Signaling corruption through conspicuous consumption*

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November 25, 2021
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Abstract

Public officers suspected of corruption are often seen consuming conspicuously luxury goods. Since this raises public awareness about them, it can backfire and lead to an investigation that eventually finds them guilty. One plausible explanation to rationalize this behavior is that they are signaling their willingness to be corrupt, to attract the pool of corrupt firms and obtain higher bribes. In this work, we consider a public procurement setting where the government delegates a procurement officer (PO) to run the process. If the cost of the luxury good is low enough, then there exists a separating equilibrium where the corrupt PO signals his type and obtains a higher bribe. Even if the government fixes a budget constraint or maximum price before assigning a PO, a signaling equilibrium can still exist, but with a lower reserve price than socially optimal. Therefore, even though the government can reduce the bribe revenue, corruption and signaling results in aggregate welfare loss.

Keywords: corruption, public procurement, signals.

JEL Codes: D44, D73, H57.

*I am especially grateful to Christian Ruzzier for his advice and support. I also thank Cevat Aksoy, Gonzalo Ballestero, Lucía Quesada, Facundo Pernigotti and participants in the LVI Annual Meeting of the AAEP for their useful comments and suggestions. All errors and omissions are my own.

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1 Introduction

We frequently observe that (suspected) corrupt public officers are seen with luxury goods, which raises public awareness about them. For example, during his time in office as Argentina's Secretary of Transportation, Ricardo Jaime was repeatedly seen in a luxurious yacht and a private airplane (Alconada Mon, 2019), among other notorious goods and gifts. Jaime was in charge of allocating subsidies to transportation projects, some of which were poorly completed or not executed at all, and later on, he was found guilty of accepting bribes. Another Argentinian example is the former federal judge Norberto Oyarbide, who was seen with a notorious diamond ring valued at USD 250,000. He first claimed that he had bought the ring but later on denied this version.[1] Another example, which illustrates that this is not only a local phenomenon, is the case of Equatorial Guinea's former Agriculture Minister Teodorin Obiang Jr., the son of the country's President.[2] Despite his formal 3,200 Euros wage, he was seen in Paris driving luxury cars such as Ferrari or Porsche, among other goods. In addition to these examples, there is also cross-country empirical correlation between the corruption perception and sales of luxury cars and spending (Gokcekus and Suzuki, 2014; Tajaddini and Gholipour, 2018).

Regardless of whether these public officers effectively bought the goods or not, it is surprising that they were *seen* using and consuming them.[3] After all, conspicuous consumption can backfire and lead to an investigation that eventually finds them guilty of corruption. To rationalize this behavior, there must be some gains from publicly consuming these goods. One plausible explanation is that officers want to effectively signal their willingness to be corrupt and attract a pool of more corrupt firms, raising their expected revenue from bribes. While some firms might be willing to bribe a public officer, there is uncertainty about the officer they are facing, and they would certainly not try to bribe the most honest officer. With this signal, firms could have a better understanding of the type of agent that they are meeting and the actions that will let them win the procurement.

In this article, we show that there exists a separating equilibrium in which a corrupt officer signals his type by buying a luxury good. To do this, we consider a procurement auction where the government delegates the allocation of the project to a procurement officer (PO), who is potentially corrupt. We find that, if the cost of conspicuous consumption is low enough, in the separating equilibrium firms learn about the PO's type and only try to bribe the corrupt one. Compared to the equilibrium without the signaling stage, the PO attracts higher bribes from all firms, whereas when there is uncertainty about his type, then only firms with high cost will bribe. As a result of this, conspicuous consumption lets the firms know perfectly who is running the procurement. Moreover, even if the government can set a budget constraint or maximum reserve price before assigning a PO, we find that a signaling equilibrium still exists. The optimal reserve price in this equilibrium is below the social optimum, which implies that corruption entails a higher probability of declaring the procurement void and total welfare loss.

The idea that conspicuous consumption can act as a signal relates to the work of Fabrizi and Lippert (2017), who consider a principal-agent model where PO distinguish from another by the probability in which they are subjected to an audit. With imper-

[1] Reported in *Perfil*, available here.

[2] Reported in *The Guardian*, available here. See Fabrizi and Lippert (2017) for a detailed discussion of his case.

[3] In the previous examples, both Ricardo Jaime and Teodorin Obiang were found guilty of accepting bribes and corruption, respectively.

fect information about this audit probability, firms are uncertain about the value of the relationship and thus about the correct bribe level. If the officer's bargaining power is high enough, there exists a separating equilibrium where a PO consumes conspicuously or "burns money" and thus attracts higher bribes. However, this public servant is actually signaling his ability to succeed at corruption and not his corruptness, because firms know that they should try to bribe but are uncertain about the correct amount of the bribe. In this work, we show that a PO can directly signal his willingness to be corrupt through conspicuous consumption.

Since corruption can take many forms, a public officer can collude with the bidders and influence the result of a procurement in several ways.[4] A majority of the literature, starting with the seminal work of Che (1993), has focused on public procurement using scoring rules that include price and quality bids. Under a scoring scheme, an agent might bribe the PO to: misrepresent the *ex-post* effective quality (Burguet, 2017; Celentani and Ganuza, 2002), manipulate the assessment of quality in the bid (Burguet and Che, 2004), or provide private information about competing bids to one firm so it can resubmit a more aggressive price bid (Compte et al., 2005), among others. In these works, corruption typically entails that the government pays a higher price and gets a lower quality delivered, thus indicating inefficiency and welfare loss.

In this work, we will refrain from the scoring rule literature and consider the simpler framework of the public procurement of a single and homogeneous good, or a reverse auction. If a corrupt PO runs such procurement and assigns it to the firm with the largest bribe bid, under a predetermined price, Beck and Maher (1986) show that there is an isomorphism between bribery and competitive bidding. They show that there is a symmetric equilibrium, such that the firm with the lowest cost bids the largest bribe, and Lien (1986) shows that this equilibrium is unique. In this model, corruption entails no efficiency problem, only a redistribution between the PO and the government. However, if there is a collusive agreement between the PO and one firm, such that the former provides private information of the other bids, and all firms are aware of this informational advantage, Arozamena and Weinschelbaum (2009) show that corruption can change bidding behavior in a first price auction. In this model, there is a positive probability that the firm with the lowest cost does not win the auction, distorting the allocation of the project.

