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Estimating realized returns of Public-Private Partnerships in Chile

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Abstract

Realized internal rates of return (IRR) for 50 highway and airport public-private partnerships (PPP) in Chile are calculated from cash flow data for projects that have concluded, and estimated using regression-based simulations of future cash flows for ongoing projects. These estimates represent the cost to society of PPP provision of infrastructure. The average IRR is 6.8%, with averages of 9.1% and 3.1% fixed and variable term PPPs, respectively. Returns show a large dispersion, which suggests that infrastructure projects are intrinsically risky, independent of the contractual form, and that private participation entails risk shifting from the budget to concessionaires. These results are robust to an alternative estimation methodology based on time series models. When using the official estimates for upfront investment instead of reported construction costs, we obtain an "upper bound" for the average return of approximately 10%, a value close to the average estimate from a survey we conducted with 24 experts. Estimated IRRs show a decreasing trend over time, which may be explained the routine use of variable term contracts beginning in 2007, the reform of the PPP legislation in 2010, decreasing debt costs and a reduction in political risks as the PPP program matured.

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1 Introduction

Beginning in 1994, Chile has implemented a Public-Private Partnership (PPP) program in public infrastructure areas such as highways, airports, hospitales and other services, which has formed the backbone of infrastructure provision during the last three decades. PPPs emerge as an alternative to traditional provision,[1] with private parties undertaking and financing (part of) the project. Nonetheless, this type of provision does not save fiscal resources, as pointed out by Engel *et al.* (2014), and hence it is relevant to assess its related costs and benefits.

To address this matter, we estimate the realized or *ex post* internal rate of return (IRR) of 50 PPPs infrastructure projects. *Ex post* IRRs can inform about the cost to society and profitability of PPP projects, on the basis of its annual return. Estimating realized IRR for PPPs is a methodological challenge, since 36 out of 50 concessions are still ongoing contracts. Moreover, it is necessary to account for the fact that the termination period in variable term contracts is determined by its own demand realizations.

This work contributes by developing a methodology based on a simulation approach to estimate the IRRs for unfinished projects. Our starting point is a regression-based model that uses the observed cash flow data to forecast future cash flows streams. We take advantage of the fact that concessionaires are Single-Purposed Vehicles (SPVs), hence flows are specifically related to the infrastructure project. In addition, since IRR is a non-linear function of cash flows, we sample with replacement from the model's residuals to simulate different trajectories for each project and calculate the corresponding IRR. These estimates are conditional on the data. Our methodology takes into account variable term contracts, by estimating an auxiliary model to determine the termination period for each trajectory.

To the best of our knowledge, this paper presents the first estimates of the returns on a countrywide PPPs program. However, there are *ex post* IRR estimates for infrastructure projects such as highways, airports and railways. Shin and Kim (2019) presents a meta-analysis of IRR in Korea highway projects, with their data showing average IRRs of 5%-8%, with a large dispersion. Kelly *et al.* (2015) estimate realized IRRs for 10 EU cohesion funded transport infrastructure projects assuming two demand scenarios (High and Low). Values range from 3.7%-56% for high demand to 2.6%-53% for low demand. Luiu *et al.* (2018) gathers IRRs from different sources to diverse highway projects in Africa, with values ranging -5.5% to 127%[2].

Regarding our estimates, we find that the average IRR of PPPs in Chile is 6.8 percent (median 7.5 percent). These values lie in the lower range of the 7%-10% returns on assets obtained in Chile by regulated industries such as electricity transmission and distribution, and water utilities. Interestingly, ex-post IRRs of Variable term concessions are significantly lower than IRRs of Fixed term concessions. Also, a robustness check we performed suggests IRRs may

[1] Traditional provision is when projects are procured and executed by an agency of the government, which is also in charge of managing and maintaining it.

[2] In this case, differences in cost and benefits accountability may be critical

be a couple of percentage points higher, in line with the average estimate from a survey of 24 experts we conducted. We also find that there is a large dispersion in the IRRs of individual projects, ranging from -23 percent to 25 percent, with seven PPPs with negative IRRs. This suggests that public infrastructure projects are intrinsically risky and that private participation entails significant risk shifting from the budget to concessionaires and their financiers.

Regression analysis show that variable term contracts reduce the annual cost of PPP provision approximately 5%-7%, which may be explained by lower demand risk due to this contractual regime and efficiency gains. We observe a downward time trend on IRRs, which represents a decrease of 7.5%-12% on a span of 15 years, and we discuss that this may be due to the routinely use of variable term contracts, a decrease in debt cost and an initially large political risk that dissipates as the PPP program matured.

The remainder of this paper is organized as follows: Data is presented in Section 2. Section 3 presents the baseline methodology to simulate cash flows and estimate returns. Section 4 presents the main results and robustness checks, which we analyze and discuss in Section 5. Section 6 concludes.

2 Data

2.1 Cash Flow data

In order to build cash flow data, we obtained the Financial Statements for the concession companies, from 2001 onwards, from the website of the Financial Market Commission (CMF, by its acronym in Spanish). For years prior to 2000, we requested the information from the CMF by the Chilean equivalent of the Freedom of Information Act.

Financial Statements include information on firms' Balance Sheets, Income Statements and Cash Flow Statements. Cash Flow Statements present all cash inflows and outflows during the year, classifying them into three categories: Operative, Investment and Financing. Operative cash flows are the inflows and outflows associated with the activities necessary to produce net income, i.e. the operation of the project. Investment cash flows include transactions associated with the acquisition and sale of long-term assets related to the project. The financing flows contemplate the activities necessary to raise money, via debt or equity, and the payment of these liabilities.

To calculate the Internal Rate of Return, we used the Net Operative cash flows, without considering interest payments, and Net Investment cash flows. These are cash flows associated with the concession's income, and therefore, its profitability. We define Net Cash Flow in year t as:

$$CF_t = (\mathrm{OP}_t - \mathrm{INTP}_t) + \mathrm{INV}_t$$

where OP_t is the Net Operative cash flow, INTP_t is interest payments listed as operative flow and INV_t is the net investment cash flow. We emphasize that these are net cash flows, and thus include cash inflows and outflows.

Some judgement calls were needed to determine Net Cash Flows in our data. First, firms choose whether they present cash flows using the direct or the indirect method. These methods differ in how they record operative cash flows: the direct method reports cash inflows and outflows from operating activities, while the indirect method adjusts the period's net income by adding changes in short-term assets and liabilities to determine the implied cash flow. While the direct method allows us to identify the cash flow from interest payments related to operating activities, the main challenge is to obtain interest payments when firms use the indirect method. In this case, interest payments cannot be identified because they are lumped together with other outflows under operational flows. We used financial costs as a proxy for interest payments reported under this method. Finally, the financial statements prior to 2000 do not include Cash Flow Statements. In Appendix A we describe how we built flow statements from the information available for these years.

2.1.1 A note on cash flow data

One of the challenges we faced when calculating the IRRs was the switch from traditional Chilean accounting standards to IFRS standards that took place between 2009 and 2011. This meant that the income statements could not be used directly, because several of its components are marked to market under IFRS. This change also implied that fluctuations in interest rates can affect the operational results, which would bias our IRR estimates. For this reason, we used cash inflows and outflows –which are not marked to market– to determine the profitability of projects.

A second consideration is that cash flows are somewhat erratic in individual years, with inflows and outflows that are large in magnitude and whose nature is sometimes unspecified.[3] Even though Net Cash Flow is less granular than its individual componentes, it smoothes the effect of unspecified (and sometimes large) transactions.

2.2 Contract and Toll Revenue data

There are two contractual regimes for PPPs in Chile: Fixed term contracts and Variable term contracts. Fixed term contracts lasts until a fixed date, specified in the PPP contract. For variable term contracts, on the other hand, firms bid on the present value of revenues (PVR) that they will receive and the concession ends when that amount is collected.[4] MOP provided us with monthly toll revenue (in UF) data for ongoing variable term contracts, which we use for simulations as its explained in Section 3. The dataset also includes government transfers and the discount rate used for the calculation of the Present Value of Revenues (PVR) for a given month.

[3]These flows are lumped together and listed as *Other operational inflows/outflows* and *Other investment inflows/outflows*.

