INFRASTRUCTURE, PRIVATE INVESTMENTS AND ALLOCATION OF RISKS An Economic Analysis of Lessons Learned

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May 2018

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ACKNOWLEDGMENT

The authors wish to thank several Brattle colleagues for their helpful feedback in developing this paper, including Dan Harris, Robert B. Mudge and former colleague Elaine Buckberg. They are also grateful to Rachael Barza, Lucrezio Figurelli and Nicola Villani who provided their time, consideration, and valuable input. Any errors or omissions, as well as the views and opinions expressed in the paper, are those of the authors alone.

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INTRODUCTION

The global economic and financial crisis of the past years has reduced the amount of public funds available for infrastructure development in most countries. Although most economies have recovered from the crisis, the lack of public funds for infrastructure development still persists and it is challenging governments to find new ways to fund investments. The European Commission recently identified more than €350 billion of relevant projects related to infrastructure development in European countries, under the so-called Juncker Plan launched in 2014. In the United States, President Trump has targeted more than \$1 trillion of projects to bridge the infrastructure gap.

Experts in the infrastructure sector think that private capital will play an important role in financing infrastructure projects over the next years, largely through the creation of Public-Private Partnerships (PPP or 3P). PPP contracts, which have been less common in recent years, are currently experiencing an increasing trend—especially in the United States.³ This contractual framework is well suited to rapidly filling the infrastructure gap, since it allows federal and local governments to transfer specific risks and rewards of infrastructure projects to private investors for a pre-defined term, and to regain full control of the assets at the expiry date of the contract.

This article builds on the infrastructure plans of both Europe and the United States, which are based on the involvement of private capital; it applies economic analysis we have conducted on specific projects, describes the main lessons learned about contractual risk allocation in infrastructure projects, and highlights contractual conditions which are positively perceived by investors.⁴

Our experience indicates that privately-funded investments are realized at low cost when:

- the contractual framework is balanced with risks allocated to the party best suited to bear them; and
- project cash flows are predictable, including a terminal value—when needed and guaranteeing the proper compensation of realized investments at a fair market return.

In absence of similar contractual conditions, and without a stable regulatory environment, private investors bear high financing costs, and require high returns, providing in the end a disincentive to invest.

I. INVESTMENTS IN INFRASTRUCTURE IN EUROPE AND THE UNITED STATES

Infrastructure investments in European countries and in the Unites States have remained stable or significantly decreased in the last few years (2008-2014). The decreasing trend of infrastructure spending has been correlated largely with the global economic crisis and increasing budget constraints (Figure 1). Despite the resurgence of these economies from the crisis during the last few years, the shortage of public funds available still persists, pushing governments to find new ways to fund the investments.



Source: Global Infrastructure Hub; Infrastructure Outlook

In 2014 the European Commission has launched the "Investment Plan for Europe," also known as the "Juncker Plan," to support public and private investments of at least €315 billion.⁶ Large investments targeted by the Plan concern strategic infrastructure, including transport infrastructure, part of the Trans-European Transport Network (TEN-T).⁷

The plan has involved the creation of a European Fund for Strategic Investment (EFSI) based on funds guaranteed by the EU budget, and managed by the European Investment Bank (EIB). The fund provides a multiplier effect, by mobilizing private investments in strategic sectors, and by giving credit protection to the EIB for high-risk projects. So far the plan has mobilized investments for about €260 billion, of which about €53 billion are directly financed by the EIB.⁸ The investments completed within the framework of the strategic plan involve both private and public investors, and concern assets that have medium- to long-term returns, including investments in transport infrastructure, broadband networks, energy, environment and resource efficiency.⁹



In 2014, the United States launched the Build America Investment Initiative to promote greater private investment in traditionally public infrastructure, especially transportation and water, including through PPPs. Much of the initiative was focused on building expertise in state and local governments, so that officials would have the capacity to evaluate whether a PPP is suitable for a given project and to manage a transaction.

