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Fiscal Risks from Early Termination of Public-Private Partnerships in Infrastructure

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Abstract

Public-private partnerships (PPPs) in infrastructure provision have expanded around the world since the early 1990s. Well-structured PPPs can unleash efficiency gains, but PPPs create liabilities for governments, including contingent ones. This paper assesses the fiscal risks from contingent liabilities from early termination of PPPs in a sample of developing countries. It analyzes the drivers of early termination and identifies systematic contractual, institutional, and macroeconomic factors that can help predict the probability that a PPP project will be terminated early, using a flexible parametric hazard regression. Using the probability distributions from the regression analysis, it simulates scenarios of fiscal risks for governments from early termination of PPPs in the electricity and transport sectors, adopting a value-at-risk approach. The findings indicate that the rate of early terminations decreases with direct government support, greater constraints on executive power, and the award of the PPP by subnational governments; it increases with project size and macro-financial shocks. The simulations show that fiscal risks from infrastructure PPP portfolios are not negligible in some countries, reaching as high as 2.8 percent of GDP. A severe macro-financial shock substantially increases the estimates, with the value at risk the year after the shock 11–20 times larger.

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1 Introduction

Worldwide, almost 1 billion people are without electricity, 1 billion live more than 2 kilometers from an all-season road, and hundreds of millions are unable to access work and educational opportunities because they lack transport services they can afford. With the right policies, the annual investment needed to achieve the infrastructure-related Sustainable Development Goals (SDGs) and stay on track to limit climate change to 2℃ amounts to 4.5 percent of GDP in low- and middle-income countries. With more ambitious goals and lower efficiency, the investment needs can be as high as 8.2 percent of GDP in these countries (Rozenberg and Fay 2019).

There are different approaches to providing infrastructure services. In the traditional, public provision approach, line ministries, government agencies, or state-owned enterprises (SOEs) directly procure the infrastructure and provide the service, with the risk borne wholly by the public. In the private provision approach, regulated or unregulated private companies that own the infrastructure assets provide infrastructure by bearing the full risk of service provision. Infrastructure provision through public-private partnerships (PPPs) falls between the public and private approaches. In a PPP, the private sponsor makes the infrastructure investment and provides the service under conditions specified in a contract signed with a public entity, which apportions risk between the private sponsor and the public entity.

PPPs can help emerging markets and developing economies expand their infrastructure stock, build required infrastructure more efficiently, and maintain it more effectively over the long run. Efficiency gains can be reaped through the appropriate design of PPP contracts, which bundle various aspects of the infrastructure project and allocate risks based on the partners' ability to manage them. Countries such as Brazil, China, India, South Africa, and Turkey have used PPP arrangements to boost their infrastructure investments.

Infrastructure PPPs offer no free lunch, however. They create commitments for governments, including contingent liabilities. To share risk appropriately between the public and private parties, governments tend to provide explicit guarantees to the private party, such as revenue or credit guarantees. In addition, as the implicit guarantors of the endeavor undertaken by any PPP, governments backstop the fiscal and economic consequences of any failures by the partnership.

At the center of the PPP approach rests a trade-off between the efficiency of execution and the efficiency of financing. On the one hand, internalization of lifecycle benefits and costs, and better monitoring by private financiers let PPPs execute projects more efficiently. On the other hand, governments tend to be able to finance a project at lower rates than private sector players, who usually pay a funding premium on top of the sovereign rate.[2] If the efficiencies in project execution are systematically overestimated or the contingent liabilities from risk and uncertainty are underestimated, the government may be better off executing investments through conventional contracting of the private sector or even SOEs.

The rising popularity of PPPs means that careful management of the fiscal risks that they pose has become exceedingly important. However, opacity of financial records, confidentiality of most PPP contracts, and the prevalence of cash rather than accrual accounting systems in emerging markets and developing economies hide the fiscal risks for government finances until the contingent liability materializes.

This paper tries to assess the fiscal risks to governments from early termination of infrastructure PPPs, using the value-at-risk methodology. It gauges the expected loss from a PPP project using the probability of early termination, the exposure of the government in the event of early termination, and the loss given early termination. Using data from the World Bank's Private Participation in Infrastructure (PPI) database, *World Development Indicators*, the Polity IV Project, and Laeven and Valencia (2020), the study identifies systematic contractual, institutional, and macroeconomic factors that can help predict the probability that a PPP project will be terminated early using a flexible parametric hazard regression.

The analysis finds that, in the developing world, PPPs have a lower probability of early termination when they are (a) contracted by subnational entities; (b) backed by direct support from the government (including capital grants, revenue subsidies, and in-kind transfers); and (c) originated in countries with greater constraints on executive power. Large physical investments and macro-financial shocks increase the likelihood of early terminations.

We estimate the fiscal risks from each country's active portfolio of PPP projects using a value-at-risk approach under three scenarios. Each scenario assumes different government losses given early termination. The results show that the 99 percent value at risk from early termination of PPPs can be as high as 0.89 percent of GDP in the low scenario, 2.23 percent in the medium scenario, and 2.82 percent in the high scenario, with median value at risk of 0.14 percent, 0.25 percent, and 0.32 percent of GDP, respectively, in the sample of countries studied. A severe macro-financial shock substantially increases the estimates, with the value at risk the year after the shock 10–20 times larger.

[2] In some cases, companies in developing countries are able to borrow at lower costs than the government. Companies for which this is true tend to have substantial export earnings and/or a close relationship with either a foreign firm or the home government (Durbin and Ng 2005; Grandes, Panigo, and Pasquini 2017).

The paper is organized as follows. Section 2 reviews the related literature. Section 3 discusses the use of PPPs in infrastructure in developing countries. Section 4 presents the estimations of the probability of early termination of infrastructure PPPs. Section 5 presents the estimated fiscal risks from contingent liabilities of PPPs in a sample of developing countries and discusses the empirical approach and data used for the estimations. Section 6 summarizes the paper's main conclusions and presents some policy recommendations.

2 Related Literature

PPPs are long-term contractual relationships that bundle the infrastructure procurement, operation, and maintenance stages of a public service, allocating the risks involved in each stage of project development between the public and the private parties. Some researchers, such as Engel, Fischer, and Galetovic (2013) and Guasch (2004), consider only projects that transfer legal ownerships of assets to the public at the end of the contract period as PPPs. They do not consider build-operate-own (BOO) projects as a PPPs. Others, such as Grimsey and Lewis (2017) and Yescombe and Farquharson (2018), focus on the bundling and contractual aspects during the project's lifetime. They classify BOOs that incorporate long-term contracts, such as power purchase agreements, as PPPs. We adopt the second definition, because BOOs with purchase agreements may create fiscal costs for governments through explicit or implicit commitments originating from the contract when such a contract is terminated early.

A rich body of theoretical microeconomics literature on PPPs explores their efficiency under different conditions. It follows the seminal work of Hart (2003), who introduced the incomplete contracts framework to the study of PPPs and showed that bundling is optimal when service quality is contractible, but investment quality is not. Bennet and Iossa (2006) and Martimort and Pouyet (2008) introduced externalities from the investment stage on the operation stage and showed that if incurring additional costs during the investment stage decreases operational costs or increases contractible service quality, PPPs are optimal, as the externality is internalized with bundling. Iossa and Martimort (2012) expanded the framework to incorporate demand and operational risks in the operations stage, showing that the benefits of PPPs decline as the value of additional effort during the investment stage is lower with the risks. According to them, the efficiency advantage of bundling disappears when severe risks can be verified only by the private party in a complex project and renegotiation becomes a concern.

The literature shows that governments have incentives to seek high-risk PPPs. Emphasizing the information-revelation characteristic of a project, Auriol and Picard (2013) show that governments may prefer to implement projects with high business risk as PPPs compensated by user charges to avoid the risk. Introducing a nonbenevolent government, Maskin and Tirole (2008) show that governments may choose to use PPPs to facilitate hidden intertemporal transfers to affiliated contractors through strategically incomplete contacts. Reyes-Tagle and

Garbacik (2016) verify empirically that governments facing fiscal constraints tend to increase their levels of PPP investments as a percentage of GDP without proper institutional mechanisms to deal with the liabilities they create. Using data from French municipalities, Buso, Marty, and Tran (2017) show that municipalities facing budget constraints tend to use PPPs more.

Engel, Fischer, and Galetovic (2013) argue that by itself, private financing does not reduce the fiscal burden on the government, because, through future availability payments or forgone right to charge user fees, the government ends up funding the provision of the infrastructure service over the lifetime of the project. In contrast, Auriol and Picard (2013) argue that there is a shadow cost of public funds at a given time because of the benefits of the alternative uses or distortionary taxation. Iossa and Martimort (2012, 2015) and de Bettignies and Ross (2009) emphasize the role of private finance in resolving uncertainty and achieving a better valuation and monitoring of the project. Iossa and Martimort (2012) show that private financing can allow more infrastructure investments, by yielding efficiency gains that would allow implementation of some projects that are not feasible under public provision.

In contrast to the theoretical literature on PPPs, empirical work has been sparse. One strand looks at the determinants of PPP investments. Moszoro and others (2014) and Percoco (2014) find that institutional factors, such as rule of law, better regulatory quality, and lower corruption significantly increase PPP investments in developing countries. Using data from US states, Albalate, Bel, and Geddes (2020) show that enacting various PPP–enabling laws increases private investment in transportation infrastructure.

This paper contributes to a growing strand of the literature on the determinants of PPP cancellations. Harris and Pratap (2009) find that macroeconomic shocks, investment value, and the involvement of a foreign sponsor increase project cancellations and that local government PPPs are less likely to be canceled than national ones. Marcelo and House (2016) find that multilateral support in implementing PPPs decreases the likelihood of PPP cancellations. Marcelo and others (2019) find that experience does so. Lee and others (2020) find that various project-specific, macroeconomic, and institutional factors significantly affect cancellation rates of PPPs in developing countries in Asia. In addition to introducing methodological improvements to better match the hazard profile and providing wider coverage of the developing world, this paper uses the percentage of the contract period elapsed as the time scale rather than the calendar year, in order to make the project lifetimes of disparate projects comparable. It also eliminates management, lease, and partial divestiture projects from the dataset, in order to focus on PPPs.

Researchers have identified various sources of risks for PPPs (Irwin 2007, Guasch 2004, and Grimsey and Lewis 2017 provide good overviews). Early termination of a PPP occurs as the last resort in a chain of events triggered by one or more of these risks for the project. Building on Polackova (1998), Budina, Polackova Brixi, and Irwin (2007) provide a framework to conceptualize and categorize the fiscal risks from PPPs in terms of direct versus contingent and explicit versus implicit liabilities. Informed by the framework of Budina, Polackova Brixi, and Irwin, this paper conceptualizes early termination risk as a contingent liability but does not distinguish between the explicit and implicit dimensions, in order to provide a common method of valuation of the risk regardless of differences in PPP–contracting practices across countries.

A standard method of evaluating fiscal costs and risks from infrastructure PPPs has been the PPP Fiscal Risk Assessment Model developed by the International Monetary Fund (IMF) and the World Bank (2019). This model qualitatively evaluates various sources of fiscal risks and presents a level of priority for actions against risks. Irwin (2007) describes quantitative methods for valuing exposure to different types of risks from PPPs. Although he does not provide a specific method for valuing fiscal risks from early termination, the methods he proposes align with the value-at-risk methodology applied in this study, which identifies a probability distribution for the occurrence of an event and determines the probabilistic loss from the event. This paper proposes a way to estimate the probability distributions for early termination and apply them using a value-at-risk methodology.

3 Public-Private Partnerships in Infrastructure in Developing Countries

The active portfolio of PPPs in infrastructure in developing countries grew rapidly in the 1990s. After plateauing around 2000, the portfolio grew exponentially in 2002. Growth has slowed since 2012. The size of the portfolio in dollars has grown consistently since 1990 (figure 1, panel a). The size of the portfolio as a percentage of developing world's GDP grew at a rapid pace only during the 1990s (figure 1, panel b).[3] Between 1999 and 2008, investment growth slowed, falling behind GDP growth. After 2008, the size of the PPP portfolio as a percentage of GDP started growing again. At the end of 2020, cumulative investment in the active portfolio of PPP projects was about $1.66 trillion,[4] according to the World Bank Private Participation in Infrastructure Project Database (PPI),[5] which corresponds to about 5.25 percent of the developing world's GDP.

[3] The GDP of the developing world was calculated as the total GDP of low- and medium-income countries as classified by the World Bank, plus Romania, for which data are available until the end of first half of 2020 but which was reclassified as a high-income country in 2020.