These works on corruption consider the collusion between the bidders and the inspector as given, where every agent knows that the public officer accepts bribes, whereas in this work we are interested in the case when there is uncertainty about his willingness to be corrupt. To the best of our knowledge, this article is one of the first to show that conspicuous consumption can perfectly signal a PO's corruptness within a standard public procurement framework. Therefore, we contribute to the signaling literature with an application of luxury goods or conspicuous consumption as an informative signal about an agent's type (Di Tella and Weinschelbaum, 2008; Fabrizi and Lippert, 2017).

2 The model

Let us consider the case of $n = 2$ firms that can produce a good or a project. Each firm i independently draws its cost $c_i \sim U[0, \bar{c}]$, with a cumulative function $F(c_i)$ that

[4] For a more detailed discussion of the microeconomics of corruption in recent years, see Burguet, Ganuza, et al. (2016).

is common knowledge. The government values it in $v \geq \bar{c}$, such that the production of this good is socially desirable, and it will be assigned following a procurement process. However, the government cannot run this auction by itself and must assign a procurement officer (PO) to conduct it, in addition to setting a budget constraint $r \geq 0$ to pay to the winning bidder.

This PO can be honest (H) with probability $\alpha \in (0,1)$ or corrupt/dishonest (C) with probability $1-\alpha$, and these probabilities are common knowledge. We will assume that an honest PO will never assign the project to a firm that offers him a bribe and, similarly, a dishonest PO only assigns projects to firms that offer him strictly positive bribes. If a firm tries to bribe an honest PO, then that firm will pay a penalty equal to $M \geq 0$, which represents the monetary value of going to jail, paying a fine or even the opportunity cost of being excluded from any future procurement. Additionally, we will assume that the government cannot use a mechanism to discover the PO's type.

After being assigned by the government and before running the procurement auction, the PO can buy a luxury good or "burn money", following Fabrizi and Lippert (2017).[5] This will be through an action $s \in \{S, N\}$ visible to all, where $s = S$ represents the conspicuous consumption that costs $\psi > 0$ but provides no direct utility and $s = N$ refers to doing nothing. When the PO decides whether to burn money or not, the government has already set a maximum price r and assigned him to run the procurement.

After observing its own private cost c_i, each firm competes for the assignment of the project in the procurement. Each one must choose a non-negative amount b to bribe (potentially equal to 0) and a non-negative price p to bid. With an honest PO, all firms that submit a strictly positive bribe $b > 0$ will be reported and must pay the penalty. Because firms observe the signal s, they can use that information to calculate the posterior probability of meeting an honest PO $\mu(s)$ given s.

The timing of the more general model is as follows:

- $\mathbf{t = 0}$: The government assigns a PO to run the procurement process, given the budget constraint $r > 0$ for the project.
- $\mathbf{t = 1}$: Nature draws the costs $c_i \sim U[0, \bar{c}]$ of the firms and decides whether the PO is honest (with probability α) or not.
- $\mathbf{t = 2}$: The PO, knowing his type, decides whether to "burn money" (S) or not (N). If the action is $s = S$, it will cost him a given amount $\psi > 0$, which is the price of the luxury good.
- $\mathbf{t = 3}$: After observing s, firms submit a price and a bribe bid (potentially equal to zero).
- $\mathbf{t = 4}$: The honest PO grants the contract to the lowest price bid and reports firms that tried to bribe him. The dishonest PO assigns the project to the firm with the highest bribe.

Regarding these assumptions, even though the motivating fact is that conspicuous consumption can backfire and lead to an investigation, the model does not explicitly include an audit or conviction probability. This is because we want to show that there are *gains* from signaling corruption, given that signaling has costs. While conspicuous consumption can trigger an external audit, a PO can only be found guilty if there is evidence and proof that he accepted bribes. In countries with weak judicial institutions,

[5] The term of "burning money" refers to the fact that the agent derives no direct utility from the luxury good.

such as the ones in the motivating examples, the probability of being convicted after consuming conspicuously will be small, and because of this, we will simplify the analysis by not explicitly incorporating this cost.

Moreover, we are considering the case of a single PO, that cannot communicate externally with the firms before or during the procurement and has no information about the firms. Thus, we rule out the possibility of favoritism and/or *ex-ante* agreement on information disclosure to some firm, in addition to the possibility of a network effect outside of the procurement process (where a PO already has a corrupt reputation). This is because, in order to build this reputation or to get to an agreement, the firms and the PO must communicate, but they are both uncertain about the type of agent that they are meeting. This is, a firm might be trying to get to an agreement with an honest PO, or a corrupt PO could try to build a reputation among firms that would never bribe. Therefore, the model captures these information disclosure mechanisms through the price and bribe bidding process. Also, if a firm believes that the PO is more likely to be corrupt but is not perfectly certain, then there can still be gains from signaling (as it will become clear from Propositions 1 and 2).

Additionally, we are considering a static or one period model with a single PO, while a public servant usually works in government for many periods. This eliminates the reputation that the PO can build from successive procurement since eventually, all firms could try to bribe and thus learn about its type. However, the PO can also guarantee himself bribes for his entire lifespan by burning money once. Also, in the period following conspicuous consumption, the government could replace the PO. However, with a low discount factor, we expect that the one period gains from bribes can offset the infinite period discounted utility with firm uncertainty about its type. Therefore, the static model captures the relevant incentives that we aim to consider.

2.1 Procurement auction without a signal

Let us consider the equilibrium when there is a budget constraint $r > \bar{c}$, which does not affect the firms' entry decision. With uncertainty about a PO's type, a firm i must bid an honest price bid or a bribe, given its belief about the firm j's behavior. If the firm bids an honest price p_i and does not bribe, it can only win when meeting an honest PO (which happens with probability α) and bidding lower than firm j. Equation (1) describes the problem of a firm that decides to bid honestly.

$$\max_{p_i} \alpha(p_i - c_i)Pr(\text{win}|p_i) = \max_{p_i} \alpha(p_i - c_i)Pr(p_i < p_j) \tag{1}$$

If the firm i bribes the PO, it can only win the auction when meeting the corrupt officer (with probability $1-\alpha$) and bribing more than firm j. Since the firm can ask the corrupt PO to assign them any winning price below the budget constraint $r > \bar{c}$, any firm that bribes will bid $p(c_i) = r$. Also, this firm will meet with probability α an honest PO, who will report the bribe and force it to pay the penalty M. Equation (2) describes the problem of a firm that decides to bribe.

$$\begin{aligned} &\max_{p_i \leq r, b_i} (1-\alpha)(p_i - c_i - b_i)Pr(\text{win}|b_i) - \alpha M \\ &\equiv \max_{b_i} (1-\alpha)(r - c_i - b_i)Pr(b_i > b_j) - \alpha M \end{aligned} \tag{2}$$

Unlike the case with perfect information about the PO's type, a firm might not chose to always or never bribe. In equilibrium, we would expect that a firm's behavior is a function of its cost. On the one hand, with a high cost it will be very unlikely for this firm to win the procurement by competing in price. On the other hand, with a low cost, a firm can expect to win the procurement by bidding a price and has no incentives to bribe. Proposition 1 characterize this equilibrium, where firms bribe sometimes.

