.9)	0.02 (0.30)	30 0.12
(8)	24.8** (7.5)	0.10 (0.15)	-15.1$^+$ (8.0)	–	30 0.12
(9)	19.3* (7.2)	0.19 (0.18)	–	-0.25 (0.17)	30 0.08

Source: Own calculations.

Note: Results with statistical significance 10% and the correct expected sign (-) for the impact of ppp or $ppp \cdot plandur$ are highlighted in yellow. Regression highlighted in blue is preferred.

Resulting effects are determined in percentage points.

*Significance codes: '***' for p<0.001; '**' for p<0.01; '*' for p<0.05' and '$^+$' for p<0.1.*

Standard errors are in parentheses.

To summarise, the analysis finds the that a PPP project has lower cost overrun as well as shorter delay than a traditional procurement project in the sample of highways (Q1). This conclusion aligns with theoretical expectations set earlier in the analysis. Nonetheless, I am cautious to interpret the scale of the effect literally, especially in the case of delays that did not have a strong significance. The sample size is rather small and therefore the scale of the effect might not be as accurate. Future estimation with larger samples of data could specify the scale of the effect. On the other hand, regardless the scale of the effect, results are conclusive and seem to confirm the stated hypothesis that an application of PPP on highway construction in Latin America decreases delays and lowers cost overruns as the economic theory suggests. Therefore, I suggest that the results provide an evidence of the existence of the effect rather than an accurate estimate of its size.

2.5. Implications

The results which clearly speak in favour of PPP are related exclusively to the construction phase of the project. This evidence tells us that PPP should be more efficient than traditional public contracts but only during the construction per se. There are many different issues of PPP as well as traditional procurement before and after the construction phase and it is a long path to determine the optimal choice between the two for particular projects. Thus, my findings might add another small piece to this puzzle. However, it is a piece which has not been widely discussed yet.

In the setting of weak, undeveloped and poorly functioning institutions (such as in Latin America), PPP contracts may deliver better performance than the traditional public procurement for highways during the period of construction (Q1). Such conclusion might have two possible implications. Either to focus on improving the performance of the public sector or to further minimise disadvantages of the PPP contracts and to make them more favourable in the other stages of the project life-cycle. Earlier presented economic theory suggests that the former is difficult to attain because it goes against the nature of the public sector and basic economic principles. Then, certain inefficiency may remain as long as the public sector remains public. On the other hand, there is still a lot to improve in PPP contracts even though Latin-American governments have learnt their lesson after painful and costly re-negotiating of PPP contracts during its first boom in the 1990s. It would be a mere conjecture to claim that drawbacks of PPP contracts might be minimised or even eliminated although it is not bold to state that Latin-American countries indeed have room for improvement. In the end, it might be a choice of their second-best[15] contract as their first best is not attainable. Then, they will simply need to compare the pros and cons of each project and I propose that the PPP contracts are more advantageous as far as the construction phase is concerned.

Furthermore, it is apparent that an econometric analysis can be used to investigate effects related to the field of construction management and should then be considered as a relevant method for future research (Q2). Econometrics infers

[15] *The outcome that maximizes the principal's surplus subject to the constraint that the principal is less well informed than the agent is called the second best, and the contract that implements this outcome is called the second-best contract.* Nicholson and Snyder (2008, p. 630).

important implications which might not be possible to acquire with other research methods and therefore it provides a complement to them. On the other hand, it is necessary to admit that the method is more likely to be used for investigating general phenomena and cannot answer questions of particular projects. That also introduces the main issue a researcher may encounter while using econometrics method in the field related to construction management - not enough available data which would fulfil the *ceteris paribus* condition. This also formed an obstacle in the thesis as obtaining at least 30 observations was lengthy and complicated, although it was partly because mostly developing countries were considered for the research. In brief, the method should be considered for research of specific questions in construction management where enough unified data is accessible.

