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Abstract

In a firm organized into business units, we show when profitability increases if procurement is delegated to the division in charge of production. We highlight that our results are driven by the business unit having a different objective function than Headquarters. The profitability of procurement delegation is affected by the essentiality of production facilities to the activities of the firm, and by strategic distortions in both transfer and input prices. We also look at vertical separation of activities as an alternative to procurement delegation.

Keywords: strategic delegation, transfer pricing, procurement

JEL classification: D24, D43, M11

1 Introduction

In multinational firms, the mix of centralized and delegated activities varies from one firm to another, and this is also the case for procurement. Procter and Gamble, for instance, centralises product development or accounting while business units are responsible for sales and procurement, whereas in General Electric business units are also in charge of sales but procurement is centralised.[1] In a KPMG survey (2008) 75% of respondents consider procurement of a high strategic priority, and nearly half of firms in the survey use some form of decentralized procurement. Most importantly for our purposes, the survey also highlights that the internal organization of procurement may affect prices charged by suppliers.

A transfer pricing system for internal transactions lets a multinational company to transform its divisions into business units or profit centers. Because divisional managers tend to be evaluated according to how well the division they are in charge of performs, the introduction of a transfer price system is a powerful incentive mechanism that affects their

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[1] Extracted from Dessein et al (2010).

decision making.[2] This paper analyses the decision of a firm to delegate or centralize the procurement of essential inputs to business units in charge of production. We show under which circumstances delegation of procurement may increase firm's clout when bargaining with suppliers. When there is an increase in bargaining power, it comes from the use of a delegated agent (namely the manager of the business unit in charge of production) in bargaining with a different objective function from Headquarters. Crucially, we show that the transfer price system can be set in a way that there are no distortions in production decisions but still lead to discounts in the price of inputs.

We model the following firm's problem. In order to produce firm's good, the firm must acquire an input. The input can be obtained from two different sources: an efficient supplier or an alternative (for instance, a fringe of standard suppliers or internally). The implementation of a transfer price scheme allows the firm to decentralize production decisions to business units. Before production starts, the Headquarters chooses who leads procurement negotiations: it may keep procurement centralized, or it may delegate it to the factory manager.

Regardless of who negotiates procurement, we show that, when a two part tariff is allowed, the agreement between the firm and the supplier leads to efficient production levels. To achieve efficiency, the HQ adjusts the transfer price depending on the outcome of the bargaining stage. Still, announcing the HQ delegates procurement negotiations to the factory manager has an impact over the rents the supplier can reap in the bargaining stage. We show that delegating bargaining negotiations to a different agent from HQ, in this case the factory manager, allows the firm to shift profits away from the bargaining stage which in turn lowers the willingness to pay to the efficient supplier. Thus, announcing how the firm is organized is what provides an strategic edge, serving as a commiment device, and not the specifics of the transfer price. As pointed out by Gimeno (2012) observability and irreversability of delegation instruments are essential for using delegation strategically. Several instruments are public, at least partially. One example is compensation schemes for CEO of public limited companies, but another instance, closer to our model, is the creation of autonomous divisions such as profit centers.

To check the robustness of our result, we first study whether other organizational arrangements rather than delegating procurement to the factory manager may increase firm's bargaining strenght. We show that vertically separating the company allows the company to divert rents from bargaining through a different channel, but it is not always a superior way of organizing procurement activities. By vertically separating the company the supplier becomes a less determinant player to achieve the rents to be bargained. Secondly, we also extend our basic result by assuming that the HQ can announce at which transfer price the firm is internally trading. When procurement is delegated to the factory, and the HQ can credibly announce a transfer price, the firm finds optimal to distort the internal price at the cost of producing inefficiently. Setting the internal price artificially low lets the firm shift even more profits from the bargaining stage. However and unlike

[2] Using transfer pricing is a common practice for multinational firms (see for instance Tang, 2002 where 90% of the surveyed firms use transfer pricing). Moreover, performance evaluation of subsidiaries is one of the main objectives of decentralizing decisions through transfer pricing (Borkowsky, 1996). Acknowledging that tax purposes is key to understand how transfer pricing is set, according to Ernst and Young (2003), around 40% of the firms consider that achieving management/operational objectives has a stronger influence than tax purposes.

the existing literature, it is not always in the HQ's best interest: the use of this strategic transfer price does not allow the firm to adapt to the outcome of the negotiation stage.