Proposition 1 *Given a reserve price $r > \bar{c}$ and a penalty $M \geq 0$, there exists a symmetric and linear Bayesian Nash equilibrium in which a firm decides to bribe only if their costs are larger than some $\hat{c} \in (0, \bar{c})$. In the simple case that $M = 0$, it is sufficient that $\alpha \in (\frac{1}{2}, 1)$ for this equilibrium to exist.*

Sketch of the proof. Given a mid value $\hat{c} \in (0, \bar{c})$, a firm i will bribe and bid a price of r when $c_i \geq \hat{c}$, but will not bribe when $c_i < \hat{c}$. Given the symmetric and linear strategy for a firm with cost lower than $\hat{c}$, the probability of winning equals α times the probability that firm j has a higher cost. Since this is the problem of a firm in a public procurement, the price bid is the same as in the symmetric and linear Bayesian equilibrium.

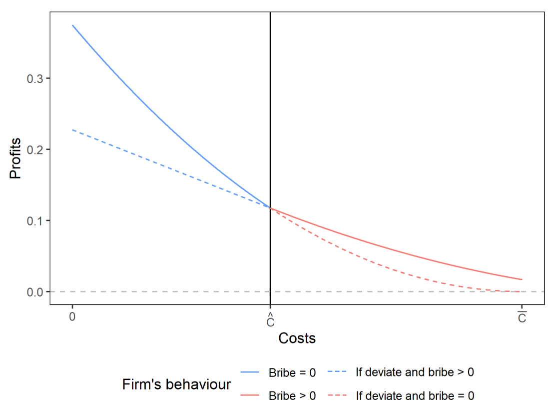
For a firm i with cost higher than $\hat{c}$, it will win if firm j has a higher cost but also if firm j has a cost lower than $\hat{c}$, conditional on meeting a corrupt PO. This increases the probability of winning and the expected utility if the penalty is small or nil. However, this reduces the bribe competition, since a firm bribe occasionally, and therefore reduces the bribe bid of firm i. Finally, the mid value $\hat{c}$ is determined by looking at the cost at which a firm with cost $\hat{c}$ is indifferent between bribing and competing honestly.

A set of conditions is needed to ensure that $\hat{c}$ is in the interval $(0, \bar{c})$, that the bribe bid is non negative, and that the utility of the firm that bribes is always non-negative for a given penalty $M \geq 0$. It can be shown that this set is non empty and also implies that no firm has incentives to deviate, because the expected utility functions are quadratic. In the simple case that $M = 0$, it is sufficient that $\alpha \in (\frac{1}{2}, 1)$.

See Appendix A.1 for a complete proof. ■

In this equilibrium, a firm bribes only if its cost is large, because the probability of meeting a firm with lower costs and losing the procurement results in a low expected utility of competing honestly. Figure 1 illustrates the expected utility of a firm as a function of its cost, and also the utility it can obtain by deviating (dashed line). As the Figure shows, a bribing firm is strictly better than without bribing. This is because the bribe bid is strictly *smaller* than with perfect certainty about the PO corruptness (if $\alpha = 0$). The intuition behind this result is that firms will bribe only sometimes, which reduces the bribery competition and the bribe bids. Therefore, while bribery and corruption with perfect information increase bribe competition (Compte et al., 2005), here the uncertainty reduces the bribery competition and the bribes, also reducing the PO's expected revenue.

Figure 1: Expected profits of a firm

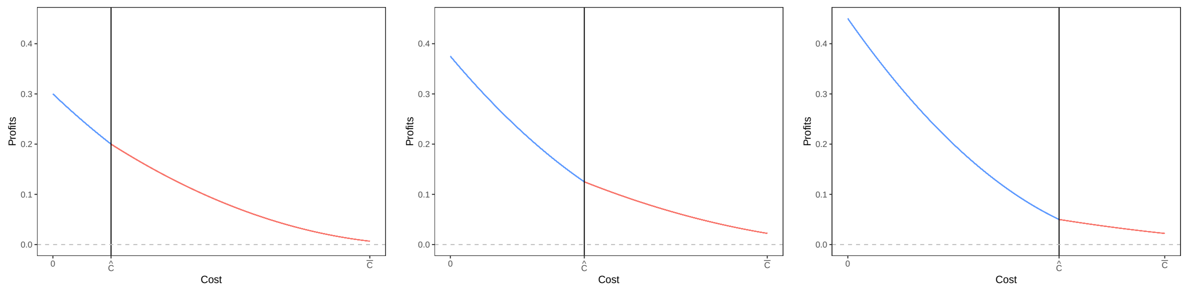


$\alpha = \frac{3}{4}$, $\bar{c} = 1$, $r = 2$ and $M = \frac{1}{100}$

Moreover, Proposition 1 shows that even if there is no direct punishment for trying to bribe an honest PO (if $M = 0$), a firm does not always bribe. The relevant friction that arise comes from the uncertainty that the firms face about the PO's type, and not from the consequences of bribing an honest PO. Figure 2 shows the expected utility of a firm when the probability α of meeting an honest PO increases. When the probability $1 - \alpha$ of meeting a corrupt PO is smaller (larger α), the share of firms that bribe is smaller, as can be seen in the Figure. However, this share is never equal to zero as long as $\alpha < 1$. Therefore, when there is any uncertainty about the PO's type, this equilibrium will exist.