Conclusion

The objective of the thesis was two-fold. Firstly, it aimed to establish a linkage between PPP contracts of highway construction in Latin America and a decrease in delays and cost overruns in contrast to their counterparts of public procurement (Q1). The second aim was to advocate the possibility to use an econometric analysis for studies on construction management and evaluate the option (Q2). Both objectives of the thesis were fulfilled. Starting with the latter, the question of the use of econometric analysis (Q2) was solved by a practical demonstration of the method backed by describing a few studies that apply it as well. Furthermore, I described its limitations and defined appropriate research questions for the method (chapter 2.5.). Therefore, the answer for this research question is that the econometric analysis might be used for research on construction management and is specifically favourable for industry-wide questions which can provide large datasets. Turning to the empirical question (Q1), it was resolved with the help of an econometric model (chapter 2.4.) that produced expected results which had been earlier predicted in the theoretical section (chapter 1.1.4.). Thus, the answer for the first research question (Q1) is that PPP projects in highway construction in Latin America have lower cost overruns and delays than their counterparts of public procurement

The theoretical background (chapters 1.1.1. – 1.2.3.) described intricacies of PPP, its use in highway construction, the problems of the public sector and specifics of Latin America. Overall, it provided economic reasoning why PPP contracts should have lower cost overruns and shorter delays. The rationale was shown with a help of two fields of economics: behaviour economics and public sector economics (chapter 1.1.4.). Overall, the public sector is seen as less efficient and generally weaker in negotiating and controlling the contracts in comparison to a private entity as it does not have strong enough or even correct incentives to behave efficiently. Moreover, public procurement suffers from asymmetric information between the two sectors. The PPP contract eliminates the problems for it minimises the role of the public sector. Essentially the public sector is replaced by a private company on the position of an employer in constructing public infrastructure. Then private companies deal with each other which eliminates the asymmetries. As described in the literature review (chapter

1.1.5.), little interest has been devoted to this topic and the impact of PPP on the construction phase if used instead of the conventional public procurement.

The empirical section consists of two parts: an introduction to econometric analysis and the econometric model. In the beginning, the path of an econometric analysis and specifically cross-sectional analysis was delineated (chapter 2.1.). It focused on tests and methods used in this paper. Afterwards, I proposed models for investigating the impact of the application of PPP on delays and cost overruns (chapter 2.2). Three regression were run for each dependent variable: with a dummy variable; an interaction term and both together. Using solely the dummy appears to deliver the most convincing results for both models. The results imply that for highways in Latin America, a PPP project has lower cost overruns and shorter delays than a project performed in the traditional way of public procurement (Q1) (chapter 2.4.). Nevertheless, I would be cautious to interpret the scale of the results literally as data set was not substantial. Instead, I propose that the results serve as an evidence for the existence of the effect that a mere application of PPP on highway construction in Latin America decreases delays or lowers cost overruns of the construction. This confirms the stated hypothesis of the thesis. Further research should investigate the size of the effect of PPP on the considered variables and other factors that might influence them. Moreover, it is necessary to remind that the paper investigates only the construction phase per se. Both ways of procurement suffer from many other issues, but my findings suggest that the construction phase speaks in favour of PPP. As this point has not been discussed in the academic debate, I argue that the construction phase should be included when comparing the two approaches of procurement of public infrastructure.

In addition, it is apparent that econometric analysis might be used in the field of construction management although some limitations exist (Q2). I propound the argument to apply econometrics in research on construction management issues as it provides different perspective than traditional methods in the field. It should specifically be considered for industry-wide questions rather than questions of a particular project. Also, it is more appropriate if large datasets are available.

To conclude, what is the lesson to be learned from Latin America with respect to PPP in highway construction? In case of inefficient public institutions (among which one could classify a half of EU countries: Bulgaria, Croatia, Cyprus, the Czech Republic, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia or Spain) (World Economic Forum, 2017), the construction phase of the project seems to be more advantageous and efficient if a project is handled as PPP rather than through traditional public procurement. Therefore, when deciding about the choice between the two, this conclusion should be taken into account. That will be especially valid for those EU countries which have little experience with PPP because, in 2020, the funding framework for investment in transport in EU, Connecting Europe Facility, will terminate together with the transport operational programmes for member countries. I propose that we learn from this Latin-American experience and start considering aspects of incentives, behavioural economics, and public sector economics into the mosaic of pros and cons of Public-Private Partnership, so our future decisions about its use would be as efficient as possible…

List of abbreviations

BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
BTO	Build-Transfer-Operate
BTL	Build-Transfer-Lease
DBFO	Design-Build-Finance-Operate
DBFOM	Design-Build-Finance-Operate-Maintain
DCMF	Design-Construct-Manage-Finance
EIB	European Investment Bank
OLS	Ordinary Least Square
PPP	Public-Private Partnership
Q1	Research question No. 1
Q2	Research question No. 2

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