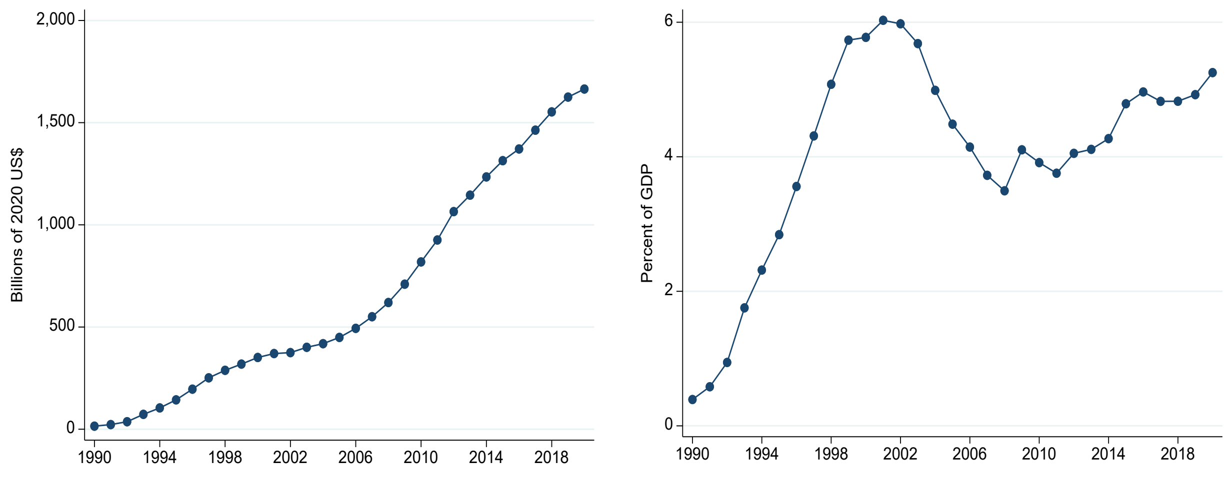
[4] All dollar figures in the study are expressed in 2020 US dollars, inflated using the US Consumer Price Index (CPI) series.

[5] See https://ppi.worldbank.org/en/ppidata.

Figure 1 Cumulative global investment in the active portfolio of public-private partnerships in the developing world, 1990–2020

a. In billions of dollars

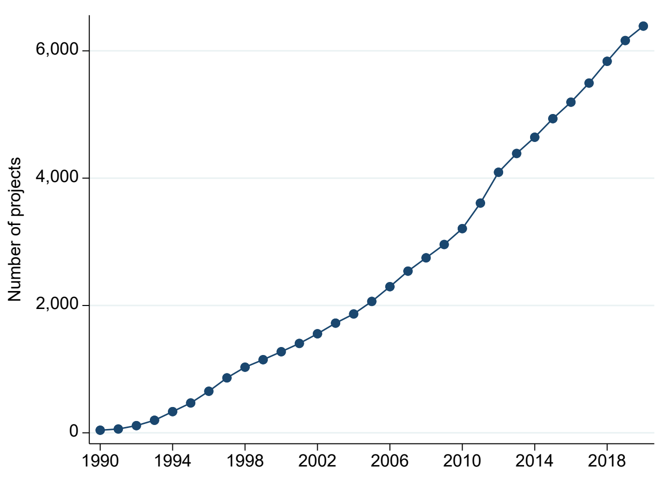
b. As percentage of GDP



Source: PPI database and World Development Indicators.

The number of active projects in developing countries has increased at a roughly constant rate since the mid-1990s, experiencing a slight jump from 2010 to 2012. As of 2020, there were 6,389 active projects in the developing world (figure 2).

Figure 2 Number of active public-private partnership projects in the developing world, 1990–2020



Source: PPI database.

In the developing world, East Asia and Pacific and Latin America and the Caribbean (LAC), implemented the most projects, followed by South Asia. LAC has implemented the largest energy projects, which increased the size of its total investments. As a share of GDP, the PPP investments in Sub-Saharan Africa have been small, but the rate of early termination has been the highest of any region, with almost 5.8 percent of projects failing. The region with the next highest risk of early termination is LAC, with a 4.4 percent early termination rate (table 1).

Table 1 Sectoral distribution of public-private partnership projects with financial closure in developing countries, by region

Region	*Item*	*ICT*	*Energy*	*Transport*	*Water and sewerage*	*Total*
East Asia and Pacific	Number of projects	22 (8)	1,133 (19)	517 (22)	659 (27)	2,331 (76)
	Investment	13,686	267,089	202,962	50,659	534,395
Europe and Central Asia	Number of projects	28 (2)	358 (6)	93 (2)	46 (2)	535 (12)
	Investment	2,033	71,851	62,683	6,416	142,983
Latin America and Caribbean	Number of projects	27 (2)	1,114 (20)	583 (45)	309 (22)	2,033 (89)
	Investment	5,092	318,260	249,872	43,806	617,032
Middle East and North Africa	Number of projects	16 (1)	110 (0)	40 (3)	28 (1)	194 (5)
	Investment	281	45,606	10,213	5,262	61,362
South Asia	Number of projects	16 (3)	669 (3)	580 (30)	23 (0)	1,288 (36)
	Investment	1,816	211,739	130,414	1,764	345,732
Sub-Saharan Africa	Number of projects	24 (3)	264 (11)	113 (7)	33 (4)	434 (25)
	Investment	742	51,619	24,050	1,151	77,562
Total	Number of projects	133 (19)	3,658 (59)	1,926 (109)	1,098 (56)	6,815 (243)
	Investment	23,649	966,164	680,195	109,058	1,779,067

Source: PPI database.
Note: The number of canceled projects is in parentheses. Investment totals are in millions of 2020 US dollars. ICT = Information and communications technology

More than half of all PPP projects in the developing world are in the energy sector (3,658 out of 6,815). Other important sectors are transport (1,926 projects) and water and sewerage (1,098 projects). The remaining 133 projects are in the information and communications technology (ICT) sector.

Almost 3.6 percent of the infrastructure PPPs initiated in the developing world were canceled. The transport sector saw the largest number of cancelations (109), and the ICT sector saw the largest share of cancelations (14 percent of projects terminated early). The early termination rate in the energy sector is the lowest (1.6 percent). Early termination rates were higher in the transport (5.7 percent) and water and sewerage (5.1 percent) sectors.

4 Probability of Early Termination

4.1 Econometric Model

The probability of early termination of a PPP at a specific point during its contract period is predicted by estimating a flexible parametric proportional hazards model (Royston and Parmar 2002; Royston and Lambert 2011).[6] The model is an extension of the parametric proportional hazards model with a Weibull baseline hazard function. The generalization allows for a nonmonotonic baseline hazard function using restricted cubic splines. Accordingly, coefficients of the following equation are estimated to maximize the likelihood of the observed distribution of failure times:

$$\ln H(t|\boldsymbol{X_{it}}) = \gamma_0 + \sum_{m=1}^{2} \gamma_m z_m(\ln t) + \boldsymbol{X_{i,proj}\beta_{proj}} + \boldsymbol{X_{it,inst}\beta_{inst}} + \boldsymbol{X_{it,macro}\beta_{macro}}, \qquad (1)$$

where $\ln H(t|\boldsymbol{X_{it}})$ is the log cumulative hazard at time t for project *i* conditional on $\boldsymbol{X_{it}} = (\boldsymbol{X_{i,proj}}, \boldsymbol{X_{it,inst}}, \boldsymbol{X_{it,macro}})$; $\boldsymbol{X_{i,proj}}$ is the vector of project-specific time-invariant covariates; $\boldsymbol{X_{it,inst}}$ is the vector of country-specific time-varying institutional covariates; and $\boldsymbol{X_{it,macro}}$ is the vector of country-specific time-varying macroeconomic shocks. The terms under the summation operator represent the set of restricted cubic spline terms in log time scale, $z_m(\ln t)$. The time scale is the percentage of the contract period elapsed.

The probability of early termination, PET_i, between time t_0 and t, given that the project survives until t_0 can be recovered using the log cumulative hazard from equation (1) and the relationship between the survival function, $S(t)$, and the cumulative hazard function (see appendix A for detailed discussion). The estimated probability of early termination can be written as follows:

$$\widehat{PET_i} = 1 - \hat{S}_i(t|t_0). \qquad (2)$$

4.2 Data

The data come from four sources: the World Bank's Private Participation in Infrastructure Project Database (PPI),[7] the Polity IV Project,[8] *World Development Indicators* (WDI),[9] and Laeven and Valencia (2020). The PPI database includes data on project characteristics agreed to at the time of the signing of the PPP contract or at the time of financial closure. These characteristics include the type of project, the sector, the contract period, the government level granting the contract, the sponsors, types of government support, the amount of investment commitments, and

[6] The model was estimated in Stata using the stpm2 routine, written by Lambert and Royston (2009).
[7] See https://ppi.worldbank.org/en/ppidata.
[8] See http://www.systemicpeace.org/inscrdata.html.
[9] See http://datatopics.worldbank.org/world-development-indicators/.

financing information. The PPI also provides the current status of the project (active, concluded, distressed, or canceled).

Many projects in the PPI database lack data for all characteristics. Missing data on the variables essential for the analysis—the contract period and the level of government that granted the contract—were added for all projects using the individual project descriptions provided in the database if available.

The Polity IV data were used to identify the institutional characteristics of a country. We used yearly executive recruitment, constraints on the executive, and political competition concept variables. We linearly interpolated the values for the interruption, interregnum, and transition periods, during which the variables are coded out of their respective ranges in Polity IV.

From the WDI, we took the annual series on the per capita growth rate and nominal exchange rates, which we used to create series of detrended and demeaned series of per capita growth rate and exchange rate shocks, using the filter suggested by Hamilton (2018). The data on financial crises come from the Systemic Banking Crises dataset of Laeven and Valencia (2020).

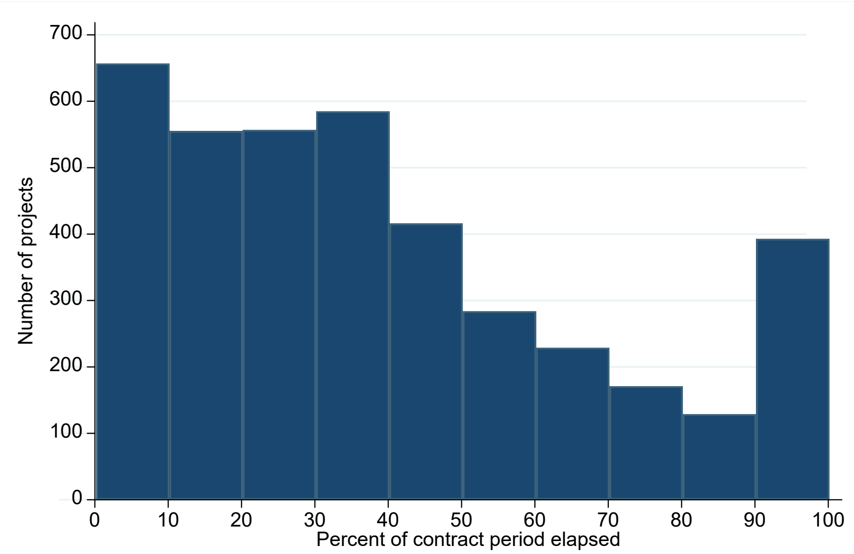
The PPI database records 8,420 projects in the developing world, encompassing 130 countries, with financial closure dates from 1990 to 2020. The sample includes projects from five sectors: ICT, energy, transport, water and sewerage, and municipal solid waste. As the municipal solid waste data are a recent addition to the database and cover only currently active projects with financial closures starting in 2009, they were dropped from the sample to make all projects comparable. ICT projects, merchant and rental greenfield projects, management and lease projects, and divestitures were also excluded from the sample, because they are not PPPs as defined in this study.

We define cancellation as early termination of a project. The PPI database labels as cancelled any project from which the private party has exited by selling or turning over its shares back to government or by ceasing operations. It labels as distressed any project that is in international arbitration or for which either the government or the private party has requested contract termination. Using news articles and other public online sources, we determined the current status of the distressed projects and relabeled projects as canceled, concluded, or active. When no definitive information about the resolution of the distress could be found, we dropped the project from the sample.

The contract periods of some projects in the PPI database that were completed are labeled as still active. Successfully concluded projects may have gone unnoticed because they were not covered in the news or because project companies may have obtained contract extensions after the fulfillment of their initial contract terms. Projects with completed contract periods that were still labeled as active were kept in the analysis and relabeled as concluded.

Figure 3 shows the distribution of the percentage of the contract period elapsed within the estimation sample. It includes 3,976 projects, of which 167 were canceled. The vast majority of projects had not passed half of their contract periods. One reason for this finding is that PPPs are a relatively new phenomenon compared with the median contract period of a PPP in the sample, which is 25 years. Another is that crucial information on some of the older projects in the PPI database is missing, such as the contract period and the level of contracting government, forcing us to drop them from the sample used for the econometric estimation.