In the second part of the paper, we analyze some economic forces that may moderate our main result over delegation. To this end, we consider first whether the factory is not essential for the company and can be replaced by an external alternative. In this case, the firm only centralizes procurement when the external alternative is highly attractive otherwise the firm prefers delegating procurement to take advantage of an improvement in the negotiations. Second, we study a situation in which the supplier may behave strategically and may announce a tariff at which the firm and the supplier trade. We show that when the HQ delegates procurement negotiations to the business unit, both the factory and the supplier may find profitable to negotiate an input price different from the efficient one. This intended high input price fosters the HQ to set a transfer price different from the efficient one. Eventually, this increases both supplier's and factory's profit at the cost of a lower firm's profit. As a consequence, HQ's tends to centralize both procurement and production to avoid this undesirable outcome.

Our paper is related to two main strands of the literature. First, our paper can be seen as an illustration of the use of delegated agents in bargaining firstly initiated by Schelling (1960). Delegating decisions may serve as a commitment device; using a third agent may allow the player to obtain some strategic advantage, since the agent playing the game can commit to a certain behavior. However, as noted by Katz (1991), delegation might not be useful if binding contracts are not observable. Although observability of contracts is an important feature to make commitments valid, Fershtman and Kalai (1997) finds out conditions under which the delegation to an agent has still some impact. In particular, they show that an incentive contract even if the specific details of the contract are unknown may have a commitment effect.[3] More recently and from an experimental perspective, several authors pointed out that delegating to an agent might help the firm to act tougher when bargaining (Fershtman and Gneezy, 2001 or Hamman et al, 2010).

Second, our paper relates to the literature on transfer pricing iniciated in the seminal paper of Hirshleiffer (1956). Our paper is not the first attempt at analyzing the strategic impact of using transfer pricing. Since Alles and Datar (1998) a very important strand of the literature has focused on the strategic use of transfer pricing, i.e., setting the transfer price away from efficient considerations, in order to gain some competitive advantage (see Baldenius and Reichelstein, 2006 and Arya and Mittendorf, 2008 and Arya et al. 2008 as a more recent examples focused on buyer-seller relationships).[4] However, as fas as we know, there is no research analyzing the impact of this type of strategic delegation on procurement activities. An exception and the closer paper to ours is Arya et al (2007). The authors analyze the interaction between procurement activities and decentralization of production activities through a TP scheme. The authors obtain that divisionalization of the firm improve firm's profit through a reduction of the supplier's bill. This improvement is obtained because the firm is able to credibly commit to the use of strategic TP greatly reducing profits of the division (through a double marginalization effect). The supplier must then reduce his demands, lowering the price that can be imposed to the division. Although

[3]More recently, Kockesen and Ok (2004), Gerratana and Kockesen (2012) (2015) further generalyze these results obtaining that renegotiation of contracts does limit the effect of strategic delegation but it does not completely break it down.

[4]See Gox and Schiller (2007) for a survey on the use of transfer prices, and in particular, as an strategic device and its limitations. See also Gimeno (2012) for a recent review of strategic delegation in general.

we also focus on how internal organization affect procurement outcomes, initially we do not allow the firm to use transfer prices statregically and second we allow the firm and the supplier to use more complex contracts, a two part tariff rather than a linear one, when negotiating for the input. Thus, delegation result is not merely based on the interaction of the efficiency distortions created by the contract and the transfer price, but a consequence of how the firm is internally designed.

The paper is organized as follows. First, we present the main characteristics of the model. In Section 3, we show when delegation of procurement improves firm's bargaining clout and compare it to other organizational arrangements. We also show in this Section which conditions are needed for the firm to implement an strategic transfer price. Finally, in Section 4, we present two different situations in which the firm may prefer to keep procurement centralized: when the factory is not an essential input and when the supplier may behave strategically. Section 5 concludes. All proofs are left in an Appendix.

2 The model

The firm, composed by a factory and a sales division, organizes its production activity as a business unit.