In 2016-2018, President Trump targeted investments in infrastructure of \$1.5 trillion over the next 10 years. Part of these investments would be provided by expanding the existing federal programs and by creating new ones, which would amount to total costs of about \$200 billion.¹⁰ Most of the planned investments foreseen cover current infrastructural deficiencies, and are related to the transport and energy systems, especially involving the water sector.¹¹ The new infrastructure initiative launched in the United States foresees the involvement of the private sector for the completion and management of specific targeted assets, leveraging the existing programs and expanding the set of financing measures, including the implementation of tax-exempt bonds funded by the private sector.¹²

A certain consensus in the infrastructure sector indicates that a large part of the new investments required will be realized in Europe and the United States through PPP contracts; or more broadly, within a concession framework, which entails the participation of private capital.¹³

A soundly designed PPP and concession contract allocates risks between the private partner and the public sector project sponsor according to their ability to manage such risks, and minimizes transaction costs.¹⁴

II. INFRASTRUCTURE PROJECTS AND KEY LESSONS LEARNED

The emerging investment opportunities in the infrastructure sector in Europe and in the United States are attracting highly specialized international investors in both the equity and debt capital markets. Such investors may require higher returns for investing in infrastructure projects compared to other sectors, to protect themselves from uncertainty about the expected projects outcomes.¹⁵ Infrastructure projects generally undergo a substantial construction phase, which requires—at least temporarily—high financial and operating leverage for



investors, linked to higher risks of default.¹⁶ Capital investments in infrastructure are for a very large part sunk, and require long-term time horizons to be fully recovered. Also, the results of infrastructure projects are to a great extent dependent on exogenous factors, not directly under the control of investors—such as, for example, the regulatory and political frameworks. Rational investors model measurable risks of infrastructure projects within their expected cash flows; on the other hand, they price uncontrollable risks in the expected rate of return, measured on limited market data.

A. ALLOCATION OF RISKS WITHIN THE CONTRACT

Successful infrastructure projects funded by private capital require robust contractual frameworks that minimize the degree of uncertainty and protect private investors and the public interests from undesired and unforeseen outcomes, such as, for example, company default, socially unsustainable levels of charges, or the abandonment of the project.

The contractual framework must identify the expected risks and returns of each specific project, and delineate clear and reasonable measures to handle the effects of unforeseen events on cash flows, such as, for example, environmental or technological changes.

We identified three broad categories of risks linked to infrastructure projects which are considered by private investors, which are: (i) operation and management, (ii) demand risk, and (iii) regulatory and risk of force majeure. Private investors have different degrees of aversion to these kinds of risks, depending on: specific sector and market conditions, phase of development of the project, and the degree of involvement of private and public stakeholders.

The three categories of risks reflect a wider range of actual and specific risks that we have summarized in Table 1. This list of risks, even if not exhaustive of all the kinds of difficulties which may prevent the successful completion of infrastructure projects, includes the most frequent kinds of issues which, in our experience, are raised by investors during the due diligence of infrastructure investments. For each risk type we included the categories of risk they refer to, a brief description, and the allocation of risks in typical contracts.

TABLE 1

General Risk Framework of Infrastructure Projects

		RISK CATEGORY			RY
	TYPES OF RISKS	OPERAT MANA	DEM	AND RISK REG	ULATORY ⁸ ULA TORY REFERENCE DESCRIPTION AND ALLOCATION OF RISKS
1	Planning & Design of Infrastructure	~			Relates to the planning and design of the infrastructure, including cost- benefit analysis when required. These risks can be borne fully or in part by private investors depending on the specific project.
2	Construction Cost	✓		✓	Relates generally to cost overruns or underestimated investment costs. After the approval of the project by public authorities, private investors bear construction risks, which are transferred to subcontractors.
3	Force Majeure	✓		✓	Refers to cost overruns due to force majeure. Such risks should not be borne by private investors and they are managed within the contract so as to guarantee completion of the project work and the expected returns for the investors.
4	Delays of Construction Work	✓		✓	Refers to delays occurred in construction work due to causes different from force majeure. Usually private investors bear these specific risks. In case of administrative delays, risks can be transfered to public authorities.
5	Public Tender of Construction Works	✓		✓	Refers to construction costs higher than planned due to different outcomes of public tenders. Depending on the degree of involvement of the private investors and the stage of development of the project, these risks can be borne fully or in part by the investors.
6	Operating Risks	✓	✓	✓	Refers to all kind of operating risks, including issues in using the infrastructure, unexpected events, and damages. These risks are mostly handled by the operating company and the private investors, except in case of force majeure or catastrophic events.
7	Approval of Projects	~		✓	Refers to the risks that planning and design costs borne by private investors are not recovered because the infrastructure project is not approved by all the public authorities involved. In general these risks are shared between private and public actors.
8	Revenues and Demand		✓	•	Refers to the possibility that, due to incorrect volume forecasts and/or over-estimated capacity, the actual cash-flows of the project do not fully compensate the investment costs, including a fair return on the invested capital. These risks, depending on the contractual design and regulatory regime, can be borne fully or in part by the operating company and private investors.
9	Expected Rate of Return		✓	✓	Refers to the difference between the expected and the actual returns of the infrastructure project. Depending on different regulatory regimes and contractual design, the risks are borne fully or in part by private investors.
10	Inflation Rate		✓	✓	Refers to difference in nominal terms about planned costs and revenues and the actual amounts obtained during the project. Certain contractual designs can imply protection for investors against the inflation risk.