[4]Variable term contracts also have a maximum duration term, but they end earlier if the bid PVR amount is collected before that date.

We obtained contractual data from MOP's Concessions website, which includes public documentation related to each project such as bidding terms, original contracts and renegotiation contracts.[5]

2.3 Sample

For our estimates, we keep concessions that have at least five operating years, i.e. years during which the concession is operational and operating revenues are obtained. This period begins in the first full year after provisional entry into service[6] The construction years, on the other hand, are all years prior to the first year in operation. The resulting dataset comprises cash flow data for 50 PPP projects, accruing 25 years between 1994 and 2019. This sample includes 31 highways PPPs and 19 airport PPPs. Table A2 in the Appendix B shows the contractual information of the 50 PPPs in our sample.

3 Methodology

3.1 Internal rate of return

We aim to estimate the Internal Rate of Return (IRR) as our measurement of returns to the project. The IRR is the discount rate that makes the Net Present Value of an investment project equal to zero, by solving the equation:

$$\sum_{t=0}^{T} \frac{CF_t}{(1+IRR)^t} = 0 \tag{1}$$

If there is more than one solution we choose (in order):

i. The smallest positive root

ii. If there are no positive root, the largest (closest to zero) negative root.

We take advantage of the fact that concessionaires are Single-Purpose Vehicles (SPVs), thus any cash flow is directly related to the infrastructure project. Furthermore, by excluding Financing we are only considering flows from the operational activities.

There are other measurements of returns for an investment project, such as Return Over Assets (ROA) or Return Over Equity (ROE), which is the ratio between net income and the corresponding financial variable. However, this measure of financial performance relates the profit generated by the project to the shareholders' contribution, and its less infomative about the return of the project as a whole. Furthermore, this measure is highly sensitive to accounting standards, hence the switch to IFRS will almost certainly affect it.

[5] The page can be acccesed through: `https://concesiones.mop.gob.cl/proyectos/Paginas/default.aspx`

[6] For example, if a project starts its operations in February 2010 or later that year, we consider 2011 as the first operating year.

Before we present the methodology, is important to point out what our internal rate of return does and does not measure. Net Cash Flow includes direct benefits and costs perceived by the firm during the concession, concerning its operations and construction. We do not take into account financial revenues, which may be not only related to the project, but to the holding company of the SPV. We also do not have an accounting of economic benefits and costs associated with the project, such as estimates of externalities or shadow prices.[7] Thus, this is not a calculation of the Economic Rate of Return (ERR) of the PPPs program.

3.1.1 On multiple internal rates of return

We must make a brief note on the criteria we establish for calculating the IRR. Multiple IRRs surge when cash flow streams "change sign" more than one time[8]. This issue is present in our data, with negative Net Cash flows appearing in middle years. Nevertheless, our criteria keeps the most "reasonable" value that solves equation (1).[9]

There is no consensus in the literature on the interpretation of multiple IRRs. This issue is particularly critical for *ex ante* evaluations of investment projects. Hazen (2003) and Hartman and Schafrick (2004) argue that IRRs are still a useful decision tool even in the presence of multiple solutions, and they provide a framework for evaluating projects in such cases. An alternative to this method is calculating Modified Internal Rates of Return (MIRRs), which guarantees unique roots. This approach assumes that firms can reinvest flows at its opportunity costs, and requires the firm's cost of capital to be known, which is beyond the scope of this research.

3.2 Baseline Model

For concessions that had concluded, we obtained the IRR directly from the cash flows by solving (1). To obtain an estimate for the realized IRR for an ongoing concession, we followed the following steps.

3.2.1 Estimating a cash flow equation

First we estimated a linear relation between operational cash-flows (normalized by MOP's estimate of total investment)[10] and year-of-operation, controlling for calendar-year and concession fixed effects:

$$\frac{CF_{it}}{I_0^i} = \alpha + \theta_{j(i,t)} + \phi_t + \delta_i + u_{it}, \tag{2}$$

where CF_{it} is cash flow of concession i in calendar calendar year t and I_0^i is MOP's investment estimate for concession i (as reported in the bidding documents). The θ_j denote year-of-operation

[7] In addition to the direct return on its investment, an infrastructure project may have externalities on productivity, employment or capital formation, and affect prices of housing or wages, among others.

[8] As a related note, Arrow and Levhari (1969) demonstrated that for an investment project which can be costleslly truncated so that the truncation period maximizes the IRR, the IRR is unique. Flemming and Wright (1971) generalize this result for discrete time and other discount function

[9] A careful inspection of the estimation shows that roots for the equation are far apart from each other, since IRR is a highly non-linear function, and our criteria selects the most plausible value.

[10] We cannot use $\log CF_{it}$ because there are many observations with negative cash-flow.

fixed effects: for every concession i there exists an integer n_i such that $j(i,t) = t - n_i$. Our data have at least five observations for the each of the first 18 years of operation, we therefore include $\theta_1, \theta_2, ..., \theta_{18}$ in the above specification. The ϕ_t denote calendar-year fixed effects and the δ_i denote concession fixed effects.[11] Errors were clustered at the concession's level. From the estimation, we obtain parameters $\widehat{\alpha}, \widehat{\theta}_j, \hat{\phi}_t$ and $\widehat{\delta}_i$ and residuals $\widehat{u}_{it}$.

As can be seen in Figure 1a, estimated year-of-operation fixed effects shows an increasing trend that flattens out, we therefore set $\widehat{\theta}_j = (\widehat{\theta}_{16} + \widehat{\theta}_{17} + \widehat{\theta}_{18})/3$ for $j \geq 19$. Estimated values of calendar-year fixed effects show no discernible trend (see Figure 1b), we therefore set $\widehat{\phi}_t = \frac{1}{23}\sum_{t=1997}^{2019} \widehat{\phi}_t$ for $t \geq 2020$.[12]

Figure 1: Estimated fixed effects

(a) Year of operation fixed effects

(b) Calendar-year fixed effects

3.2.2 Simulating cash flow series: Fixed term concessions

We simulated 1000 cash flow trajectories for each ongoing concession as follows. We used observed values of cash-flow for all years of construction and for the years of operation (at least five) when they were available. For unobserved observations we used the fitted values in (2) and added an error term sampled with replacement from the residuals, $\hat{u}_{it}^k$:

$$\frac{\widehat{CF}_{it}^k}{I_0^i} = \widehat{\alpha} + \widehat{\theta}_j + \widehat{\phi}_t + \widehat{\delta}_i + \widehat{u}_{it}^k.$$

The reason for sampling from estimated residuals is that the IRR may be a highly non-linear function of realized cash flows, ignoring this source of variation may lead to a biased estimate of the IRR and certainly would lead to overestimating the precision of the estimate. For each simulated cash flow trajectory we calculated the realized IRR. The estimated IRR is the median of the 1000 IRRs obtained this way. We prefer the median over the mean because, for some

[11] For identification, we set $\theta_1 = \phi_1 = 0$, so that the θ_j are in deviation from θ_1 and the ϕ_j in deviation from ϕ_1.

[12] We obseve the same trends when we estimate the model only for highways, as shown in Figure A1.

concessions, there was a small number of cash flow trajectories with implied IRRs that took extreme (and implausible) values.

3.2.3 Simulating cash flow series: Variable term concessions

For ongoing Variable term contracts, we simulated 1000 cash flow series in the same way as for fixed term concessions. The only difference is that the number of observations for each simulated series was the maximum duration of the concession stipulated in the contract.

To determine the actual length of the (simulated) cash flow trajectory and the number of observations that should be considered when calculating the IRR, we used an auxiliary model that relates toll revenue with cash flow and the regression for cash flow in (2) as follows:

$$\frac{Y_{it}}{I_0^i} = \beta_0 + \beta_1 \frac{CF_{it}}{I_0^i} + \beta_2 \widehat{\theta}_j + \beta_3 \widehat{\phi}_t + \beta_4 \widehat{\delta}_i + e_{it} \tag{3}$$

where Y_{it} is toll revenue (in real terms) in year t for concession i and the $\widehat{\theta}_j$, $\widehat{\phi}_t$ and $\widehat{\delta}_i$ are the coefficients estimated for (2). We obtain the estimated parameters and residuals $\hat{e}_{it}$. Table A4 reports the results from this regression.