Figure 3 Distribution of percentage of contract period elapsed



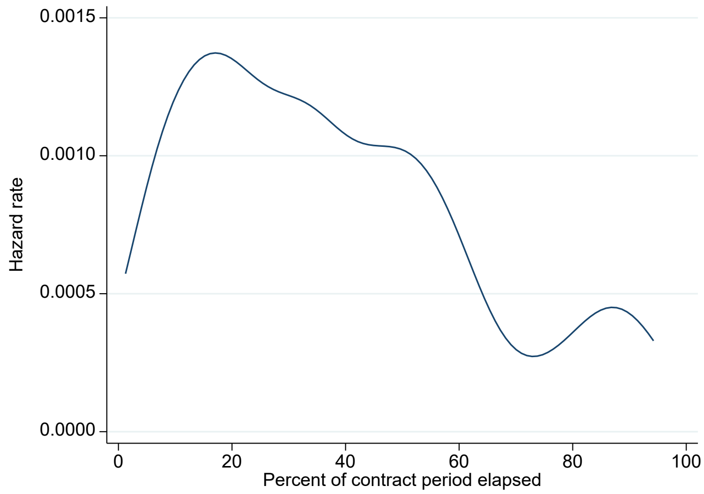
Source: PPI database.

4.3 Estimation Results

Nonparametric estimates using all PPP projects in low- and middle-income countries show that PPP projects are more likely to fail during early in their contract periods and that the risks accumulated during their contract periods are not trivial. The smoothed hazard rate estimate using Gaussian kernel and optimal bandwidth indicates a unimodal hazard profile for a PPP project (figure 4). The risk of early termination for a project increases rapidly until about 20 percent of the project's contract period elapses. It plateaus at this level before declining slightly until it reaches 50 percent. During the second half of the contract period, the risk of early termination decreases until the project approaches the end of the contract period, except for a small increase at about the 80 percent mark.

The cumulative hazard curve shows that the accumulated probability of early termination increases steadily but that its pace decreases after reaching about 50 percent of the contract period (figure 5, panel a.). The Kaplan-Meier survival curve estimate mirrors the profile and implies that the probability of an average project surviving until the end of its contract period is 0.92 (figure 5, panel b.).[10]

Figure 4 Probability of public-private partnership project terminating early by share of contract period remaining

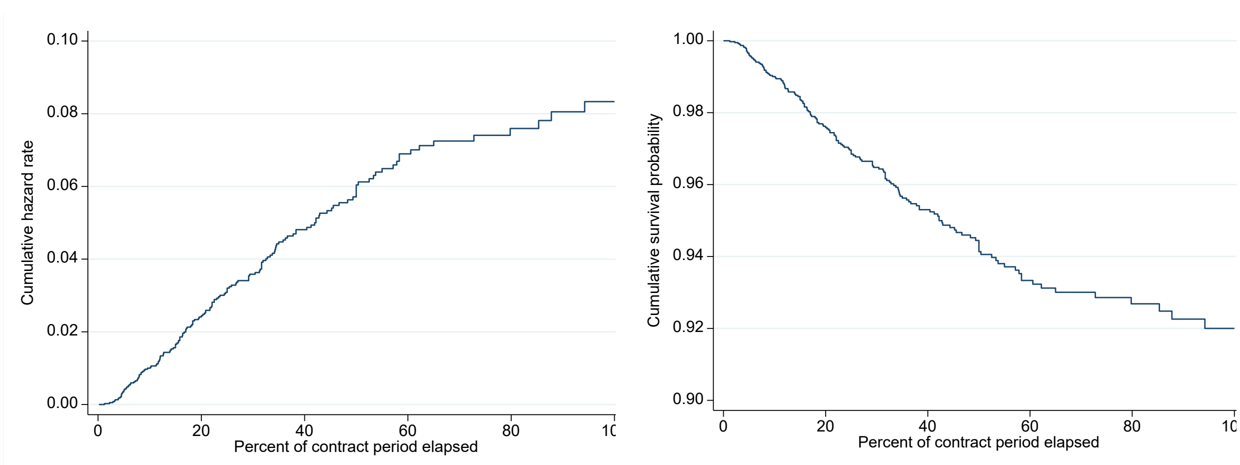


Source: Authors' calculations using PPI database.
Note: Figure shows smoothed hazard rate estimate using Gaussian kernel and optimal bandwidth.

Figure 5 Survival and cumulative hazard estimates of public-private partnership projects

a. Nelson-Aalen cumulative hazard curve

b. Kaplan-Meier survival curve



Source: Authors' calculations using PPI database.

[10] Equations A.3 and A.4 in appendix A present the relationships among hazard, cumulative hazard, and cumulative survival probability presented in figures 5, 6, and 7.

Table 2 presents the results from estimating the flexible parametric proportional hazards model in equation 2. Column 1 presents the results when controlling only for the type of private participation and sector of the project. Column 2 presents the results when also controlling for the type of government support the project receives and the contracting authority. Column 3 adds the investment commitment of the project as a control variable. Column 4 presents the results when institutional variables are included as controls. Column 5 introduces the macroeconomic shocks to the model; it is the preferred regression for inference. Positive coefficients indicate factors that increase the cumulative hazard and, ultimately, the probability of early termination; negative coefficients indicate factors that decrease the cumulative hazard and, ultimately, the probability of early termination.

Table 2 Hazard regression results for early termination of public-private partnerships

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Base type: Greenfield					
Brownfield	0.135	0.0981	0.117	0.186	0.239
	(0.539)	(0.499)	(0.498)	(0.438)	(0.402)
Base sector: Electricity					
Natural gas	0.381	0.773**	0.781**	0.812**	0.769*
	(0.279)	(0.362)	(0.375)	(0.393)	(0.406)
Airports	1.703***	1.744***	1.681***	1.652***	1.554***
	(0.638)	(0.577)	(0.590)	(0.576)	(0.561)
Railroads	2.028***	2.046***	1.861***	1.706***	1.679***
	(0.465)	(0.396)	(0.353)	(0.381)	(0.359)
Toll roads	1.268**	1.673***	1.631***	1.693***	1.506***
	(0.585)	(0.545)	(0.520)	(0.463)	(0.382)
Seaports	0.328	0.350	0.396	0.315	0.120
	(0.649)	(0.611)	(0.602)	(0.613)	(0.663)
Treatment plant	1.026***	1.784***	1.854***	1.846***	1.717***
	(0.314)	(0.486)	(0.483)	(0.454)	(0.411)
Water utility	1.192*	2.017***	1.991***	1.817***	1.718***
	(0.707)	(0.695)	(0.645)	(0.572)	(0.549)
Direct government support		–0.934***	–0.882***	–0.704***	-0.643***
		(0.226)	(0.221)	(0.234)	(0.194)
Indirect government support		–0.0970	–0.114	–0.0926	0.0356
		(0.808)	(0.804)	(0.778)	(0.751)
Multilateral support		–0.288	–0.359	–0.444	-0.499
		(0.306)	(0.332)	(0.355)	(0.311)
Subnational government contract		–1.018***	–0.940**	–0.841**	-0.783*
		(0.370)	(0.370)	(0.413)	(0.406)

Physical investment (billions of dollars)			0.538*	0.478*	0.542**
			(0.311)	(0.269)	(0.245)
Physical investment squared (billions of dollars)			–0.0744	–0.0633	-0.0784*
			(0.0510)	(0.0439)	(0.0464)
Executive recruitment concept				0.151	0.103
				(0.121)	(0.152)
Executive constraints concept				–0.478***	-0.442***
				(0.153)	(0.125)
Political competition concept				0.114	0.141
				(0.121)	(0.111)
Annual GDP per capita growth rate (detrended, previous year)					0.0937
					(0.0658)
Annual depreciation (detrended, previous year)					0.0142***
					(0.00455)
Banking crisis occurred (previous year)					1.267**
					(0.541)
Debt crisis occurred (previous year)					1.060**
					(0.540)
Exchange rate crisis occurred (previous year)					-0.666
					(0.552)
γ_1	2.096***	2.093***	2.094***	2.101***	2.082***
	(0.284)	(0.283)	(0.286)	(0.282)	(0.240)
γ_2	0.120***	0.120***	0.120***	0.120***	0.114***
	(0.0242)	(0.0245)	(0.0246)	(0.0241)	(0.0223)
Constant	–9.928***	–9.661***	–9.851***	–9.195***	–9.344***
	(0.674)	(0.697)	(0.738)	(0.881)	(0.818)
Number of projects	3,976	3,976	3,976	3,976	3,976
Number of cancelled projects	167	167	167	167	167
Number of countries	86	86	86	86	86
Akaike information criterion (AIC)	1,563.7	1,535.1	1,531.0	1,520.6	1,484.9
Bayesian information criterion (BIC)	1,598.0	1,581.9	1,584.0	1,582.9	1,562.9
Project-years	39,365	39,365	39,365	39,365	39,365

Note: Robust standard errors clustered by country are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The estimation results suggest that the probability of early termination of brownfield projects is not statistically different from that of greenfield projects. Private sponsors tend to express a preference for brownfield projects over greenfield projects because the returns of greenfield projects are uncertain. The results show that ex ante uncertainty about the return of projects is not associated with higher risk of distress.

Natural gas, railroad, toll road, treatment plant, and water utility projects have higher hazard rates than electricity projects. PPPs in water utility and treatment plant projects had high rates of early termination because of difficulties in adapting the contract to changing conditions, contract designs that were not viable, and a bidding process that led to unrealistic financial conditions. For example, the concession in Cochabamba, Bolivia, required substantial tariff hikes to make viable the large investment required from the private operator, something that proved socially unsustainable and brought about the rapid demise of the contract (Marin 2009).

Government support that decreases financing risk is most effective in preventing distress. Direct government support, which includes capital and revenue subsidies and in-kind transfers, is associated with lower probability of early termination. Indirect government support, which includes various guarantees to the sponsors, and support from multilateral organizations bear negative coefficients, but they are not statistically significant at standard levels.

PPPs with subnational governments are less likely to face early termination than PPPs with central governments. This finding could be related to better project selection at the local level, as local authorities may understand local problems better or oversee projects better because of their proximity. It could also be the case that national governments tend to engage in risky projects because they can bear the termination risk from an individual PPP project, thanks to a more diversified PPP portfolio and fiscal resources. In India, for example, all of the highway projects that were canceled between 2012 and 2015 were PPPs with the central government. State governments continued to enter into successful PPPs for road construction and operation.[11]

Larger projects are associated with a higher probability of early termination, except for the largest projects. The level of committed investment in physical assets is associated with a higher probability of early termination, as long as the investment is less than $3.4 billion. For investments in physical assets above $3.4 billion, the higher the investment the lower the probability of early termination. The $3.4 billion threshold is about the 99th percentile of the project size distribution in the sample.

Greater constraints on the executive are associated with lower probability of early termination. When the government can exercise authority without adequate checks and balances, it leaves PPPs vulnerable to expropriation by the government through a change in policy or political takeover, leaving the project susceptible to policy and political risks (Irwin 2007; Grimsey and

[11] See Herrera Dappe, Melecky, and Turkgulu (2022) for an analysis of the contractual factors in early termination of highway PPPs in India.

Lewis 2017). When the constraints on the executive are not stringent enough, the contract loses its value in mediating the relationship between the government and the private party, leaving the project more susceptible to distress.

Deviation of the annual depreciation rate from its long-run average—a surprise local currency depreciation—is associated with higher risk of distress. Irwin (2007) notes that exchange rate risk affects infrastructure investment in two ways. First, many infrastructure PPPs, such as those in power generation, use inputs priced in foreign currency. Second, given the insufficient local savings and underdeveloped local currency markets in most low- and middle-income economies, financing of long-term infrastructure projects usually relies on debt denominated in foreign currency and revenues in local currency. The currency mismatch between revenues and costs can push the project company to insolvency very quickly if the local currency sharply depreciates.

The occurrence of systematic banking and debt crises is associated with higher hazard rates for PPP projects. A systematic banking crisis undermines the ability of financial institutions to provide the financing needed to sustain long-term infrastructure projects. A debt crisis can limit the government's ability to fund PPP projects according to the terms of the contracts. It may hinder the ability of a local private party to secure debt financing through the market and increase the cost of its outstanding debt, leading to early termination of PPP projects. Because of the long-term nature of PPPs and the high transactions costs of preparing, procuring, and awarding PPPs, both parties try to negotiate changes to the contract or some kind of compensation in response to macro-financial shocks. Early termination happens only if the parties cannot reach an agreement, hence the lag in the impact of macro-financial shocks.

