Concession Contract Renegotiations: Some Efficiency vs. Equity Dilemmas*

Antonio Estache[a] Lucía Quesada[b]

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Abstract

We analyze the trade-offs between efficiency and equity and distributional conflicts in the context of contract renegotiation. We track down the possible outcomes of renegotiation initiated by the operator or the government. Society is composed by rich and poor consumers who alternate in power according to a majority-voting rule. If firm-driven renegotiations are a major concern, efficiency should not be the only variable to select an operator. Consumers may want to award the concession to a less efficient firm in order to reduce the probability of renegotiation since lower probabilities of firm driven renegotiations may be associated with higher welfare levels.

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[a] The World Bank and Université Libre de Bruxelles, ECARES, Belgium. E-mail: Aestache@worldbank.org.

[b] Corresponding author. University of Wisconsin–Madison, Department of Economics, 1180 Observatory Dr, Madison, WI 53706, USA and Centro de Estudios Económicos de la Regulación, UADE, Buenos Aires, Argentina. E-mail: lquesada@ssc.wisc.edu.

1. Introduction

During the 1990s, investments commitments in utility projects associated with some form of privatization added up to about US$750 billion in developing countries. This figure reflects commitments made through almost 2500 contracts between governments and private operators in the context of major infrastructure restructuring programs. The contracts, most of them concession contracts, were generally awarded through auctions to make the most of competition for the market ex-ante and minimize the need for discretionary regulatory decisions ex-post (Crampes and Estache, 1998). An analysis of a sample of 1000 utilities and transport contracts signed during the 1990s (Guasch, 2004) suggests that renegotiation happens in around 50% of the cases. Moreover, it suggests that the odds of renegotiations are the highest when the auction criterion is driven by the desire to minimize the average tariff to be paid by users of the services bided out. More generally, the difficulty is often related to a poor initial effort to assess the sources of demand fluctuations, often related to a limited ability to pay of a good share of the population.

These stylized facts define the policy issues this paper is concerned with. If awarding the contract to the bidder promising to cut the most the average tariff leads to renegotiations, it seems fair to be concerned with the possibility that renegotiation will end up increasing tariffs and penalizing the poorest. The main purpose of this paper is to check for some of the conditions under which there is an efficiency-equity trade-off in the context of contract renegotiation and to identify the winners and the losers of various policy options in a changing political environment.

We show that when renegotiation is a real issue, consumers may prefer to have a concession operated by a less efficient firm, since more efficient firms may ask more often for renegotiations that will increase tariffs. Furthermore, different groups of consumers may disagree about which firm should operate the concession. The negative effect of renegotiation is lower for co-owners of the concessionaire, since they participate on the increased profits of the firm. Therefore, the possibility of renegotiation creates a conflict between productive efficiency and social welfare and among different groups of consumers. Finally, we show that when firms take into account the possibility of renegotiation when submitting their bids, they are able to manipulate the outcome of the auction in their own favor.

1.1 Renegotiation and contract incompleteness

Renegotiation and contract incompleteness are quite related in the literature. The single possibility of renegotiation implies some incompleteness, because the parties are not able to commit not to renegotiate. But even this kind of incompleteness is not enough to explain why renegotiation occurs in the real world. Indeed, the renegotiation-proof principle states that any outcome that a principal can get can be achieved through a contract that leaves no room for renegotiation.

Unfortunately, there is no unique framework under which contract incompleteness can be analyzed. Tirole (1999) summarizes the main three reasons that could generate incomplete contracts. First, some contingencies that may arise during the execution of the contract cannot be foreseen when the contract is signed. Second, even if the parties could anticipate all the possible contingencies that should be included in the contract, they might be so numerous that the costs of describing them all can be prohibitive. In that case, the parties have to trade off the benefit of having a more comprehensive contract with the cost of writing new clauses. Finally, the contract can only be contingent on variables that could be verified by a third party, usually an arbitration commission or a Regulatory Agency in the context of infrastructure “privatization” contracts. If this were not the case, the contract would not be enforceable.

A seminal paper on renegotiation and incomplete information is Hart and Moore (1988). In their model they assume that actions and future contingencies are all ex post observable, but they are not verifiable by a third party. They show that in that case the parties cannot achieve an ex ante optimal level of investment and renegotiation is used to achieve ex post efficiency.

On the other hand, Aghion et al. (1994) argues that the assumption of unverifiability is not enough to explain under-investment. Very often, this problem can be overcome with an appropriate ex ante design of the renegotiation process itself. In their model, playing with the default option and the bargaining power at the renegotiation stage restores efficiency even when actions are not verifiable.

Closer to the model presented here are the papers of Jeon and Laffont (1999) and Kartacheva and Quesada (2000). Jeon and Laffont (1999) modeled a government regulating a firm under some uncertainty conditions on the demand faced by the firm and its fixed cost. They assume that both the government and the firm are myopic and are not able to anticipate future renegotiations. Ex post, if the profit of the firm is negative, the regulatory contract is renegotiated. In this context, renegotiation occurs more often when the firm is inefficient, which is not always the case in our model.

Finally, Kartacheva and Quesada (2000) assume a government auctioning the concession of some public utility. Firms anticipate that renegotiation will occur if demand is low and take this fact into account at the auction stage. Firms know that if profits are negative the government will prefer to renegotiate rather than to stop production and they will face no competition at that point. As a consequence, the announced bid will be biased downward given that a firm expects renegotiation if it makes losses. Furthermore, different firms can have different degrees of bargaining power at the renegotiation stage. Both effects give incentives for firms to announce a bid lower than the one that would have been announced without the possibility of renegotiation. This implies also that the ex post probability of renegotiation is higher.

This paper differs from the previous ones in that we allow here to have renegotiation both driven by the firm and by the government. Of course, the outcome of renegotiation will be different in one case or in the other. Moreover, we allow in our model to have two different types of consumers and, therefore, we are able to analyze how renegotiation affects differently each of these groups.

Section 2 presents a model of contract award through an auction. Society is composed by two groups of consumers, rich and poor, who alternate in power according to a majority-voting rule. After a firm has been awarded the contract, renegotiation can be driven either by the firm, in which case it will happen if the firm's profits are negative, or by the government, in which case it will occur if a new group is in power at the renegotiation stage. In Section 3 we solve the model and we obtain the characteristics of the winning firm, assuming that firms behave naively concerning renegotiations, and those of the renegotiated price. Section 4 analyzes the results in terms of efficiency and equity trade-offs. Section 5 analyzes the case in which firms are strategic in the sense that they take into account the possibility of renegotiations when bidding for the concession. Section 6 summarizes the main findings of the paper and suggests some lines of future research. All proofs are relegated to the Appendix.

2. The model

The government wants to concession a public utility. To choose the firm to operate the concession, it runs an auction and chooses the firm that bids the lowest price it will charge to users. The chosen firm will produce for two periods. We are not looking for the optimal auction from the government's perspective, but we consider the mechanism as given. So we assume that the government does not consider (or does not care about) the possibility of renegotiation when designing the auction. This behavior may be explained in several ways. It may be the case that the government overestimates its commitment power. More realistically, what may matter more is that the political cycles are much shorter than the typical concession contract duration and more often than not, the political turnover is such that the "privatizing team" of a government is no longer around when renegotiation takes place and hence has little incentive to be too concerned about it. From the viewpoint of firms, we consider a benchmark in which firms are naive, and then solve for the case in which firms are strategic. The basic results do not change with this assumption, but they are actually strengthened when firms behave strategically.

On the supply side, each firm i is characterized by two parameters. The first parameter is its marginal cost of production $\theta_i \in [\underline{\theta}, \overline{\theta}]$ and is firm i's private information. The marginal cost of production remains the same in the two periods. The second parameter is the bargaining power the firm would have whenever renegotiation occurs, $\alpha_i \in [0,1]$ and is ex ante unknown to anyone but would become common knowledge at the renegotiation stage. To simplify, we assume that all θ_i are independent and identically distributed with a cumulative distribution function $F(\theta_i)$ and probability density function $f(\theta_i)$. We consider an increasing return to scale production technology with a constant marginal cost.[1] The profit of firm i is

$$\pi_i = (p - \theta_i)\, q(p) - I,$$

where p is the price of the public utility, $q(p)$ is the demand function and I is a fixed cost.

