RENEGOTIATIONS AND CORRUPTION IN INFRASTRUCTURE: THE ODEBRECHT CASE

Preliminary and incomplete

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Abstract

In 2016 Brazilian construction firm Odebrecht was fined $2.6 billion by the US Department of Justice (DOJ). According to the plea agreement, between 2001 and 2016 Odebrecht paid $786 million in bribes to politicians and public officials in ten Latin American and two African countries. The bribes helped it obtain around 150 contracts for major infrastructure projects. The DOJ estimated that bribe payments increased Odebrecht's profits by $3.2 billion, the largest amount ever among cases prosecuted under the Foreign Corruption Practices Act passed in 1977.

Judicial documents and press reports on the Odebrecht case have revealed detailed information on the working of corruption in the infrastructure sector. We use this and other information to establish four facts. First, we find a systematic link between contract renegotiations and corruption. For projects where Odebrecht paid bribes, renegotiations averaged 71.3 percent of the original estimated cost, in contrast with 6.5 percent for projects where the Brazilian firm paid no bribes. Second, the bribes Odebrecht paid were small compared with the investments at stake, of the order of one percent of project total costs. Third, Odebrecht's profits also were small, both in projects where it paid bribes (less than two percent of total investment) and in its overall operation. Fourth, after the creation in 2006 of the Division of Structured Operations (DSO), a unit that centralized and streamlined bribe payments, Odebrecht's sales increased almost ten-fold while its profits remained small.

We present a model that predicts a large increase in Odebrecht's market share without a commensurate increase in profits. In our model, firms pay bribes to increase their bargaining power in renegotiations, projects are assigned in competitive auctions, and firms anticipate renegotiations. In equilibrium, firms' profits are small, there is substantial lowballing, and renegotiated amounts are large. When similar firms compete intensely in the auction, innovation by one firm in the bribing technology substantially increases its market share, without a significant increase in profit margins.

JEL Codes: H54, H57, K42.

Keywords: Corruption, infrastructure, bribes, auctions, renegotiations, lowballing.

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1 Introduction

It is widely believed that corruption in infrastructure is widespread and costly, and that the bribes that firms pay to public officials and politicians are large. Yet the evidence on which these beliefs are based is scant. Indeed, little is known about how corruption works, how much firms pay to politicians and public officials, and what firms receive in exchange for these payments. In this paper we present novel evidence on how corruption works, report reliable data on the amounts of bribes paid, and build a model consistent with our findings.

Our window into the workings of corruption is the Odebrecht case. In 2016 the Brazilian construction firm Odebrecht was fined $2.6 billion by the US Department of Justice (DOJ). Between 2001 and 2016, Odebrecht paid $788 million in bribes to politicians and public officials in ten Latin American and two African countries in around 150 contracts for major infrastructure projects. The DoJ estimated that by paying bribes, Odebrecht increased its profits by $3.2 billion, the highest amount among cases prosecuted under the Foreign Corruption Practices Act passed in 1977. The detailed project-level data collected by the DOJ on bribe payments, the legal statements of close to 100 Odebrecht executives who planned, designed and managed the corruption scheme, and a host of media reports reveal several novel facts about corruption in infrastructure.

One of the striking facts emerging from the Odebrecht case is the large and positive correlation between bribe payments and the size of contract renegotiations. We analyze all projects in which Odebrecht participated in eight countries during the period considered in the plea agreement with the DOJ, and find that in the 63 projects where Odebrecht paid bribes the amounts invested increased by 71.3 percent after renegotiations, more than ten times as much as in the 27 projects were it did not pay bribes (6.5 percent). Also, and despite the fact that renegotiated amounts were large, the bribes that Odebrecht paid were small relative to invested amounts—of the order of 1 percent of initial investments.

Similarly, and perhaps as striking, over the entire period of the plea agreement, Odebrecht made small profits, of the order of one percent of sales, both in projects where it paid bribes and in the rest of its operations. Indeed, it seems that all profits Odebrecht made during this period (around US$2.5 billion) came from bribing. The last fact is that Odebrecht became an innovator in bribe paying in 2006, by creating the Division of Structured Operations (DSO), a stand-alone internal bribe department in charge of vetting bribes and making payments in off-shore accounts. The creation of the DSO was followed by exponential growth both in sales and in bribe payments.

We build a model that combines competitive auctions to assign infrastructure projects with bilateral renegotiations after the contract is awarded. Our aim is to provide a coherent setting that incorporates the four facts mentioned above. Two assumptions, which reconcile the fact that renegotiated amounts are large when bribes are paid and yet firms make small profits, are central. First, by bribing, a firm increases its bargaining power—that is, in a bilateral renegotiation, a firm that bribes obtains a larger share of the surplus being renegotiated. Second, we assume that auctions are competitive, so that the project is awarded to the lowest bid.

We first analyze an auction where firms draw their cost parameter from identical distribution and are equally efficient in bribing, the equilibrium prior to the creation of the DSO. In the first stage of the

game, firms compete in an auction for the contract; in the second stage the contract is renegotiated with positive probability. In equilibrium, firms anticipate that, conditional on winning, they will renegotiate the contract. Because renegotiations are not competitive, firms obtain a rent, but competition in the auction forces each firm to bid below cost to dissipate it. Thus, assuming competition in the auction rationalizes the observed fact that firms obtain low profits, despite of the fact that they renegotiate bilaterally.

Our model shows that conditional on bribing, the firm appropriates a larger fraction of any surplus that can be appropriated in a renegotiation. In equilibrium, therefore, lowballing increases and renegotiated amounts are larger with bribes. The relation between bribes and renegotiated amounts thus suggests that firms bribe to buy goodwill and obtain better terms in renegotiation. However, competition in the auction dissipates the rents thus acquired.