For example, construction risk, which relates to cost overruns and underestimated investment costs, is included in both operating and management risks, and in regulatory and risks of force majeure. Private investors should be well-suited contractual counterparts to quantify *ex-ante* construction costs and to include in the project cash flows a reasonable percentage of costs overruns to guarantee their expected returns. However, force majeure and regulatory risks, related to unexpected and exogenous events, including catastrophic events and changes in regulation and legislation which affect construction works, can directly affect the profitability of investments. Despite their specific nature, these risks are only with difficulty: (i) directly controlled by investors, (ii) transferred to counterparts, and (iii) taken into account in the remuneration rate, due to absence of insurance instruments and limited market information.¹⁷

Investors who go through a deep due diligence process before undertaking specific infrastructure investments and signing contracts to build and operate the assets, quantify *ex-ante* construction, operation and management costs, including insurance costs, to minimize risks related to operating and management, and demand or volume risks.

Force majeure and regulatory costs depend on actions which are out of investors' control. In the presence of possible downside outcomes not counterbalanced by potential upside results, they provide a potential non-symmetric allocation of risks, which investors evaluate negatively and absorb either in requesting higher returns, or in a disincentive to invest. A non-symmetric allocation of risks results in a requirement for higher remuneration rates. In contrast, allocation of risks to the public counterpart would reduce the remuneration rate of private investors, diminishing—at least in theory—the overall social costs of the investment.¹⁸ However, in our experience, such transfer of risks to the public sector in PPP contracts should be done carefully to avoid the default of projects, which may occur due to force majeure and public budget constraints.¹⁹

Box 1 provides an illustrative example of how private investors react, in terms of requiring higher returns, to different probabilities of unexpected events, such as an earthquake, when projected cash flows are not straightforward to model while including operating risk related to infrastructure default, or operating delays linked to the recovery phase after the catastrophic event.

BOX 1

Catastrophic Risks and Remuneration of Capital

It is standard practice among investors to calculate returns as the weighted average of the cost of debt and of the cost of equity, with cost of equity calculated with the Capital Asset Pricing Model (CAPM).²⁰ The CAPM provides a measure of the relationship between perceived market risks and expected returns from the perspective of the market investor. The model specifically measures the expected returns required by investors to hold assets that have more risks than risk-free investments, and which cannot be otherwise diversified. The market risk of the assets, or the project, that is not diversifiable by investors is measured by the parameter beta included in the CAPM formula.²¹ Risks associated with catastrophic events such as an earthquake should be—at least in theory—diversifiable risks by rational investors, and therefore should not affect the asset beta. In practice, investors face much greater uncertainty holding assets exposed to disaster risks and would expect higher returns.²²

We have estimated the beta of two groups of infrastructure projects with different exposure to force majeure events: (i) the first group of assets includes toll-road companies which operate within countries not exposed to earthquake risks; (ii) the second group includes toll-roads which are mostly located in earthquake sensitive areas. Specifically, to identify the sample of toll-road companies subject to seismic risk:

- we selected the geographic areas which are most sensitive to earthquake risk and the listed toll-road companies that operate in these areas;
- we calculated for each company the share of revenues deriving from assets located in areas with high seismic risk;
- we performed a liquidity test on those companies whose share of revenues coming from assets located in areas with high seismic risk is higher than 70%.²³

Finally, we estimated the average asset betas of the two groups reported in Figure 2 by applying standard econometric techniques and the Modigliani-Miller formula.²⁴



As expected, the differences in terms of average asset beta among the two peer groups is relatively low, considering the asset beta measures the non-diversifiable risks of investors and that the estimates are based on limited samples and market data.²⁶ However, investors would still ask for higher returns if they think the assets they are holding are subject to risks of force majeure that cannot be rationally diversified, or that they find hard to model within their expected cash flows.²⁷ Infrastructure projects which are of general economic interest may not be realized in absence of reasonable contractual conditions, which protect investors and the public interest from the consequence of unforeseeable events.²⁸

For illustrative purposes we have calculated the implicit "uplift" on the market returns expected by investors, related to the additional risks of disaster events, by using a Discount Cash Flow (DCF) analysis (Figure 3).²⁹ The analysis, which is for illustrative purposes only, takes into account a probability distribution of the disaster event and different hypotheses regarding operation recovery after the disaster. The DCF analysis is generally considered by practitioners a more sound approach to determine the effects of additional risks perceived by investors on the present value of specific infrastructure projects. This methodology—if based on robust hypotheses—can lead to credible results on which public and private stakeholders should agree. For the purposes of our illustrative analysis below we have:

- calculated the present value of a toll-road's cash flows based on traffic projections, level of charges, operative costs, and depreciation of the assets, by using a discount rate calculated on available market data;
- identified different probabilities of an earthquake in each year of the economic and financial plan of the tollroad, taking into account past observations and the public information provided by experts;
- assumed different scenarios of interruption and recovery of the operation of the toll-road after the earthquake (no recovery at all of operation; partial recovery of operation; total recovery of operation);³⁰
- determined the present value of the cash flows for each scenario and calculated the implicit average rate of return which makes the investors indifferent to uncertainty related to the additional risks of the earthquake.



After business interruption



The illustrative results of our analysis reported in Figure 3 show the average "uplift" required by investors in the presence of different scenarios and degrees of uncertainty. When the PPP contract gives investors full protection against disaster risks, investors require lower market returns, based on market available data; investors will require higher expected returns in case of partial cost recovery from the public partner, or no recovery at all.³¹

Similar conclusions can be drawn in jurisdictions which allow governments to terminate PPP contracts at-will for broadly stated public reasons, or give them discretional power in changing users' rates, or in terminating contracts by making reference generically to poor performance. Investors face not only risks that they can control, but also regulatory and legislative risks outside their control, implying higher promised returns.

B. COHERENCE BETWEEN REVENUES, DEPRECIATION AND TERMINAL VALUE

Infrastructure assets are long-lived and many contracts entitle investors to receive returns for more than 30 to 40 years.

Investments on infrastructure are sunk; they cannot be converted to an alternative utilization. It is of utmost importance, therefore, that project cash flows are predictable, so as to include a terminal value—when needed— and to guarantee the proper compensation of realized investments at a fair market return when:

- revenues are calculated on forecast volumes in order to cover operating expenditures, return on invested capital, and depreciation; and
- terminal value amounts to the value of undepreciated assets and has to be reimbursed at the end of the concession.

PPP contracts must provide rules on how tariffs are calculated every year in order to ensure recovery of costs, including an expected return on invested capital. Investors finance costs of investments through a mixture of equity and debt, and are remunerated through (i) revenues received during the concession and (ii) the terminal value paid by the grantor of the concession, or by the new concessionaire, at end of the concession.³²



Contract rules, however, do not always ensure coherence between revenues, yearly depreciation and terminal value. For example, in some jurisdictions, unexpected changes in regulation, or to the regulatory accounting rules, may determine that investors accrue a terminal value lower than the actual value of the undepreciated assets. In these cases, investors have a disincentive to invest as they would not expect to recover all the value of their investments, including a reasonable market return.³³

In those cases, private funding is not able to sustain adequate investments because of lower than expected market returns. **Box 2** provides a factual example in two different jurisdictions in Europe about the unintended effects of asymmetric contractual design related to the residual value of the assets.