Figure 2: Expected profits of a firm, as function of α

(a) $\alpha = 0.6$ (b) $\alpha = 0.75$ (c) $\alpha = 0.9$



$\bar{c} = 1$, $r = 2$ and $M = 0$

Finally, this equilibrium entails allocation and welfare inefficiencies. First, there is a positive probability that the procurement will be declared void, which happens when all firms have costs larger than $\hat{c}$ and try to bribe the honest PO, or when all firms have costs smaller than $\hat{c}$ and meet the corrupt one. Second, there is a positive probability that the firm with the largest cost wins the procurement. With a corrupt PO, if a firm has a cost lower than $\hat{c}$ while the other firm's cost is larger than $\hat{c}$, then the latter will win the procurement process because it will be the only firm that bribes the PO. Since the production of the good is socially desirable, because $v > \bar{c}$, all these welfare implications are undesirable.

2.2 Procurement auction with conspicuous consumption

Since imperfect information results in lower bribes and the described inefficiencies, can the PO do any better? Let us introduce conspicuous consumption as a signal, a costly action that the PO makes before the procurement and that the firms can observe. Firms can incorporate this information to have a better understanding of the PO's type, to learn what action is going to let them win.

Given the signal $s \in \{S, N\}$, a firm considers that it is meeting an honest PO with probability $\mu(s)$, and given its cost c_i, firm i can bid a different price $p(c_i|s)$ and bribe $b(c_i|s)$ according to the observed action of the PO. With this additional action, there is a separating perfect Bayesian equilibrium where a corrupt PO signals his type. Proposition 2 characterizes the set of parameters for such an equilibrium to exist.

Proposition 2 *Given $r > \bar{c}$, if the cost of burning money is small enough ($\psi \leq r - \frac{2\bar{c}}{3}$), then there exists a separating equilibrium in which a corrupt PO signals that it is dishonest by consuming conspicuously. In this equilibrium:*

i. The firm with the lowest cost wins the procurement (by bribing or bidding a price).

ii. The government expected price is $\alpha\frac{2\bar{c}}{3} + (1-\alpha)r$.

Sketch of the proof. Given the PO's action in the separating equilibrium, the firm is certain about the PO's type. A firm will bid a price equal to r and a bribe that maximize the expected utility when meeting the corrupt PO. Therefore, the bribe equals to $r - \frac{c+\bar{c}}{2}$ when $s = S$, and the firm will not bribe when $s = 0$. The expected utility of a corrupt PO will be equal to $r - \frac{2\bar{c}}{3}$ minus the cost ψ.

Given the firm's strategies, consuming conspicuously must be the best response of a corrupt PO. Since the PO will not obtain any bribe if $s = N$, it is sufficient that the expected utility $r - \frac{2\bar{c}}{3} - \psi$ is at least zero, which results in the condition $\psi \leq r - \frac{2\bar{c}}{3}$.

See Appendix A.2 for a complete proof. ■

In this signaling equilibrium, the corrupt PO burns money or buys a luxury good. By doing this, each firm updates its priors and can perfectly know who is running the procurement. Therefore, a firm will only try to bribe the PO with the luxury good and will compete honestly with a price bid if the PO does not consume conspicuously. For this equilibrium to exist, the cost of burning money must be small enough, such that the net profit of the bribes exceeds the cost, but positive such that the signal is costly and informative.

Additionally, in this equilibrium, the procurement will never be declared void and the firm with the lowest cost will always win the project. The government expected utility is equal to $v - \alpha\frac{2\bar{c}}{3} - (1-\alpha)r$ and the expected rent that the PO will get (weighted by the probability of being corrupt) is $(1-\alpha)(r - \frac{2\bar{c}}{3} - \psi)$. Therefore, the sum of expected utilities or total welfare is equal to $v - \frac{2\bar{c}}{3} - (1-\alpha)\psi$. This total welfare equals the government expected utility with an always honest PO or the maximum welfare attainable through a first price procurement auction of $v - \frac{2\bar{c}}{3}$, minus the cost of the signal. Therefore, while the signal eliminates the allocating distortion, it generates an efficiency problem through the welfare loss of burning money. This inefficiency is reduced when the probability of being corrupt or the signaling cost are small, but it is always positive.

Given the separating equilibrium that Proposition 2 characterizes, let us consider the other equilibria. As Proposition 3 states, there is a pooling equilibrium in which both an honest and dishonest PO do not burn money. In this equilibrium, the firms bid prices and bribes just like in Proposition 1. However, because the cost of the luxury good is strictly positive and the honest PO will never accept bribes nor assign the procurement to a corrupt firm, the honest PO will never choose $s = S$.

Proposition 3 *In this model:*

1. *There exists a pooling equilibrium with* $\mu(N) = \alpha$*, under the same set of conditions as in Proposition 1. In this equilibrium, if* $s = N$ *firms bid according to the strategy in Proposition 1. If* $s = S$*, then no one will bribe, and an out-of-equilibrium belief of* $\mu(S) = 1$ *is consistent with this strategy.*
2. *There is no pooling nor separating equilibrium where the honest PO consumes conspicuously.*

Note that the existence of the pooling equilibrium in Proposition 3 implies a certain firm's behavior out of the equilibrium path. This equilibrium exists if firms do not bribe when $s = S$ (which, of course, does not happen in equilibrium), and it explains why a corrupt PO has no incentive to deviate from $s = N$.

Moreover, because of the firms' symmetric cost distribution and the participant's risk aversion, the signaling equilibrium in Proposition 2 can be generalized to the case of a second-price auction (where the firm with the lowest price wins but obtains the second lowest price), an English auction and a Dutch auction. Under these settings, an analogous to a Revenue Equivalence Theorem holds, and the following Proposition formalizes it:

Proposition 4 *Given a reserve price $r \geq \bar{c}$, if the cost of burning money is small enough ($0 < \psi \leq r - \frac{2\bar{c}}{3}$), then there exists a separating equilibrium regardless of whether the honest PO runs a first-price, second-price, English or Dutch auction. In this equilibrium:*

i. The firm with the lowest cost wins the procurement.

ii. The government expected price is $\alpha\frac{2\bar{c}}{3} + (1-\alpha)r$.

Proof. The result follows from the standard Revenue Equivalence Theorem. With probability α, the firms meet an honest PO who runs a first-price, second-price, English, or Dutch auction. Since firms draw their costs from an identical distribution, the Revenue Equivalence Theorem holds and the government expected revenue equals $v - \frac{2\bar{c}}{3}$ (or the expected price is $\frac{2\bar{c}}{3}$).