Our model has additional implications that go beyond the observed correlation between bribes and renegotiations, and which are driven by competition in the auction. First, cost overruns are not unexpected, but result from the anticipation of renegotiations. Moreover, we provide content to the belief that large cost overruns suggest corruption. Essentially, bribes stimulate cost overruns because they increase renegotiation rents, thereby leading to lowballing in the auction. Second, small bribes are necessary for cost overruns to be large. If bribes are large, there is little surplus left to split in a renegotiation, firms bid close to costs in the auction and renegotiations are small. Third, because firms that pay bribes expect to earn more in renegotiations, they can bid more aggressively. Competition does nor "protect" firms that do not pay bribes and they are at a clear disadvantage in the auction. Last, we show that when all firms are similarly efficient in paying bribes, their profits depend neither on the size of the bribes they have to pay, nor on the frequency of renegotiation or the size of renegotiation rents—there is little relation between bribing and firm profits. This occurs because when firms are symmetric in terms of bribing and renegotiation, they compete away the rents wrought by renegotiation through lowballing. Because of this, the auction is decided only by cost differences and the most efficient firm wins. Thus, from the point of view of the result of the auction, corruption and bribes are a wash.

Next we take our model to task and analyze the equilibrium when one firm enjoys a cost advantage in bribing, the equilibrium after the creation of the DSO. When competition in the auction is intense, an advantage in bribing buys a large increase in the probability of winning, but only a modest increase in profits. Moreover, the increase in profits is proportional and of the same order as the size of the bribes—exactly what we see in the data. This is reminiscent of Bertrand competition with homogeneous products: a small cost advantage generates a large change in market share but no commensurate increase in profits.

Relation to the literature

[To be provided.]

The remainder of the paper is organized as follows. Section 2 describes the facts on corruption in infrastructure revealed by the Odebtrecht case. Section 3 builds a model aimed at explaining these fact in a coherent framework. Section 4 provides a discussion on the implications of our model. Section 5 concludes and is followed by several appendices.

2 Facts

Table 1 shows information about corruption, culled from the DOJ Statements of Marcelo Odebrecht, the company's CEO. The first two columns are derived directly from Odebrecht's plea agreement. The first column reports bribes paid by Odebrecht in each country. The second column reports, as stated in the Statement of Facts in the agreement, "any profit earned on a particular project for which a profit was generated as the result of a bribe payment."

Table 1: Profits and bribes according to the Department of Justice

Country	Bribes US$MM*	Gross Profits US$MM**	Bribes/Profits (%)	Investment (US$MM)***	Period	Projects
Argentina	35	278	12.6	12.515	2007-2014	8
Brazil	349	1900	18.4		2004-2016	
Colombia	11	50	22.0	1.828	2009-2014	4
Ecuador	33,5	116	29.3	3.465	2007-2016	10
Guatemala	18	34	52.9	384	2013-2015	1
Mexico	10,5	39	28.2	2.158	2010-2014	6
Panama	59	175	33.7	8.843	2010-2014	21
Peru	29	143	20.3	12.868	2005-2014	24
Dominican Republic	92.0	163	56,4	3.959	2001 -2014	16
Venezuela	98				2006-2015	
Angola	50	262	19.1		2006-2013	
Mozambique	0,9				2011-2014	
Total	**785.9**	**3159,9**	**24.9**	**46.620**	**2001 - 2016**	**90**

*The information comes from the Plea Agreement against Odebrecht S,A. of the Department of Justice (DOJ) United States of America, **The term benefit as used in the Statement of Facts relates to any profit earned on a particular project for which a profit was generated as the result of a bribe payment. As stated in the agreement, for projects that resulted in profits to Odebrecht that were less than the amount of the associated bribe payment, the amount of the bribe payment was used to calculate the benefit, ***Investment: authors' calculations.

We are able to determine investments, both before and after renegotiations, as well as whether bribes were paid or not, for all Odebrecht projects in eight countries during the period considered in the agreement.[2] These countries include all countries in Latin America mentioned in the agreement, with the exception of Venezuela (because of data limitations) and Brazil (which we plan to include in future versions). This amounts to 90 projects provided either as a public-private partnership (21 projects) or the traditional approach (69 projects).

The data analysis that follows considers information from the 90 projects mentioned above and additional sources to establish and the following facts central to the model we develop in section 3. First, renegotiations were much larger when bribes were paid. Second, bribes and profits are "modest" relative to investments. Third, Odebrecht made important innovations in bribing technology. Fourth, Odebrecht increased its market share and volume more than three-fold following this innovation. Fifth, auctions were competitive both before and after the innovation.

[2]The countries are Argentina, Colombia, Dominican Republic, Ecuador, Guatemala, Mexico, Panama and Peru

2.1 Bribes and size of renegotiations

Contract renegotiations of infrastructure projects, especially in the case of public-private partnerships, have long been suspected of being associated with corruption,[3] yet no direct evidence existed to date. Below we establish a large and positive correlation between actual bribe payments and the size of contract renegotiations.

Table 2: Increase of value of projects after renegotiations

		Evidence on bribes	
		Only legal	Legal and Media
No bribes	Number of projects:	50	27
	Simple Avge.:	27.6%	18.4%
	Weighed avge:	11.8%	6.5%
Bribes	Number of projects:	40	63
	Simple Avge.	67.9%	57.1%
	Weighed avge.	80.9%	71.3%

Authors' calculations using data from DOJ, media and investments as reported by government agencies..