Costs and revenues. Revenues $R(q)$ satisfy $R' > 0$, $R" \leq 0$. Production costs are given by $C(q)$, with $C' > 0$, $C" > 0$. To produce the good the firm must acquire an essential input on a one-to-one basis for each unit of output produced. There exists two sources for the input, one more efficient than the other. The efficient one features marginal costs of production c_1 whereas the less efficient procures the input at a higher unit cost $c_2 > c_1$. We will name the efficient source as the efficient supplier or simply the supplier whereas the inefficient source will be named the alternative.[5]

We assume that the parties in the negotiation can use a two-part tariff $T(q) = F + wq$ where w is the marginal wholesale price and F is the fixed component. Thus profits of the firm are $R(q) - C(q) - T(q)$. The quantity q^* that maximize firm's profits satisfies the first-order condition $R'(q^*) - C'(q^*) - w = 0$.[6] Define

$$\Pi(w) = \max_q \{R(q) - C(q) - wq\} \tag{1}$$

as the level of profits that can be achieved (gross of any fee paid to suppliers). Our assumptions on revenues and cost guarantees the existence of a unique solution $q(w)$ to this maximization problem, strictly decreasing in the input cost, $q'(w) = \frac{1}{R" - C"} < 0$; and that the profit is decreasing in the input cost, $\Pi'(w) = -q(w) < 0$.

It is clear that under our technological assumptions optimality involves the use of the efficient supplier. Assume that the firm and this supplier are indeed one entity; in this

[5] One interpretation of the source of input c_2 is that the firm can alternatively obtain the input from a less efficient competitive fringe. In this case, payments to the competitive suppliers become $T(q) = c_2 q$. An alternative interpretation is that the firm produces the input internally rather than buying it from the market. Still another interpretation of this industry structure is that the firm is in negotiations with a labour union to implement new production methods. The old way of producing the output leads to a marginal cost c_2 whereas the introduction of the new method leads to a new marginal cost c_1. The labour union and the firm bargain over wages, w, and other benefits, F (see Zhao, 1998, 2001 and Chongvilaivan et al, 2013 for a related discussion on internal organization and labor unions)

[6] FOC are necessary and sufficient for a unique global maximum since the problem is strictly concave. Note that SOC are $R'' - C'' < 0$ according to our assumptions on R and C.

case, the firm produces $q(c_1)$ which leads to $\Pi(c_1)$ as the maximum rents that the firm can achieve. If, instead, the firm produces using the alternative, both the quantity, $q(c_2)$, and the rents generated, $\Pi(c_2)$, are lower. The difference of profits between choosing the supplier or the alternative, $\Pi(c_1) - \Pi(c_2)$, can be shared between the firm and the supplier. The aim of this paper is to study how the allocation of authority over procurement may affect whether this increase in rents is achieved, and its effect on the distribution of these rents.

Timing. The whole interaction between the HQ, the factory and the supplier is as follows: First, the HQ allocates authority over procurement decisions (to be discussed below). Then the firm must produce the good, which involves two stages: first, to negotiate with the supplier the terms of the contract $T(q)$, and second, after reaching (or not) an agreement, production of the good.

Note that this timing allows the firm to adjust production decisions to the outcome of the negotiation stage, that is, to adjust production in accordance to the real marginal cost. This flexibility assumption is crucial to our analysis. If production decisions were taken before the bargaining stage, and could not be modified afterwards, the supplier would take advantage of this situation capturing larger rents at the negotiation stage;[7] foreseeing what would happen in the bargaining stage, the firm would presumably reduce its production in the first place, leading to lower total profits.

Firm organization over production. The firm organizes its production activity as a business unit. In charge of the business unit there will be a manager that must maximize the profits of the factory. The HQ sets a transfer price p and the business unit will have profits $pq - C(q) - T(q)$. Given a unit price of the input w and a transfer price p, define

$$q(p, w) = \arg\max_q \{pq - C(q) - wq\} \tag{2}$$

as production that maximizes the business unit's profits,

$$\pi_f(p, w) = \max_q \{pq - C(q) - wq\}, \tag{3}$$

as the profits then achieved by the business unit (gross of any fee paid to suppliers) and finally

$$\pi(p, w) = R(q(p, w) - C(q(p, w)) - wq(p, w) \tag{4}$$

as those achieved by the whole firm (also gross of any fee paid to suppliers). As we know since Hirschleifer (1956), profits in (1) can be achieved in a decentralized way if HQ set a transfer price $p(w) = R'(q(w))$, since then the factory fully internalizes the impact of production in firm's profits. Thus the business unit produces the optimal quantity, $q(p(w), w) = q(w)$ and we have $\pi(p(w), w) = \Pi(w)$. Define then

$$\Pi_f(w) = \pi_f(p(w), w) \tag{5}$$

as the profits of the business unit when the transfer price is set optimally.