At the auction stage, the only difference across firms is the marginal cost. Therefore, a firm with a low value of θ is unambiguously more efficient than another firm with a larger θ. On the other hand, the bargaining power, α_i, is statistically independent of the marginal cost of production, θ_i, and is drawn from a cumulative distribution function $G(\alpha_i)$ with probability density function $g(\alpha_i)$.

On the demand side, we assume that there are two groups of consumers. The first group (indexed by 1), the rich consumers, appropriates all the rents of the firm, whereas the second group (indexed by 2), the poor consumers, does not share the profits of the firm. The proportion of rich consumers in period t is $\beta_t^* \in [0,1]$. Both groups of consumers alternate in power depending on whether β_t^* is larger or smaller than 1/2. We call $S(q)$ the aggregate gross consumer utility and $u(q) = S(q) - pq$ the aggregate net utility. The demand function is $q(p)$, determined by utility maximization, so $q(p)$ is such that $S'(q(p)) = p$.

The utility function is stochastic in such a way that $q(p) = \bar{q}(p) + \tilde{\varepsilon}$, where $\tilde{\varepsilon} \sim U[-\varepsilon, \varepsilon]$ is a demand shock and $\bar{q}(p)$ is the mean demand function. We assume that demand shocks are small in the sense that, even under the worst possible demand conditions, any firm charging the monopoly price makes strictly positive profits. Once the demand function is realized it remains the same in both periods. That is, at the end

[1] The assumption of a constant marginal cost is made just to simplify computations and all our results will still be valid with a more general cost function of the form $C(q(p),\theta_i)$, increasing in θ_i, increasing and convex in q.

of the first period, when renegotiation can happen, the demand for the second period is perfectly known.

In this model contracts are incomplete because we assume that the government cannot make the price contingent on the realized level of demand. We also assume a lack of commitment on the government side in the sense that a group in power cannot force a new group to commit to the contract.

A rich majority will want to maximize its own surplus, W_1. They receive a proportion β_t^* of the total net utility and all the firm's profits, therefore

$$W_1 = \beta_t^*[S(q(p)) - pq(p)] + \pi_i = \beta_t^* S(q(p)) + (1 - \beta_t^*)pq(p) - \theta_i q(p) - I.$$

On the other hand, a poor majority will maximize

$$W_2 = (1 - \beta_t^*)[S(q(p)) - pq(p)],$$

because they get only a proportion $(1 - \beta_t^*)$ of the total net utility Any group has to take into account the constraint that the profits of the firm are non-negative for the firm to be willing to produce.

Finally, we assume that after production, the profits of the firm are perfectly observable by the government and, therefore, renegotiation occurs under complete information. Both the profit and the demand are observed by the government and therefore the marginal cost, θ_i, can be inferred.

The timing of the game is as follows:

1. Each firm *i* learns its private information, θ_i.

2. A first-price sealed-bid auction is run and each firm chooses a price to sell the good, p_i. The firm with the lowest bid wins the auction and is selected to produce the good for 2 periods.

3. The actual demand is realized and is observed by the government and the firm.

4. The first period of production ends and the firm and the government observe the first

period profit of the firm.

5. If the profit is negative the firm asks the government to renegotiate the contract. If there is a new majority and the price that can be obtained when renegotiating is smaller than the actual price, the government asks for renegotiation. We assume that at this stage both the government and the firm are locked in the relationship. We model renegotiation as a Nash bargaining game with bargaining powers α_i for the firm and $1 - \alpha_i$ for the government.

6. If an agreement is reached, the firm runs the concession in the second period with a new price, p_h^R, where $h = 1,2$ refers to the group that is in power in the second period. Both the government and the firm get 0 if there is no agreement.

7. If there is no renegotiation, the original contract prevails.

3. Optimal bidding and renegotiation

In this section we will look for the solution of the auction game and its implications on the renegotiation process. Because we assume that firms are myopic in the sense that they do not consider the possibility of renegotiation at the auction stage, we start by solving the equilibrium of the first-price sealed-bid auction, considering that a firm, if it wins, will produce for two periods with the same price.

3.1 First stage: solution of the first-price sealed-bid auction

We look for a symmetric Bayesian Nash equilibrium in monotone strategies of the auction in which each firm bids according to a function $p(\theta_i)$, increasing in θ_i and we denote by $\psi(p_i)$ the inverse of the bidding function. For simplicity, we assume that neither firms nor consumers discount the future. All qualitative results hold as long as the discount factor is low.

So, the objective function of firm i can be written as

$$\max_{p_i} \gamma(p_i) 2E_{\tilde{\varepsilon}}\left[(p_i - \theta_i)(\bar{q}(p_i) + \tilde{\varepsilon}) - I\right]$$

where $\gamma(p_i)$ is the probability of winning the auction when bidding p_i and all firms other than i follow the equilibrium strategy. Therefore, $\gamma(p_i) = \Pr(p_i < p_j, \forall j \neq i) = \Pr(\psi(p_i) < \theta_j, \forall j \neq i) = [1 - F(\psi(p_i))]^{N-1}$ with N being the number of firms participating in the auction.

Thus, firm i's objective function writes:

$$\max_{p_i} \left[1 - F(\psi(p_i))\right]^{N-1} 2E_{\tilde{\varepsilon}}\left[(p_i - \theta_i)(\bar{q}(p_i) + \tilde{\varepsilon}) - I\right] \tag{1}$$

Proposition 1. *The winning firm is the most efficient one in the pool.*[2] *The expected profit of the winning firm is strictly positive at the symmetric equilibrium for any finite N and for $N \geq 2$, the winning bid is lower than the monopoly price.*

As is standard in the literature on auctions, since firms do not take into account that an ex post renegotiation with the government could increase the price in the second period, the auction succeeds in selecting the most efficient firm to produce the good. The intuition is that given the price of the good, a more efficient firm has always higher profits, and therefore is willing to reduce a little bid its bid in order to increase the probability of winning the auction. This will always be true as long as firms are symmetric in the sense that all marginal costs are drawn from the same distribution function.

On the other hand, competition at this stage implies that the price of the good is smaller than the monopoly price, $p^M(\theta_i, \tilde{\varepsilon})$, but larger than the Ramsey price computed at $\tilde{\varepsilon} = 0$, where the Ramsey price for a given demand shock, $p^\rho(\theta_i, \tilde{\varepsilon})$, is defined such that $(p^\rho(\theta_i, \tilde{\varepsilon}) - \theta_i)(\bar{q}(p^\rho(\theta_i, \tilde{\varepsilon})) + \tilde{\varepsilon}) = I$. Remember that our assumption of increasing returns to scale implies that competition in the market is not desirable. Moreover, the

[2] By efficiency, we mean productive efficiency, that is, low costs. Allocative efficiency may not coincide if a firm with low costs asks more often for renegotiations in the second period.

fact that total costs are not observable ex-ante by the government makes regulation by average cost pricing (or Ramsey pricing) impossible. Therefore, the best way to avoid monopoly pricing is to introduce competition for the market. The benefits are illustrated in Proposition 1. In order to increase the probability of winning the auction firms prefer to charge a price lower than the monopoly price. Furthermore, as the number of firms participating in the auction increases, the price converges to the Ramsey price.

3.2 Renegotiation

There are two cases in which renegotiation can happen in this model. In the first case, the firm triggers renegotiation if the demand shock is such that profits become negative. In the second case, the government may trigger renegotiation. A new government majority will ask for renegotiations if these can reduce the price.

3.2.1 Changes in prices from renegotiation

Since the probability of renegotiation is influenced by the resulting price, we first need to see how the renegotiated price depends on the bargaining power of the firm. Of course, this renegotiated price will depend on the majority at the renegotiation stage. The outcome of renegotiation is described in the next proposition.