Table 2 shows the number of projects with bribes and the increase in the value of projects after renegotiations, under two interpretations. The column 'Only legal' considers evidence on bribes only from legal determinations. In contrast, the column 'Legal and Media' describes the number of projects with bribes under an interpretation that combines both data coming from legal determinations and from investigative media. The fraction of projects with evidence of bribe payment is 44 percen under the first definition and 70 percent under the second definition. The second and third rows in each set show the increase in the cost of the project after renegotiation, both weighed (by initial project investments) and unweighed. It is clear that renegotiations after a bribe are far more generous to Odebrecht than in cases when no bribe has been paid.[4] For example, if we consider evidence from legal documents and media sources, total investment in the 63 projects where Odebrecht paid bribes grew by 71.3 percent after renegotiations, compared with 6.5 percent for the 27 projects with no bribes. Also, the fact that the difference between renegotiations with and without bribes is larger when considering weighed averages, suggests that the correlation between bribe payments and renegotiations increases with the size of the project.

2.2 Bribes and profits are small relative to investments

Table 3 shows bribes and profits accrued thanks to bribe payments, as a fraction of investments. We consider both initial investments, I_0, and investments including renegotiations, $I_0 + I_1$. Bribes as a fraction of investments are small, less than 1 percent if we consider all projects, 1.5 percent if we only consider projects with bribes and normalize by initial investments.[5] Profits generated with bribes are somewhat

[3] See Guasch and Straub (2009), etc.

[4] This positive difference is statistically significant as well (see the Appendix).

[5] For Colombia and Peru there is evidence that the DOJ-Odebrecht plea agreement underestimates actual bribe payments. Nonetheless, these percentages remain small once these additional bribes are included.

larger but still small. The largest value of 5.3 percent is obtained when considering projects with bribes and normalizing by investments before renegotiations.

Table 3: Bribes and associated profits relative to investment

	Number	Bribes/I_0	Bribes//$(I_0 + I_1)$	Profits/I_0	Profits/$(I_0 + I_1)$
Projects with bribes:	40	1.52%	0.54%	5.25%	1.87%
All projects:	90	0.59%	0.25%	2.03%	0.85%

Authors' calculations using data from DOJ, media and investments as reported by government agencies. Projects with bribes are those with evidence only from legal sources. Percentages in the first row would be smaller if also media sources were considered.

2.3 The Division of Structured Operations.[6]

In its 2016 plea agreement with the DOJ, Odebrecht admitted engaging in a massive bribery scheme beginning in 2001, in order to win business in many countries. A major development in this scheme occurred in 2006, when Odebrecht created the Division of Structured Operations (DSO) to manage and make bribe payments and illegal campaign contributions more efficient and which, according to the DOJ, effectively functioned as a stand-alone bribe department within Odebrecht. As mentioned in the introduction, the creation of the DSO was followed by exponential growth both in sales and in bribe payments.[7] We argue next that the DSO provided Odebrecht with a competitive advantage in the bribing business that explains the rapid growth in market share that followed.

Three Odebrecht executives and four secretaries worked at the DSO, in charge of paying bribes into foreign accounts or in cash through so-called *doleiros*.[8] As mentioned by the DOJ, "to conceal its activities, the Division of Structured Operations utilized an entirely separate and off-book communications system, which allowed members of the Division of Structured Operations to communicate with one another and with outside financial operators and other co-conspirators about the bribes via secure emails and instant messages, using codenames and passwords." The DSO also used a bespoke information management system (MyWebDay) for bookkeeping and to track information flow.

Bribe payments followed a clear organizational flow. Until 2009, the head of the DSO reported to the highest levels of Odebrecht to obtain approval of bribe payments. Thereafter, contract manager would deal with potential bribe recipients—public officials and politicians—and reported to the country manager. The country manager decided and paid small bribes with local funds, larger bribes had to be approved in Brazil by a business leader who reported directly to the company CEO, Marcelo Odebrecht, who had the final say.

Once a bribe was authorized, the DSO registered, managed, and made the payment through a complex

[6]Based on "Odebrecht and Braskem Plead Guilty and Agree to Pay at Least $3.5 Billion in Global Penalties to Resolve Largest Foreign Bribery Case in History." US Department of Justice. Office of Public Affairs. December 21, 2016, and other sources.

[7]In his confession, Mascarenhas da Silva, the executive who headed the DSO, told the DAs that after the division was created in 2006, the amounts paid in bribes grew from an annual average of BR$ 60-70 MM a year to BR$ 420MM in 2010 and BR$ 720 MM in 2012. Source: https://idl-reporteros.pe/asi-perdio-el-juego-odebrecht/.

[8]The DSO combined three compensation options: legal contributions to political campaigns, illegal contributions to political campaigns, and bribes paid to public officials and politicians.

network of shell companies, off-book transactions and off-shore bank accounts.[9] An independently funded parallel cash trove (Caixa 2) was used to pay bribes and campaign contributions. In this way, the DSO reduced transaction costs for bribe recipients and helped establish long-term relationships between the company and corrupt officials.

Thanks to the DSO, the center knew how much was being paid in bribes and to whom, which minimized 'leakage' when paying bribes. The size of this advantage is likely to have been large, as suggested by evidence from a major corruption case uncovered recently in Argentina, the Bribery Notebooks scandal, that also involves infrastructure projects. In this case there was little control as a driver moved bags with US dollars to several locations in Buenos Aires, including the personal house of then President Kirchner, with leakage of the order of 50 percent of bribe disbursements.