BOX 2

Unintended Consequences of Misalignment of Asset Values

The tariffs of telecom networks in Europe are updated on a regular basis at 3-5 year tariff cycles to remunerate, in addition to operating expenses, capital investments calculated on theoretical values of assets and depreciation (long-run replacement costs). At each new tariff cycle, assets are expressed at the cost of replacement of the technology. Depreciation over the new tariff cycle is also calculated by mimicking technological depletion. In reality, technological innovation has been faster than predicted, with the result that the replacement cost of the next tariff cycle is lower than originally envisaged. Public information is available for the fixed telecom companies in Denmark and Sweden.³⁴ The new cost of replacement calculated for the new tariff cycle has been lower than the historical cost net of depreciation, implying a present value for investors lower than the actual value of their investments.

It is of fundamental importance, therefore, that contractual conditions assure coherence between revenues, depreciation and terminal values.

III. CONCLUSION

Due to limited public funds available for infrastructure, private capital will play an important role in financing infrastructure projects over the coming years through PPP contracts. Their design will allow low-cost financing from private counterparts and an efficient management of the assets when two conditions are met: (i) risks are allocated to the party best suited to bear them; and (ii) project cash flows are predictable and guarantee the proper compensation of realized investments at a fair market return. In the absence of a proper allocation of risks, private investors will ask for higher returns, or be unwilling to invest.

Our experience shows that successful infrastructure projects funded by private capital require robust contractual frameworks which minimize the degree of uncertainty and protect private investors and the public interests from undesired outcomes, such as, for example, a company default, or socially unsustainable levels of charges.

Investors go through a deep due diligence process before funding specific infrastructure investments, quantifying *ex-ante* costs of construction and management, and demand volatility. Force majeure and regulatory costs depend on actions which are out of investors' control. In the presence of possible downside outcomes not counterbalanced by potential upside results, they provide a potential non-symmetric allocation of risks, which investors evaluate negatively and absorb either in requesting higher returns, or in a disincentive to invest.

Economic analysis based on reasonable hypotheses and sound methodologies can help investors and public stakeholders to agree on contractual frameworks which allocate risks efficiently (without creating asymmetries for investors) and on the expected returns. Even if not directly analyzed in this paper, PPP and concession contracts, which will be used in the next year to build and to renew the infrastructure system, will need also to include proper controls and monitoring measures to guarantee in the long run the quality of services at efficient social costs and a fair compensation of public and private interests.