With probability $1-\alpha$, the government meets a corrupt PO that perfectly signals his type, such that the expected price equals r. In this case, firms compete in a first bribe auction and the firm with the lowest cost wins. ■

2.3 Government optimal reserve price

Since the government can fix a budget constraint r that the PO must respect, regardless of its type, we will now discuss the existence of the signaling equilibrium and the optimal reserve price r. Let us first consider the case of the government meeting an always honest PO ($\alpha = 1$) and an always corrupt PO ($\alpha = 0$). This will determine the optimal reserve price with an honest PO (r^H) and with an always corrupt PO (r^C), which will be useful to characterize the signaling equilibrium.

With an honest PO and given a reserve price $r \leq \bar{c}$, following Krishna (2009)[6], the optimal price bid for a firm i with cost $c_i \leq r$ is to take the expected value of the minimum of cost c_j and r, given that the other firm has larger cost (or $c_j > c_i$). This results in a price bid of $p(c_i) = \frac{c_i+\bar{c}}{2} - \frac{(\bar{c}-r)^2}{2(\bar{c}-c_i)}$, as Proposition 5 states. Given the budget constraint, the government obtains a utility of $v - \min\{p_1, p_2\}$ only if at least one of the firms has a cost lower than r. The following Proposition characterizes this equilibrium.

Proposition 5 *If the government values the project in $v \geq \bar{c}$ and the PO is always honest, then:*

i. The optimal price bid for a firm with costs $c \leq r$ is $p(c) = \frac{c+\bar{c}}{2} - \frac{(\bar{c}-r)^2}{2(\bar{c}-c)}$, while a firm with cost $c > r$ does not bid.

ii. The optimal reserve price for the government is $r^H = \min\{\frac{v}{2}, \bar{c}\}$, with an expected utility of $EU^H(r) = \frac{\frac{4}{3}r^3 - r^2(v+2\bar{c}) + 2v\bar{c}r}{\bar{c}^2}$.

This implies that, if the government valuation is $v \leq 2\bar{c}$ such that $r^H = \frac{v}{2} < v$, then there is a positive probability that the procurement is declared void if both firms have costs above the maximum reserve price. This result is standard within the auction or procurement literature (Krishna, 2009; Thomas, 2005), and the intuition of this result is that the constraint lowers the price bids. Therefore, this increases the expected utility $v - \min\{p_1, p_2\}$ when one of the firms has a cost less than r, which offsets the loss of declaring the procurement void when meeting two high costs firms.

If the PO was always corrupt, this drastically modifies the government's problem because it will pay the reserve price for sure. In this case, the government expected utility equals $v - r$ times the probability that one of the firms has a cost less than r.

[6]The result for auctions is that, given two individuals with valuations v_i, v_j, the optimal bid in a first price auction if $v_i \geq r$ is $p(v_i) = E[\max\{v_j, r\}|v_j < v_i]$.

Since the government will always pay r, there is a trade-off between setting a high price r and getting a low benefit $v - r$ with high probability or setting a low price with high benefit but low probability. As a result of this, the government should reduce the price compared to the case with an honest PO. Proposition 6 characterizes the government's optimal reserve price in this situation.

Proposition 6 *If the government values the project in $v \geq \bar{c}$ and the PO is always corrupt, then:*

i. The optimal bribe bid for a firm with costs $c \leq r$ is $b(c) = \frac{(r-c)^2}{2(\bar{c}-c)}$, while a firm with cost $c > r$ does not bid.

ii. The optimal reserve price for the government r^C depends on v and $\bar{c}$ and it is smaller than r^H. Also, the government expected utility is $EU^C(r) = \frac{r^3 - r^2(v+2\bar{c}) + 2v\bar{c}r}{\bar{c}^2}$

It is important to notice that, in this equilibrium, the expected utility of the government $EU^C(r)$ is smaller than with an honest PO $EU^H(r)$. Given a reserve price, the difference between these two utilities is exactly $\frac{r^3}{3\bar{c}}$, which is the expected revenue of the PO. However, with an always corrupt PO, the government should fix a lower reserve price r^C than with an honest PO r^H, which results in total welfare loss.

Finally, with imperfect information about the PO's type, a similar signaling equilibrium as in Proposition 2 exists. As in Proposition 2, if the signaling cost is positive but lower than the expected bribe revenue $\frac{r^3}{3\bar{c}}$, we can characterize a separating perfect Bayesian equilibrium where the PO signals his type. In this equilibrium, the firm with the lowest cost will win the procurement, either by bribery or by bidding a price.

Proposition 7 *Even if the government can select the reserve price before assigning the PO, then there exists a separating equilibrium where the PO signals his type with a sufficiently low cost $0 < \psi < \frac{r^3}{3\bar{c}}$. In this equilibrium, the government's optimal reserve price r^S is in the interval (r^C, r^H).*

Therefore, a separating equilibrium is still possible for a sufficiently low signaling cost and the government's optimal reserve price is below r^H but above r^C. The optimal reserve price r^S in this equilibrium implies two (related) inefficiencies. On the one hand, because the optimal price in this separating equilibrium is lower than with an honest PO (*i.e.*, $r^S < r^H$), there is a higher probability of declaring the procurement void. This is unwanted since the project is socially desirable given that $v \geq \bar{c}$. On the other hand, the total welfare before including the signaling cost is smaller with r^S than with r^H.

Regarding the latter claim, the corrupt PO expected revenue (before including the signaling cost) is $\frac{r^3}{3\bar{c}^2}$, while the government expected utility is:

$$\begin{aligned} EU^S(r) &= \alpha EU^H(r^S) + (1-\alpha)EU^C(r^S) \\ &= \frac{\alpha r^3}{3\bar{c}^2} + \frac{r^3 - r^2(v+2\bar{c}) + 2v\bar{c}r}{\bar{c}^2} \end{aligned}$$

The total expected welfare is the sum of the expected utilities (weighted by the likelihood of meeting the dishonest PO), which equals:

$$\begin{aligned} W(r) &= \frac{(1-\alpha)r^3}{3\bar{c}^2} + EU^S(r) \\ &= \frac{\frac{4}{3}r^3 - r^2(v+2\bar{c}) + 2v\bar{c}r}{\bar{c}^2} \end{aligned}$$

From Proposition 5 we know that the reserve price that maximizes this total welfare $W(r)$ is r^H, which implies that $W(r^S) < W(r^H)$. As a result of this, imperfect information results in a welfare loss before accounting for the signaling cost, even when the PO can perfectly signal its type to the firms. Therefore, allowing the government to set a reserve price does not eliminate the distortions and, while reserve price can increase the government expected utility, corruption and signaling result in a total welfare loss.