2.4 Profitability and sales: Before and after the creation of the DSO

Next we establish that Odebrecht's sales grew at a fast pace, both in Brazil and internationally, after the creation of the DSO. By contrast, its profits, as a fraction of sales, did not pick up and remained low.[10]

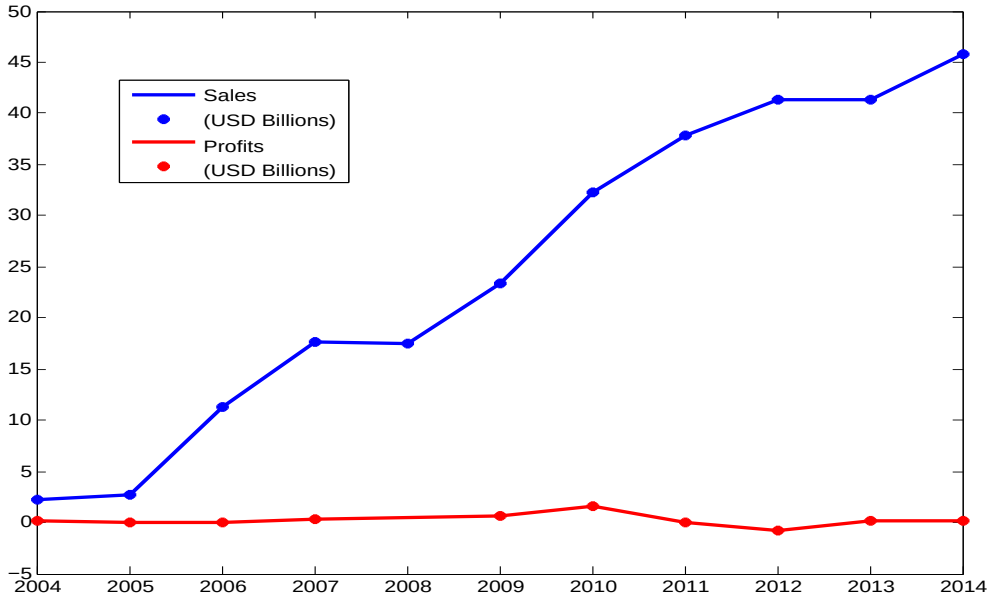


Figure 1: Total revenues and profit/revenue ratio of Odebrecht

From the Odebrecht financial statements there is a large increase in sales in 2007, the year after introducing the improvement in their corruption technology. Sales increased by 57 percent that year, and until

[9]This network included the Anrigua subsidiary of Austria's Meinl Bank, acquired for this purpose by Odebrecht. Source: https://bloomberg.com/news/features/2017-06-08/no-one-has-ever-made-a-corruption-machine-like-this-one

[10]In the appendix we present evidence suggesting that overall for firms in the infrastructure sector, profits, as a fraction of sales, are low.

the Lava Jato case in 2014, the rate of increase in sales was 20 percent per year. However, the profitability on these sales remained limited and on average was lower than 2 percent. This can be seen in figure 2.4 which shows both sales and the rate of profits on sales for the years 2004-2014.[11,12]

While Odebrecht's profits as a percentage of sales were fairly low—of the order of one percent—, paying bribes was quite profitable. To see why, note that over the period covered by the plea agreement and according to its financial statements, Odebrecht made US$2.4 billion in profits (a number that excludes the unavailable profit data for 2008). This is a respectable 11.3 percent rate of return on equity (higher than the 8 percent average for other Brazilian construction companies, see Appendix A), albeit only a 1 percent return on assets. Moreover, recall that the DOJ estimated that by paying US$788 MM in bribes, Odebrecht made about US$3.3BN in gross profits, that is, around US$2.5 billion net (which, not coincidentally, happens to be close to the fine that the DOJ ultimately imposed). Therefore, most of the profits Odebrecht made during the period came from bribing.

In summary, the effect of improving the corruption technology was to increase sales, without affecting the low ratio of profit over sales. At the same time, bribing significantly boosted Odebrecht's profit, which nonetheless were low.

2.5 Competitive auctions with bribes

Elsewhere we provide detailed studies on how corruption took place in a representative sample of projects with evidence of bribe payments. These studies show that, despite the payment of bribes, the environment where projects were auctioned was fairly competitive, as suggested by the low returns we described in section 2.4.

For example, the auction of Metro Line 1 in Lima, Peru, was allocated based on a weighted average of a technical score and economic offer. The technical score included subjective elements, the economic offer did not. Odebrecht bribed officials involved in assigning the technical score yet, as it turned out, would have won without the bribe since its economic offer was 18 percent lower than that of its closest competitor.

3 Model

Our aim is to explain four facts within a unified framework. First, conditional on bribes, the model should yield substantial lowballing and large renegotiations. Second, conditional on no bribes, the model should yield negligible lowballing and small renegotiations. Third, even when paying bribes, firms should make small profits in equilibrium. Last, a firm enjoying a cost advantage in bribing should see a major increase in market share without a significant increase in profits.

Two assumptions, which are consistent with the facts of the case, are central in our model. First, by bribing, a firm increases its bargaining power, that is, in a bilateral renegotiation the firm that bribes

[11] There is no publicly available data for Odebrecht's profits in 2008.

[12] The relatively low profits depicted in this figure are consistent with a very different source of information: during the last decade, according to Forbes, net worth of the Odebrecht family remained in the US$4-6BN range.

obtains a larger share of the surplus being renegotiated. Second, we assume that auctions are competitive, so that the project is awarded to the lowest bid.

Section 3.1 provides the basic set up. Section 3.2 characterizes the timeline of the auction and renegotiation and derives various results consistent with the facts established in Section 2. Section 3.3 derives expressions for expected profits in equilibrium in an auction where firms are identical ex ante. We then consider, in section 3.4, how this equilibrium changes once we incorporate Odebercht?s cost advantage following the creation of the DSO.

3.1 Basic Set Up

The gross value of the project is W. This value may reflect social welfare or the value to a politician of the project. Firms are risk neutral and characterized by two parameters, θ and ρ. The parameter $\theta > 0$ is the firm's building cost. We assume that the project is socially desirable (or desirable to the politician), that is, $W > \theta$. The parameter ρ is specified shortly.