Proposition 2. *(a) If the rich win the election for the second period, (i.e.* $\beta_2^* > 1/2$*), the renegotiated price is given by:*

$$\begin{aligned} &\frac{p_1^R-\theta_i}{p_1^R}=\frac{1}{\eta\left(p_1^R\right)}\left[\frac{\alpha_i W_1\left(p_1^R\right)+\left(1-\beta_2^*\right)\left(1-\alpha_i\right)\pi\left(p_1^R\right)}{\alpha_i W_1\left(p_1^R\right)+\left(1-\alpha_i\right)\pi\left(p_1^R\right)}\right]\ \forall\ \alpha_i\in(0,1] \\ &p_1^R=\max\left\{p^{\rho}\left(\theta_i,\tilde{\varepsilon}\right),p_1^*\left(\theta_i,\tilde{\varepsilon}\right)\right\}\ \textit{for}\ \alpha_i=0 \end{aligned} \tag{2}$$

where $p_1^*\left(\theta_i,\tilde{\varepsilon}\right)$ *is such that*

$$\frac{p_1^*(\theta_i,\tilde{\varepsilon})-\theta_i}{p_1^*(\theta_i,\tilde{\varepsilon})}=(1-\beta_2^*)\frac{1}{\eta(p_1^*(\theta_i,\tilde{\varepsilon}))}$$

and $\eta(p)=-\frac{d\bar{q}(p)}{dp}\frac{p}{\bar{q}(p)+\tilde{\varepsilon}}>0$ *is the demand elasticity.*

If the poor win the election (i.e. $\beta_2^* < 1/2$*), the renegotiated price is given by:*

$$\begin{aligned}&\frac{p_2^R-\theta_i}{p_2^R}=\frac{1}{\eta(p_2^R)}\left[\frac{\alpha_i W_2(p_2^R)-(1-\beta_2^*)(1-\alpha_i)\pi(p_2^R)}{\alpha_i W_2(p_2^R)}\right]\forall\ \alpha_i\in(0,1]\\&p_2^R=p^\rho(\theta_i,\tilde{\varepsilon})\ \mathit{for}\ \alpha_i=0\end{aligned}\qquad(3)$$

Intuitively, Proposition 2 implies that the renegotiated price is a weighted average of the government's most preferred price and the firm's most preferred price, and the weights are roughly given by each party's bargaining power.

The extreme solutions of this Nash bargaining game are actually quite interesting as well. If the firm has all the bargaining power ($\alpha_i = 1$), the renegotiated price is equal to the monopoly price whatever the group in power. On the other extreme, when the government has all the bargaining power ($\alpha_i = 0$), the renegotiated price is equal to the Ramsey price (equal to the average cost).[3] These extremes define the upper and lower bounds for the renegotiated price prevailing under intermediate values of α_i.

From the outcome of renegotiation we get information on how the changes in each one of the parameters influence the results.

Proposition 3. *The comparative static results are given by:*

- p_h^R *is increasing in* I, θ_i, *and* α_i *for* $h = 1,2$.
- p_1^R *is decreasing in* β_2^* *and* p_2^R *is constant in* β_2^*.

[3] If there is a majority of rich consumers and β_2^* is close to 1/2 it could be the case that the renegotiated price for $\alpha_i = 0$ is larger than the Ramsey price, if the Ramsey price is smaller than p_1^*. But, of course, it will never be lower than the Ramsey price. Moreover, the non-negativity constraints of profits is binding if $\alpha_i = 0$. Intuitively, a majority of poor consumers, for instance, would like to set the price equal to 0, but this violates the firm's participation constraint.

- *For given values of the parameters, and for any* β_2^*, $p_2^R \leq p_1^R$, *with equality when* $\alpha_i = 1$.

The comparative static results are quite intuitive. Bargaining would achieve lower prices with more efficient and weaker firms, so the renegotiated price is higher the higher θ_i, I and α_i. Moreover, a majority of poor consumers is credibly tougher in bargaining, since they care more about price reductions than the group of rich consumers. Therefore, everything else being equal, a group of poor consumers achieves a lower price at the renegotiation stage.

Finally, the renegotiated price obtained by the group of poor consumers is independent of how big a majority they are. This implies that, things won't get any better for the poor after they renegotiate since under permanent ruling by the poor, prices are likely to be as low as possible from the beginning.

Figure 1 summarizes the main results and illustrates how the renegotiated price changes with the proportion of rich consumers.

INSERT FIGURE 1 HERE.

3.2.2 Computing the probability of renegotiation

Using the results of Proposition 2, we compute the probability of renegotiation as a function of the parameters of the model. Define

$$\phi = \Pr(\beta_2^* > 1/2 \;/\; \beta_1^* < 1/2) = \Pr(\beta_2^* < 1/2 \;/\; \beta_1^* > 1/2),$$

the probability of having a new majority in period 2. For simplicity of exposition we assume that this probability is the same, whether in the first period there is a rich majority or a poor majority.

The total probability of renegotiation if there is initially a majority k is

$$\Pr(R / k) = \Pr(R_f) + \Pr(R_g / k),$$

where $\Pr(R_f)$ is the probability of renegotiation driven by the firm and $\Pr(R_g / k)$ is the probability of renegotiation driven by the government, given that in the first period group k is in power.

Consider now separately the cases in which the firm and the government initiate the renegotiation.

The firm asks for renegotiations when its profits are negative which happens when the demand shock is low enough:

Define $\varepsilon^*(p(\theta_i),\theta_i)$ so that $\varepsilon^*(p,\theta) = \max_{[-\varepsilon,\varepsilon]} \tilde{\varepsilon}$ such that $(p-\theta)(\overline{q}(p)+\tilde{\varepsilon}) \leq I$. So ε^* is the minimum demand shock that allows the firm to make positive profits and therefore is the maximum demand shock that triggers renegotiation by the firm.

Given the uniform distribution assumption,

$$\Pr(R_f) = \Pr(\tilde{\varepsilon} < \varepsilon^*(p(\theta_i),\theta_i)) = \tfrac{1}{2} + \tfrac{\varepsilon^*(p(\theta_i),\theta_i)}{2\varepsilon}.$$

The price bid in the first period is higher than the Ramsey price for $\tilde{\varepsilon} = 0$, so $\varepsilon^*(p(\theta_i),\theta_i) < 0$ for any θ_i and therefore $\Pr(R_f) < 1/2$.

The government asks for renegotiations if there is a new majority, $h \neq k$, which occurs with probability ϕ, and only when the price can be decreased, which means both that the profit of the firm is positive, so the firm can accept to produce with a lower price, and that its bargaining power is small enough, because the renegotiated price increases with α_i. Thus,

$$\Pr(R_g / k) = \phi \int_{\varepsilon^*(p(\theta_i),\theta_i)}^{\varepsilon} G(\alpha_h^*(p(\theta_i),\theta_i,\tilde{\varepsilon}))\frac{d\tilde{\varepsilon}}{2\varepsilon}, \tag{5}$$

where $\alpha_h^*(p,\theta,\tilde{\varepsilon})$ is defined such that

$$p_h^R(\alpha_h^*(p,\theta,\tilde{\varepsilon}),\theta,\tilde{\varepsilon}) = p$$

So the renegotiated price will be lower than the initial price if and only if

$\alpha_i < \alpha_h^*(p(\theta_i), \theta_i, \tilde{\varepsilon})$.

From the implicit function theorem, α_h^* is increasing in p, decreasing in θ, and $\alpha_h^*(p(\theta_i), \theta_i, \varepsilon^*(p(\theta_i), \theta_i)) \equiv 0$, since no further reduction in prices can be obtained if the firm's profit is already equal to 0.

Because the renegotiated price is always lower when there is a poor majority, it can be shown that, given $(p, \theta, \tilde{\varepsilon})$, $\alpha_1^* < \alpha_2^*$, meaning that, ceteris paribus, $\Pr(R_g / 1) > \Pr(R_g / 2)$, that is, the probability of renegotiation is larger if in the first period the rich consumers were in power. Figure 2 shows this fact.

INSERT FIGURE 2 HERE.

Intuitively, if the group of rich consumers is in power in period 1, then the government can ask for renegotiations only if in period 2 the group of poor consumers becomes a majority. And all things equal, bargaining with the group of poor consumers achieves a lower price than bargaining with a group of rich consumers, as stated in Proposition 3. Therefore, the renegotiated price will be lower than the old price for a larger range of values of α_i when the new majority is a poor one.