[7] Assume for instance that the firm commits to $\overline{q} = q(c_1)$ then there are no efficient distortions with the efficient supplier. It is easy to see that $F^{\overline{q}} = \frac{1}{2}(c_2 - c_1) q(c_1) > F^C = \frac{1}{2}(\Pi(c_1) - \Pi(c_2))$. By a revealed preference argument $(c_2 - c_1) q(c_1) > (\Pi(c_1) - \Pi(c_2)) \iff \Pi(c_2) > \Pi(c_1) - (c_2 - c_1) q(c_1) \iff \Pi(c_2) > R(q(c_1)) - C(q(c_1)) - c_2 q(c_1)$ and the last inequality holds since $\Pi(c_2)$ maximizes profits when the input cost is c_2

Procurement. The HQ must allocate authority over procurement decisions. Under *Centralized procurement* (or C), it is the HQ who bargains with the supplier, whereas under *Delegated procurement* (or D) the business unit manager is in charge of negotiations. In either case, the firm and the supplier bargain over a two-part tariff $T(q) = F + wq$, and furthermore we assume all agents involved have equal bargaining power.[8]

Regardless of firm's organization, the supplier has profits $\pi_s = T(q) - c_1 q$ in case of agreement whereas its outside option is to achieve zero profits. If there is *Centralized procurement*, the alternative for HQ is to achieve profits $\Pi(c_2)$. Hence, if there is agreement the joint profits of the firm and the supplier increase from $JP^C_{off} = \Pi(c_2)$ to $JP^C = \pi + \pi_s = R(q) - C(q) - c_1 q$.

With *Delegated procurement*, the alternative for the manager of the business unit is to achieve $\pi_f(p, c_2)$. If there is agreement the joint profits of the business unit and the supplier increase from $JP^D_{off} = \pi_f(p, c_2)$ to

$$JP_D = \pi_f + \pi_s = pq - C(q) - c_1 q. \tag{6}$$

Given our assumptions of equal bargaining power by those involved in negotiations, the payment will cover costs of production $c_1 q$ and assign half of the extra rents $JP - JP^{off}$ to the supplier. The assignment of those rents depends on who is actually bargaining with the supplier, the HQ and the factory manager, and whether parties involved in bargaining can alter strategically the transfer price p or the input price w.

3 Organization as an strategic device

In this section we analyze the strategic role of the allocation of procurement decisions. First, we show that efficiency over production can be achieved by means of efficient bargaining and then we show that the firm gains clout over the supplier by assigning procurement decisions to the business unit manager. The details of the Nash bargaining program both under centralized and delegated procurement are left in Appendix A.

When there is *Centralized procurement*, it is straightforward to see that $q(c_1)$ is the quantity that maximizes JP_C. This can be achieved by setting $w = c_1$ and, at the production stage, setting a transfer price $p(c_1) = R'(q(c_1))$. Thus, total surplus $JP_C = \Pi(c_1)$ is achieved and rents are redistributed through a fixed payment

$$F^C = \frac{1}{2}\left(\Pi(c_1) - \Pi(c_2)\right). \tag{7}$$

In the presence of *Delegated procurement*, to represent the interaction that lead to non-strategic contracts is more convoluted. HQ cannot commit to a particular transfer price p, and the factory and the supplier can renegotiate the tariff at any moment. We can represent their interaction as follows: first, the business unit and the supplier negotiate the terms of the contract. Then, the business unit communicates to HQ the outcome of the negotiation stage, that is, whether there is agreement and the details of the contract; but those details have no strategic effect on the transfer price that HQ sets, since the tariff can be modified. In case of disagreement, the HQ sets the optimal transfer price that

[8] Our results are not sensitive, at least qualitatively, to this assumption as long as parties always retain some bargaining power. Besides, we do not assume that the factory is more or less able than the manager when negotiating with the efficient supplier.

maximizes profits when marginal cost of the input is c_2 , the firm achieves profits $\Pi(c_2)$ and the factory have profits $\Pi_f(c_2)$.