To obtain simulated trajectory k for concession i, we first obtained the $\widehat{CF}_{it}^k$ as described above. Next we calculated the corresponding series of toll revenues using (3) and estimated residuals from this regression as follows:

$$\frac{\widehat{Y}_{it}^k}{I_0^i} = \widehat{\beta}_0 + \widehat{\beta}_1 \frac{\widehat{CF}_{it}^k}{I_0^i} + \beta_2 \widehat{\theta}_j + \beta_3 \widehat{\phi}_t + \beta_4 \widehat{\delta}_i + \widehat{e}_{it}^k$$

where the $\widehat{e}_{it}^k$ are obtained sampling with replacement from the residuals from (3). Next we added the discounted values of $\widehat{Y}_{it}^k$ over t until the sum was larger than the winning bid or the number of periods reached the maximum specified in the contract, whichever happened first. This determined the number of observations in the $\widehat{CF}_{it}^k$ series to be used when calculating the k-th simulated IRR for concession i.

4 Results

4.1 Baseline Results

The first column in Table 1 presents summary statistics for our estimates of realized IRRs for the 50 PPPs in Chile. We considered all highway and airport PPPs with at least five years of operations. The first row reports the average IRR across the projects considered. The second row reports the median of the 50 estimated IRRs. The rows that follow report measures of dispersion of estimated IRRs: the standard deviation and the 25th and 75th percentile (the difference of the latter two is the interquartile range).

It follows from the first column in Table 1 that the mean and median of the estimated IRRs

Table 1: Median Returns (IRR) - Baseline Results

	All	Fixed Term	Variable Term	Highway PPPs	Airport PPPs
Mean	6.8%	9.8%	2.6%	9.1%	2.9%
Median	7.5%	9.4%	4.7%	7.9%	5.8%
SD	9.4%	7.2%	10.5%	5.8%	12.5%
25% Quantile	3.7%	6.8%	-3.8%	5.5%	-4.5%
75% Quantile	11.1%	13.2%	8.3%	10.7%	12.7%
N	50	29	21	31	19

are 6.8 and 7.5%. Table A3 in the Appendix B reports our estimates of realized IRRs for every concession. For seven concessions the estimated IRR is negative while for four it is larger than 20%. The largest IRRs are 25.2% (Acceso Norte Concepción) and 25.0% (second Acceso Vial Aeropuerto Arturo Merino Benítez concession) while the smallest IRRs are -23.0% (second El Loa Airport concession) and -17.9% (second Punta Arenas Airport concession).

The second and third columns in Table 1 report the summary statistics for the subset of 29 fixed term projects and for the 21 Variable term projects, respectively. They show that the IRRs for fixed term contracts (mean: 9.8%, median: 9.4%) are significantly higher than for Variable term contracts (mean: 2.6%, median: 4.7%). One possible explanation is that with less demand risk, the required rate of return on projects is lower. Another possible explanation is that fewer renegotiations under Variable term provide incentives for concessionaires to be more efficient, thereby reducing the threshold returns required to procure a project as a PPP.

The fourth and fifth column in Table 1 report the summary statistics for the subsets of 31 highway PPPs and the 19 airport PPPs. The returns for highway PPPs (mean: 9.1%, median: 7.9%) are considerably higher than for airport PPPs (mean: 2.9%, median: 5.8%). The seven PPPs with negative estimated IRRs are all flexible term airport PPPs, providing yet another possible explanation for lower returns under Variable term contract.

In the following subsection we present three robustness checks to assess our baseline estimates. First, we contrast the *ex post* IRRs for finished and ongoing concessions; second, we replace reported investment during construction year with MOP Investment estimates to assess the possibility that concessionaires inflate their costs; third, we estimate IRRs using a time series approach instead of our baseline model.

4.2 Robustness Checks

4.2.1 Finished and ongoing projects

We present robustness checks for the two main findings obtained above, that is, an average IRR of approximately 7 percent and higher IRRs for fixed term projects than for variable term projects. As first robustness checkg, we contrast the IRRs of finished and ongoing PPPs. Table 2 summarizes the median IRRs for both groups. Consider first the 14 concessions that have concluded. No simulations were needed to estimate the IRR for these projects. These estimates, therefore, are likely to be more precise. Their average and median are 7.9% and 7.5%. These returns are similar to those reported in Table 1, especially once we note that the fraction of fixed term projects in this subsample (64%) is larger than this fraction in the entire sample of projects (58%). Ongoing fixed term contracts have lower realized IRRs (mean 9.3%, median 8.4%) than finished ones (mean 10.8%, median 12.2%), which is consistent with the decreasing time trend that we discuss in Section 5, since the former includes more recent projects.

In the case of Variable term contracts, the average IRR for finished and ongoing PPPs is noticeably similar (2.7% vs 2.5%), considering that this are less precise estimates. This result supports the finding that variable term contracts lower the cost of PPP provision.

Table 2: Median Returns (IRR) - Comparison between finished and ongoing projects

	Finished PPPs			Ongoing PPPs		
	All	Fixed Term	Variable Term	All	Fixed Term	Variable Term
Mean	7.9%	10.8%	2.7%	6.3%	9.3%	2.5%
Median	7.5%	12.2%	3.7%	7.6%	8.4%	7.1%
SD	9.7%	10.9%	3.7%	9.4%	5.1%	12.0%
25% Quantile	3.7%	7.5%	1.7%	4.3%	5.7%	-4.4%
75% Quantile	13.2%	16.5%	4.9%	10.6%	12.1%	9.5%
N	14	9	5	36	20	16

4.2.2 Replacing reported Investment with MOP Investment Estimates

Our second robustness check focuses on the possibility that SPVs are inflating their investment costs, which would bias the estimated IRRs downwards. This could happen, for example, if the concessionaire hires a company related to the owners of the SPV to build the road at an inflated price. To allow for this possibility, we replaced net investment costs with the MOP's estimate of construction costs for construction years' cash flow. We excluded all airport PPPs because they typically have small initial investments, making them closer to an Operations and Maintenance (O&M) contract than a PPP. We also excluded a highway PPP where the contract specifies significant investments after the project becomes operational, one highway where the investment was done in two stages, which results in an insufficient number of observations for this exercise, and one highway where MOP's estimated budget does not correspond to the entire project.

Table 3 summarizes our findings. The left panel replicates the first three columns of Table 1 for the subset of projects considered. The right panel reports summary statistics when MOP estimates are used to proxy investments during construction. This time the difference is substantial. The mean and median of the IRRs increase by approximately 3 percent. This increase is larger for fixed term concessions (approximately 5%) than for Variable term contracts (approximately 2%). This difference could be overestimating the actual bias in Table 3, since renegotiations during construction may lead to larger outlays than the value estimated by MOP. For this reason these estimates should be considered, informally, as an “upper bound” for the actual IRRs.

Table 3: Median Returns (IRR) - Replacing effective investment during construction with MOP estimate

	IRR with reported investment			IRR with MOP estimation		
	All	Fixed Term	Variable Term	All	Fixed Term	Variable Term
Mean	7.4%	8.1%	6.5%	10.2%	11.8%	7.8%
Median	6.8%	7.1%	6.4%	9.9%	12.9%	8.5%
SD	4.1%	4.8%	2.7%	5.5%	5.7%	4.3%
25% Quantile	4.4%	4.6%	4.3%	7.1%	8.8%	4.3%
75% Quantile	9.5%	10.2%	7.9%	14.3%	16.0%	10.3%
N	39	26	13	39	26	13

Notes: MOP estimation corresponds to the budget reported in the official bidding terms. For this excercise, the amount was divided evenly among all the construction years, while we exclude all investment outflows for that period.

4.2.3 Time Series Model Simulation

As third robustness check, we estimate IRRs using simulations based on a time-series model. In this case, estimates are obtained from a project-specific model, in contrast with the pooled baseline estimation. We assume that operational years cash flows for a given project follows an AR(1) process:

$$CF_t = \alpha + \rho CF_{t-1} + u_t$$

We estimate parameters $\widehat{\alpha}$ and $\widehat{\rho}$ and obtain residuals $\widehat{u}_t$ for each concession individually, and we forecast future cash flows using estimated parameters and sampling with replacement from the residuals. For each ongoing project we run 1000 simulations.