Using (4) and (5), the probability of renegotiation when group k is in power in period 1 is equal to:

$$\Pr(R/k) = \frac{1}{2} + \frac{\varepsilon^*(p(\theta_i), \theta_i)}{2\varepsilon} + \phi \int_{\varepsilon^*(p(\theta_i), \theta_i)}^{\varepsilon} G(\alpha_h^*(p(\theta_i), \theta_i)) \frac{d\tilde{\varepsilon}}{2\varepsilon}.$$

3.2.3 Efficiency and the probability of renegotiation

Since we have shown that the auction procedure selects the most efficient firm, it seems relevant to be able to assess how the initial efficiency levels obtained through the auction affect the probability of renegotiation under any type of majority. It also helps in assessing the impact of regulatory decisions aiming at changing these efficiency levels. The formula for $\Pr(R / k)$ allows us to address this concern and to test for the impact of efficiency changes for both sources of renegotiation. Indeed:

$$\frac{d\,\Pr(R/k)}{d\theta_i} = \frac{1}{2\varepsilon}\frac{d\varepsilon^*}{d\theta_i} + \phi\int_{\varepsilon^*}^{\varepsilon} g(\alpha_h^*)\frac{d\alpha_h^*}{d\theta_i}\frac{d\tilde{\varepsilon}}{2\varepsilon},$$

where $\frac{d\varepsilon^*}{d\theta_i} = \frac{\partial\varepsilon^*}{\partial p}p'(\theta_i) + \frac{\partial\varepsilon^*}{\partial\theta_i}$ and $\frac{d\alpha_h^*}{d\theta_i} = \frac{\partial\alpha_h^*}{\partial p}p'(\theta_i) + \frac{\partial\alpha_h^*}{\partial\theta_i}$.

Notice that the efficiency parameter of the firm affects both the probability of renegotiation driven by the firm, which is determined by ε^* and the probability of renegotiation driven by the government, determined by α_h^*. Whether the probability of renegotiation increases or decreases with the efficiency parameter, depends on how these two variables change. Using again the implicit function theorem, we can show that

$$\frac{d\varepsilon^*}{d\theta_i} = \frac{-(p'(\theta_i)-1)\overline{q}(p(\theta_i)) - (p(\theta_i)-\theta_i)\frac{d\overline{q}(p(\theta_i))}{dp}p'(\theta_i)}{p(\theta_i)-\theta_i},$$

$$\frac{d\alpha_h^*}{d\theta_i} = \frac{p'(\theta_i) - \frac{\partial p_h^R}{\partial\theta_i}}{\frac{\partial p_h^R}{\partial\alpha_i}},$$

so we cannot a priori determine the signs, which depend on the slope of the bidding function, $p'(\theta_i)$. This slope is higher (and in particular, greater than 1) if N is large enough or N is small and $q(p)$ is convex enough. When this is the case, an increase in efficiency may induce a greater (smaller) probability of firm (government) driven renegotiations. Table 1 explains the opposite effects of efficiency on both types of renegotiations.

INSERT TABLE 1 HERE.

4. Renegotiation and the efficiency-equity trade-off

In this section we discuss how the model developed so far answers questions such as: Is there a conflict between efficiency and equity? How does renegotiation affect rich and poor consumers? Is there any conflict between the two groups of consumers? What is the role played by the bargaining power of the firm in this context?

4.1 Why users may prefer to start with an inefficient firm

One source of trade-off between efficiency and equity arises when users have a collective incentive not to prefer to have the most efficient firm winning the auction knowing that a renegotiation is likely. If both parties could perfectly commit to the concession contract signed at the auction stage, there would be no possible conflict between efficiency and equity. Indeed, the auction allows the government to choose the most efficient firm within the candidates and this firm charges the lowest possible price, which benefit the poor consumers in a larger proportion. And given the informational asymmetry there is no better way to select the firm.

When the possibility of renegotiation is opened, a conflict between efficiency and equity may appear. For instance, we know that the welfare of the poor consumers decreases when *the firm* initiates renegotiation, because the price increases. On the other hand, we also know that this welfare increases when *the government* initiates renegotiation, because in this case the price decreases. In the previous section we showed that the probability of renegotiation might increase or decrease with the efficiency parameter of the firm. We want to know how the poor consumers' welfare changes with the efficiency parameter of the firm. So suppose that $\frac{d\Pr(R_f)}{d\theta_i} < 0$ and $\frac{d\Pr(R_g/k)}{d\theta_i} > 0$, that is that an improvement in efficiency (a decrease in θ_i) improves the chances of a renegotiation by the firm –which the poor dislike– and reduces those requested by the government –which the poor like.[4] This suggests that poor consumers may prefer to have a less efficient firm winning the auction to provide opportunities for government driven renegotiations which will lead to realistic tariff reduction requests

[4] Remember that this case is more plausible when the number of bidders is large or the number of bidders is small and the demand function is convex enough.

and reduce opportunities of firm driven renegotiations. But of course, they have to take into account that a less efficient firm will operate with a higher price in the first period, and also in the second period if there is no renegotiation.

To see how the two effects work together, consider the following very simple example. Assume first that $\phi = 0$, so the government never asks for renegotiations and, second, that the probability of renegotiation driven by the firm decreases with θ,[5] that is

$$\frac{d\varepsilon^*}{d\theta_i} = \frac{\partial \varepsilon^*}{\partial p} p'(\theta_i) + \frac{\partial \varepsilon^*}{\partial \theta_i} < 0. \tag{8}$$

This implies that a more efficient firm has more often negative profits in the first period, and, therefore, asks for renegotiations more often. But when the firm makes negative profits, renegotiation always increases the price. Now, the magnitude of the increase in price will depend on the bargaining power of the firm at the renegotiation stage, which is ex ante unknown.

The ex ante expected welfare for the two groups of consumers as a function of θ is the sum of the expected welfare in period 1 given the price level charged initially by the firm and of the expected welfare resulting from the price in the second period which is determined by the existence or absence of renegotiation. That is, for $k = 1,2$,

$$EW_k(\theta) = \int_{-\varepsilon}^{\varepsilon} W_k\left(p(\theta), \theta, \tilde{\varepsilon}\right) \frac{d\tilde{\varepsilon}}{2\varepsilon} + \int_{\varepsilon^*(\theta)}^{\varepsilon} W_k\left(p(\theta), \theta, \tilde{\varepsilon}\right) \frac{d\tilde{\varepsilon}}{2\varepsilon}$$
$$+ \int_{-\varepsilon}^{\varepsilon^*(\theta)} \int_0^1 W_k\left(p_h^R(\theta, \alpha, \tilde{\varepsilon}), \theta, \tilde{\varepsilon}\right) g(\alpha) d\alpha \frac{d\tilde{\varepsilon}}{2\varepsilon}$$

where p_h^R is an increasing function of α, and $q(p)$ is an increasing function of $\tilde{\varepsilon}$.

The first term is the expected welfare in the first period given that the firm charges a

[5] If the only source of renegotiations is negative profits, then if the probability of renegotiation driven by the firm increases with θ, all consumers will always prefer the most efficient firm. Indeed, a more efficient firm will charge a smaller price in the first period, which is good, and will trigger renegotiation less often, which is also good.

price equal to $p(\theta)$. The second term is the expected welfare in the second period if there is no renegotiation, so the price is still equal to $p(\theta)$. Finally, the third term is the expected welfare in the second period if there is renegotiation, in which case the price is equal to p_h^R, which depends on the majority in power in the second period, h.

We are interested in how the expected welfare would change if there were a small decrease in the efficiency level (a small increase in θ).

$$\frac{dEW_k}{d\theta} = \int_{-\varepsilon}^{\varepsilon} \frac{dW_k}{d\theta}(p,\theta,\tilde{\varepsilon})\frac{d\tilde{\varepsilon}}{2\varepsilon} + \int_{\varepsilon^*(\theta)}^{\varepsilon} \frac{dW_k}{d\theta}(p,\theta,\tilde{\varepsilon})\frac{d\tilde{\varepsilon}}{2\varepsilon} + \int_{-\varepsilon}^{\varepsilon^*(\theta)}\int_0^1 \frac{dW_k}{d\theta}\left(p_h^R,\theta,\tilde{\varepsilon}\right)g(\alpha)d\alpha\frac{d\tilde{\varepsilon}}{2\varepsilon}$$
$$-\frac{d\varepsilon^*}{d\theta}\int_0^1\left[W_k\left(p,\theta,\varepsilon^*\right)-W_k\left(p_h^R,\theta,\varepsilon^*\right)\right]\frac{g(\alpha)}{2\varepsilon}d\alpha,$$

where

$$\frac{dW_k}{d\theta} = \frac{\partial W_k}{\partial\theta} + \frac{\partial W_k}{\partial p}p'(\theta).$$

Four effects of θ on the expected welfare can be distinguished. The first three are the classical effects: an increase in θ reduces welfare in each period, whether there is renegotiation or not, both because the firm's costs are higher and because the price of the good in any case is also higher. [6] These effects are represented by the first 3 terms, which are negative, implying that, with the same probability of renegotiation, more efficiency is better for the two groups of consumers.