5 Fiscal Risks from Contingent Liabilities Associated with Early Termination of Public-Private Partnerships

This section values the fiscal risks from contingent liabilities that are realized when an infrastructure PPP project is terminated early in a sample of developing countries. The fiscal costs are the costs a government incurs in the event of early termination of the project, which can occur because of a government default or the voluntary termination of a project, a private partner's default or breach of contract, or force majeure.

To value the fiscal risks, we adopt a value-at-risk methodology. The fiscal risk faced by country c from a portfolio of projects I_c is valued as the maximum expected loss with 99 percent confidence:[12]

[12] In the calculation of $EL_{c,99\%}$, correlations across projects in the same country are taken into account via both the distress probabilities and the standard errors calculated via the delta method using the coefficient variance-covariance matrix, which was estimated assuming that the observations are clustered at the country level.

$$EL_{c,99\%} = \sum\nolimits_{i \in I_c} EL_i + z_{1\%} \times s.e.\left(\sum\nolimits_{i \in I_c} EL_i\right), \tag{3}$$

where EL_i is the expected loss from the early termination of project i:

$$EL_i = PET_i \times EAT_i \times LGT_i, \tag{4}$$

where PET_i is the probability of early termination for project *i*, EAT_i is the exposure of the government from project i at termination, and LGT_i is the loss of the government from project i given termination.

PET_i, EAT_i, and LGT_i are obtained separately. The probability of early termination of a PPP is predicted using the econometric estimations presented in section 3. EAT_i is estimated based on the debt and equity invested in the project. LGT_i is determined based on different practices by countries in case of termination of PPP contracts and the recovery rates of defaulted loans to infrastructure projects.

5.1 Sample Description

This paper is part of a research project that analyzes the fiscal risks from SOEs and PPPs in the electricity and transport sectors. The project focuses on a sample of 19 countries, selected based on the availability of detailed financial information of SOEs. Two of the 19 countries are not included in the PPI database. Therefore, the sample of countries used here are the remaining 17 countries: Albania, Argentina, Bhutan, Brazil, Bulgaria, Burundi, Ethiopia, Georgia, Ghana, Indonesia, Kenya, Kosovo, Peru, Romania, the Solomon Islands, South Africa, and Ukraine. As the broader research agenda focuses on the electricity and transport sectors, the rest of this paper also confines itself to these two sectors.

Table 3 summarizes the active portfolio of the sample countries in terms of portfolio size, number of implemented projects, the distribution of projects by sectors, and type of implementation; it excludes projects that elapsed their imputed or observed contract period. As the PPI database lacks some data values, additional data collection and estimations had to be carried out. Data on the contract period and investment commitments were collected or estimated. Appendix D explains how missing values were imputed. Management and operation of projects without investment commitments, projects determined to have been canceled on further investigation, and projects in disputed territories were dropped from the sample.

Table 3 Number of active public-private partnerships, by sector and total size of investment, in sample countries

Country	Investment (millions of US$)	Total	Number of projects: Electricity	Airports	Railroads	Roads	Seaports
Albania	2,747	14	11	1	0	1	1
Argentina	30,853	96	76	5	6	4	5
Bhutan	243	1	1	0	0	0	0
Brazil	326,753	685	557	11	18	54	45
Bulgaria	2,833	34	29	1	0	0	4
Burundi	16	1	1	0	0	0	0
Ethiopia	131	1	1	0	0	0	0
Georgia	1,060	6	4	0	0	0	2
Ghana	6,716	9	7	0	0	0	2
Indonesia	61,686	74	56	0	1	16	1
Kenya	3,791	19	15	0	0	4	0
Kosovo	548	4	3	1	0	0	0
Peru	31,182	108	69	4	6	19	10
Romania	6,236	28	27	0	0	0	1
Solomon Islands	236	1	1	0	0	0	0
South Africa	28,075	90	85	0	1	3	1
Ukraine	4,177	41	38	0	0	0	3
Total	507,284	1,212	981	23	32	101	75

Source: PPI database and authors' data collection and calculations.
Note: Dollar amounts are in 2020 dollars.

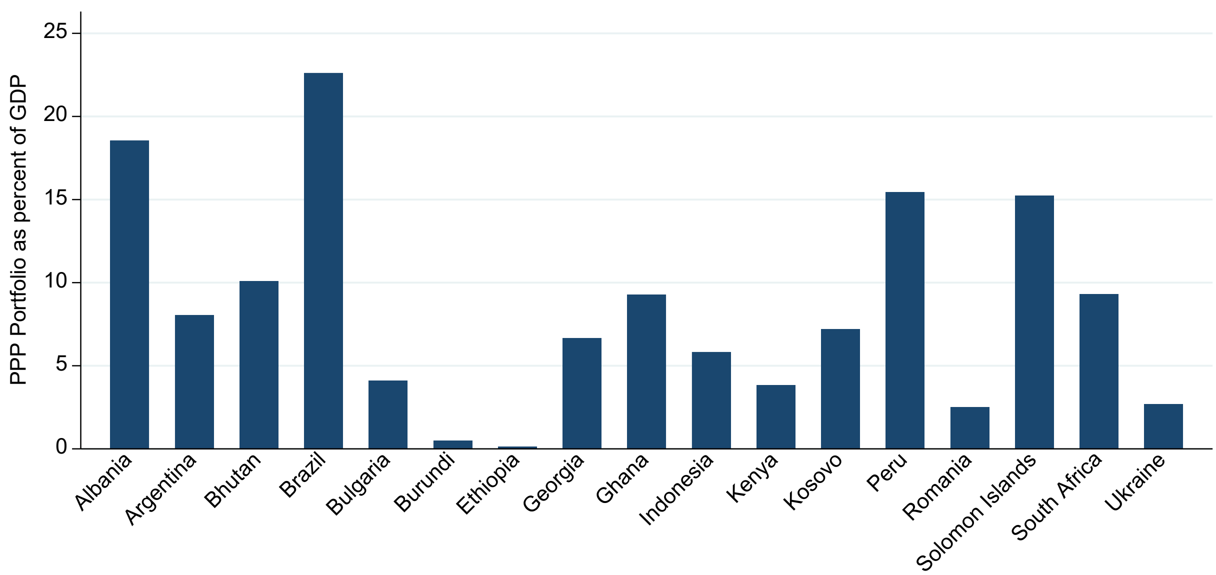
Brazil has the largest active portfolio in terms of both the number of projects and total investments, with 685 PPP projects and $327 billion of investment commitments. It is followed by Indonesia, Peru, Argentina, and South Africa in terms of investment commitments. The next tier of countries consists of Albania, Bulgaria, Georgia, Ghana, Kenya, Romania, and Ukraine with active portfolios of $1–$7 billion and fewer than 41 active projects. Bhutan, Burundi, Ethiopia, Kosovo, and Solomon Islands have only one to four active PPP projects.

Most active projects in the sample countries are in the electricity sector (981 out of 1,212 active PPPs). Every country in the sample has at least one active electricity PPP. Most of the active transport PPPs in our sample are in Latin America. Indonesia is the only country in our sample outside Latin America that has more than five active PPPs in transport.

In Argentina and Brazil, a substantial number of active PPPs have been implemented through equity sales (32 and 24 projects, respectively). All of them are in the electricity sector, with most of them in the distribution subsector. As the investment commitments of these projects are based on quality improvements rather than specific sets of investments, their contribution to the total portfolio is measured by the investments made between the year of their implementation and the end of 2020.[13]

A somewhat different picture emerges once the portfolio size is expressed as a percentage of GDP (figure 6). Brazil, with its large PPP portfolio, and Albania rank at the top, with active PPP portfolios representing 22.6 percent and 18.6 percent of their GDPs, respectively. The Solomon Islands' single active PPP represents about 15.2 percent of its GDP. Peru, Ghana, Bhutan, South Africa, Argentina, Kosovo, Georgia, and Indonesia follow, with active portfolio sizes reaching at least 5 percent of their GDPs. The PPP portfolios of Ethiopia and Burundi are below 1 percent of their GDPs.

Figure 6 Size of public-private partnership portfolios as percentage of GDP



Source: Authors' calculations based on data from PPI and WDI databases.

5.2 Predicted Probabilities of Early Termination in Sample of Developing Countries

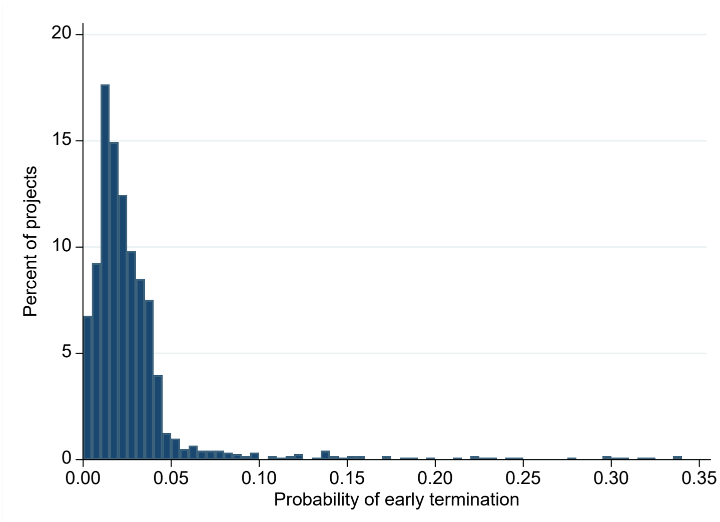
We predict the probabilities of early termination using equation (2), assuming all active projects survived until the end of 2020. We tried to fill in missing values for project-specific variables essential for prediction; when such efforts proved fruitless, we imputed these values using the

[13] To remain true to the spirit of the PPI database, we collected each year's investment amount using the financial statements of the special purpose vehicles whenever possible. The financing composition was determined using the last five years of statements, considering that each new debt contributes to financing of seven years of investment. The investment commitments of these projects do not reflect potential future investments.

characteristics of similar projects. Appendix D presents the details of the imputation process for all variables.

Figure 7 shows the distribution of predicted probabilities of early termination of active projects over the remainder of their contract periods after 2020. The predictions assume that no banking or debt crisis occurs and that the local currency does not depreciate by more than its historical trend against the US dollar. Institutional variables are assumed to remain at their 2018 levels. The median predicted probability of early termination is 0.020 and the mean is 0.029**.** For 25 projects out of 1,212, the probability is predicted to be greater than 0.15.

Figure 7 Distribution of predicted probabilities of early termination during remainder of contract period



Source: Authors' calculations.

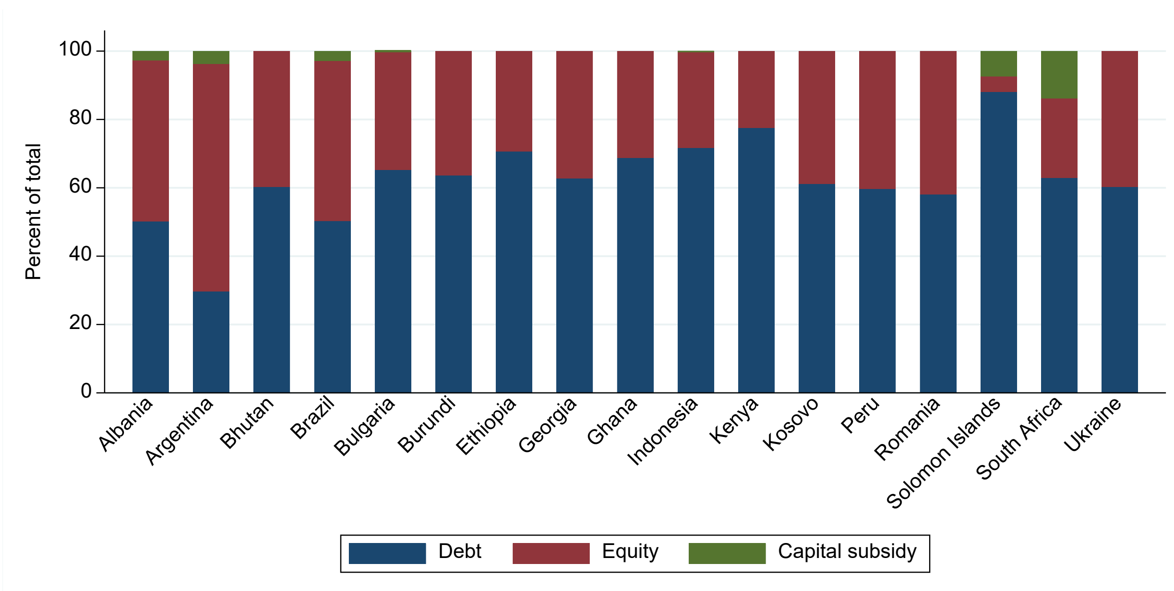
5.3 Exposure at Early Termination

Governments are generally exposed to obligations from the debt and equity financing of an infrastructure project when the PPP is terminated; as the ultimate guarantor of the public infrastructure service, the government steps in to resolve the matter. As indicated in the World Bank's Guidance on PPP Contractual Provisions, the market practice in the event of a PPP contract termination is that both the lenders and the equity owners be compensated if distress occurred without any fault of either party (World Bank 2019). Without such explicit or implicit guarantees, private finance cannot be effectively mobilized, especially in emerging market and developing economies.