When there is agreement between the factory and the supplier, they choose the tariff that maximize joint profits in (6) given their expectation about the transfer price p. For any such expectation on p, in order to produce the quantity that maximizes (6), the tariff must feature a marginal payment w equal to the marginal cost of the input, c_1. Therefore, what matters is whether there is agreement or not in the negotiation; HQ knows that any announced tariff featuring $w \neq c_1$ would be renegotiated afterwards. Whenever an agreement is announced, since the HQ expects $w = c_1$, it sets the optimal transfer price $p(c_1) = R'(q(c_1))$. The joint profits of the factory and the supplier in (6) when the transfer price is $p(c_1)$ become $\Pi_f(c_1)$ and the fee in the tariff will split equally the extra surplus created through the agreement,

$$F^D = \frac{1}{2}(\Pi_f(c_1) - \Pi_f(c_2)). \tag{8}$$

Thus, no matter who negotiates the contract with the supplier, there is efficient production $q(c_1)$ when there is a deal with the supplier, and production $q(c_2)$ in case of no deal. Hence, any preference HQ have for one structure or the other must come from a different distribution of the surplus between the firm and the supplier; in other words, the HQ should choose the allocation of authority that minimizes the fixed payment to the supplier.

The following Proposition states the main result of the paper.

Proposition 1 *If $R" < 0$, then payments under Delegated procurement are lower than under Centralized procurement, $F^D < F^C$.*

According to Proposition 1, allocating authority over procurement to the factory manager reduces the fee paid to the supplier ($F^D < F^C$) without changes in total surplus. Crucially this reduction of payments is not obtained because the factory makes different production decisions but because the amount of profits to be bargained are different depending on who is negotiating the terms of the agreement. Rewrite firm's profit as:

$$\Pi(w) = R\,(q(w)) - R'(q(w))q(w) + \underbrace{R'(q(w))q(w) - C(q\,(w)) - wq\,(w)}_{\Pi_f(w)}$$

where $R'(q(w))q(w)$ is the transfer payment to the factory. Delegation of procurement is profitable whenever $R\,(q(w)) - R'(q(w))q(w) > 0$ is increasing in the efficiency of the firm ($R\,(q(c_1)) - R'(q(c_1))q(c_1) > R\,(q(c_2)) - R'(q(c_2))q(c_2)$ when $c_1 < c_2$).[9] In words, *Delegated procurement* is the best way to organize procurement not because the rents to be obtained in case of agreement are lower (not because $\Pi_f(c_1) < \Pi(c_1)$) but because the increase in rents for the factory in case of agreement $\Pi_f(c_1) - \Pi_f(c_2)$ is lower than the increase for the whole firm $\Pi(c_1) - \Pi(c_2)$. This requires revenues to be strictly concave ($R" < 0$), since otherwise both increases $\Pi_f(c_1) - \Pi_f(c_2)$ and $\Pi(c_1) - \Pi(c_2)$ become equal.

The strategic effect of delegation is not driven by using strategically transfer prices since the HQ sets the transfer price that maximizes firm's profit, given the marginal cost of production. The organization itself serves as a commitment device, or, in other words, the

[9] We are of course assuming that production optimally adapts to the real marginal cost c_1 or c_2.

strategic delegation in procurement activities is effective as long as the organization itself cannot be easily modified. Thus, our result requires observability of internal organization, but structural arrangements such profit centers or autonomous divisions are potentially public unlike internal transfer prices which requires further conditions to assume observability and irreversibility.

The following figure graphically represents the difference between firm's revenues ($R(q)$) and transfer payment ($R'(q)q$) for two frequently used demand functions (linear and CES).