The fourth term measures the effect of renegotiation. Given the assumption made in (8) more efficiency implies higher probability of firm driven renegotiations and, therefore, more often high prices in the second period. From this perspective, consumers

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[6] In the case of the rich consumers it is not always true that an increase in price reduces welfare. Indeed, if the price is lower than p_1^*, which is the price that maximizes rich consumers' welfare, a small increase in price increases welfare. If β_2^* is close to 0, p_1^* is close to the monopoly price and the price without renegotiation is smaller than p_1^*. This case just exacerbates the distributional conflicts between the two groups of consumers.

prefer a less efficient firm.[7]

Therefore, the net effect of θ over the expected welfare can be either negative, in which case efficiency is always better, or positive if the fourth effect is large enough, in which case consumers prefer to forgo some efficiency in order to reduce the likelihood of renegotiations.

The fourth effect will be large, and hence a less efficient firm will be preferred, when the bargaining power distribution function $g(\alpha_i)$ is biased towards large values of α_i, because more weight is put on the cases for which the increase in the price is the largest. In practice, this bias exists when competition is limited on the supply side (as is the case in the water sector and to a lesser extent in the power, port and railways sectors, for instance where the number of global players is such that competition for the market seldom results in no more than 2-3 bidders) or when regulatory capture is a real concern.[8]

In addition, to the equity efficiency trade-off just described, there is an underlying distributional conflict between rich and poor. For β_2^* small enough (i.e. when the poor rule significantly), [9] we have that $\left|\frac{dW_2}{d\theta}\right| > \left|\frac{dW_1}{d\theta}\right|$, and, therefore, there are cases in which poor consumers prefer a less efficient firm while the reverse is true for the rich consumers. The efficiency-equity trade-off continues to hold as well since the auction procedure will always select the most efficient firm.

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[7] Of course, if the probability of renegotiation decreases with the efficiency of the firm ($\frac{d\varepsilon^*}{d\theta} > 0$), this fourth effect would go in the same direction as the first three and more efficiency would be always better for consumers.

[8] Any time we can expect a close relationship between the operators and the government (or a politically driven regulator), collusion is a risk; the fewer the alternatives, the stronger the firm's bargaining power and hence the stronger the risks of collusion. It is clearly easy to associate collusion with more bargaining power for the firm.

[9] The exact condition is that $\beta_2^* < \frac{1}{2} + \frac{p-\theta}{p}\frac{\eta(p)}{2}\frac{dp}{d\theta}$. In particular, the condition is satisfied when poor consumers are majority.

4.2 When rich and poor consumers don't see eye to eye

The distributional conflict just eluded suggests that it is also important to understand more generally the differences in efficiency outcomes since they may result in conflicts between the two groups of consumers. In particular, we are interested in trying to understand the situations in which rich and poor consumers agree or disagree about the situation they prefer the most. The possible situations are described in Table 2.

INSERT TABLE 2 HERE.

Cases 1a and 2a show that if the firm has negative profits in the first period, both groups of consumers are better off when poor consumers win the election and rule during the second period, as long as the proportion of rich consumers is not too small. This is because the magnitude of the increase in price –and the price will increase after renegotiations under any type of majority– is always lower when the poor are in charge in the second period. Indeed, according to Proposition 3, the renegotiated price will be smaller if $\beta_2^* < 1/2$ (see Figure 1). Furthermore, the probability of being in one of these two cases is the same because the price charged in the first period is independent of who was in power in the first period.[10]

Cases 1b and 2c show that if the firm has positive profits and there is no change in majority, whatever the majority, no renegotiation happens whatever the bargaining power of the firm. Moreover, given our assumption that the probability of preserving the majority is independent of β_1^*, both cases also arise with the same probability.

The most interesting cases are 1c and 2b when the firm has positive profits but there is a change in majority. In these two cases, renegotiation occurs if the bargaining power of the firm is small enough. According to Figure 2, $\alpha_1^* < \alpha_2^*$ and therefore $\Pr(\alpha_i < \alpha_1^*) < \Pr(\alpha_i < \alpha_2^*)$ and renegotiation occurs more often when there is a poor majority in the second period. Furthermore, even when $\alpha_i < \alpha_1^* < \alpha_2^*$, so renegotiation

[10] This is not true anymore when firms are strategic, In that case, bids are lower if in the first period the poor are a majority.

occurs under any majority, the renegotiated price will be lower in case 1c than in case 2b, because poor consumers are more concerned with a decrease in price. Without ambiguity, poor consumers prefer case 1c to case 2b. Rich consumers also prefer case 1c whenever $p_2^R(\alpha_i, \theta_i) \geq p_1^*(\theta_i)$, which happens when α_i is large enough. On the other hand, if $\alpha_1^* < \alpha_i < \alpha_2^*$, renegotiation occurs in case 1c, while it does not in case 2b.

The conflict between rich and poor consumers arises as follows. When the rich win the election, for β_2^* small enough (close enough to 1/2) $p_1^*(\theta_i)$ may be larger than the renegotiated price obtained with a poor majority. If this were the case, the group of rich consumers chooses not to renegotiate and maintain a price close to their most preferred price. This behavior hurts the poor, which would have bargained a much lower price had they been in charge under the same circumstances and is thus the main source of conflict in the second period.

A final source of distributional conflict is that the loss incurred by poor consumers when the price is higher than the Ramsey price is always larger than the one incurred by rich consumers because the latter group receives the increased profits of the firm.

5. Strategic underbidding

So far, we have assumed that firms are naive when deciding on their bids at the auction stage, in the sense that they do not take into account the possibility of renegotiations in the second period. However, it seems natural to think that firms understand that they may be favored by future renegotiations and they should include these profits when computing the “value” of the concession. Intuitively, by reducing the bid at the auction stage, a firm increases the probability of “good” renegotiations (good from the firm’s perspective) and reduces the probability of “bad” renegotiations. Of course, there is a trade-off, because at the same time, the firm will operate for sure with a lower price in the first period and with some probability in the second period. In this section, we analyze how our results change when firms act strategically when deciding their bids. We still assume that the auction rules are given and, then, the government is not trying to find the optimal mechanism. This assumption seems realistic, given what is observed in real concession award procedures.

Note that the renegotiation stage equilibrium, where a particular firm has already won the auction, remains the same when bidders are strategic. So the analysis of section 3.2 is still valid here. Furthermore, it is exactly that analysis that will help answering the question of what the optimal bidding strategies are in the first place. Thus, given the results of the renegotiation game, firms reason backwards and decide on their bids for the concession.

Consider the problem of a firm with marginal cost θ_i facing a majority *k* at the auction stage. The firm chooses p_i to maximize its expected profits in the two periods, but now the second period profits include the probability of renegotiation. Therefore, the two-period total expected profits of firm *i* conditional on winning the auction are given by:

$$\pi_i^S = (p_i - \theta_i)\overline{q}(p_i) - 2I + \int_{\varepsilon^*(p_1,\theta_i)}^{\varepsilon} \left(1 - \phi G\left(\alpha_h^*(p_i,\theta_i,\widetilde{\varepsilon})\right)\right)(p_i - \theta_i)q(p_i)\frac{d\widetilde{\varepsilon}}{2\varepsilon}$$
$$+\phi \int_{\varepsilon^*(p_i,\theta_i)}^{\varepsilon} \int_0^{\alpha_h^*(p_i,\theta_i,\widetilde{\varepsilon})} \left(p_h^R - \theta_i\right)q\left(p_h^R\right)dG(\alpha)\frac{d\widetilde{\varepsilon}}{2\varepsilon} + \int_{-\varepsilon}^{\varepsilon^*(p_i,\theta_i)} \int_0^1 \left(p_h^R - \theta_i\right)q\left(p_h^R\right)dG(\alpha)\frac{d\widetilde{\varepsilon}}{2\varepsilon} \quad (9)$$

The first term is the expected profit in the first period. The second term is the expected profit in the second period if there is no renegotiation. The third and forth terms are the expected profits in the second period when there is renegotiation driven by the government and the firm respectively. It is important to notice that the renegotiated price, p_h^R, is lower than p_i in the third term (government driven renegotiations) and higher in the forth term (firm driven renegotiations). The firm decides on a price to bid in order to solve the following problem:

$$\max_{p_i} \gamma(p_i)\pi_i^S(p_i,\theta_i),$$

where again $\gamma(p_i) = [1 - F(\psi(p_i))]^{N-1}$, because we look for a symmetric Bayesian Nash equilibrium in monotone strategies.