In valuing the fiscal risks from early termination of PPPs, the exposure at distress of each project is calculated using the debt and equity data in the PPI database. The PPI database provides the shares of the physical investment that have been financed through debt, equity, and capital grant from the government.

The total debt used to finance the 1,202 active greenfield and brownfield PPP projects in electricity and transport in our sample is estimated at $274 billion, and the total equity financing is estimated at $226 billion. The average leverage ratio at the time of financial closure is 2.25. Debt financing makes up 60–80 percent of total physical investments in most countries in the sample (figure 8). The two notable exceptions are Argentina and Brazil, which have debt financing ratios of about 30 and 50 percent, respectively. These ratios are lower because a significant portion of PPPs in these countries was implemented through the sale of shares of state-owned utilities, which translated into financing strategies that are different from those used to achieve financial closure in a project finance scheme.

Figure 8 Composition of public-private partnership financing for active projects in the sample, by country



Source: Authors, based on data from PPI database and own data collection.

5.4 Value at Risk

The losses from debt and equity obligations in the case of early termination depend on the causes of termination. There are three major reasons for early termination of PPPs: the government's default or voluntary termination of the project, the private partner's default or breach of contract, and force majeure.

In the first case, the private party expects to be compensated for the full amount invested in the project (debt and equity) plus the equity return it had forecasted (World Bank 2019). In the second case, the practice is to provide some amount of compensation. The justification for compensation is that if there is none, the government might be seen as enjoying windfall gains unfairly and would have a hard time attracting lenders and investors for PPP projects in general (EPEC 2013; World Bank 2019). Even in the case of its own default, the private partner may legally allege government responsibility, so the government becomes liable to compensate the private party or incur additional legal costs (World Bank 2019). In the case of force majeure, because the distress event is outside both parties' control, both parties should share the risk. The government is liable for less than full compensation and has the right to take over the relevant asset, while the private partner loses any return on its invested equity and possibly some of the invested equity itself (EPEC 2013; World Bank 2019).

Limited data are available on losses incurred by governments in cases of early termination of PPPs. The data on the recovery rates of bank loans to PPP projects collected by the Data Alliance Project Finance Consortium, mainly in developed economies, show that the average ultimate recovery rate is 79.3 percent (Moody's Investor Service 2019).[14]

Data on compensation of private equity is even scarcer than data on recovery rates of bank loans. The sample of contracting terms from the countries of interest that could be accessed provide generous early termination clauses.[15] For example, in an airport project in Albania, if the project company defaults, the government will take on the liabilities of the company. In road PPPs in Kenya, if the project company defaults, the government is liable only for the debt due. In road PPPs in Argentina, even if the company defaults, the government has to compensate the private party for the total accumulated unamortized project cost net of penalties charged to the private sponsor for failing to fulfill the contract.

In the case of early termination of the contract by the government, all the countries for which some information could be gathered stipulate full compensation for the total accumulated investment and some measure of return on the invested equity. In Bulgaria, this type of compensation is written into the PPP law. In Albania and Kosovo, the private party is entitled to its debt, share of capital, and additional accumulated equity. In Kenya, the private party is due the net present value of the equity it invested in the project. In road PPPs in Argentina, on top of the unamortized investments, the private sponsor receives a termination payment determined as the expected loss of the company as a result of loss of the concession contract.

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[14] A study by Moody's of project defaults between 1983 and 2017 shows that 209 of the 1,970 PPP projects included in the dataset were in emerging markets and developing economies (Moody's Investor Service 2019).
[15] Contracts and other contracting terms have been examined in Albania, Argentina, Bulgaria, Kenya, and Kosovo.

Contracts vary significantly in the case of force majeure. In the Kosovo airport PPP, the contract asks the parties to agree on the terms of termination. The contracts of road PPPs in Argentina mandate that the government compensate the private party for the whole accumulated investment amount without penalties.

In India (not one of our sample countries), PPP contracts include a compensation scheme that aligns with the PPI database's conceptualization of PPP financing. Road concession agreements, for example, express compensation as a percentage of debt and equity financing of the project, depending on the source of termination of the contract. In the case of default by the project company, the concession agreements do not foresee any compensation on equity; in the case of default by the public authority, the contract entitles the private sponsor to 150 percent of its equity, which can be seen as an approximation of the return on equity invested, as stipulated in the contracts mentioned before. In the case of a force majeure event indirectly caused by a political event, the private sponsor of an Indian road PPP is entitled to 110 percent of the equity it invested in the project.

When a project is terminated, it is assumed that the government loses all its equity. As a result, equation (4) can be rewritten as follows:

$$\widehat{EL}_i = \widehat{PET}_i\left(Debt_i LGT_{Debt} + Public\ Equity_i + Private\ Equity_i LGT_{Equity}\right), \qquad (5)$$

where $\widehat{PET}_i$ is the predicted probability of early termination of project i, $Debt_i$ is the debt of project i, LGT_{Debt} is the proportion of debt lost because of early termination, $Public\ Equity_i$ is the government equity in project i, $Private\ Equity_i$ is the private equity in project i, and LGT_{Equity} is the proportion of private equity lost because of early termination.

Three scenarios are considered:

- Low: $LGT_{Debt} = 0.793$; $LGT_{Equity} = 0$
- Medium: $LGT_{Debt} = 1$; $LGT_{Equity} = 1$
- High: $LGT_{Debt} = 1$; $LGT_{Equity} = 1.5$.

In the low scenario, the proportion of debt covered by the government because of early termination is assumed to be the recovery rate estimated by Moody's Investor Service (2019). The government does not cover the loss of private equity, losing only its own equity in the PPP. In the medium scenario, the proportion of debt and private equity covered by the government because of early termination are assumed to be 1, so that the government guarantees the total financing of the project but does not compensate for the forgone return. This outcome is equivalent to compensating the project company for the accumulated investment amount in the PPI database's financing framework. In the high scenario, on top of the debt, the government compensates the private party for 150 percent of the equity it invested in the project, in line with the contract terms for India's road sector.

With 99 percent confidence, the maximum expected losses from early termination of PPPs in country c are the sum of the expected losses within the set of all active projects in the country, I_c, which is obtained by plugging equation (5) into equation (3).

5.5 Predicted Fiscal Risks

5.5.1 Baseline

The fiscal risks from early termination of active PPPs at the 99th percentile reflect the size of each country's PPP portfolio. They are highest in Brazil ($12.8–$40.8 billion), Indonesia ($4.0–$6.8 billion), and Peru ($943 million–$2.5 billion), followed by (Argentina ($399 million–$1.2 billion) and South Africa ($408–$790 million) (table 4). These risks are lowest in Burundi ($0.4–$1 million) and Ethiopia ($3.9–$5.9 million). Although most Eastern European countries in our sample have PPP portfolios that are comparable to those of Ghana and Kenya, the fiscal risks are larger in the two African countries in absolute terms (tables 3 and 4).

The maturity of the portfolios drives the share of the total fiscal risks that are specific to the period 2021–25. For countries with more mature portfolios, such as Brazil, Ghana, Kenya, Kosovo, South Africa, and Ukraine, 37–59 percent of the fiscal risks are concentrated in the 2021–25 period. In Argentina, which implemented 95-year electricity distribution projects in the 1990s, only 22–35 percent (depending on the scenario) of the fiscal risks are concentrated in 2021–25.

Table 4 Fiscal risks from early termination of public-private partnership portfolio in sample countries (2020 million US dollars)

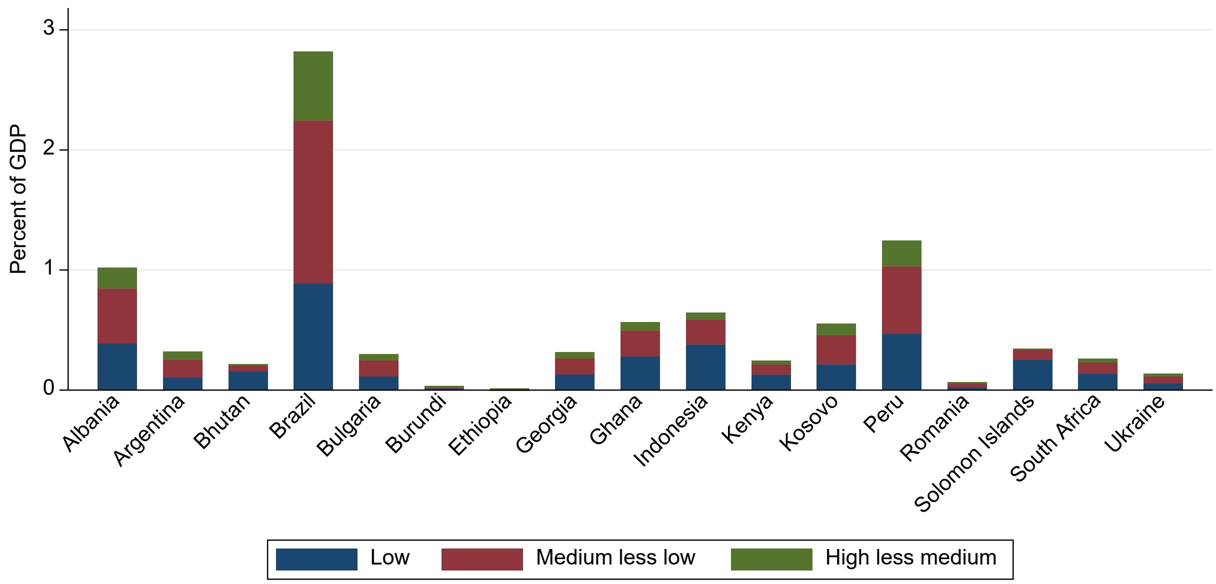
		From the end of 2020 to end of					
Country	*Scenario*	*2021*	*2022*	*2023*	*2024*	*2025*	*Contract period*
Albania	Low	4	8	11	15	17	58
	Medium	9	18	26	34	40	125
	High	11	22	32	42	49	151
Argentina	Low	20	39	56	72	87	399
	Medium	72	140	203	263	321	971
	High	97	189	274	355	433	1,236
Bhutan	Low	0.34	0.67	0.98	1.29	1.59	3.81
	Medium	0.44	0.86	1.27	1.67	2.05	4.93
	High	0.46	0.91	1.34	1.75	2.16	5.18
Brazil	Low	1,212	2,343	3,405	4,402	5,341	12,872
	Medium	3,197	6,141	8,886	11,449	13,851	32,392
	High	4,058	7,788	11,260	14,496	17,529	40,753
Bulgaria	Low	6	11	16	22	26	80
	Medium	12	24	35	45	56	172
	High	15	28	42	55	67	208
Burundi	Low	0.02	0.05	0.08	0.11	0.13	0.42

	Medium	0.04	0.10	0.16	0.21	0.26	0.84
	High	0.05	0.12	0.18	0.25	0.31	0.99
Ethiopia	Low	0.39	0.75	1.09	1.40	1.70	3.88
	Medium	0.55	1.06	1.54	1.98	2.40	5.49
	High	0.59	1.14	1.65	2.13	2.58	5.89
Georgia	Low	0.91	1.82	2.70	3.56	4.37	21
	Medium	1.81	3.62	5.40	7.13	8.76	42
	High	2.14	4.28	6.39	8.45	10.39	50
Ghana	Low	21	40	57	72	86	205
	Medium	37	69	99	126	150	356
	High	42	80	114	145	173	409
Indonesia	Low	206	408	602	788	966	3,987
	Medium	332	657	968	1,263	1,544	6,187
	High	370	732	1,078	1,406	1,717	6,825
Kenya	Low	9	18	28	37	45	123
	Medium	16	32	48	64	79	213
	High	18	37	55	73	90	243
Kosovo	Low	2	4	5	7	8	16
	Medium	4	8	11	14	18	35
	High	5	9	13	17	21	42
Peru	Low	63	123	182	238	292	943
	Medium	137	269	395	517	635	2,075
	High	165	325	479	626	769	2,518
Romania	Low	5	10	14	19	23	63
	Medium	11	21	31	41	50	138
	High	13	26	38	49	60	167
Solomon Islands	Low	0.16	0.37	0.60	0.83	1.05	3.92
	Medium	0.22	0.50	0.80	1.10	1.39	5.21
	High	0.22	0.51	0.82	1.13	1.43	5.34
South Africa	Low	39	77	113	148	181	408
	Medium	67	131	192	251	308	697
	High	75	148	217	283	348	790
Ukraine	Low	13	23	32	41	48	85
	Medium	27	50	70	88	104	178
	High	33	61	85	106	126	214

Source: Authors' calculations.
Note: Figures are the maximum expected loss at the 99 percent confidence.