In the case of Variable term contracts, we additionally assume that real toll revenues follow an AR(1) process:

$$Y_t = \beta + \phi Y_{t-1} + \varepsilon_t$$

We follow the same procedure than cash flows, estimating parameters $\widehat{\beta}$ and $\widehat{\phi}$ and obtaining residuals $\widehat{\varepsilon}_t$. From this process, we simulate future toll revenues sampling with replacement from residuals $\widehat{\varepsilon}_t$ and we determine the termination period for each trajectory.

Table 4: Median Returns (IRR) - Autoregressive Model

	All	Fixed Term	Variable Term	Highway PPPs	Airport PPPs
Mean	6.9%	9.1%	3.9%	8.5%	4.4%
Median	7.4%	8.9%	4.7%	7.3%	7.5%
SD	8.8%	7.5%	9.8%	6.4%	11.5%
25% Quantile	3.7%	6.0%	2.5%	4.3%	-2.0%
75% Quantile	11.0%	13.1%	8.4%	10.6%	12.3%
N	50	29	21	31	19

Table 4 presents summary statistics for our estimates of IRRs assuming an autoregressive process. The first column of the table shows that the mean and median of the estimated IRRs are 6.9% and 7.4%, which is remarkably similar to the baseline estimates of 6.8% and 7.5% presented in Table 1. Mean and median (9.1% and 8.9%) for fixed term contracts are lower than baseline estimates, but these differences are small. On the other hand, variable term contracts show an increase of over 1 percent in the mean, while the median is the same as the baseline estimates. This differences may be due to the assumptions made for this model. In any case, we underline that starting from a completely different framework, our two main findings hold: an average IRR near 7% and variable term PPPs having significantly lower returns that fixed term PPPs.

4.3 Assesing the magnitude of IRRs

Is an average IRR of around 7 percent for a typical concession project in Chile a reasonable return or is it low or high? The answer is not obvious since, to the best of our knowledge, there is no equivalent previous study estimating internal rates of return for a countrywide PPP program[13]. One possibility is to compare with the IRR of regulated companies in Chile, even though these sectors are not part of the Chilean concession program. For example, in electricity and water distribution, tariffs are set aiming for an IRR between 7 and 10 percent for an efficient company. These returns suggest the IRRs we estimates are in the right ballpark.

Another possibility is to contrast our estimates with the opinion of experts. To this effect we conducted a survey with 24 experts, which included former authorities at the Ministry of Public Works and related ministries, private sector executives involved in investment decisions in the PPP sector and academics specialized in project evaluation.[14] The average IRR was 10.7% (median: 10.0%) with a relatively large dispersion (standard deviation: 2.7%). These estimates are 3-4% higher than the estimates from our benchmark model and very close to the estimates from our second robustness exercise (Table 3), which we consider as an upper bound. Table 5 summarizes the IRRs, which suggests that the return to the PPPs program lies between 6.8% and 10.2%. Therefore, we could interpret this value as the annual cost to society of this type of provision.

5 Regression Analysis

In this section, we present descriptive regressions relating the estimated returns to contractual characteristics of each project and we assess an observed downward time trend on returns.

[13] Vergara-Novoa *et al.* (2020) estimate the revenues, costs and average costs for highway concessions in Chile directly from financial statements. This study does not consider the change in accounting standards mentioned above.

[14] The experts we contacted are: Marcela Allue, Eduardo Bitrán, Fernando Britos, Eduardo Contreras, Leonardo Daneri, Álvaro Fuentes, Andrés Gómez-Lobo, Aldo González, Luz Granier, Ignacio Guerrero, Cristina Holigue, Cristián López, Rodrigo Manzur, Edgardo Mimica, Ricardo Mogrovejo, Juan Carlos Muñoz, Raúl O'Ryan, Cristián Palacios, José Antonio Sanhueza, Jennifer Soto, Daniel Ulloa, Juan Vargas, Thomas Verbeken, Leonel Vivallos. The response rate was 20 out of 24.

Table 5: Summary of IRRs

	Estimated IRRs			
	Baseline	AR(1)	MOP Investment	Experts Survey
Mean	6.8%	6.9%	10.2%	10.7%
Median	7.5%	7.4%	9.9%	10.0%
SD	9.4%	8.8%	5.5%	2.7%
N	50	50	28	50

5.1 Contractual regime, renegotiations and 2010 legal reform

PPP contracts are inherently long-lived incomplete contracts because unforeseen circumstances may arise over the life of a concession. Thus, renegotiations can be expected to occur over time, and they provide the flexibility necessary to adapt to changing conditions. Nevertheless, there are two problematic features about renegotiations of PPP contracts. First, renegotiations often occur during early stages of the contract. Second, renegotiations tend to favor the private partner (i.e. the concessionaire).[15] The concessions' law reform of 2010 was introduced in order to reduce the fiscal risks related to contract renegotiations. Due to this reform, the 'excepcionality" of variable term contracts was eliminated, which began to being routinely used in the late 2000s.[16] We ran a regression analysis to relate our baseline IRR with renegotiations, the 2010 legal reform and whether the project is a variable term contract. Additionally, we include an airport PPP regressor to assess if there are significant differences due to this type of infrastructure.

Table 6 show the results of regressing the baseline IRR against a dummy for Variable term, a dummy that indicates if the contract was granted after the promulgation of 2010 law, a dummy that indicates if it is an airport PPP and renegotiations per year (normalized by MOP's estimate of total investment). Variable term contracts have significantly lower returns than fixed term contracts, and this result is robust to different specifications. One possible explanation is that since variable term contracts reduce demand risk (see Engel *et al.*, 2014), required returns on project are lower. In addition, this type of contracts may foster efficiency among concessionaires, reducing the threshold return needed to provide a project as a PPP. We do not observe a significant effect of renegotiations, which may be related to the fact that variable term PPPs are less prone to renegotiations, and that contractual regime already explains the most part of differences in return.

Airport concessions have a lower return, but this effect is signficant only at the 10 percent level. We do not observe a significant effect of the 2010 legal reform when the Variable term dummy is included. Nevertheless, since only five contracts in our sample were granted under

[15] Both facts are documented in Guasch (2004) and Engel *et al.* (2009).

[16] We highlight three additional changes: First, the elimination of supervening cause as a motive for renegotiation was a significant change from the point of view of fiscal risk. By default, the reform required that any risk not expressly allocated by the PPP contract to the government remained with the concessionaire.The only exception was an act of the government, but only if it satisfied several restrictive conditions. Second, the fact that any additional works must be procured in a competitive auction under the supervision of MOP. Third, the new law modified the governance of PPP renegotiations by creating an independent Experts Panel.

Table 6: Descriptive regressions

	(1)	(2)	(3)	(4)	(5)
Variable Term	-0.072**		-0.065*	-0.067*	-0.071*
	(0.03)		(0.03)	(0.03)	(0.03)
Granted after 2010 Law		-0.108*	-0.095	-0.071	-0.071
		(0.04)	(0.05)	(0.05)	(0.05)
Airport Concession				-0.050	-0.057
				(0.03)	(0.03)
Reneg. per year (% of MOP Budget)					-0.239
					(0.27)
Constant	0.098***	0.078***	0.104***	0.122***	0.130***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Observations	50	50	50	50	49
R^2	0.15	0.12	0.24	0.30	0.31

Notes: The dependent variable is the Median IRR from our baseline estimates. Variable term, Granted after 2010 Law and Airport Concession are dummies with take value equal to 1 when the project fulfills such condition. Renegotiations per year as % of MOP Budget represent the whole renegotiated amounts up to 2019, divided among all the years of concession. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

that law we cannot rule out a possible effect.[17] More data is required to have statistical power to evaluate this hypothesis.[18]

In summary, this first regression analysis suggests that variable term contracts lower IRRs in approximately 7%. However, this analysis does not account for time trends we observe in our results, which we review in the following subsection.