3 Concluding remarks

We motivated this work with some real-life examples of a connection between luxury goods or conspicuous consumption and corruption from former public servants. While the losses and consequences of raising public awareness are clear, we were interested in the potential gains from signalizing the type, such that this observed behavior can be rationalizable.

In our model, the procurement officer has incentives to signal his type to attract higher bribes from all firms. The underlying mechanism is that the firms can understand better the actions that will let them win the procurement, and thus they can completely switch to competition in bribes instead of competing with price bids. As a result of this, it raises the PO expected revenue from bribes. Moreover, if the government tried to deter corruption by fixing a budget constraint, it could improve its expected utility but not completely eliminate corruption and conspicuous consumption. With a low signaling cost, the PO can still perfectly signal his type, which is a surprisingly weak condition.

Regarding the allocation of the procurement and the total welfare, in the signaling equilibrium, the PO never grants the procurement to a firm with the highest cost. Therefore, even though the government pays a higher price, the efficient firm provides the good, although the money that the corrupt PO burns in conspicuous consumption directly results in welfare loss. Moreover, with the budget constraint $r \leq \bar{c}$, the government should set a maximum price below the social optimum. As a result of this, there is a higher probability of declaring the procurement void than with an honest PO, which results in total welfare loss.

Therefore, in this model, signaling corruption never implies that the winning firm has a higher cost than its competitors, while other inefficiencies may arise. Since the literature suggests that there is a positive probability that the firm with the lowest cost does not win the model, resulting in allocation distortion, future studies can extend the model to capture the firm's heterogeneity in the bribery technology. Additionally, future research can broaden the model to a dynamic setting where a PO can build a reputation.

Overall, we conclude that conspicuous consumption can act as a strong signal about a public servant's type and honesty.

A Proofs

A.1 Proposition 1

Let us consider a symmetric Bayesian Nash equilibrium, where a firm bids a price if its cost is smaller than some $\hat{c} \in (0, \bar{c})$ and a bribe equal to zero, but bribes a positive quantity if its cost is larger than $\hat{c}$ and demands a price equal to r. With symmetric and linear price and bribe bids:

$$(p(c_i), b(c_i)) = \begin{cases} (ac_i + k, 0) & if \quad c_i < \hat{c} \\ (r, m(r - c_i) + d) & if \quad c_i \geq \hat{c} \end{cases}, \text{ with } a, k, m, d > 0 \tag{3}$$

For a firm with $c_i < \hat{c}$, the probability of winning given a price bid p_i and conditional on meeting an honest PO, which happens with probability α, is equal to:

$$\begin{aligned} Pr(\text{win}|p_i) &= Pr(\text{win} \cap \text{firm } j \text{ bribes}|p_i) + Pr\left(\text{win} \cap \text{firm } j \text{ bids } p_j|p_i\right) \\ &= Pr(c_j \geq \hat{c}) + Pr\left(p_i < p_j = ac_j + k \wedge c_j < \hat{c}|p_i\right) \\ &= 1 - F(\hat{c}) + Pr\left(c_j > \frac{p_i - k}{a} \wedge c_j < \hat{c}|p_i\right) \\ &= 1 - F(\hat{c}) + Pr\left(\frac{p_i - k}{a} < c_j < \hat{c}|p_i\right) \\ &= 1 - F(\hat{c}) + \left(F(\hat{c}) - F\left(\frac{p_i - k}{a}\right)\right) \\ &= 1 - F\left(\frac{p_i - k}{a}\right) \end{aligned}$$

Therefore, the firm solves the problem below. Since this equals the problem with an always honest competition, its price bid is equal to $p(c_i) = \frac{c_i + \bar{c}}{2}$ and its expected utility is $u_i^H = \alpha \frac{(\bar{c} - c_i)^2}{2\bar{c}}$.

$$\max_{p_i}(p_i - c_i)\alpha\left(1 - F\left(\frac{p_i - k}{a}\right)\right) = (p_i - c_i)\alpha\left(1 - \frac{p_i - k}{a\bar{c}}\right)$$

For a firm with cost $c_i > \hat{c}$, the probability of winning given a bribe and conditional on meeting a dishonest PO, which happens with probability $1 - \alpha$, is equal to:

$$\begin{aligned} Pr(\text{win}|b_i) &= Pr(\text{win} \cap \text{firm } j \text{ bribes}|b_i) + Pr\left(\text{win} \cap \text{firm } j \text{ bids } p_j|b_i\right) \\ &= Pr(b_i > b_j = m(r - c_j) + d \wedge c_j \geq \hat{c}|b_i) + Pr(c_j < \hat{c}) \\ &= Pr(c_j > r - \frac{b_i - k}{a} \wedge c_j \geq \hat{c}|b_i) + F(\hat{c}) \\ &= Pr\left(c_j > \max\left\{r - \frac{b_i - k}{a}, \hat{c}\right\}\right) + F(\hat{c}) \end{aligned}$$

$$\text{if } \frac{ar - b_i + k}{a} \geq \hat{c} \rightarrow = 1 - F\left(\frac{ar - b_i + k}{a}\right) + F(\hat{c})$$

Therefore, the firm with costs $c_i \geq \hat{c}$ solves the following problem:

$$\begin{aligned} &\max_{b_i}(1 - \alpha)(r - c_i - b_i)\left(1 + F(\hat{c}) - F\left(\frac{ar - b_i + k}{a}\right)\right) - \alpha M \\ &= (1 - \alpha)(r - c_i - b_i)\frac{(a\bar{c} + a\hat{c} - ar + b_i + k)}{a\bar{c}} - \alpha M \end{aligned}$$

The first order condition is that $r - c_i - b_i = a\bar{c} + a\hat{c} - ar + b_i + k$ and therefore, based on the proposed linear strategy, the firms bribes $b(c_i) = \frac{r-c_i}{2} + \frac{r-\bar{c}-\hat{c}}{2} = r - \frac{c_i+\bar{c}+\hat{c}}{2}$. Note that this bribe is smaller than the case where all firms bribe. Also, its expected utility is equal to $u_i^C = (1-\alpha)\frac{(\bar{c}+\hat{c}-c_i)^2}{2\bar{c}} - \alpha M$ and note that for this bribe, the inequality $\frac{ar-b_i+k}{a} = c_i \geq \hat{c}$ holds.