Among the sample countries, the fiscal risks from early termination of active PPPs over their lifetime as a share of GDP are highest in Brazil, Peru, and Albania (figure 9). These figures give an idea of the resources that would be needed in case of early termination relative to the size of the economy. Over the entire lifetime of the PPP portfolio, the fiscal risks are 0.89–2.82 percent of GDP in Brazil, 0.47–1.25 percent in Peru, and 0.39–1.02 percent in Albania. Indonesia (0.38–0.64 percent), Ghana (0.28–0.57 percent), and Kosovo (0.21–0.55 percent) follow. Although the size of the PPP portfolio amounts to more than 14 percent of GDP in Solomon Islands, the fiscal risk associated with its portfolios is 0.25–0.34 percent.

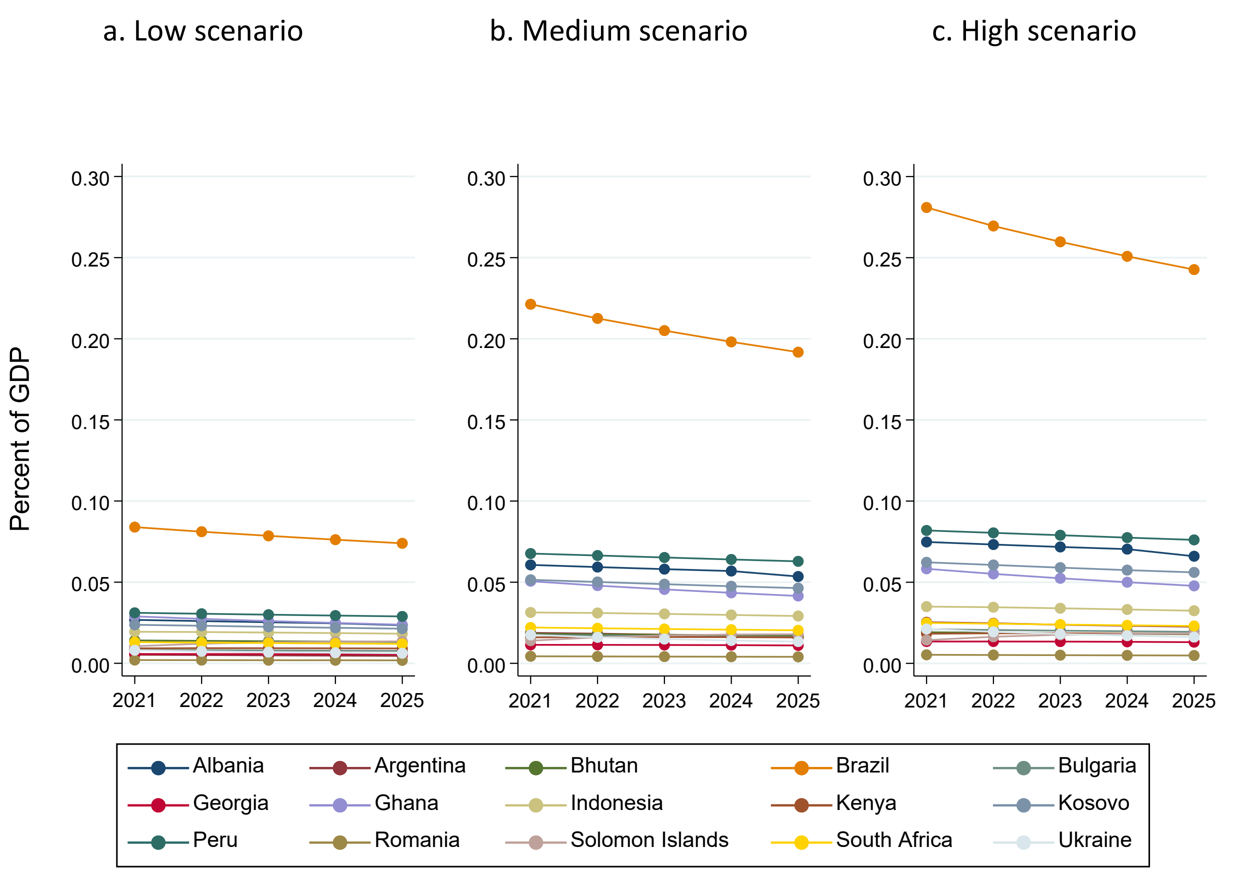
Figure 9 Total fiscal risks from early termination of public-private partnership portfolio in sample countries as percentage of GDP



Source: Authors' calculations.
Note: Total fiscal risks are the maximum expected loss at the 99 percent confidence over the entire contract period, expressed as percentage of GDP of a single year.

Figure 10 presents the annual average fiscal risks for different periods, all starting at the end of 2020, as percentage of 2020 GDP. The fiscal risks decline for most countries, because active projects get older, and some reach the end of their contract periods. The largest annual average fiscal risk is 0.08–0.28 percent of 2020 GDP, depending on the scenario, for Brazil in 2021. Peru and Albania have the next highest risks.

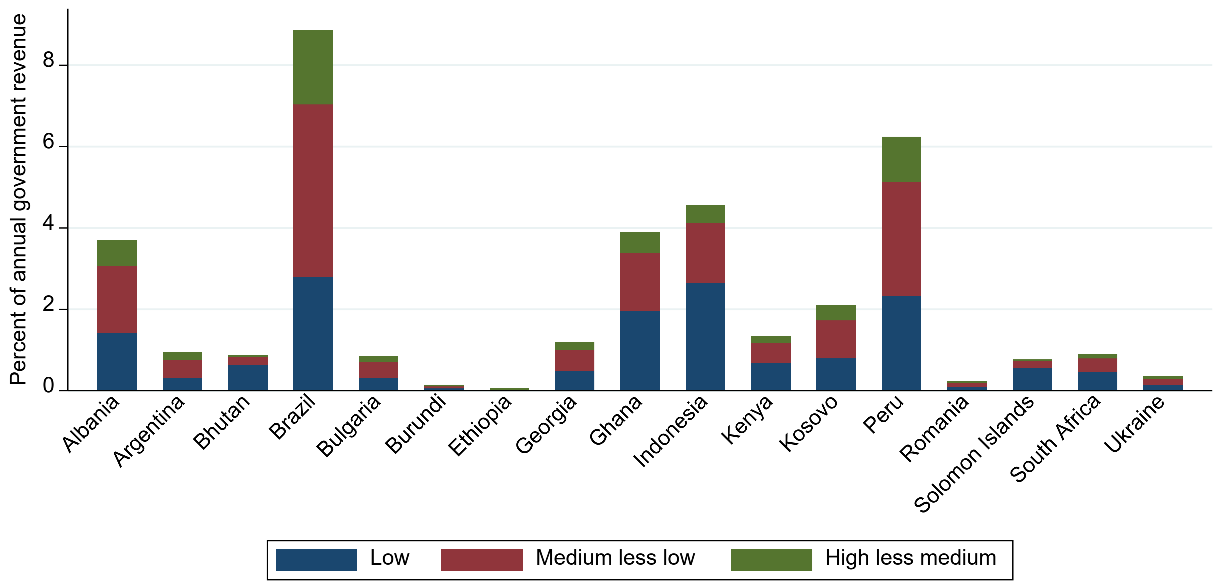
Figure 10 Fiscal risks from early termination of public-private partnership portfolio in sample countries as percentage of 2020 GDP



Source: Authors' calculations.
Note: Each data point represents the average annual maximum expected loss at the 99 percent confidence level from early termination of the PPP portfolio over the period starting at the end of 2020 and ending at the end of the corresponding year as a percentage of 2020 GDP. Figure excludes Burundi and Ethiopia, for which the highest fiscal risk estimates do not reach 0.002 percent of GDP.

Expressing the fiscal risks as a percentage of annual government revenues gives an idea of the fiscal challenge each country could face. Brazil's fiscal risks are 2.80–8.85 percent of annual government revenues, depending on the scenario. The fiscal risks as percentage of annual government revenues reflect differences in the sizes of the economies, with a few notable exceptions (figure 11). The fiscal risks from early termination of the PPP portfolios in Ghana and Indonesia are larger relative to other countries in the sample as percentage of annual government revenues. These risks are as high as 1.96 percent in Ghana and 3.90 percent in Indonesia. Fiscal risks in Peru are much closer to those of Brazil when expressed as a percentage of government revenues than they are when are expressed as a percentage of GDP.

Figure 11 Total fiscal risks from early termination of public-private partnership portfolio in sample countries as percentage of annual government revenue



Source: Authors' calculations.
Note: Total fiscal risks are the maximum expected loss at the 99 percent confidence over the entire contract period, expressed as percentage of GDP of a single year.

5.5.2 Adverse Macro-Financial Shock

Multiple types of macroeconomic shocks have significant effects on the probability of early termination (see table 2). The fiscal risks presented so far assume no macro-financial shock, such as depreciation of local currency or a stress in the banking sector.

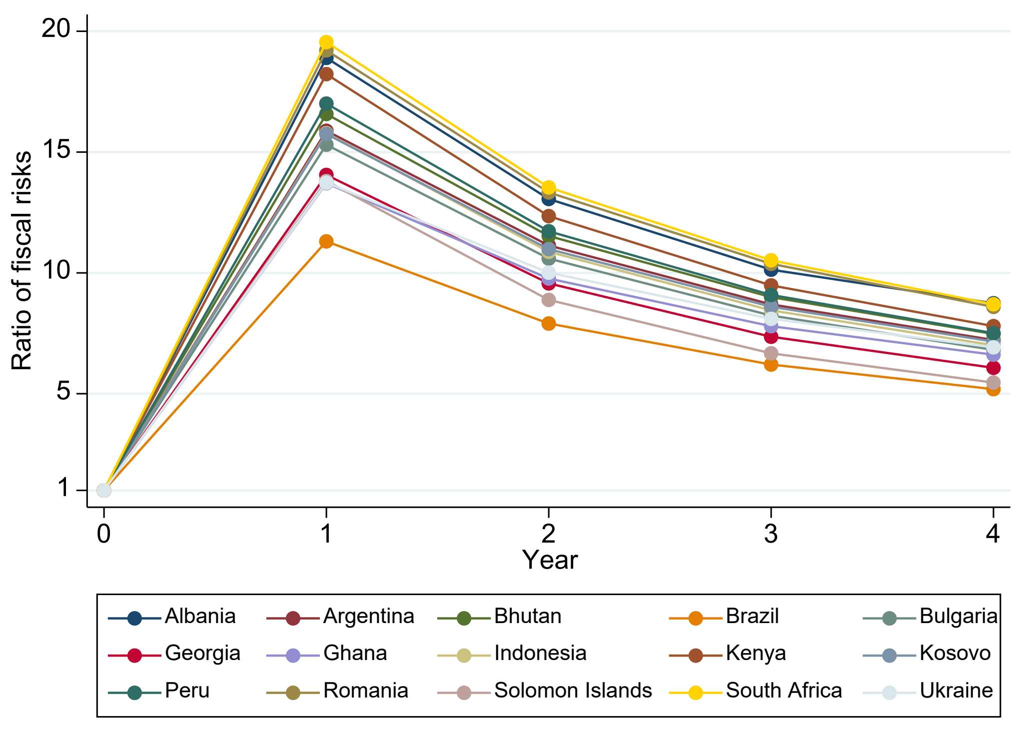
This section simulates the results of a macro-financial shock. The Systematic Banking Crises dataset of Laeven and Valencia (2020) identifies 104 banking crisis episodes among the countries included in the PPI dataset, 13 of which also involved both sovereign debt and currency crises. During these 13 episodes, the maximum yearly deviation in depreciation rate from its long-run average ranged from 15.1 to 116.0 percentage points, with an average of 48.3 percentage points.[16] The simulation assumes a 48.3 percentage-point depreciation shock and the occurrence of both a banking and a debt crisis in year 0.[17] The PPP portfolio of each country is assumed to

[16] The statistics exclude two episodes in Ecuador, because the adjusted currency conversion factor remained stable even though the official rate of depreciation was 56.8 percent in the banking crisis of the early 1980s and 77.2 percent in the crisis of the late 1990s.
[17] The scenario abstracts from the sequencing of different macro events, as all events are assumed to occur in the same year.

be the portfolio at the end of 2020. Such a profound macroeconomic crisis is similar to some crises in emerging markets and developing economies that led to early termination of many PPPs.