Proposition 4. *The winning firm is the most efficient firm. If the distribution of the bargaining power is not too skewed towards low values, for any* θ_i*, firms bid strictly less than in the case of naive firms.*

The intuition for this result is quite clear. It is a standard result in auction theory that the greater the marginal value of the concession, the more aggressive the bids. More aggressive bids in this case, mean lower prices in the first period. The whole trick of the proof lies in showing that, indeed, the marginal value of the concession is higher. This is not completely obvious, since the price decreases when there is a renegotiation driven by the government. Therefore, we need to assume that renegotiation driven by the government will not reduce the price too much. This happens if the distribution of the bargaining power is sufficiently skewed towards high values. If the distribution of α is too skewed towards low values and the number of firms is small, they may want to bid more than in the naive case in order to maintain a high price when there is no change in majority.

The fact that firms bid lower, allows us to make the following comparison:

Corollary 1. *When firms act strategically, for a given marginal cost,* θ_i*, the probability of renegotiation driven by the firm is higher and the probability of renegotiation driven by the government is lower than in the case of naive firms.*

To see why this is true, just remember that ε^* is an increasing function of the price while α_h^* is a decreasing function of the price. Since firms bid lower prices, the range of negative demand shocks increases while the probability that the new majority is able to decrease the price decreases. Therefore, firms succeed in manipulating the different probabilities of renegotiation in there own benefit.

Another interesting feature about firms being strategic is that the bid is actually a function of the group that is ruling at the auction stage. The reason is that the probability of government driven renegotiations and the actual renegotiated price in the second period are both functions of the majority that takes over in the second period. We expect less underbidding at the auction stage when the rich group is in power in the first period.

Indeed, if the auction is run under a rich majority, government driven renegotiations occur only under a poor majority. These renegotiations, bad from the firm's perspective, occur more often with a poor majority and, at the same time, achieve a less favorable price. Therefore, the value of the concession is lower if the firm expects a poor majority to carry on renegotiations in the second period.

It is easy to see that the results of Section 5 extend to the case of strategic firms. The only difference is that the probability of renegotiation is now, to a larger extent, under the firm's control. The conflicts between efficiency and equity and among groups of consumers are strengthened when there is underbidding for strategic reasons.

The analysis of strategic firms allows us to make the following thought experiment. Suppose that among the firms participating in the auction, some of them are naive and the others are strategic. Of course, the auction is not symmetric anymore, so no symmetric equilibrium exists. However, given the results we have found in this section, we expect the strategic firms to bid lower, for the same marginal cost, than the naive firms. Then, it may be the case that the auction procedure fails in selecting the most efficient firm. A strategic firm with a higher marginal cost may bid less than a naive firm with a lower marginal cost, if the efficiency gap is not too large.

6. Concluding remarks

In this paper we wanted to analyze the possible sources of renegotiation and their impact on the efficiency-equity trade-off in non-competitive markets in which regulation by average cost pricing cannot be implemented because there is incomplete information about the firm's costs.

To do this, we presented a model of incomplete contracting for concession award in which renegotiation happens due to demand shocks or political cycles. Competition for the contract through an auction ensures that the consumers benefit by a price that is lower than the monopoly price and allows the government to select the firm with the lowest costs. To avoid ratchet effect kinds of problems, we have assumed that once the firm has started to produce, the marginal cost of the firm can be inferred, so at the renegotiation stage the government and the firm share the same information. The government still cannot always force the firm to charge a price equal to the average cost because at this stage the firm has acquired some bargaining power and therefore the government is not able to extract all the rents from it.

The model provides possible explanations for the various types of renegotiations that have been observed in the last decade and offers testable results. First, the probability of election-driven renegotiations inducing reductions in tariffs is larger if: (i) in the first period the "rich" consumers (i.e. the co-owners of the operating firms) are in power, (ii) the operators are making profits, (iii) the "poor" take over after a change in government, (iv) the government expects to have a strong bargaining power and (v) firms behave naively at the auction stage. Second, whatever the bargaining power and the marginal cost of the firm, bargaining with the group of poor consumers will achieve a lower price than bargaining with a group of rich consumers. Third, the smaller the group of rich in the population, provided that they are a majority, the higher the chances of having high prices, because they receive the whole increase in the profit of the firm while losing a small proportion of the reduction in the consumer surplus. This implies that conflicts between rich and poor consumers are more likely to occur the larger the relative size of the poor at the time of renegotiation. Fourth, the expected direction of the effects of changes in the firm's marginal cost on the probability of renegotiation depends on a set of factors working in opposite directions and is hence an empirical matter reflecting the relative strength of these factors. Fifth, the perverse effects of excessive bargaining power by the firm tend to penalize the poor relatively more because they pay a higher price without benefiting by the increase in the firm's profits.

In terms of policy advise, the model suggests that if the fear of renegotiation is a major concern, consumers might want to award the concession to a less efficient firm in order to reduce the probability of renegotiation since lower probabilities of firm driven renegotiations may be associated with higher welfare levels. Second, the model suggests also that a "benevolent, welfare maximizing government" should make every possible effort to balance the bargaining power of its regulators with that of the operators to ensure a fair treatment of all users. One of the actions to take, and certainly not the least important, is to minimize the possibility of collusion/corruption between the firm and the government units in charge of the renegotiations and who may not have the same degree of benevolence. Reducing bargaining power will also reduce strategic bids and low-balling by firms convinced that they could win any renegotiation and get closer to monopoly prices ex-post. Third, any policy instrument that reduces demand uncertainty will be in the interest of all users but in particular the poor. Indeed, less demand uncertainty reduces the circumstances in which the firm asks for renegotiations due to negative demand shocks, which consumers, and in particular the poor, dislike. Finally, when renegotiations are a real concern, an appropriate design of the mechanisms of concession award that explicitly considers this possibility will help reducing the perverse effects on social welfare, mainly in favor of the poorest.

In order to refine some of the results, additional research could explore the following ideas. First, we have considered the bargaining power of the firm as an exogenous parameter. In practice, it depends on several variables such as the owners of the firm, the political interference with the choice of bidders resulting from tied bilateral aid, the level of profits or of sunk costs, etc. A more careful study of the potential effects of each one of these factors seems appropriate. Second, there is a reputation effect that is not captured in the model. In order to avoid the kind of strategic behavior aforementioned, the government can build a reputation of being tough regarding renegotiations. This would have a dynamic positive effect on welfare, by avoiding underbidding and, therefore, ex post non-desired increases in price. A final additional direction for improvement could be the modeling of the distributional payoffs of insurance mechanisms to protect from demand uncertainty.

Appendix

Proof of Proposition 1. We are looking for a subgame perfect Nash equilibrium of the game. Each firm bids according to the first order condition:

$$\overline{q}(p_i)+(p_i-\theta_i)\frac{d\overline{q}}{dp_i}(p_i)-(N-1)\frac{f(\psi(p_i))}{1-F(\psi(p_i))}\frac{(p_i-\theta_i)\overline{q}(p_i)-I}{p'(\psi(p_i))}=0. \qquad (10)$$

Now we need to verify that a solution of equation (10) satisfies $p'(\theta_i)>0$ at the symmetric equilibrium, which means that the lowest price is offered by the firm with the lowest marginal cost.

At the symmetric equilibrium $p_i = p(\theta_i)$ and $\psi(p_i) = \theta_i$, so condition (10) writes:

$$\begin{aligned}&(N-1)\frac{f(\theta_i)}{1-F(\theta_i)}\frac{(p(\theta_i)-\theta_i)\overline{q}(p(\theta_i))-I}{p'(\theta_i)}= \\ &\overline{q}(p(\theta_i))+(p(\theta_i)-\theta_i)\frac{d\overline{q}}{dp_i}(p(\theta_i))>0\end{aligned} \qquad (11)$$

where the inequality holds because the price is lower than the monopoly price whenever $N > 1$. If the price were higher than the monopoly price, the firm could increase both the expected profit and the probability of renegotiation by decreasing the price.