5.2 Downward Time Trend

Figure 2 plots the IRR against the year when construction of the project began. A downward trend is evident.[19] Estimates from a linear regression of the IRR on the year where construction began suggests a negative slope and an estimated decrease of the IRR of approximately 12 percent between 1998 and 2013. Table 7 shows the results of the regressions displayed in Table 6, but adding a linear time trend. The variable term is still significant at the 5 percent level, while the linear time trend is significant at the 10 percent level. In summary, estimates suggest a negative slope with an (imprecisely) estimated decrease of 7.5%-12%.[20]

This downward trend in IRRs can be attributed to the firm´s learning curve[21], the growing

[17] Table A5 replicates the regression in Table 6 excluding post 2010 contracts.

[18] Table A1 summarizes renegotiations before and after the 2010 law. The decrease after 2010 of renegotiated amount is significant, hence we cannot discard that this may affect the returns on those projects.

[19] Concessions' estimated fixed effects of the baseline model also show a decreasing trend, see Figure A2.

[20] When considering only highways, the negative slope dissapears (see Figure A3). This might be biased product of an outlier observatins, thus we run two additional robust regressions that show a negative (but less steep than Figure 2) slope.

[21] This is a relevant point, since many SPVs are owned by holdings that participate in different projects.

Figure 2: IRR vs Year of procurement

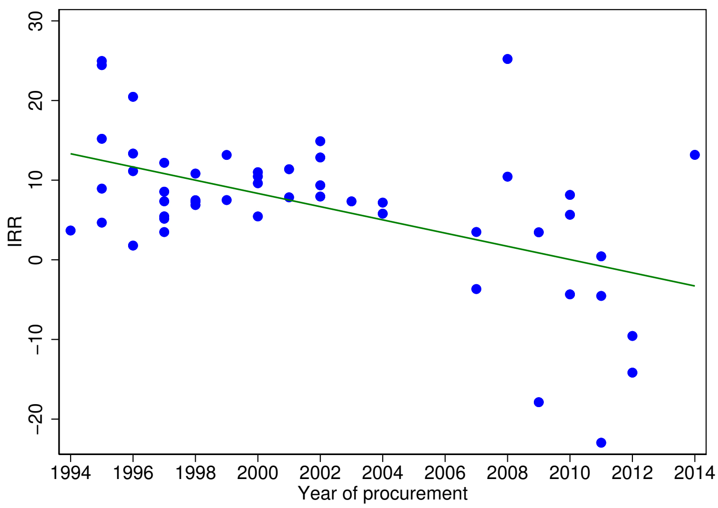


Table 7: Descriptive regressions with time trend

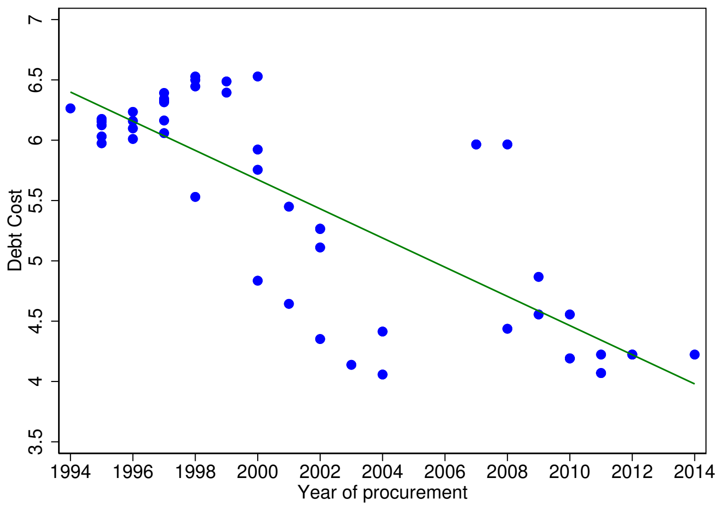
	(1)	(2)
Variable Term	-0.049*	-0.054*
	(0.020)	(0.022)
Granted after 2010 Law	-0.020	-0.014
	(0.056)	(0.058)
Airport Concession	-0.040	-0.050
	(0.023)	(0.026)
Linear Time Trend	-0.005	-0.006
	(0.003)	(0.003)
Reneg. per year (% of MOP Budget)		-0.368
		(0.296)
Constant	0.147***	0.162***
	(0.022)	(0.027)
Observations	50	49
R^2	0.37	0.38

Notes: The dependent variable is the Median IRR from our baseline estimates. Variable term, Granted after 2010 Law and Airport Concession are dummies with take value equal to 1 when the project fulfills such condition. The linear time trend takes as starting year . Renegotiations per year as % of MOP Budget represent the whole renegotiated amounts up to 2019, divided among all the years of concession. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

use of variable term contracts since the mid-2000s and the legal reform of 2010. As we discussed above, variable term concessions show lower returns, and since it was routinely adopted during the 2000s, it may be affecting the returns. With respect to the 2010 Law, Engel *et al.* (2021) provide evidence that suggests that renegotiations are significantly lower with the new law, hence reducing the opportunities for concessionaries to obtain major gains from this mechanism.

Another possible explanation is provided by Figure 3. This figure presents some very simple estimates for the cost of debt of every project (see the Appendix E for how we calculated the estimates), plotted against the year of procurement. A downward trend is evident. If the decision to undertake a PPP project depends on its *ex ante* IRR being above a threshold that reflects the cost of debt, a downward trend in the cost of debt would lead to the observed trend in realized IRRs.

Figure 3: Estimated debt cost vs Year of procurement



Note: Debt cost is assumed to be a risk-free rate plus a corporate spread.

The downward trend in IRRs should not be attributed to the initial projects being the "low-hanging fruits", because there was competition for the projects, which should reduce those rents. There is however the possibility of initial political risk related to the PPP program, thus requiring higher returns. This risk may have dissipated over time given the relative success of the program, and this could also explain (part of) the downward trend.[22] Finally, results suggests that variable term contracts may reduce IRRs (and hence, cost to society) in a magnitude of 5%-7% per year with respect to a fixed term regime.

[22]A related discussion concerning political incentives is the role that optimism bias may play on the *ex ante* appraisal of infrastructure projects by its promotors, overestimating its benefits and underestimating its costs, as exposed in Flyvbjerg *et al.* (2002). In this sense, it would be useful to know *ex ante* return estimates to contrast over time.

6 Concluding Remarks

We presented a regression-based methodology for estimating the realized return of infrastructure PPPs. Our approach assumed a fixed effect model for cash flows, and included an auxiliary regression for variable term projects. We used the estimated parameters from this model to forecast the future cash flows, sampling with replacement from the residuals of the regression. Robustness checks allowed us to calculate an “upper bound” for the IRRs, which is close to the estimates from experts.

We summarize our main findings as follows: annual cost to society of having PPPs lies somewhere between 7% and 10% of total investment value and can be lowered by using variable terms as the contract mechanism, in the order of 5%-7%. In addition, IRRs show a decreasing time trend, which may be explained by (a combination of) diverse factors: the routinely use of variable term contracts since the mid-2000s, the decrease of debt costs to finance projects, the effect of the 2010 law and an initial political risk that has dissipated over time. This trend would have meant a decrease of 7.5%-12% of the IRR between 1998 and 2013. Finally, we observe that there is a large variation in the return of projects, independently of the type of contract, which suggests that infrastructure is intrinsically risky and that private participation shifts risk from the budget to concessionaires.

This research raises further questions on the estimation and examination of returns on PPPs. First, there can be improvements to the IRR estimation through the utilization of Modified Internal Rates of Return (MIRRs)[23], which requires accurate measures of the firms' cost of capital. Second, address the different hypotheses we raised on the decreasing time trend of IRRs. Third, it may be interesting to compare the *ex post* IRRs we calculated with *ex ante* values estimated by the SPVs, an exercise that would require knowing the *ex ante* estimates.

[23] As was mentioned in Section 3, MIRR assumes that firms can reinvest positive cash flow at its cost of capital.

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Appendices

A Data

A.1 Building cash flows prior to 2000

Since financial statements prior to 2000 do not include Cash Flow Statements, we constructed the cash flows under the indirect method from the variations in the balance sheet (i.e. changes in assets, liabilities and equity). We used a common criterion for all concessions to define cash and operating, investing and financing cash flows, based on the following accounting identity:

$$\Delta \text{Cash}_t = \text{OP}_t + \text{INV}_t + \text{FIN}_t - \Pi_t$$

where the right hand terms are Net Operative, Investment and Financing Cash Flows respectively, and Π_t is an inflation-correction factor.