A profound macroeconomic crisis in year 0 would significantly increase the fiscal risks from early termination of PPPs, particularly in year 1 after the shock. The year after the shock, the fiscal risks would be 11–20 times the fiscal risks without a shock (figure 12), with the average ratio for the sample 16. Relative to the case without a shock, South Africa would experience the largest increase in fiscal risks, and Brazil would experience the smallest increase. Given the size of Brazil's portfolio and the magnitude of its fiscal risks without a macroeconomic shock, its annual average fiscal risks could be as high as 3 percent of 2020 GDP under a macro shock.

Figure 12 Increase in fiscal risks from early termination of public-private partnership portfolio associated with a profound macro-financial



Source: Authors' calculations.
Note: Each data point represents the ratio of the annual average maximum expected losses at the 99 percent confidence level from early termination of the PPP portfolio with a severe adverse shock to that without a shock under the high scenario.

6 Concluding Remarks and Policy Recommendations

The fiscal risks from current infrastructure PPP programs are not negligible for some of the developing countries in the sample. Under a severe adverse scenario, the fiscal risks from early termination of electricity and transport PPPs would increase by 11–20 times, based on the portfolio. Closing the infrastructure gap, while decarbonizing the electricity and power sectors and increasing their climate resilience, will require significant investments. In the aftermath of the COVID-19 crisis, fiscally constrained governments will surely aim to mobilize private financing of infrastructure through PPP arrangements. Improving the design and management of infrastructure PPPs to mitigate potential fiscal risks while ensuring financially responsible and timely implementation of infrastructure projects to address the infrastructure deficit is therefore an important agenda in the developing world.

The analysis identifies several overarching lessons from the global PPP data. Measures that reduce the financing risk of a project, such as providing support through capital grants, revenue subsidies, or in-kind transfers, can reduce the rates of early termination. Risk depends partly on the sector and size of the PPP project. PPPs in the power and seaport sectors are less likely to experience early termination than PPPs in the other infrastructure sectors analyzed. Early terminations are also more common for larger projects. Delegating PPP contracting and monitoring to state and local governments should be considered when it is institutionally and economically possible, because it reduces the probability of early termination. PPPs in countries with stronger constraints on executive power have lower probability of early termination. Macro-financial shocks are an important cause of early termination of PPPs, highlighting the importance of macroeconomic management in enabling sustainable funding and financing of PPP projects.

Government capacity to prepare, procure, and manage PPP projects must be built to ensure that the expected efficiency gains are achieved and the fiscal risks from contingent liabilities are contained and properly managed. Good practices on preparation, procurement, and management of PPPs can help governments improve their ability to take advantage of PPPs at more acceptable levels of risks (World Bank 2018). The fiscal implications of PPPs, including their budgetary, accounting, and reporting treatment, need to be determined, and the Ministry of Finance or central budget authority needs to have the authority to approve or reject a PPP based on the long-term financial implications of the project (World Bank 2018).

Given the complexity, magnitude, and inherently long-term nature of PPP projects, the procuring authority should exercise appropriate due diligence and perform rigorous assessments to gauge the viability of infrastructure projects before deciding on PPP procurement. Sound PPP preparation starts by identifying potential infrastructure projects that could be procured as PPPs. To reduce the risk of early termination, governments need to conduct feasibility studies that assess and determine the appropriate allocation of risks and sound out the market to gauge its appetite and capacity for proposed projects.

Implementation will determine whether the project delivers the expected value for money and fiscal risks are properly managed. Modification and renegotiation of the contract should be regulated, in order to reduce the incentives of the private partner and the procuring authority to use it opportunistically. Specific circumstances—force majeure, material adverse government action, change in the law, refinancing—that may arise during the life of the contract should also be regulated, and mechanisms should be in place allowing the parties to resolve disputes in an efficient and satisfactory manner without adversely affecting the project (ADB, DFID, JICA and WB 2018). Giving lenders step-in rights for cases when the private partner is at risk of default, or the contract is under threat of termination for failure to meet service obligations, can also reduce the risk of early termination and fiscal costs. Having well-defined grounds for termination of the PPP contract and its associated consequences can also reduce the fiscal costs from early termination (World Bank 2018).

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Appendix A Econometric Model

This paper uses the flexible parametric proportional hazards model proposed by Royston and Parmar (2002). The specification implies that the log cumulative hazard is linear in covariates and the restricted cubic spline functions:

$$\ln H(t|\boldsymbol{X_{it}}) = \gamma_0 + \sum_{m=1}^{M} \gamma_m z_m(\ln t) + \boldsymbol{X_{i,proj}\beta_{proj}} + \boldsymbol{X_{it,inst}\beta_{inst}} + \boldsymbol{X_{it,macro}\beta_{macro}}. \quad (\text{A}.1)$$

The restricted cubic spline functions are

$$z_1(\ln t) = \ln t$$
$$z_m(\ln t) = (\ln t - k_m)_+^3 - a_m(\ln t - k_{min})_+^3 - (1 - a_m)(\ln t - k_{max})_+^3 \; for \; m > 1,$$

where k_m are the interior knots, which are picked at the centiles of the uncensored log event-time distribution, and $a_m = (k_{max} - k_m)/(k_{max} - k_{min})$. The likelihood function is

$$L(\boldsymbol{\gamma}, \boldsymbol{\beta}) = \prod_{j=1}^{N} \frac{S(t_j|\boldsymbol{X_j\beta}, \boldsymbol{\gamma})}{S(t_{j0}|\boldsymbol{X_j\beta}, \boldsymbol{\gamma})} \left[h\left(t_j|\boldsymbol{X_j\beta}, \boldsymbol{\gamma}\right)\right]^{d_j}, \quad (\text{A}.2)$$

where j denotes each observation used in the analysis. The number of observations in the estimation sample is the number of project-years, because all of the time-variant variables are annual. The variable t_{j0} denotes the beginning of the period for a specific observation ending at time t_j, during which the covariates remain constant at $\boldsymbol{X_j}$**.** The variable d_j equals 1 if the project goes into distress at time t_j, and 0 if the project survives time t_j.

To estimate the probability of early termination at a specific interval (t_0, t), we restate the survival function $S(\cdot)$ and the hazard function $h(\cdot)$ in terms of $\ln H(t|X_{it})$ in equation (A.1) using the relations

$$S(t|\boldsymbol{X_{it}}) = \exp(-\exp(\ln H(t|\boldsymbol{X_{it}}))) \quad (\text{A.3})$$

and

$$h(t|\boldsymbol{X_{it}}) = \frac{d}{dt}\exp(\ln H(t|\boldsymbol{X_{it}})). \quad (\text{A.4})$$

Then, after obtaining $\boldsymbol{\gamma}$ and $\boldsymbol{\beta}$, we recover the probability of early termination for any period (t_0, t) for any project i using the relationship between the survival and the cumulative hazard functions:

$$\hat{S}\left(t_j|\boldsymbol{X_{it_j}}\right) = \exp\left(-\exp\left(\ln \widehat{H}\left(t_j|\boldsymbol{X_{it_j}}\right)\right)\right) \quad (A.5)$$

and

$$\hat{S}_i(t|t_0) = \prod_j \frac{\hat{S}\left(t_j|\boldsymbol{X}_{\boldsymbol{it_j}}\right)}{\hat{S}\left(t_{j0}|\boldsymbol{X}_{\boldsymbol{it_j}}\right)}\ , \qquad (\mathrm{A}.6)$$

where j is any observation for project i such that $\left(t_{j0}, t_j\right) \subseteq (t_0, t)$. The probability early termination between (t_0, t) can then be written as:

$$\widehat{PET}_i = 1 - \hat{S}_i(t|t_0)\ . \qquad \text{(A7)}$$

Appendix B Variable Definitions

Table B.1 Definition and sources of project-level variables

Variable	*Definition*	*Source*
Early termination	1 if project is canceled, 0 otherwise. A project is canceled if the private party exits by selling or turning over its shares back to the government or by ceasing operations.	PPI database and authors' collection
Contract period	Percentage of contract period elapsed until early termination (as defined above), otherwise until end of 2020	PPI database and authors' collection
Type	*Greenfield* if the special purpose vehicle (SPV) builds and operates a new facility, *brownfield* if the SPV takes over an existing asset and either rehabilitates or expands it, *management and lease* if the SPV takes over the management of the public asset while ownership and investment decisions remain with the government	PPI database
Sector	Electricity, natural gas, telecom, airports, railroads, toll roads, seaports, treatment plants, water utility	PPI database
Direct government support	1 if capital, revenue or in-kind subsidies exist, 0 otherwise	PPI database
Indirect government support	1 if payment, debt, revenue, or other kind of guarantee exists, 0 otherwise	PPI database
Multilateral support:	1 if a multilateral bank provides financial support, 0 otherwise	PPI database
Subnational government contract	1 if local or provincial/state government grants the contract, 0 otherwise	PPI database and authors' collection
Physical Investment	Total investment in physical assets, in 2020 billion US dollars	PPI database and authors' collection

Table B.2 Definition of macroeconomic variables

Variable	*Definition*
Annual GDP per capita growth rate	Annual GDP per capita growth rate for previous year, detrended and demeaned using the filter suggested by Hamilton (2018). Calculated using the GDP per capita growth series from *World Development Indicators* (WDI).
Annual depreciation	Depreciation rate of local currency against US dollar the previous year, detrended and demeaned using the filter suggested by Hamilton (2018). Calculated using the "DEC alternative conversion factor (LCU per US$)" series from the WDI.
Banking crisis occurred	1 if a systematic banking crisis occurred in the country the previous year, 0 otherwise (from Laeven and Valencia 2018)
Debt crisis occurred	1 if a debt crisis occurred in the country the previous year, 0 otherwise (from Laeven and Valencia 2018)
Exchange rate crisis occurred	1 if an exchange rate crisis occurred in the country the previous year, 0 otherwise (from Laeven and Valencia 2018)

Table B.3 Definition of institutional variables

Variable	*Description*	*Source*
Executive Recruitment Concept	Index of openness of executive recruitment, ranging from 1 (succession by birthright) to 8 (competitive election).	Polity IV Project
Executive Constraints Concept	Index of degree of constraints on the executive, ranging from 1 (unlimited authority) to 7 (executive parity or subordination).	Polity IV Project
Political Competition Concept	Index of degree of competition in politics, ranging from 1 (suppressed) to 10 (institutional electoral).	Polity IV Project

Note: For all three variables, values for interruption, interregnum, and transition periods were recalculated using interpolation.

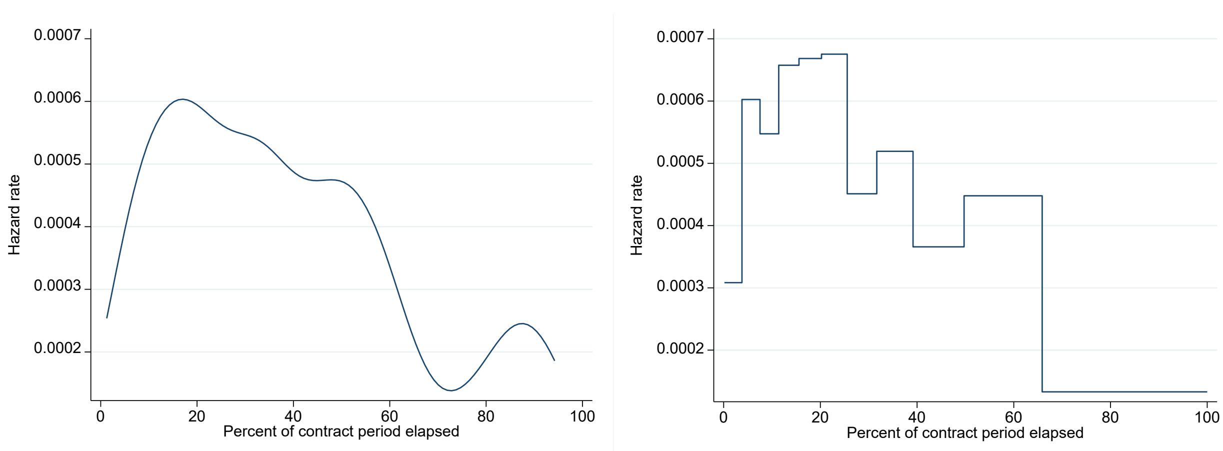
Appendix C Model Selection

This study estimates a nontraditional flexible parametric model—rather than one of the usual out-of-the box models using distributions such as the Weibull or the loglogistic models—because the regular parametric models fail to fit the pattern of the baseline hazard function in this study. We define the baseline hazard as the hazard profile of the project for which all dummies are at their base cases, all shocks are set to zero, and all other continuous variables are set to their means.