Construction costs, θ, are drawn from a distribution (details in Section 3.3). Actual draws are private information. Without loss of generality, we may assume that the firm that builds the project is selected in a competitive, second price auction. The bidding variable in this auction is revenue desired for building the project, R.

The initial contract is renegotiated, after having been auctioned, with probability $\alpha \in [0, 1]$. When a renegotiation takes place, the social surplus that is "up for grabs" is

$$V = W - R,$$

where we recall that W has two possible interpretations. First, W could be the social value of the project, assuming a benevolent government representative at the negotiating table (different from the corrupt official that receives a bribe). Alternatively, W could represent the political value to the government official renegotiating the contract, say the increase in probability of being reelected if the project is completed.

A renegotiation consists in dividing the net surplus from the project between the firm, government and the public official receiving the bribe. This means that a renegotiation is a means by which the firm can claw back part of the benefits of the project, or of a lowball offer that allowed it to get the contract in the first place. Specifically, when a contract is renegotiated, a fraction x of this surplus goes to the corrupt official while the remainder is divided in proportion ρ to $1 - \rho$ between the firm and the country. Figure 2 summarizes the timeline of the model.

The parameter $\rho \in [0, 1]$ captures the firm's renegotiating ability. A higher renegotiating parameter implies that the firm obtains a higher fraction of the amount of net social welfare V if there is a renegotiation of the contract.

There exist two types of projects, those where a public official will be available at the renegotiation stage to benefit the firm and those where not. Firms know the type of project when they make their bids. Also, the value of ρ is larger for projects where goodwill at the renegotiation can be bought with a bribe. In presenting the model below we consider a project with bribe payments, yet the model also applies, albeit

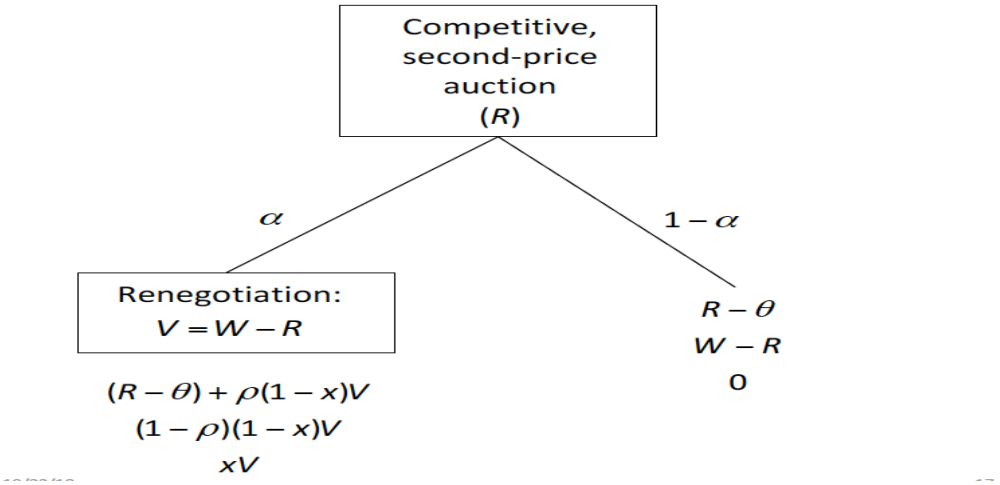


Figure 2: Timeline of the auction

with different values for ρ and $x = 0$, to projects without bribes.

3.2 Competitive auction and renegotiation

If the firm wins and the second highest bid is $\tilde{R}$, its profits are

$$\Pi(\tilde{R}) \equiv \tilde{R} - \theta + \alpha\rho(1-x)(W-\tilde{R}), \tag{1}$$

where $\tilde{R} - \theta$ represents profits if no renegotiation takes place and $\alpha\rho(1-x)(W-\tilde{R})$ corresponds to expected profits from the renegotiation. These benefits are higher if renegotiations are more likely or the firm's bargaining power is higher (larger value of $\alpha\rho$). They also grow with the amount up for grabs at a renegotiation, $W - \tilde{R}$.

Because firms compete in a second price auction it is a dominant strategy to make a zero-profit bid. Hence, bids can be derived from the firm's zero expected profit condition:

$$R - \theta + \alpha\rho(1-x)(W-R) = 0.$$

This yields

$$R = \theta - \frac{\alpha\rho(1-x)}{1-\alpha\rho(1-x)}(W-\theta), \tag{2}$$

and implies that firms bid below their costs.

Note that firms anticipate that, conditional on winning, they will renegotiate the contract with probability α. Because renegotiations are not competitive, firms obtain a rent when they renegotiate. Nevertheless, competition in the auction forces each firm to bid below cost to dissipate the renegotiation rent. Thus, assuming competition in the auction is necessary to rationalize the observed fact that firms obtain low profits even though renegotiated amounts are substantial.

It follows from (2) that the firm lowballs by

$$\mathcal{L} \equiv \theta - R = \frac{\alpha\rho(1-x)}{1-\alpha\rho(1-x)}(W-\theta) > 0. \tag{3}$$

This amount is increasing in α, ρ and $W-\theta$. By contrast, a higher bribe reduces the amount for grabs at a renegotiation and therefore lowers $\mathcal{L}$. We also have that a combination of large ρ and α, and small x, yields substantial lowballing. By contrast, large values of x lead to small lowballing.

The following results follow directly and summarize the relation between bribes and large renegotiations that we observe in the data.