We assigned the available information to the different kinds of flows as follows:

- Cash: Current Assets on Hand, Short-term Deposits, Negotiable Securities and non-categorized current assets (listed as "Other Current Assets").
- Operative Cash Flow: Changes in current assets not considered as cash, depreciation of fixed assets, amortization, current (or short-term) liabilities and the period's results (profits).
- Investment Cash Flow: Variation in the position of fixed assets and other non-current assets.
- Financing Cash Flow: Changes in the long-term liability position and changes in equity.
- Inflation-correcting factor: Obtained by applying the period's inflation, π_t, to the three cash flow variables, i.e. $\Pi_t = \pi_t(\text{OP}_t + \text{INV}_t + \text{FIN}_t)$.

These adjustments allowed us to determine net cash flows for all the years in the sample.

B Descriptive Tables

Table A1: Renegotiations of Chilean PPPs (up to 2021)

	(1) All PPPs	(2) Old Law	(3) New Law
Number of Projects	98	63	35
Initial Investments (UF)	432,721,408	221,560,816	211,160,608
Total Renegotiated Amounts	134,082,784	130,966,144	3,116,637
Renegotiated during construction	58,514,092	57,369,424	1,144,668
Average years after adjudication	18.06	19.66	8.11
Years during construction	4.31	4.3	4.33
Average years after operations	13.75	15.36	3.78
Number of projects with renegotiations	55	48	7
Total number of renegotiations	189	179	10
Average number of renegotiations	3.44	3.73	1.43
Number of projects with renegotiations (during construction)	32	29	3
Number of renegotiations (during construction)	70	66	4
Average number of renegotiations (during construction)	2.19	2.28	1.33
Amount renegotiated/Total investment (%)	30.99%	59.11%	1.48%
Amount renegotiated/Total investment (%) (during construction)	13.52%	25.89%	0.54%
Total renegotation/[Total investment x total number of years of concession]	1.72%	3.01%	0.18%
Total renegotation/[Total investment x total number of years of concession] (during construction)	10.13%	10.19%	8.48%
Average time until the first renegotiation (conditional on at least one renegotiation)	4.1	4.0	4.3
Number of concession with term extensions	23	21	2

Source: Engel *et al.* (2021). Initial Investment is based on MOP estimated budget in the concession terms. Construction period is defined as the time between the start of the concession and the begging of operations. Investment and renegotiation amounts are in UF (USD 38-44).

Table A2: PPP Contract Information

Project Name	Term	Type	Initial Year	Ending Year	I_0 MOP (UF)	PTR (UF)
Camino de la Madera	Variable Term	Highway	1994	2012	905,039	
Concesión Acceso Norte a Concepción	Fixed Term	Highway	1995	2023	3,403,643	
Camino Nogales - Puchuncaví	Variable Term	Highway	1995	2017	226,000	
Concesión Autopista Santiago - San Antonio, Ruta 78	Fixed Term	Highway	1995	2021	3,392,830	
Aeropuerto Diego Aracena de Iquique	Fixed Term	Airport	1996	2011	149,893	
Aeropuerto El Tepual de Puerto Montt	Fixed Term	Airport	1996	2008	222,088	
Acceso Vial Aeropuerto Arturo Merino Benítez	Fixed Term	Highway	1996	2008	235,634	
Concesión Ruta 5 Tramo Santiago - Los Vilos	Fixed Term	Highway	1997	2023	8,200,000	
Concesión Ruta 57 Santiago - Colina - Los Andes	Fixed Term	Highway	1997	2026	3,700,000	
Concesión Ruta 5 Tramo Los Vilos - La Serena	Fixed Term	Highway	1997	2022	7,986,345	
Aeropuerto La Florida de La Serena	Fixed Term	Airport	1998	2008	74,294	
Concesión Ruta 5 Tramo Chillán - Collipulli	Variable Term	Highway	1998	2022	6,640,000	
Aeropuerto El Loa de Calama	Fixed Term	Airport	1998	2010	70,800	
Concesión Ruta 5 Tramo Temuco - Río Bueno	Fixed Term	Highway	1998	2023	5,955,000	
Primera Concesión Aeropuerto Internacional Arturo Merino Benitez	Variable Term	Airport	1998	2013	4,600,000	
Concesión Ruta 5 Tramo Talca - Chillán	Variable Term	Highway	1999	2021	4,500,000	
Concesión Ruta 5 Tramo Collipulli-Temuco	Variable Term	Highway	1999	2025	7,131,000	
Concesión Interconexión Vial Santiago-Valparaíso-Viña del Mar, Ruta 68	Variable Term	Highway	1999	2024	12,090,000	11,938,207
Concesión Ruta 5 Tramo Santiago-Talca y Acceso Sur a Santiago	Variable Term	Highway	1999	2032	17,815,500	
Aeropuerto Carriel Sur de Concepción	Fixed Term	Airport	1999	2015	629,300	
Aeropuerto Cerro Moreno de Antofagasta	Fixed Term	Airport	2000	2010	250,000	
Aeropuerto Carlos Ibáñez del Campo de Punta Arenas	Fixed Term	Airport	2000	2009	320,573	
Concesión Sistema Norte - Sur (Autopista Central)	Fixed Term	Highway	2001	2032	15,190,000	
Concesión Red Vial Litoral Central	Fixed Term	Highway	2001	2031	2,383,470	
Concesión Ruta Interportuaria Talcahuano-Penco	Fixed Term	Highway	2002	2033	517,700	
Concesión Ruta 5 Tramo Río Bueno - Puerto Montt	Fixed Term	Highway	2002	2023	5,297,000	
Concesión Nuevo Aeropuerto Regional de Atacama	Fixed Term	Airport	2002	2023	1,000,574	
Concesión Sistema Américo Vespucio Sur, Ruta 78-Av.Grecia	Fixed Term	Highway	2002	2032	10,350,000	
Concesión Sistema Américo Vespucio Norponiente, Av.El Salto-Ruta 78	Fixed Term	Highway	2003	2033	10,100,000	
Concesión Variante Melipilla	Fixed Term	Highway	2003	2033	669,100	
Concesión Sistema Oriente - Poniente (Costanera Norte)	Fixed Term	Highway	2003	2036	9,482,776	
Concesión Acceso Nororiente a Santiago	Variable Term	Highway	2004	2044	5,468,000	11,473,502
Concesión del Aeropuerto Chacalluta de Arica	Fixed Term	Airport	2004	2019	327,809	
Concesión Camino Internacional Ruta 60 CH	Fixed Term	Highway	2004	2036	6,680,000	
Concesión Variante Vespucio El Salto-Kennedy (Túnel San Cristóbal)	Fixed Term	Highway	2005	2037	2,500,000	
Segunda Concesión Aeropuerto El Tepual de Puerto Montt	Variable Term	Airport	2008	2023		
Segunda Concesión Acceso Vial Aeropuerto Arturo Merino Benitez	Variable Term	Highway	2008	2048	1,500,000	1,299,000
Concesión Ruta 160 Tramo Tres Pinos - Acceso Norte a Coronel	Variable Term	Highway	2008	2048	6,500,000	7,950,000
Concesión Ruta 5 Tramo Vallenar - Caldera	Variable Term	Highway	2009	2044	7,230,000	6,696,696
Segunda Concesión Aeropuerto Carlos Ibáñez del Campo de Punta Arenas	Variable Term	Airport	2010	2025	314,115	175,990
Concesión Autopista de la Región de Antofagasta	Fixed Term	Highway	2010	2030	7,750,000	
Concesión Nuevo Aeropuerto Región de La Araucanía	Variable Term	Airport	2010	2030	2,681,000	415,000
Concesión Ruta 5 Tramo Puerto Montt - Pargua	Variable Term	Highway	2010	2050	4,125,000	4,000,000
Segunda Concesión Aeropuerto El Loa de Calama	Variable Term	Airport	2011	2022	880,000	586,970
Concesión Alternativas de Acceso a Iquique	Variable Term	Highway	2011	2043	5,000,000	3,886,000
Segunda Concesión Aeropuerto Cerro Moreno de Antofagasta	Variable Term	Airport	2011	2026	665,000	284,777
Segunda Concesión Aeropuerto Diego Aracena de Iquique	Variable Term	Airport	2012	2016	371,200	327,832
Tercera Concesión Aeropuerto Diego Aracena de Iquique	Fixed Term	Airport	2012	2018	109,000	
Segunda Concesión Aeródromo La Florida de La Serena	Variable Term	Airport	2012	2022	174,000	120,798
Tercera Concesión Aeropuerto El Tepual de Puerto Montt	Fixed Term	Airport	2014	2018	90,000	