This also implies that the expected profit of the firm is strictly positive for any θ_i, so the price is higher than the Ramsey price. If this were not the case, the expected profit of the firm would be negative, and therefore, it would win by bidding the Ramsey price. *QED*

Proof of Proposition 2. a) Suppose first that $\beta_2^* > 1/2$ so at the renegotiation stage there is a rich majority. Nash bargaining implies that the optimal renegotiation price solves the following problem:

$$\begin{cases}\max_p [W_1(p)]^{1-\alpha_i}[\pi(p)]^{\alpha_i} \\ \textit{subject to} \\ \pi(p)\geq 0\end{cases}$$

So, using the definitions of W_1 and π and remembering that $S'(q(p))=p$ we obtain the first order condition, $FOC_1(p)=\frac{d\left([W_1(p)]^{1-\alpha_i}[\pi(p)]^{\alpha_i}\right)}{dp}=0$:

$$-(1-\alpha_i)\left[(1-\beta_2^*)q(p)+(p-\theta_i)\frac{dq}{dp}(p)\right]$$
$$=\alpha_i\frac{W_1(p)}{\pi(p)}\left[(p-\theta_i)\frac{dq}{dp}(p)+q(p)\right].$$

Rearranging terms, equation (2) can be found. The constraint is binding for $\alpha_i = 0$ if $p^{\rho}(\theta_i,\tilde{\varepsilon}) > p_1^*(\theta_i,\tilde{\varepsilon})$ and is not binding for any $\alpha_i \in (0,1]$.

b) Now suppose that $\beta_2^* < 1/2$ so at the renegotiation stage there is a poor majority. The optimal renegotiation price solves the following problem:

$$\begin{cases}\max_p [W_2(p)]^{1-\alpha_i}[\pi(p)]^{\alpha_i} \\ \textit{subject to} \\ \pi(p)\geq 0\end{cases}$$

So, using the definitions of W_2 and π and remembering that $S'(q(p)) = p$ we obtain the first order condition, $FOC_1(p)=\frac{d\left([W_1(p)]^{1-\alpha_i}[\pi(p)]^{\alpha_i}\right)}{dp}=0$:

$$(1-\alpha_i)(1-\beta_2^*)q(p)$$
$$=\alpha_i\frac{W_2(p)}{\pi(p)}\left[(p-\theta_i)\frac{dq}{dp}(p)+q(p)\right],$$

wich gives equation (3). The constraint is always binding for $\alpha_i = 0$ and is not binding for any $\alpha_i \in (0,1]$. *QED*

Proof of Proposition 3. For comparative static analysis, we use the implicit function theorem. To simplify notations, we will call $q_h^R = q(p_h^R)$. Thus, $sign\left(\frac{dp_h^R}{da}\right)= sign\left(\frac{\partial FOC_h}{\partial a}\right)$ for any parameter a.

$$\frac{\partial FOC_1}{\partial \theta_i} = -\frac{dq_1^R}{dp}\left(1-\alpha_i + \alpha_i \frac{W_1\left(p_1^R\right)}{\pi\left(p_1^R\right)}\right)$$
$$+\alpha_i\left[\left(p_1^R - \theta_i\right)\frac{dq_1^R}{dp} + q_1^R\right] q_1^R \frac{W_1\left(p_1^R\right) - \pi\left(p_1^R\right)}{\left[\pi\left(p_1^R\right)\right]^2} > 0,$$

$$\frac{\partial FOC_1}{\partial I} = \alpha_i\left[\left(p_1^R - \theta_i\right)\frac{dq_1^R}{dp} + q_1^R\right]\frac{W_1\left(p_1^R\right) - \pi\left(p_1^R\right)}{\left[\pi\left(p_1^R\right)\right]^2} > 0,$$

$$\frac{\partial FOC_1}{\partial \alpha_i} = \beta_2^* q_1^R + \left[\left(p_1^R - \theta_i\right)\frac{dq_1^R}{dp} + q_1^R\right]\frac{W_1\left(p_1^R\right) - \pi\left(p_1^R\right)}{\pi\left(p_1^R\right)} > 0,$$

$$\frac{\partial FOC_1}{\partial \beta_2^*} = -\frac{1-\alpha_i}{W_1\left(p_1^R\right)}\left[\left(p_1^R - \theta_i\right)\frac{dq_1^R}{dp} + q_1^R\right]\frac{W_1\left(p_1^R\right) - \pi\left(p_1^R\right)}{\beta_2^*}$$
$$-\frac{1-\alpha_i}{W_1\left(p_1^R\right)}\pi\left(p_1^R\right)q_1^R < 0,$$

$$\frac{\partial FOC_2}{\partial \theta_i} = -\alpha_i \frac{W_2\left(p_2^R\right)}{\pi\left(p_2^R\right)}\frac{dq_2^R}{dp}$$
$$+\alpha_i\left[\left(p_2^R - \theta_i\right)\frac{dq_2^R}{dp} + q_2^R\right] q_2^R \frac{W_2\left(p_2^R\right)}{\left[\pi\left(p_2^R\right)\right]^2} > 0,$$

$$\frac{\partial FOC_2}{\partial I} = \alpha_i\left[\left(p_2^R - \theta_i\right)\frac{dq_2^R}{dp} + q_2^R\right]\frac{W_2\left(p_2^R\right)}{\left[\pi\left(p_2^R\right)\right]^2} > 0,$$

$$\frac{\partial FOC_2}{\partial \alpha_i} = \left(1-\beta_2^*\right)q_2^R + \left[\left(p_2^R - \theta_i\right)\frac{dq_2^R}{dp} + q_2^R\right]\frac{W_2\left(p_2^R\right)}{\pi\left(p_2^R\right)} > 0,$$

$$\frac{\partial FOC_2}{\partial \beta_2^*} = -\alpha_i \left[\left(p_2^R - \theta_i\right)\frac{dq_2^R}{dp} + q_2^R \right] \frac{W_2\left(p_2^R\right)}{\left(1-\beta_2^*\right)\pi\left(p_2^R\right)}$$
$$+\left(1-\alpha_i\right)q_2^R = 0,$$

which give our results.

To show that $p_2^R \leq p_1^R$ it suffices to show that the first order condition when there is a poor majority evaluated at p_1^R is negative, meaning that, decreasing the price will increase the objective function. That is, we will show that $FOC_2(p_1^R) < 0$.

$$FOC_2\left(p_1^R\right) = \left(1-\beta_2^*\right)\left\{-\left(1-\alpha_i\right)q_1^R + \alpha_i \frac{S\left(q_1^R\right) - p_1^R q_1^R}{\pi\left(p_1^R\right)}\left[\left(p_1^R - \theta_i\right)\frac{dq_1^R}{dp} + q_1^R\right]\right\}$$

Now, taking into account that, by definition of p_1^R, $FOC_1(p_1^R) = 0$, we can replace and we obtain:

$$FOC_2\left(p_1^R\right) = -\left(1-\alpha_i\right)\left(1-\beta_2^*\right)\left\{q_1^R + \frac{S\left(q_1^R\right) - p_1^R q_1^R}{W_1\left(p_1^R\right)}\left[\left(p_1^R - \theta_i\right)\frac{dq_1^R}{dp} + \left(1-\beta_2^*\right)q_1^R\right]\right\}$$

Finally, using the definition of $W_1(p_1^R)$, we have

$$FOC_2\left(p_1^R\right) = -\frac{\left(1-\alpha_i\right)\left(1-\beta_2^*\right)}{W_1\left(p_1^R\right)}\underbrace{\left[q_1^R \pi\left(p_1^R\right) + \left(S\left(q_1^R\right) - p_1^R q_1^R\right)\left[\left(p_1^R - \theta_i\right)\frac{dq_1^R}{dp} + q_1^R\right]\right]}_{(+)}$$

So, $FOC_2(p_1^R) < 0$, meaning that $p_2^R \leq p_1^R$. *QED*

Proof of Proposition 4. In order to show that the most efficient firm is selected to run the concession, we just need to prove that the bid function, $p(\theta_i)$ is increasing. We assume first that it is increasing and show that this is true at the symmetric equilibrium. If the bid function is increasing, firms solve the following problem:

$$\max_{p_i}\left[1 - F\left(\psi\left(p_i\right)\right)\right]^{N-1}\pi_i^S\left(p_i, \theta_i\right)$$

and the first order conditions evaluated at the symmetric equilibrium are

$$-(N-1)[1-F(p(\theta_i))]^{N-2}\frac{f(\theta_i)}{p'(\theta_i)}\pi_i^S(p_i,\theta_i)+[1-F(p(\theta_i))]^{N-1}\frac{\partial\pi_i^S}{\partial p_i}(p_i,\theta_i)=0. \quad (12)$$

The second term of the equation is positive. Suppose not. Then, decreasing the price would increase expected profits conditional on winning. But by definition of the auction procedure, decreasing the price also increases the probability of winning, so decreasing the price would be optimal.