Result 1 *A combination of large α and ρ, small x, and large $W-\theta$, yields substantial lowballing and large renegotiations.*

Result 2 *If the value of ρ for contracts with bribes is larger than the value for contracts without bribes, then bids are lower and lowballing is higher when bribes are paid.*

Results 1 and 2 explain the first two facts described in Section 2. Conditional on bribing, the firm obtains a larger fraction of any surplus that can be appropriated in a renegotiation. In equilibrium, lowballing increases and renegotiated amounts are larger. The relation between bribes and renegotiated amounts thus suggests that firms bribe to buy goodwill and obtain better terms in the renegotiation. However, competition in the auction dissipates the rents thus acquired.

Renegotiations are often attributed to unexpected cost overruns. Nevertheless, results 1 and 2 suggest that cost "overruns" are endogenous and a result of the expectation of a renegotiation. Moreover, the fact that construction firms make small profits even though renegotiated amounts are large, suggests that overruns are anticipated, not unexpected.

The following result, reveals a surprising relation between the size of the bribes and the magnitude of renegotiations (and lowballing).

Result 3 *Large bribes (a large x) would yield both small lowballing and small renegotiations.*

The mechanics of result 3 is surprising, but straightforward. If x is large and close to 1, there is little surplus left to split in a renegotiation. In this case, when firms compete in the auction their bids tend to be close to cost and renegotiations are small. Result 3 suggests, therefore, that large renegotiations indicate that small bribes are being paid.

The last implication is that bribes, renegotiations and competitive auctions may exclude firms that do not pay bribes.[13]

Result 4 *A firm that decides not to bribe, when others are willing to bribe, faces a competitive disadvantage.*

[13]Implicit in the result that follows is an extension of our model, where bribing is optional in projects where paying bribes is a possibility.

Consider the firm's decision of whether to bribe or not in a project where bribes can buy goodwill at a renegotiation. That is, $\rho = \rho^B$ if the firm anticipates paying the bribe and $\rho = \rho^N$ otherwise, with $\rho^B(1-x) > \rho^N$.[14] The logic of result 4 can then be appreciated by noting that,

$$R^B = \theta - \frac{\alpha\rho^B(1-x)}{1-\alpha\rho^B(1-x)}(W-\theta) < \theta - \frac{\alpha\rho^N}{1-\alpha\rho^N}(W-\theta) = R^N,$$

where R^B and R^N denote the firm's bid with and without bribes. That is, when $(\rho^B - \rho^N)/\rho^B > x$, firms that pay bribes expect to earn more in renegotiations and bid more aggressively.

3.3 Pre-innovation equilibrium

We analyze the equilibrium prior to Odebrecht's innovation in the bribe technology in 2006. We consider a competitive auction with two identical firms. The project-specific values of θ for both firms are independent draws from a normal distribution with mean $\bar{\theta}$ and variance σ^2.[15] Their renegotiation parameter, ρ, is fixed and takes the same value for both firms.

Denoting by θ_i and R_i the draw of θ and the bid of firm i, $i = 1, 2$, it follows from (2) that

$$R_i = \theta_i - \frac{\alpha\rho(1-x)}{1-\alpha\rho(1-x)}(W-\theta_i), \quad i = 1, 2.$$

Firm 1 wins if and only if $R_1 \leq R_2$ which is equivalent to $\theta_1 \leq \theta_2$, which happens with probability 1/2. It follows from (1) that when it wins, firm 1's profits are given by

$$\Pi_1(R_2) = R_2 - \theta_1 + \alpha\rho(1-x)(W-R_2) = \theta_2 - \theta_1.$$

The public official expects to collect bribes in the amount of

$$B = \alpha x(W-R_2) = \frac{\alpha x}{1-\alpha\rho(1-x)}(W-\theta_2),$$

and social surplus (or the surplus of the politician, depending on the interpretation of W), is given by

$$S = \frac{1-\alpha\rho}{1-\alpha\rho(1-x)}(W-\theta_2).$$

Total surplus—the sum of Π_1, B and S—is equal to $W - \theta_2$. Bribes are paid one-for-one by consumers, firms' profits do not depend on the size of the bribes and all projects that are socially valuable (or valuable to the politician) get built.

We summarize the above results in the following proposition:

Proposition 1 (Pre-innovation equilibrium) *Consider two firms with the same parameter ρ and where their values of θ are i.i.d. draws from a normal distribution with mean $\bar{\theta}$ and variance σ^2.*

[14] That is, the increase in renegotiation power associated with bribe payments is large enough to compensate for bribe payments.

[15] Since the variance is small, the fact that a normal distribution can take negative values is irrelevant in what follows. Similarly, if $\bar{\theta}$ is sufficiently smaller than W, the probability that θ takes values larger than W will also be negligible

Then, firm 1 wins if $\theta_1 < \theta_2$, which happens with probability 1/2. Expected profits for firm 1 and expected bribe payments for the public official[16]

$$\begin{aligned} \mathrm{E}[\Pi_1] &= \frac{\sigma}{\sqrt{\pi}}, \\ \mathrm{E}[B] &= \frac{\alpha x}{1-\alpha\rho(1-x)}\mathrm{E}[\min(W-\theta_1, W-\theta_2)]. \end{aligned}$$

Proof See Appendix B. ∎

It follows from proposition 1 that expected bribe payments are increasing in x, α, ρ and W and decreasing in the highest cost draw among firms. More interesting, proposition 1 also implies that profits neither depend on the bribing parameter x, nor on the renegotiation parameters α and ρ, that is, there is no relation between the size of bribes and firm profits. On the one hand, when σ is low, construction firms have similar costs and compete intensely in the auction. Consequently, profits are low, despite the fact that renegotiations are large. The data, therefore, suggests that competition in the auctions is intense. On the other hand, if cost dispersion is large, competition is not intense and profits are large. In this case profits have little to do with bribes and renegotiations. Why? Technically, in the model this occurs because the lowballing expression vanishes from the firm's profit. The economics is that when firms are symmetric in terms of bribing and renegotiation, they compete away the rents wrought by renegotiation through lowballing. Because of this, the auction is decided only by cost heterogeneity—bribes and corruption are a wash as far as auction outcome is concerned.