Table A3: PPP Estimated Returns

	All PPPs			Highway PPPs Model			Highway PPPs w/ MOP I0			
Project Name	IRR (Median)	STD	IQR	IRR (Median)	STD	IQR	IRR (Median)	STD	IQR	Complete
Camino de la Madera	3.7%			3.7%			3.5%			YES
Concesión Acceso Norte a Concepción	25.0%	0.1%	0.0%	24.9%	0.1%	0.0%				NO
Camino Nogales - Puchuncaví	4.7%			4.7%			10.9%			YES
Concesión Autopista Santiago - San Antonio, Ruta 78	8.9%	0.1%	0.1%	8.9%	0.1%	0.1%	14.7%	0.1%	0.1%	NO
Aeropuerto Diego Aracena de Iquique	15.2%									YES
Aeropuerto El Tepual de Puerto Montt	24.4%									YES
Acceso Vial Aeropuerto Arturo Merino Benítez	20.5%			20.5%			17.7%			YES
Concesión Ruta 5 Tramo Santiago - Los Vilos	1.8%	8.1%	0.6%	1.3%	10.8%	0.7%	13.7%	0.3%	0.2%	NO
Concesión Ruta 57 Santiago - Colina - Los Andes	13.3%	0.2%	0.3%	13.1%	0.3%	0.3%	15.6%	0.2%	0.2%	NO
Concesión Ruta 5 Tramo Los Vilos - La Serena	3.5%	0.9%	0.8%	2.9%	12.5%	0.8%	3.6%	12.7%	0.8%	NO
Aeropuerto La Florida de La Serena	7.5%									YES
Concesión Ruta 5 Tramo Chillán - Collipulli	8.6%	0.4%	0.4%	8.2%	0.4%	0.4%	6.9%	0.3%	0.3%	NO
Aeropuerto El Loa de Calama	12.2%									YES
Concesión Ruta 5 Tramo Temuco - Río Bueno	7.3%	0.4%	0.4%	7.0%	0.4%	0.4%	9.3%	0.3%	0.3%	NO
Primera Concesión Aeropuerto Internacional Arturo Merino Benitez	5.5%									YES
Concesión Ruta 5 Tramo Talca - Chillán	11.1%	0.1%	0.1%	11.0%	0.1%	0.1%	15.5%	0.1%	0.1%	NO
Concesión Ruta 5 Tramo Collipulli-Temuco	6.9%	0.3%	0.3%	6.7%	0.3%	0.3%	8.5%	0.3%	0.2%	NO
Concesión Interconexión Vial Santiago-Valparaíso-Viña del Mar, Ruta 68	7.3%	0.5%	0.6%	6.9%	4.3%	0.7%	8.6%	4.3%	0.5%	NO
Concesión Ruta 5 Tramo Santiago-Talca y Acceso Sur a Santiago	10.8%	0.3%	0.3%	10.5%	0.3%	0.4%	10.3%	0.3%	0.3%	NO
Aeropuerto Carriel Sur de Concepción	7.5%									YES
Aeropuerto Cerro Moreno de Antofagasta	13.2%									YES
Aeropuerto Carlos Ibáñez del Campo de Punta Arenas	11.0%									YES
Concesión Sistema Norte - Sur (Autopista Central)	10.5%	0.3%	0.4%	10.0%	0.3%	0.4%	12.9%	0.3%	0.3%	NO
Concesión Red Vial Litoral Central	5.4%	0.9%	1.0%	4.2%	7.8%	1.1%	6.9%	1.0%	1.0%	NO
Concesión Ruta Interportuaria Talcahuano-Penco	9.4%	0.4%	0.5%	8.8%	0.5%	0.5%	19.1%	0.3%	0.3%	NO
Concesión Ruta 5 Tramo Río Bueno - Puerto Montt	5.2%	0.5%	0.5%	4.7%	0.5%	0.5%	9.4%	0.4%	0.4%	NO
Concesión Nuevo Aeropuerto Regional de Atacama	12.8%	0.4%	0.4%							NO
Concesión Sistema Américo Vespucio Sur, Ruta 78-Av.Grecia	11.4%	0.5%	0.6%	10.7%	0.6%	0.6%	13.9%	0.4%	0.5%	NO
Concesión Sistema Américo Vespucio Norponiente, Av.El Salto-Ruta 78	7.9%	0.6%	0.6%	7.1%	0.6%	0.7%	10.3%	0.5%	0.6%	NO
Concesión Variante Melipilla	7.8%	0.8%	0.9%	6.7%	1.0%	1.1%	7.3%	0.9%	1.0%	NO
Concesión Sistema Oriente - Poniente (Costanera Norte)	9.6%	0.4%	0.5%	9.0%	0.5%	0.6%	20.8%	0.4%	0.4%	NO
Concesión Acceso Nororiente a Santiago	7.3%	0.8%	1.0%	5.9%	1.0%	1.1%	8.1%	0.9%	1.1%	NO
Concesión del Aeropuerto Chacalluta de Arica	5.8%									NO
Concesión Camino Internacional Ruta 60 CH	14.9%	0.6%	0.6%	14.3%	0.6%	0.7%	17.1%	0.5%	0.5%	NO
Concesión Variante Vespucio El Salto-Kennedy (Túnel San Cristóbal)	7.2%	0.9%	1.0%	5.7%	1.2%	1.3%	9.3%	1.1%	1.2%	NO
Segunda Concesión Aeropuerto El Tepual de Puerto Montt	3.5%									YES
Segunda Concesión Acceso Vial Aeropuerto Arturo Merino Benitez	25.2%	380.9%	1.5%	25.2%	352.8%	1.6%				NO
Concesión Ruta 160 Tramo Tres Pinos - Acceso Norte a Coronel	10.4%	2.0%	2.3%	9.1%	1.9%	2.2%				NO
Concesión Ruta 5 Tramo Vallenar - Caldera	3.5%	64.8%	2.9%	4.2%	46.7%	3.2%	2.1%	12.9%	3.0%	NO
Segunda Concesión Aeropuerto Carlos Ibáñez del Campo de Punta Arenas	-17.9%	7.7%	1.5%							NO
Concesión Autopista de la Región de Antofagasta	5.7%	11.8%	3.2%	2.3%	20.2%	4.6%	-0.6%	19.4%	4.1%	NO
Concesión Nuevo Aeropuerto Región de La Araucanía	-4.3%	58.6%	4.0%							NO
Concesión Ruta 5 Tramo Puerto Montt - Pargua	8.2%	4.4%	2.5%	6.4%	6.5%	2.9%	10.3%	4.8%	2.9%	NO
Segunda Concesión Aeropuerto El Loa de Calama	-23.0%	41.6%	4.2%							NO
Concesión Alternativas de Acceso a Iquique	0.4%	17.1%	5.7%	2.8%	20.7%	3.7%	0.5%	23.9%	3.5%	NO
Segunda Concesión Aeropuerto Cerro Moreno de Antofagasta	-4.5%	53.5%	11.5%							NO
Segunda Concesión Aeropuerto Diego Aracena de Iquique	-3.7%									YES
Tercera Concesión Aeropuerto Diego Aracena de Iquique	-14.2%									YES
Segunda Concesión Aeródromo La Florida de La Serena	-9.6%	273.0%	6.0%							NO
Tercera Concesión Aeropuerto El Tepual de Puerto Montt	13.2%									NO