A semi-parametric Cox model can be fit, and the baseline hazard extracted as a residual. Alternatively, the total contract period of the project can be partitioned based on the centiles of distresses and assuming that the hazard is constant within each partition, a step function that would indicate the hazard profile over the contract period of a project. Figure C.1 shows the resulting baseline hazard profile using the two methods.

Figure C.1 Baseline hazard profile estimates using semi-parametric methods

a. Cox regression b. Constant hazard with time dummies



Source: Authors' calculations.
Note: Panel a shows the Gaussian kernel and optimal bandwith. Panel b uses 11 interiour knots.

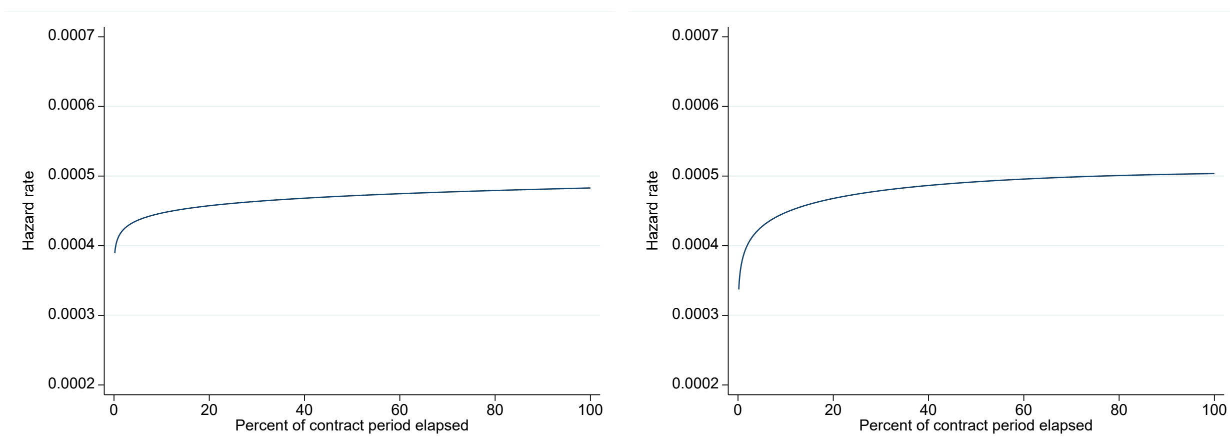
The baseline hazard increases and then decreases after about 15–30 percent of the contract period has elapsed. The overall shape of the baseline hazard function does not differ drastically compared with the nonparametric estimation of the overall hazard presented in the text. However, the baseline is scaled down. The parametric model chosen needs to be able to reasonably replicate the major characteristics of these curves.

Two of the common specifications for the baseline hazard are the Weibull and loglogistic functions. These models have proportional hazards and proportional odds properties, respectively. When the model is fit using the Weibull and loglogistic hazard functions, the resulting estimates of the baseline hazard function are monotonically increasing. Neither function captures the unimodal concave aspect of the baseline hazard captured using the semi-parametric methods (figure C.2). This result may reflect the fact that the sample overrepresents projects in the early stages of their contract periods and the models, in their attempt to fit the data, underpenalize the lack of fit in the later stages.

Figure C.2 Baseline hazard profile estimates using parametric methods

a. Weibull

b. Loglogistic



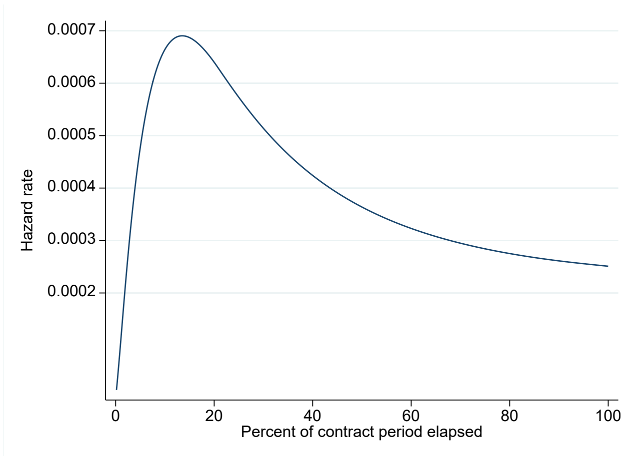
Source: Authors' calculations.

Royston and Parmar (2002) provide generalizations of the parametric survival models using Weibull and loglogistic functions. These models partition the analysis period into multiple periods; using restricted splines, they make the relationship between the strict functional forms of the Weibull and loglogistic functions and the analysis period more flexible. The underlying distributions are no longer Weibull or loglogistic, but their proportionality properties are preserved. Hence, the flexible models are characterized by the property and degree of freedom they provide.

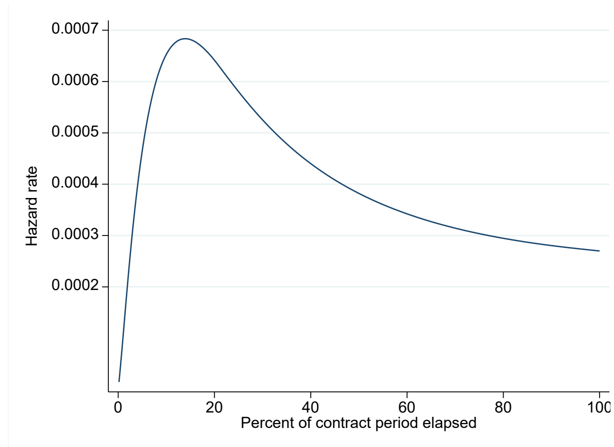
Figure C.3 presents the baseline hazard functions using the flexible parametric methods with only a single interior knot, which means that two parameters are used in characterizing the baseline. Even with just one interior knot, the model captures the unimodal relationship implied by the semi-parametric methods in figure C.1.

Figure C.3 Baseline hazard profile estimates using flexible parametric methods

a. Proportional hazards: PH(2)



b. Proportional odds: PO(2)



Source: Authors' calculations.
Note: Figures uses one interior knot.

More interior knots can be added to obtain a better fit using the flexible parametric approach but doing so may result in overfitting the sample. To avoid doing so, we fitted flexible parametric proportional hazards (PH) and proportional odds (PO) models with different degrees of freedom and used the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) to select the appropriate model (table A.3). As PH(2) yields the lowest AIC and BIC, the analysis overall uses the PH(2) model. The choice of the model does not have substantial qualitative or quantitative effects on the estimates.

Table C.1 Akaike information criterion and Bayesian information criterion under different orders of flexible parametric methods

Proportional hazards and odds	*Akaike information criterion*	*Bayesian information criterion*
PH(1)	1,505.4	1,580.3
PO(1)	1,512.1	1,586.9
PH(2)	1,484.9	1,562.9
PO(2)	1,494.0	1,571.9
PH(3)	1,486.8	1,567.8
PO(3)	1,495.8	1,576.9
PH(4)	1,487.3	1,571.5
PO(4)	1,498.4	1,585.7
PH(5)	1,490.1	1,580.5
PO(5)	1,501.1	1,594.7

Appendix D Imputing the Missing Values for Predictions

Physical Investment

Greenfield electricity projects

We imputed the missing physical investment amounts in greenfield infrastructure for small hydro projects in Indonesia; wind and solar PV projects in Romania and Ukraine; solar PV projects in South Africa; and small hydro, biomass, and solar PV projects in Brazil by estimating the amount of investment needed per megawatt for the energy projects using the same technology in the same country. The imputations are obtained from the following regression:

$$Physical\ Investment_i = \beta \times Capacity_i + u_i.$$

We used the following number of observations to input missing values:

- Indonesian small hydro projects: 7 observations were used to impute 1 missing value.
- Romanian wind projects: 18 observations were used to impute 2 missing values.
- Romanian solar PV projects: 4 observations were used to impute 2 missing values.
- Ukrainian wind projects: 6 observations were used to impute 1 missing value.
- Ukrainian solar PV projects: 25 observations were used to impute 3 missing values.
- South African solar PV projects: 37 observations were used to impute 1 missing value.
- Brazilian small hydro projects: 73 observations were used to impute 1 missing value.
- Brazilian biomass projects: 36 observations were used to impute 2 missing values.
- Brazilian solar PV projects: 17 observations were used to impute 1 missing value.

Brownfield roads projects in Indonesia

We imputed the missing physical investment amounts for build, rehabilitate, operate, and transfer projects in Indonesia by estimating the physical investment in roads projects with the same type of PPP implementation method in the East Asia and Pacific region based on the contract period and road length, using the following regression:

$$Physical\ Investment_i = \ Road\ Length_i + Contract\ Period_i + u_i.$$

We used 29 observations to impute two missing values.

Projects implemented by equity sales in Argentina

We imputed the missing physical investment amounts for Argentinian projects awarded through equity sales (all of which are electricity projects) by estimating the yearly investments in other projects awarded in the same manner using the initial size of the project. Initial size is the initial number of connections for any project involving electricity distribution (generation capacity in megawatt hours for generation projects and transmission line length for transmission projects):

$$Annual\ Physical\ Investment_i = \beta \times Initial\ size_i + u_i.$$

Debt to Physical Investment Ratio

To obtain the estimates for the missing financing variables (debt and equity), for projects not awarded through equity sales, we predicted the debt to net physical investment ratio using type, sector, country, and financial closure year dummies:

$$Debt\ to\ Net\ Physical\ Investment\ Ratio_i = \beta_0 + Type_i + Sector_i + Country_i + Financial\ Closure\ Year_i + u_i,$$

where i represents each project in the PPI sample. Of the 1,906 observations, we imputed 546 missing values. We apportioned physical investments, net of direct subsidies if observed, based on the predicted ratio between debt and equity. Direct subsidies were assumed to be zero if not input in the dataset.

For projects awarded by equity sales (in Brazil and Argentina), where the debt-to-investment and direct subsidies-to-investment ratios are missing for some years, we used the average ratios for the project for all years available. If no financing information was observed for any of the years, we imputed the debt to net physical investment ratio in the same manner as for projects not awarded through equity sales.

Contract Period

We imputed the missing contract period using the following regressions and rounded to the nearest integer.

Electricity projects

We imputed missing values of contract period for electricity projects in Albania, Argentina, Brazil, Bulgaria, Ghana, Indonesia, Kenya, Peru, South Africa, and Ukraine using implementation type, segment in electricity sector, and type of technology, by running a linear ordinary least squares regression separately for each country.

We imputed missing values of the contract period for electricity projects in Ethiopia, Georgia, and Kosovo using the same variables as in the other countries. However, because of sample limitations, we ran regressions using all the projects in the same region:

$$Period_i = \beta_0 + Type_i + Segment_i + Technology_i + u_i.$$

We used the following number of observations to input missing values:

- Albania: 9 observations were used to impute 2 missing values.
- Argentina: 82 observations were used to impute 4 missing values.
- Brazil: 565 observations were used to impute 13 missing values.

- Bulgaria: 18 observations were used to impute 15 missing values.
- Ghana: 7 observations were used to impute 1 missing value.
- Indonesia: 52 observations were used to impute 14 missing values.
- Kenya: 15 observations were used to impute 3 missing values.
- Peru: 46 observations were used to impute 23 missing values.
- South Africa: 75 observations were used to impute 11 missing values.
- Ukraine: 35 observations were used to impute 2 missing values.
- Ethiopia: 199 observations were used to impute 1 missing value.
- Georgia and Kosovo: 201 observations were used to impute 4 missing values.

Airport projects

We imputed missing values of contract period for airport projects in Kenya, South Africa, and Peru using implementation type and fiscal closure year over all the projects in the same region:

$$Period_i = \beta_0 + Type_i + Fiscal\ Closure\ Year_i + u_i.$$

For Kenya and South Africa, we used nine observations to impute two missing values. For Ethiopia, we used 45 observations to impute 1 missing value.

Seaport projects

We imputed missing values of contract period for airport projects in Argentina, Brazil, Indonesia, Kenya, Georgia, Romania, and Ukraine using implementation type and fiscal closure year over all the projects in the same region:

$$Period_i = \beta_0 + \ Type_i + Financial\ Closure\ Year_i + u_i.$$

We used the following number of observations to input missing values:

- Argentina and Brazil: 121 observations were used to impute 7 missing values.
- Kenya: 53 observations were used to impute one missing value.
- Indonesia: 78 observations were used to impute 2 missing values.
- Georgia, Romania, and Ukraine: 16 observations were used to impute 5 missing values.

Toll road projects in Indonesia

We imputed missing values of contract period for toll road projects in Indonesia using implementation type and fiscal closure year over all projects in Indonesia:

$$Period_i = \beta_0 + Type_i + Fiscal\ Closure\ Year_i + u_i.$$

We used 24 observations to impute 4 missing values.