In order to find the value $\hat{c}$, a firm with cost $c_i = \hat{c}$ must be indifferent between bribing and competing honestly. Therefore, $\bar{c}$ results from the following equation:

$$\alpha\frac{(\bar{c}-\hat{c})^2}{2\bar{c}} = (1-\alpha)\frac{\bar{c}^2}{2\bar{c}} - \alpha M$$

$$\alpha\hat{c}^2 - 2\alpha\bar{c}\hat{c} + (2\alpha - 1)\bar{c}^2 + 2\alpha\bar{c}M = 0 \tag{4}$$

This results in a quadratic equation with up to two real solutions, one less than $\bar{c}$ and one larger than $\bar{c}$, which are $\hat{c}_{1,2} = \bar{c}\left(1 \pm \sqrt{\frac{(1-\alpha)}{\alpha} - \frac{2M}{\bar{c}}}\right)$. Therefore, $\hat{c} = \bar{c}\left(1 - \sqrt{\frac{(1-\alpha)}{\alpha} - \frac{2M}{\bar{c}}}\right)$

In order to have a $\hat{c}$ in the set $(0, \bar{c})$, it must be that the root of Equation 4 is in that set (condition *i*). Additionally, the square root in $\hat{c}$ must be real valued, and therefore this term must be larger than zero (condition *ii*). Also, since the firms expected revenue is decreasing in its costs, it must be the case that for a firm with costs $c_i = \bar{c}$, the utility of being corrupt must be at least 0 (the utility of competing honestly, in condition *iii*). Finally, the bribes must be non negative, and it is sufficient that the bribe of a firm with cost $\bar{c}$ is at least zero (condition *iv*). Thus, these conditions are:

(i) $1 - \sqrt{\frac{(1-\alpha)}{\alpha} - \frac{2M}{\bar{c}}} > 0 \iff (1-2\alpha)\bar{c} < 2\alpha M \iff \alpha > \frac{\bar{c}}{2M+2\bar{c}}$.

(ii) $\frac{(1-\alpha)}{\alpha} - \frac{2M}{\bar{c}} > 0 \iff (1-\alpha)\bar{c} > 2\alpha M \iff \alpha < \frac{\bar{c}}{2M+\bar{c}}$.

(iii) $\frac{(1-\alpha)\hat{c}^2}{2\bar{c}} - \alpha M \geq 0 \iff \alpha \leq \frac{\hat{c}^2}{2\bar{c}M+\hat{c}^2} \underbrace{<}_{\hat{c}\leq\bar{c}} \frac{\bar{c}}{2M+\bar{c}}$

(iv) $r - \frac{2\bar{c}+\hat{c}}{2} \geq 0 \iff r \geq \frac{2\bar{c}+\hat{c}}{2} = \bar{c} + \frac{\hat{c}}{2} > \bar{c}$

Finally, we must check that a low cost firm does not want to bribe and that a high cost firm does not want to compete honestly. If a firm with low costs $c_i \leq \hat{c}$ decided to bribe, it will surely win the bribery game with a bribe slightly less than $b(\hat{c}) = r - \frac{2\hat{c}+\bar{c}}{2}$ with an utility equal to $u_i^{deviate} = (1-\alpha)\left(\hat{c} - c_i + \frac{\bar{c}}{2}\right) - \alpha M$. Therefore, its expected profits can be at most equal to this value, which is less than the utility of being honest $u_i^H = \frac{\alpha(\bar{c}-c_i)^2}{2\bar{c}}$. This is because both values are equal to the same value at $c_i \to \hat{c}$ (because of the definition of $\hat{c}$), but since $\frac{\partial u_i^H}{\partial c_i} < \frac{\partial u_i^{deviate}}{\partial c_i}$, the firm has no incentive to deviate. This last inequality holds because of conditions *i* and *ii*. Similarly, if a firm with high costs $c_i \geq \hat{c}$ decides to compete honestly, it would get at most an utility equal to $\frac{\alpha(\bar{c}-c_i)^2}{2\bar{c}}$, which is less than $(1-\alpha)\frac{(\bar{c}+\hat{c}-c_i)^2}{2\bar{c}} - \alpha M$ because of the listed conditions. Also, note that if $M = 0$, then all conditions hold if $\alpha \in (\frac{1}{2}, 1)$ ∎

A.2 Proposition 2

In the separating equilibrium, $\mu(N) = 1$ and $\mu(S) = 0$, this is, the PO that burns money is not honest and the one that does not consume conspicuously is honest. If that is the case, from a standard procurement auction and from Beck and Maher (1986) we know that firms should bid $p(c|S) = r$ and $b(c|S) = r - \frac{c+\bar{c}}{2}$ if they observe S, but should bid $p(c|N) = \frac{c+\bar{c}}{2}$ and $b(c|N) = 0$ if not.

Given the firms' strategies and beliefs, we must check that the PO effectively wants to signal out its type. If the corrupt PO burns money, it loses $\psi > 0$ but has an expected revenue from bribes equal to $r - \frac{2\bar{c}}{3} > 0$. Thus, if $0 < \psi < r - \frac{2\bar{c}}{3}$, then the PO is strictly better by signaling and prefers to do so.

Note that the firms have no incentives to deviate: if they decided not to bribe given $s = S$, then they will not be granted the project for sure. Also, if they do not see this signal and decided to bribe, they would pay the penalty M for sure. Additionally, the PO has no incentives to deviate: if the corrupt PO decided not to consume conspicuously, it would get no bribe for sure. If the honest PO decided to burn money, it would only lose $\psi > 0$.

Finally, the firm with the lowest cost wins the procurement auction: with probability α by bidding the lowest price and with probability $1-\alpha$ by submitting the largest bribe. Therefore, the expected price with an honest PO is $\frac{2\bar{c}}{3}$ and with a dishonest PO is r. ∎

A.3 Proposition 3

1. Given the firms belief that $\mu(N) = \alpha$, let us consider the price and bribe strategies considered in Proposition 1, to bribe only if costs are above a mid value $\underline{c}$. In order for such a strategy to characterize an equilibrium, the same set of conditions are needed. In this case, the dishonest PO has a positive expected revenue and pays no cost. However, in order to ensure that the PO has no incentives to deviate, firms must not try to bribe a PO, so $b(c|S) = 0$. In that case, burning money yields no expected benefit and the PO would be strictly worse by trying to signal his type.