C Regression Tables

Table A4: Auxiliar regression for Variable term contracts

	(1)	(2)
CF as % of I_0	0.069*	0.049
	(0.03)	(0.03)
Concession's fixed effect	0.662*	1.293***
	(0.24)	(0.28)
Year fixed effect	0.201	0.429*
	(0.21)	(0.15)
Year of operation fixed effect	0.607***	0.632***
	(0.14)	(0.11)
Constant	0.100***	0.078***
	(0.02)	(0.02)
Observations	181	142
R^2	0.54	0.73

Notes: The dependent variable is Toll Revenue as % of I_0. (1) shows estimated parameteres for the model considering all variable term contracts, and (2) only highway variable term contracts. Both models are estimated separately. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A5: Descriptive regressions excluding post 2010 contracts

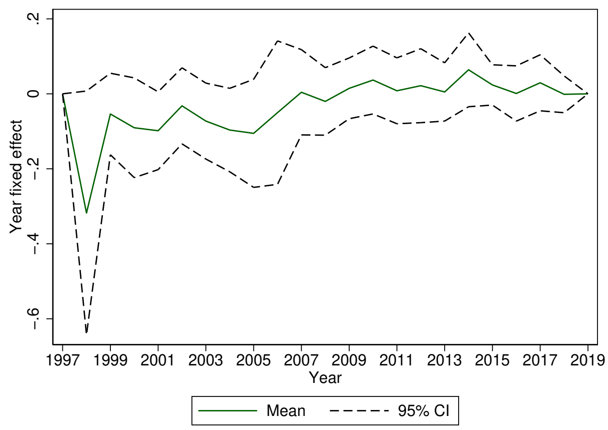
	(1)	(2)	(3)
Variable Term	-0.068*	-0.068*	-0.072*
	(0.03)	(0.03)	(0.03)
Airport Concession		-0.048	-0.055
		(0.03)	(0.03)
Reneg. per year (% of MOP Budget)			-0.225
			(0.27)
Constant	0.106***	0.121***	0.130***
	(0.01)	(0.02)	(0.02)
Observations	45	45	44
R^2	0.15	0.22	0.22

Notes: The dependent variable is the Median IRR from our baseline estimates. Variable term and Airport Concession are dummies with take value equal to 1 when the project fulfills such condition. Renegotiations per year as % of MOP Budget represent the whole renegotiated amounts up to 2019, divided among all the years of concession. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

D Graphs

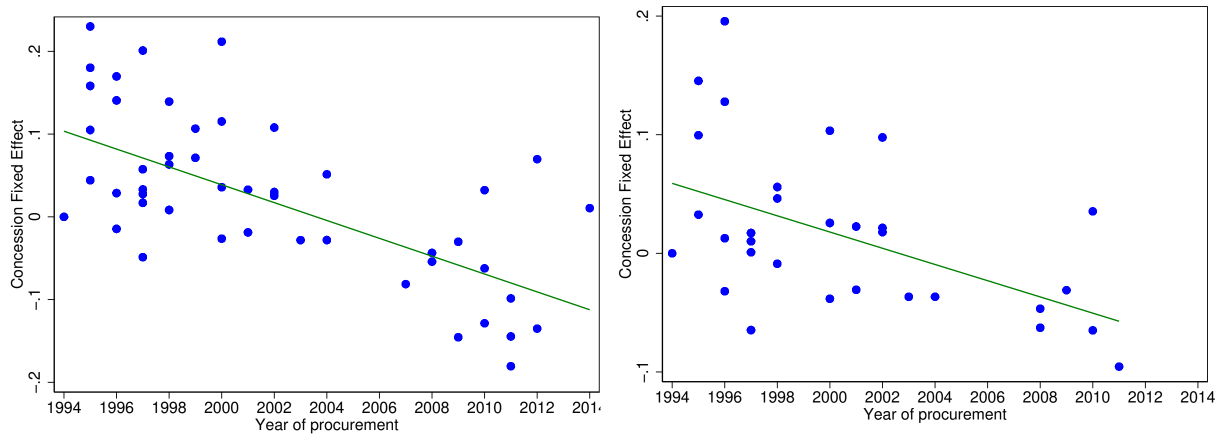
Figure A1: Estimated fixed effects - only highways

(a) Year of operation fixed effects



(b) Calendar-year fixed effects

Figure A2: Concessions' fixed effects

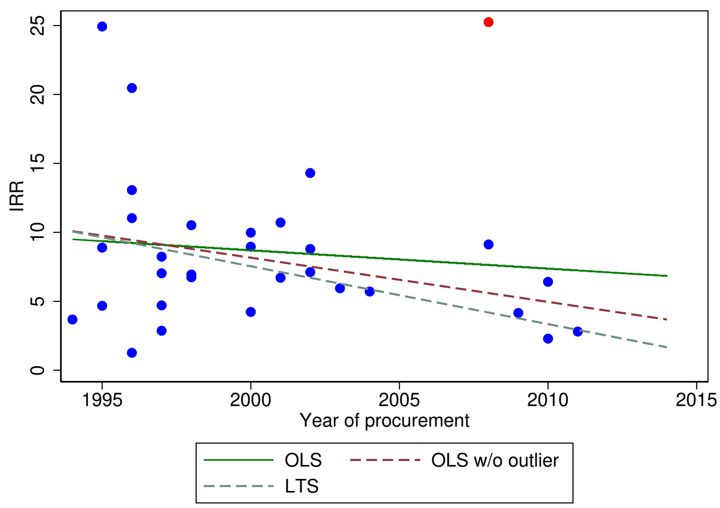


(a) Concession's fixed effect vs Year of procurement.

(b) Concession's fixed effect vs Year of procurement - only highways

Notes: The graphs plot the estimated concessions' fixed effects obtained from the baseline model presented in Section 3 against the year of procurement of the contract. Panel (a) show the fixed effects of the model considering all the projects and panel (b) considering only highways.

Figure A3: IRR vs Year of procurement. Only highways with robust regressions



Notes: The outlier is pointed with a red dot. We ran OLS regressions with and without that observation. We also ran Least Trimmed Squares regression, which estimates parameters excluding the upper and lower 25% percentile, based on Leroy and Rousseeuw (1987).

E Cost of Debt

To estimate the cost of debt for a PPP project, we proceed as follows: First, we assume that cost of debt is a risk-free rate plus a corporate spread. Second, we obtain the minimum required equity share, α, from the concession contract and we assume that the firm finances with debt the remaining fraction $(1-\alpha)$ of the project. Third, we assume that firms acquire debt in the construction period, financing the first fraction α with equity and the remainder with debt. Thus, the effective rate is approximated by the average rate of the last $(1-\alpha)m$ months of construction.[24] For simplicity, we impose that a month's rate is the average rate of the corresponding year. Fourth, we assume that firms finance the entire project at this rate.[25]

Additional assumptions are the following:

- For 2003 and prior years, the cost of debt is approximated by the rate of a 20-year treasury bonds discounted by effective inflation plus an average Moody's BAA bond spread.
- For years 2004 to 2011, the cost of debt is the rate of a 20-year inflation-indexed treasury bonds plus an average Moody's BAA bond spread.
- For years 2012 to 2019, the cost of debt was obtained from information provided by Chile´s financial regulator (CMF) on the rates for several syndicated corporate loans, including many concession projects. For companies included in this data set, we use their cost of debt. For those not included but which started the concession in this period, we use the average cost over the 2012-2019 period.

The above assumptions ignore the fact that prior to the financial crisis of 2007, many concessions were financed with monolines (see Engel *et al.* (2010)) which presumably led to a lower cost of financing. Unfortunately there is no data on the premia paid by the SPVs to have the monolines insure AAA ratings. Table A6 present the results for the 50 PPPs in our sample.

Table A6: Average Debt Cost

	All	Fixed Term	Variable Term
Mean	5.4%	5.6%	5.2%
Median	5.9%	6.0%	4.9%
SD	0.9%	0.8%	1.0%
25% Quantile	4.4%	4.9%	4.2%
75% Quantile	6.2%	6.2%	6.2%
N	50	31	19

[24]For example, for a project with $\alpha = 0.25$ and 48 months of total construction time, the debt cost rate will be the average rate of the last 36 months.

[25]Incorporating the fact that the SPV often issues bond when construction ends does not change our estimates significantly, since this amounts to giving more weight to the final months of the construction period in our estimates.