ENDNOTES

- 1. Principal, The Brattle Group.
- 2. Senior Associate, The Brattle Group.
- 3. In Europe, and especially in the UK, PPPs have been used largely in the late 1990s beginning of 2000s. Since the beginning of the economic crisis in 2008, the number and value of the PPP projects in Europe have fallen sharply. To reverse this trend, public authorities and experts—both in the UK and in the EU—are currently discussing new forms of public-private partnerships to implement, limiting the burden on taxpayers and reducing the risks of default for private investors. Also, for more details about the development of the PPP market in the United States, please see the report "Rising Tide of Next Generation U.S. P3s—and How to Sustain It," prepared by Elaine Buckberg, Robert Mudge, and Hannah Sheffield of The Brattle Group, available at: http://www.brattle.com/news-and-knowledge/news/public-private-partnerships-could-play-significant-role-in-addressing-the-us-infrastructure-crisis-according-to-brattle-economists
- 4. There is an ongoing discussion among experts both in Europe and the U.S. about the conditions for successful PPP contracts. In the UK experts identified at least three conditions for successful PPP projects which are: (i) the presence of a market for the service; (ii) the definition of clear and transparent performance requirements; and (iii) the limitation of PPP contracts to sectors that are not crucial for the public interest (such as, for example, the construction and management of hospitals in certain areas). In 2001, the European Commission launched a consultation to identify the different approaches of member states towards public-private partnerships, and to design common guidelines for successful projects. Through the consultation, the Commission identified issues of PPP contracts—similar to the ones identified by the experts in the UK—which must be addressed in order to obtain successful projects, which are related to: (i) market competition, including the compatibility of the projects with State Aid rules; (ii) the definition of transparent rules, as well as performance and quality requirements; and (iii) the protection of the public interest. A recent article by the World Bank elaborates on these topics and analyzes the current evolution of PPP projects in the UK—one step forward, two steps back?," consulted on March 15, 2018 on: http://blogs.worldbank.org/ppps/evolving-infrastructure-models-uk-one-step-forward-two-steps-back.
- 5. Data downloaded from Global Infrastructure Hub, https://www.gihub.org/. Includes investments in ports, roads, railways, and airports.
- 6. The Juncker Plan is part of a series of other recovery measures to create new jobs, boost growth, and meet long-term economic improvement expectations.
- 7. The TEN-T network launched by the European Commission in January 2014 is part of a transport infrastructure policy aimed at identifying specific infrastructure needs to close the gaps between Member States.
- 8. Values updated in February 2018. Source: European Commission, "Investment Plan results," https://ec.europa.eu/commission/ priorities/jobs-growth-and-investment/investment-plan-europe-juncker-plan/investment-plan-results_en. Within the framework of the Juncker Plan, the European Investment Bank helps finance infrastructure and other strategic investment projects which otherwise would not be completed by private investors. As an example, the EIB is currently financing, for about €430 million, the construction of a new motorway in Slovakia, which is part of the TEN-T network. The project is a public-private partnership, including the construction and 30 years of operation and maintenance of the motorway.
- 9. https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan-europe-juncker-plan/investment-plan-results_en (February 2018).
- 10. The White House (2018), Legislative Outline for Rebuilding Infrastructure in America. https://www.politico.com/f/?id=00000161-8a9d-d53a-a5f5-bffd597b0000 (consulted on March 2018).
- 11. In his electoral program, President Trump pointed out that: (i) there are more than 60,000 bridges in the United States that must be renovated because they are structurally deficient; (ii) 2,000 water systems must be changed due to technical problems; (iii) major improvement are needed in the transportation system of about €1 trillion; (iv) the energy sector would attract investment of at least €33 billion to complete coal and shale energy export facilities, or major pipelines. Moreover, the Priority List of "Emergency & National security programs" that the Trump team has shared with the press in January 2017 identifies 50 infrastructure projects that would be prioritized in any funding plan: this list includes rail and road infrastructure, new airport terminals, bridges, and energy plants. In January 2018, during the State of the Union, President Trump confirmed the need to invest in infrastructure, declaring an increased amount of total expected spending equal to \$1.5 trillion. According to the president's statement, expected investment in infrastructure will be funded together by the federal government partnering with local and state governments, and—where appropriate—by private investors. For more details on this please see http://www.infrastructure-channel.com/infrastructure/ trumps-plan-to-update-uss-aging-national-infrastructure/ (consulted on March 2018); White House, Fact Sheet, 2018 Budget, and The White House (2018); "Legislative Outline for Rebuilding Infrastructure in America".
- 12. White House (2018), Fact Sheet, 2018 Budget: Infrastructure Initiative. According to the White House fact sheet: "[t]he private sector can provide valuable benefits for the delivery of infrastructure, through better procurement methods, market discipline, and a long-term focus on maintaining assets"; and also "[w]hile public-private partnerships will not be the solution to all infrastructure needs, they can help advance the Nation's most important significant projects". See also The White House (2018), "Legislative Outline for Rebuilding Infrastructure in America".