Then, the first term has to be negative. Since the expected profit conditional on winning is positive (otherwise, the firm would not participate), it must be that $p'(\theta_i)>0$. So, the most efficient firm bids the lowest price and wins the auction.

Now, to show that firms bid lower than in the naive case, we just need to show that, if they bid their naive price, the left hand side of equation (12) is negative, so decreasing the price is an optimal strategy. It is, then, enough to show that

$$\pi_i^S(p^N(\theta_i),\theta_i)>\pi_i^N(p^N(\theta_i),\theta_i),$$
$$\frac{\partial\pi_i^S}{\partial p_i}(p^N(\theta_i),\theta_i)<\frac{\partial\pi_i^N}{\partial p_i}(p^N(\theta_i),\theta_i).$$

where $p^N(\theta_i)$ is the bidding strategy when firms are naive and

$$\pi_i^N(p^N(\theta_i),\theta_i)=2[(p^N(\theta_i)-\theta_i)\overline{q}(p^N(\theta_i))-I].$$

Remember that $\varepsilon^*=\varepsilon^*(p,\theta)$ and $\alpha_h^*=\alpha_h^*(p,\theta,\tilde{\varepsilon})$ with $\frac{\partial\varepsilon^*}{\partial p}<0,\frac{\partial\varepsilon^*}{\partial\theta}>0$, $\frac{\partial\alpha_h^*}{\partial p}>0,\frac{\partial\alpha_h^*}{\partial\theta}<0$ and $\alpha_h^*=\alpha_h^*(p,\theta,\tilde{\varepsilon})\equiv 0\ \forall\tilde{\varepsilon}\le\varepsilon^*(p,\theta)$.

Using those relationships and with some computations it can be shown that

$$\pi_i^S\left(p_i^N,\theta_i\right)-\pi_i^N\left(p_i^N,\theta_i\right)=\int_{-\varepsilon}^{\varepsilon^*}\int_0^1\left[\left(p_h^R-\theta_i\right)q\left(p_h^R\right)-\left(p_i^N-\theta_i\right)q\left(p_i^N\right)\right]dG(\alpha)\frac{d\tilde{\varepsilon}}{2\varepsilon}$$
$$+\phi\int_{\varepsilon^*}^{\varepsilon}\int_0^{\alpha_h^*}\left[\left(p_h^R-\theta_i\right)q\left(p_h^R\right)-\left(p_i^N-\theta_i\right)q\left(p_i^N\right)\right]dG(\alpha)\frac{d\tilde{\varepsilon}}{2\varepsilon}. \tag{13}$$

Differentiating with respect to p and evaluating at the naive bidding strategy, we show that

$$\frac{\partial\pi_i^S}{\partial p_i}\left(p_i^N,\theta_i\right)-\frac{\partial\pi_i^N}{\partial p_i}\left(p_i^N,\theta_i\right)=-\int_{-\varepsilon}^{\varepsilon^*}\int_0^1\left[\left(p_i^N-\theta_i\right)\frac{dq_i^N}{dp}+q_i^N\right]dG(\alpha)\frac{d\tilde{\varepsilon}}{2\varepsilon}$$
$$+\frac{1}{2\varepsilon}\frac{\partial\varepsilon^*}{\partial p}\int_0^1\left[\left(p_h^R-\theta_i\right)q_h^R-I\right]dG(\alpha) \tag{14}$$
$$-\phi\int_{\varepsilon^*}^{\varepsilon}\int_0^{\alpha_h^*}\left[\left(p_i^N-\theta_i\right)\frac{dq_i^N}{dp}+q_i^N\right]dG(\alpha)\frac{d\tilde{\varepsilon}}{2\varepsilon}.$$

It is easy to see that (14) is negative. The first term of (13) is clearly positive, because it is evaluated at values of the shock for which the profit is negative without renegotiation. The second term, however, is negative, decreases when the distribution of α is more skewed towards low values, since the probability that the bargaining power is smaller than α_h^* is higher, and is equal to 0 if $G(\alpha) = 0\ \forall\ \alpha < 1$ and $G(1) = 1$. Therefore, there is a distribution sufficiently skewed to the right such that (13) is positive. For this distribution, the left hand side of (12) is negative when evaluated at the naive bidding strategy. Hence, firms want to bid lower than in the naive case. *QED*

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Tables

Table 1

		Pr(R_f)	**Pr(R_g / k)**
↑ θ (lower efficiency)	Direct effect	↑ Cost ⇒ ↑ ε^* ⇒ ↑ Pr(R_f)	↑ Cost ⇒ ↓ α_h^* ⇒ ↓ Pr(R_g / k)
	Indirect effect	↑ Bid ⇒ ↓ ε^* ⇒ ↓ Pr(R_f)	↑ Bid ⇒ ↑ α_h^* ⇒ ↑ Pr(R_g / k)
	Total effect	Indeterminate	Indeterminate

Table 2

		1) Rich in period 1	**2) Poor in period 1**
a) $\pi < 0$, any majority in period 2		Renegotiation, ↑ p	Renegotiation, ↑ p
b) $\pi < 0$, rich in period 2	$\alpha > \alpha_1^*$	No renegotiation	No renegotiation
	$\alpha < \alpha_1^*$		Renegotiation, ↓ p
c) $\pi < 0$, poor in period 2	$\alpha > \alpha_2^*$	No renegotiation	No renegotiation
	$\alpha < \alpha_2^*$	Renegotiation, ↓ p	

Figures

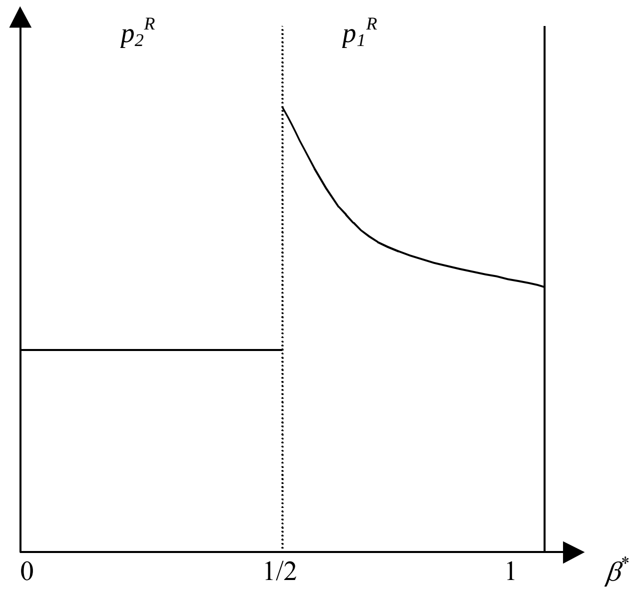

Figure 1: Renegotiated price as a function of β^*

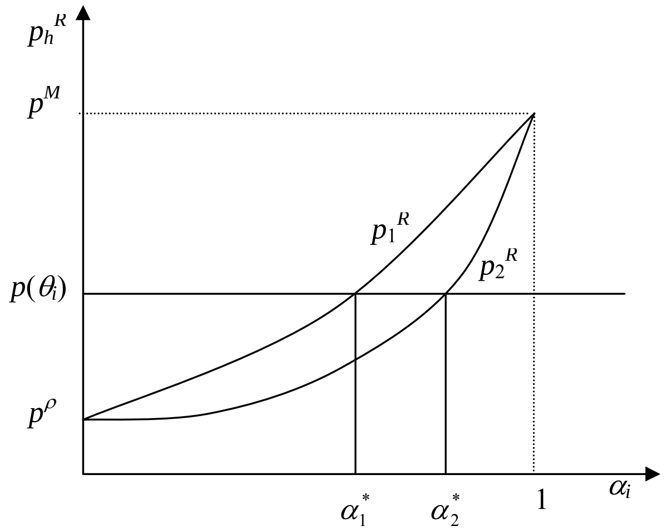

Figure 2: Determination of α_h^*