2. The dishonest PO has no incentives to select $s = S$, since it would lose $\psi > 0$ for sure and not get anything in return. This rules out the separating and pooling equilibria where the dishonest PO burns money. ∎

A.4 Proposition 5

Given a reserve price r and when facing an honest PO, following Krishna (2009), the optimal price bid for a firm is $p(c_i) = E[\min\{c_j, r\}|c_j > c_i]$. Since $Pr(c_j \geq x|c_j > c_i) = \frac{Pr(c_i<c_j\geq x)}{Pr(c_j>c_i)} = \frac{F(x)-F(c_i)}{1-F(c_i)} = \frac{x-c_i}{\bar{c}-c_i}$ for the uniform distribution, this has a density function of $\frac{1}{\bar{c}-c_i}$. Therefore, $p(c_i) = \int_{c_i}^{r} \frac{c_j}{\bar{c}-c_i} dc_j + \int_{r}^{\bar{c}} \frac{r}{\bar{c}-c_i} dc_j = \frac{c_i+\bar{c}}{2} - \frac{(\bar{c}-r)^2}{2(\bar{c}-c_i)}$.

Since the government values the project in v, it will get an utility of $v - \min\{p_1, p_2\}$ when meeting a firm that has a cost lower than r. Therefore, the government expected utility is equal to $EU^H(r) = \int_0^r \left(v - \frac{c+\bar{c}}{2} + \frac{(\bar{c}-r)^2}{2(\bar{c}-c)}\right) \frac{2(\bar{c}-c)}{\bar{c}} dc$, which results in $EU^H(r) = \frac{\frac{4}{3}r^3 - r^2(v+2\bar{c}) + 2v\bar{c}r}{\bar{c}^2}$.

Taking the first order condition of $EU^H(r)$, the optimal reserve price r^H is such that:

$$\begin{aligned} 0 &= 4r^2 - 2r(v + 2\bar{c}) + 2v\bar{c} \\ &= 2(r - \bar{c})(2r - v) \end{aligned}$$

Therefore, $r^H = \min\{\bar{c}, \frac{v}{2}\}$, which verifies the second order condition. This results also follows directly from Result 2 of Thomas (2005) which states that the optimal reserve price r^* is such that $v = r^* + \frac{F(r^*)}{f(r^*)}$ if $r^* \leq \bar{c}$ and $r^* = \bar{c}$ otherwise. ∎

A.5 Proposition 6

Given a maximum reserve price r, firm i will set the price of $p(c_i) = r$ if $c_i \leq r$ and select a bribe $b(c_i) = E\left[\max\{0; r - c_j\} | c_j > c_i\right] = \int_{c_i}^{r} \frac{r-c_j}{\bar{c}-c_i} dc_j = \frac{(r-c_i)^2}{2(\bar{c}-c_i)}$. However, the expected revenue of the government is not related to the bribe, and it is equal to $v - r$ times the probability that one of the firms has a cost less than r. This is, $EU^C = \int_0^r (v-r)\frac{2(\bar{c}-c)}{\bar{c}^2} dc$, which results iN $EU^C(r) = \frac{(v-r)(2\bar{c}r - r^2)}{\bar{c}^2} = \frac{r^3 - r^2(v+2\bar{c}) + 2v\bar{c}r}{\bar{c}^2}$.Taking the first order condition of $EU^C(r)$, the optimal reserve price r^C is such that $0 = 3r^2 - 2r(v + 2\bar{c}) + 2v\bar{c}$

Note that this is a quadratic equation and therefore has two roots, although it can only be applied if $r^C \leq \bar{c}$. When we evaluate it at $r = \bar{c}$ we obtain that the right hand side is equal to $-\bar{c}^2 < 0$, a negative value, and therefore the solution must be the smaller root of the quadratic equation. This is, $r^C = \frac{2(v+2\bar{c}) - \sqrt{4(v+2\bar{c})^2 - 24\bar{c}}}{6}$. Additionally, if we evaluate it at $r = \frac{v}{2}$, the right hand sind of the equation is equal to $-\frac{v}{4} < 0$, which again implies that r^C is smaller than $\frac{v}{2}$, proving that $r^C < r^H$. Also, note that if $v = \bar{c}$, then this is equal to $r^C = \left(1 - \frac{1}{\sqrt{3}}\right)\bar{c} < \frac{\bar{c}}{2}$ $\blacksquare$

A.6 Proposition 7

Given a reserve price r, the dishonest PO chooses to "burn money", which reduces its utility in $\psi > 0$. After seeing this, a firm decides to bribe $b(c|S) = \frac{(r-c)^2}{2(\bar{c}-c)}$ if its cost is smaller than the reserve price and set a price $p(c|S) = r$. If $s = 0$, then it bids a price $p(c|N) = \frac{c+\bar{c}}{2} - \frac{(\bar{c}-r)^2}{2(\bar{c}-c)}$ with $b(c|N) = 0$. In this case, a firm has no incentive to deviate, since it would lose the procurement for sure if bidding honestly to a corrupt PO and it would pay a penalty if bribing an honest PO.

Note that the PO's expected revenue depends on this bribe. Since $b(c|S)$ is negatively related to the cost c, the PO is looking for the minimum value c which provides the largest bribe and therefore his expected revenue is equal to $\int_0^r \frac{(r-c)^2}{2(\bar{c}-c)} \frac{2(\bar{c}-c)}{\bar{c}^2} dc = \frac{r^3}{3\bar{c}}$. Therefore, given the firms belief, the dishonest PO effectively wants to signal his type if there is a positive expected benefit from it, this is as long as $\frac{r^3}{3\bar{c}} > \psi > 0$. In that case, neither the dishonest PO has incentive to deviate, because the signal provides a positive increase in his expected utility, nor the honest PO, because it would only burn money but would not get any of the benefit.

Finally, given the PO and firms strategies, the government has an expected utility equal to the revenue that it would get with each type of PO. Therefore, its expected utility is equal to $EU^S(r) = \alpha EU^H(r) + (1-\alpha)EU^C(r) = \frac{\alpha\bar{c}}{3} + \frac{r^3 - r^2(v+2\bar{c}) + 2v\bar{c}r}{\bar{c}^2}$. If $\alpha = 0$ then $EU^S(r) = EU^C(r)$ and if $\alpha = 0$ then $EU^S(r) = EU^H(r)$, and since this is a cubic equation, the solution must lie between the solutions $r^S(\alpha = 1) = r^H$ and $r^S(\alpha = 0) = r^C$. Therefore, $r^S \in \left(r^C, r^H\right)$. $\blacksquare$

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