We now show that heterogeneity in bribing is key to explain Odebrecht's increase in market share.

3.4 Post-innovation equilibrium

Assume now that firm 1 (Odebrecht) innovates in the bribing business, so that it needs to pay a fraction $(1-\gamma)x$ of the renegotiated amount to the corrupt official, instead of x. The parameter $\gamma \in (0, 1]$ measures the size of the innovation. This captures both the reduction in leakage for the bribing firm and the decrease in transaction costs for the corrupt official that resulted from the creation of the DSO (see section 2.3). Otherwise the assumptions are the same as in section 3.3.

With the same rationale that led to (2), and denoting $x_1 = (1-\gamma)x$ and $x_2 = x$, we obtain that the i-th firm's bid will be:

$$R_i = \theta_i - \mathcal{L}_i,$$

with

$$\mathcal{L}_i = \frac{\alpha\rho(1-x_i)}{1-\alpha\rho(1-x_i)}(W-\theta_i).$$

As before, the amount by which the firm lowballs in the auction increases with α and ρ. Also, the firm with the advantage in bribing technology will lowball by more than its competitor. Facing a reduced bribe

[16] The expression that follows includes the possibility that firm one does not win the auction. Expected profits conditional on winning are twice as large.

payment leaves more money for the firm and increases profits from the renegotiation, which in turn leads to a more aggressive bid.

Firm 1 wins if $R_1 < R_2$, that is if

$$\theta_1 < \theta_2 + \frac{\alpha\rho\gamma x}{1 - \alpha\rho(1 - x)}(W - \theta_2). \tag{4}$$

It follows that firm 1 may win even when it is less efficient than firm 2, a scenario that is impossible when firms have identical bribing technologies. This introduces an allocative inefficiency in the post-innovation equilibrium that was not present in the symmetric case. The magnitude of this inefficiency can be measured by the second term on the r.h.s. of (4). This term is equal to the largest cost disadvantage that can be compensated by an advantage in the bribing technology. As expected, the inefficiency increases with the bribe parameter, x, and with the bribe innovation parameter, γ. Also, the size of the inefficiency (and the advantage of firm 1 due to its superior bribe payment technology) is amplified by the likelihood of renegotiations, α, and by the firm's bargaining power, ρ, since the amount up for grabs at a renegotiation increases with both these parameters.

When firm 1 wins, its profit with be equal to

$$\Pi_1(R_2) = R_2 - \theta_1 + \alpha\rho(1 - x)(W - R_2) = \theta_2 - \theta_1 + \frac{\alpha\rho\gamma x}{1 - \alpha\rho(1 - x)}(W - \theta_2).$$

Compared with the symmetric case where the firm's profits are $\theta_2 - \theta_1$, the firm with the bribing advantage obtains an extra profit equal to the efficiency cost associated with having the less efficient firm build the project. This advantage is proportional to x, and therefore likely to be small when bribes are small. Nonetheless, if productivity shocks are small as well (small σ), the increase in firm 1's market share following an innovation in bribing can be large. Firm 1 will win most projects (because σ is small) but rents from its bribing advantage will be small (because x is small). We formalize this insight in the following proposition:

Proposition 2 (Post-innovation equilibrium) *Consider the same assumptions as in proposition 1, yet allow for firm-specific values of the bribe parameter x: $x_1 = (1 - \gamma)x$ and $x_2 = x$ with $0 < \gamma \leq 1$. Define*

$$C = \frac{\alpha\rho\gamma x}{1 - \alpha\rho}. \tag{5}$$

Then, firm 1 wins if and only if

$$\theta_1 < \theta_2 + C(W - \theta_2),$$

and the firm's profits, conditional on winning, are equal to

$$[\Pi_1 | wins] = \theta_2 - \theta_1 + C(W - \theta_2). \tag{6}$$

Define

$$\mu = C(W - \bar{\theta}), \quad \tau^2 = [(1 - C)^2 + 1]\sigma^2.$$

The probability that firm 1 wins and its unconditional expected profits are then given by:

$$\Pr(\textit{Firm 1 wins}) = \Phi(\mu/\tau), \tag{7}$$

$$\mathrm{E}[\Pi_1] = \mu\Phi(\mu/\tau) + \tau\phi(\mu/\tau), \tag{8}$$

where Φ and ϕ denote the cumulative distribution function and probability density function for a standard normal random variable.

Proof See Appendix B. ∎

The general lesson from Proposition 2 is that when competition in the auction is intense (small σ) and bribes are small (small x), an advantage in bribing buys a large increase in the probability of winning but only a modest increase in profits. A competitive advantage in bribing implies a positive value of μ, thus μ/τ can be arbitrarily large when competition is intense and it follows from (7) that the probability that firm 1 wins will take values close to one. By contrast, it follows from (8) that expected profits will increase little, since the first term on the r.h.s. is proportional to x and the second term is proportional to σ. This is reminiscent of Bertrand competition with homogeneous products: a small cost advantage generates a large change in market share but no no major difference in profits.

4 Implications

[To be provided.]

5 Conclusion

[To be provided.]

References

[To be provided.]

Appendix

A Profit rates in the infrastructure sector

On of the striking features of the infrastructure industry worlwide is that profitability, as a fraction of sales, is low. This may seem at odds with the notion that there is corruption in the industry, and that corruption would lead to large profits (in terms of sales) for the corrupting firms. To examine this issue we have divided the world into groups of countries according to a somewhat idiosyncratic division into: Spanish Latin America, Europe without Scandinavia, Scandinavia, Japan, Korea, Australia, China, Brazil and the US.