- 13. PPP contracts can take different forms depending on the level of involvement of the private sector. The World Bank has classified the types of PPP arrangements from low private sector participation to high participation. According to the World Bank scale, PPP contracts include: (i) management and operating contracts; (ii) leases; (iii) concessions, BOT Projects, DBOs; and (iv) joint venture and partial divestiture of public assets. https://ppp.worldbank.org/public-private-partnership/agreements.
- 14. PPP projects can be considered as a specific kind of concession contracts, where private investors are allowed to construct, manage and operate public infrastructure, and are generally paid by users' charges. Within the paper we use both terms, PPP and concession, to refer to the same kind of contractual agreements.
- 15. In terms of asset pricing, and evaluation of risks, uncertainty affects the expected value of future cash flows, and therefore the present value of the asset.
- 16. Financial and operating leverages are usually high during the early phases of infrastructure projects, especially in the case of green fields, or existing assets which undergo huge renovation. In such cases, cash flows of infrastructure projects tend to be negative during the first years of development, due to limited or absent revenues, and significant up-front costs.
- 17. There is a relatively limited amount of public information available about the insurance market for force majeure and natural disasters on infrastructure projects. So far, natural disaster insurance take-up rates have been generally low due to "optimism bias" or non-sustainable insurance costs for investors. A public report published by Aon Benfield, "Weather, Climate & Catastrophe Insight, Annual Report 2017," indicates that the percentage of insured economic losses in the world due to natural disasters—not specific for infrastructure projects—was equal to about 38% of the total economic losses in 2017, much higher than the percentage of insured losses recorded in 2000, equal to about 16%. For specific kinds of disasters, such as earthquakes, the law of high numbers which is used by practitioners to calculate reasonable and stable insurance premiums cannot be easily applied due to relatively low occurrence frequency and the potential huge amount of losses determined by the event. These characteristics create a problem of adverse selection and difficulty making the risks insurable.
- 18. According to economic theory, the costs incurred by public authorities for public services are lower than the costs required by private investors due to the socialization of the costs associated with the risks (i.e., the social cost of risk is lower than the risks borne by private investors). However, according to some articles, the risk associated with specific projects is not washed out by the socialization of costs among all tax-payers, and it is only determined by idiosyncratic factors, which may not always be offset through stabilization policies. Please refer for more details to Baumstark L. & Gollier C. (2014), The relevance and limits of the Arrow-Lind Theorem, *Journal of Natural Resources Policy Research*, Volume 6, 2014 Issue 1.
- 19. For example, in the presence of cost overruns due to force majeure, the private investors may require public funds to complete the investments which may not be available due to budget constraints. To complete the infrastructure project, the operating company would need to access debt capital markets under certain conditions related to the bankability of investments, such as, for example, the residual number of years of the concession to recover the investments, or the recognition of a terminal value. In these cases, a reasonable flexibility of the contractual terms, after careful scrutiny of the conditions, and taking into account measures to avoid investors' over-compensation can generate better outcomes, allowing the completion of the projects.
- 20. We acknowledge that there are different methodologies to estimate the cost of equity that have been explored and proposed by the economic and financial literatures, such as, for example, the Discounted Cash Flow (DCF) model. For the purpose of our illustrative example we have used first the CAPM to discuss the risks perceived by infrastructure investors, and afterward a DCF analysis.
- 21. The standard CAPM model requires estimating the equity beta based on the available market data. In particular the beta measures the volatilities of companies' stocks and of a representative market index, and the covariance between the stocks' returns and the returns of the market. The idea behind the beta is that rational investors holding a market portfolio diversify their risks; the beta of a specific asset indicates how much risk investors cannot diversify and they will therefore add to their portfolio holding the new asset. The market risk of the asset measured by the beta indicates how sensitive the asset is to market movements: stocks with betas greater than 1 generally amplify the overall movements of the market; companies with a beta between 0 and 1 move in the same direction as the market does, with less intensity. The beta associated with a specific activity or project is usually measured taking as reference a group of peer companies publicly listed. The equity beta measured on market data will depend on each company's financial leverage. To estimate an average beta from the peer group, free of the effects of companies' financing decisions, analysts calculate the unlevered, or asset beta. For more details about the beta and the CAPM model, please refer to Chapters 7-9 of Brealey, Myers, and Allen, *The Principles of Corporate Finance*, Tenth Edition.
- 22. There is a specific body of the financial-economic literature that has explored the implications of disaster risks on asset pricing. The basic intuition of disaster risk is that it does not follow a normal distribution and therefore it cannot be easily identified using standard econometric techniques. In a normal distribution framework, a relatively small amount of data can be used to make inferences about the population and to obtain accurate estimate of the risk. In contrast, risk in rare disaster models is difficult to measure; in fact, a small amount of data is not straightforwardly informative of the investors' risks. For the same reason, in the disaster risk framework, it is hard to hold the standard rational expectation assumptions of economic models. A rational expectation model in fact assumes that agents know the probabilities of the different states of the world, and the relative assets' prices in all the events. However, this may not be the case in case of rare disasters. For a review of disaster models see: Tsai J., Wachter J.A. (2015), "Disaster Risk and Its Implications for Asset Pricing," *The Annual Review of Financial Economics*, 2015. 7:219-52.
- 23. The companies that satisfy such criteria are Petra Citra Marga, which holds most of its assets in Indonesia, and OHL Mexico, which holds most of its assets in Mexico. The sample of companies with no seismic risk considered in the beta analysis includes European toll-road companies, e.g., Abertis, Atlantia, Sias and Vinci. To estimate the equity beta of each company we have used both a local market index, and a global market index for all companies, obtaining similar results.