Table 4: Average Profit Margin (profit/sales) by group of countries, in percent

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
Sp. Latin America	7,70	11,77	6,03	8,08	8,90	7,59	6,90	6,65	4,92	5,31	8,05	7,45
Australia	4,58	5,50	6,67	5,11	5,10	3,59	3,07	2,83	2,50	1,75	2,86	3,96
Brazil	8,90	7,91	6,58	7,49	4,70	6,28	-3,39	2,20	-1,43	-7,70	-22,23	0,85
China	2,16	2,66	2,28	2,54	2,08	2,48	2,50	2,45	2,54	2,71	2,83	2,48
South Korea					4,81	4,42	2,58	-2,50	-0,03	5,15	-0,02	2,06
United States	3,03	3,11	1,90	3,46	3,78	3,89	2,25	3,35	3,35	-0,48	0,06	2,52
Scandinavian	3,59	3,55	3,00	3,23	2,94	3,28	2,37	2,49	3,20	3,13	2,98	3,07
Europe	2,38	2,10	1,36	1,47	1,52	1,74	0,85	1,26	1,18	1,39	2,27	1,59
Japan	1,76	1,93	1,57	0,04	-0,32	1,05	0,30	1,00	1,56	2,01	4,34	1,39

Source: Authors.

This division provides gives a fairly broad view of the industry, considering groups of countries with different levels of corruption according to the standard indicators (Transparency International's CPI and the World Bank Control of Corruption indicator). In each country group we have looked at the 5 largest firms that have (usually) audited financial information for recent years.[17] The average rate of profits on sales is very low, with Spanish LA firms having the highest rates, as shown in table 4. Even then it is a fairly low number, and seems consistent with the higher risks of the industry in Spanish LA. Thus, the low profitability of Odebrecht does not seem to be an outlier.

While the return on sales is highest for Spanish LA countries, the return on equity in LA for the period is 13.98%, which is smaller than the 18.10% return in Australia and the 21.19% return on equity in Scandinavia, see table 5. Scandinavia has low profits on sales, but the stability of the market means that firms require less capital in order to operate, leading to the highest RoE among the groups of countries analyzed. Thus the higher margin in Spanish LA may reflect a market in which higher margins on sales are needed to obtain a reasonable return. This is corroborated when considering the variation in the return on assets, as measured by the standard deviation of annual returns, which ranges from 6.39% in Spanish LA to a 1.26% in Japan, see Table 6. Thus we conclude that this is an industry that is fairly competitive,

[17] The firms are diverse, and often have divisions that are unrelated to Infrastructure. For example, Spanish firms hace divisions that have working PPPs, which are very profitable, but are unrelated to the construction of infrastructure. Some firms include mining services, another unrelated business. Unfortunately, the profitability of the Engineering and construction division –closest to our interest– in terms of assets and equity, or even of sales is usually unavailable.

Table 5: Average return on equity by group of countries, in percent

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
Sp. Latin America	19.75	20.39	12.18	14.80	19.27	16.38	13.44	10.91	8.46	8.45	9.71	**13.98**
Australia	27.48	24.96	32.76	21.50	20.21	14.43	15.79	14.45	11.59	6.30	9.63	**18.10**
Brazil	36.15	30.10	32.15	35.89	17.20	16.71	-16.71	9.81	-6.28	3.10		**15.81**
China	23.84	18.38	5.05	9.20	7.92	8.41	8.45	8.62	8.02	9.42	9.33	**10.60**
South Korea					12.32	9.94	6.31	-8.29	0.58	6.53	-4.50	**3.27**
United States	21.05	17.93	11.16	17.46	13.80	16.89	11.27	16.65	18.69	-2.69	-0.58	**12.87**
Scandinavian	28.77	29.08	25.00	21.85	16.06	20.80	16.33	15.98	21.22	19.35	18.62	**21.19**
Europe	34.33	6.70	5.58	5.96	5.83	7.60	3.48	4.82	4.69	5.50	8.64	**8.47**
Japan	7.34	7.92	7.87	-0.57	-0.58	4.55	1.10	3.93	5.53	6.68	13.13	**5.17**

Source: Authors.

without large margins on sales, but is reasonably profitable in terms of ROE. Observe that from the point of view of welfare, having low profits on sales means that the cost of a projects does not involve large rents for the construction company. The low margins on sales and standard profitability is important for our theoretical analysis.

Table 6: Average return on assets by group of countries, in percent

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
Latin America	8.31	10.02	5.20	7.02	8.83	7.05	6.12	5.60	3.87	3.57	4.70	6.39
Australia	9.74	9.01	10.11	8.55	7.67	5.79	5.44	4.90	4.09	2.70	3.78	6.53
Brazil	17.48	13.61	15.14	11.66	3.59	5.14	-3.99	2.03	-2.38	1.00		6.33
China	2.17	2.43	1.99	2.59	2.31	2.25	2.08	1.81	1.90	1.89	1.95	2.13
South Korea					4.32	3.73	2.49	-1.88	0.08	2.56	-0.34	1.57
United States	6.81	6.13	5.37	6.96	5.57	6.62	3.94	5.93	5.61	0.07	0.39	4.86
Scandinavian	6.35	7.09	5.53	5.32	4.62	5.17	3.71	4.04	5.43	4.80	4.78	5.17
Europe	4.02	2.68	1.70	1.92	1.81	2.30	1.09	1.48	1.44	1.70	2.72	2.08
Japan	1.49	1.66	1.49	0.05	-0.35	0.88	0.27	0.91	1.44	2.02	4.04	1.26

Source: Authors.

B Proofs

[To be provided.]