- 24. As we explained in footnote 21, the non-diversifiable risk of the asset, not affected by the financial leverage, is captured by the asset beta. To calculate the asset beta from publicly available market data we used the standard Modigliani-Miller formula and assumed a debt beta of zero for all analyzed companies. The simplified formula for the asset beta is: β_{asset} = β_{debt} ×(^a/_b) + β_{equity}×(^b/_b); where D, E, and V are respectively the market value of debt, equity and the sum of debt and equity for each company.
- 25. Betas have been estimated on both local and global market indexes. The global index is the FTSE All Share, while the local index is the EuroStoxx 600 for European market, Mexbol for the Mexican market, and Jakarta Stock Exchange for the Indonesian market. The chart reports the results of the beta estimated on the local indexes; these results are in line with the ones obtained from estimates based on the global index.
- 26. A t-test for the significance of the difference between the means of the two groups shows that the difference is not statistically significant at the 99% level.
- 27. According to Brealey, Myers, and Allen, financial managers increase discount rates to offset risks of projects that they think cannot be diversified. However, by adding so-called "fudge factors" in the discount rates, managers "displace clear thinking about future cash flows," especially in the case of long-term investments, where the cumulative effect of higher discount rates implies more significant 'haircuts' to the present value of the asset. On the other hand, in regulated settings, where the cash flows of projects are based on strict accounting rules, investors may not be able to plug-in *ex-ante* the effects of unforeseen events into the expected cash flows. For such cases, where investors would require a different protection/guarantee to invest, we provide an alternative methodology based on discounted cash flows which allows investors to calculate reasonable rate of returns.
- 28. The European Commission (EC) has defined the services of general economic interests (SGEI) as economic activities that public authorities identify as being of particular importance to citizens and that would be not supplied (or would be supplied under different conditions) without public intervention. In general the EC tends to think of SGEI as projects with low risks, which therefore require small compensation. In our experience, private investors have different expectations, particularly in certain jurisdictions, where SGEI are subject to high regulatory and political risks.
- 29. For references on the methodological approach, see Brealey, Myers, Allen "Principle of Corporate Finance. Tenth Edition," Chapter 9, pp. 222-223.
- 30. The illustrative analysis does not take into account the costs of additional investments to rebuild the infrastructure after the earthquake, but only the effects of the interruption of operations for different periods of time.
- 31. It is important to note that we are not arguing that the overall costs of the recovery would necessarily be lower if socialized through the intervention of public authorities. Our point here is that PPP contracts should provide the right degree of protection for investors for such events, based on specific and robust analysis ideally conducted *ex-ante*, and a symmetric allocation of risks, which avoids over-compensation. In case of lack of public funds, or the impossibility of raising charges, contracts may still allow some degree of flexibility for investors in terms of duration, or recognizing a reasonable terminal value.
- 32. The terminal value is equal to the initial value of assets net of depreciation. It is positive when the technical life has not come to the end and yearly technical depreciation is utilized. It is zero if so required by recognizing yearly financial accelerated depreciation.
- 33. The incentive not to invest is amplified when the concession is closer to expiration compared to the situation when there are many years of the concession remaining.
- 34. Companies include TDC, and Telia Sonera, Telenor.

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