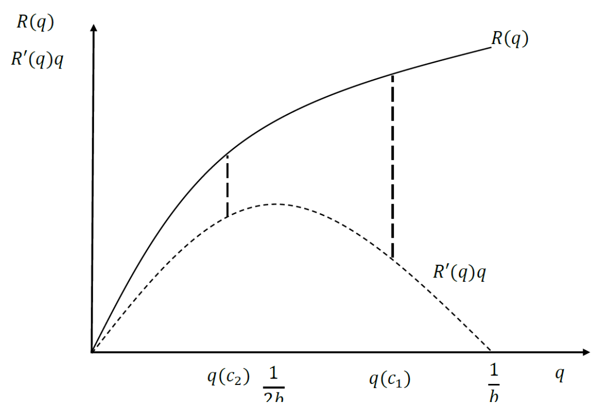

Figure 1 (a) Linear demand function

$$R(q) = \left(1 - \frac{b}{2}q\right) q$$

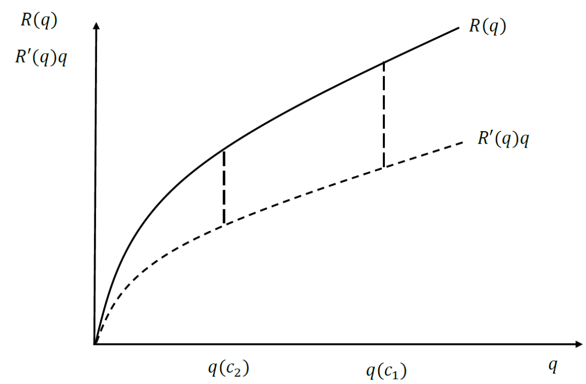

Figure 1 (b) CES demand function

$$R(q) = \frac{1}{1-\gamma} q^{1-\gamma}$$

A linear demand quadratic cost case can illustrate Proposition 1. With revenues $R(q) = \left(1 - \frac{bq}{2}\right) q$, quadratic cost $C(q) = m\frac{q^2}{2}$ and input costs $T(q) = F + wq$, optimal production, namely, the one solving (1), is $q(w) = \frac{1-w}{b+m}$ and gross profits (i.e. not taking into account the fee) are $\Pi(w) = \frac{(1-w)^2}{2(b+m)}$. At the production stage, the factory produces $q(p,w) = \frac{p-w}{m}$. Optimal production can be decentralized with a transfer price $p(w) = R'(q(w)) = \frac{m+bw}{b+m}$ and the factory achieves gross profits (again, not taking into account the fee) $\Pi_f(w) = \frac{m}{2}\left(\frac{1-w}{b+m}\right)^2$.

In this linear example, the way profits are shifted between divisions can be captured by the parameter $\theta = \frac{m}{b+m} \in (0,1)$, that is, factory's profits are a share of firm's profits $\Pi_f(w) = \theta\Pi(w)$. Interestingly, the input cost plays no role in the way those profits are split between divisions. What matters exclusively is the relative steepness of firm's cost and revenue function. For instance, if $b = m = 1$, $\theta = \frac{1}{2}$ meaning that factory's profit accounts for half of the whole company.[10] Delegating procurement becomes less appealing when the rents the factory manager and the HQ bargain with the supplier are similar, that is, when revenues are less concave (b low) and/or costs are more convex (high m). To see this facts in more detail, normalize input costs as $0 = c_1 \leq c_2 = c \leq 1$. When the HQ

[10]The way profits are shifted from one division to the other is still the same, that is, $\theta = \frac{m}{b+m}$ when the revenue and cost function are $R(q) = \left(v - \frac{bq^s}{1+s}\right) q$, and $C(q) = m\frac{q^{1+s}}{1+s}$ with $s > 0$.

centralizes procurement, the fee in (7) becomes

$$F^C = \frac{1}{2}\left(\Pi(c_1) - \Pi(c_2)\right) = \frac{\theta(2-c)c}{4m} \tag{9}$$

and net profits are

$$\Pi^C = \Pi(c_1) - F^C = \frac{1}{2}\left(\Pi(c_1) + \Pi(c_2)\right) = \frac{\theta\left(2-(2-c)\,c\right)}{4m} \tag{10}$$

If the firm decentralizes procurement, the fee in (8) becomes

$$F^D = \frac{\Pi_f(c_1) - \Pi_f(c_2)}{2} = \frac{\theta\left(\Pi(c_1) - \Pi(c_2)\right)}{2} = \frac{\theta^2(2-c)c}{4m}. \tag{11}$$

and net profits are

$$\Pi^D = \Pi(c_1) - F^D = \Pi(c_1) - \frac{1}{2}\left(\Pi_f(c_1) - \Pi_f(c_2)\right) = \frac{\theta\left(2-\theta\left(2-c\right)c\right)}{4m} \tag{12}$$

Direct comparison of equations (9) and (11) show that the fee paid to the supplier is lower under *Delegated procurement*, $F^C > F^D$, whenever $\theta < 1$ and similarly comparing equations (10) and (12) show that profits under Delegated procurement are higher, $\Pi^C > \Pi^D$, whenever $\theta < 1$.

The HQ could introduce a contract that links manager's payment to firm's performance and not only to factory's success. That is, factory's manager incentives could be a combination of both corporate and divisional performance, that is,

$$\mu\pi + (1-\mu)\pi_f,$$

with weights μ chosen by HQ. If $\mu = 1$, the manager just tries to maximize firm's profits; when $0 \leq \mu < 1$, the objective function of the manager is not perfectly aligned with firm's interests. It is clear that Proposition 1 extends to any μ that satisfies $0 \leq \mu < 1$. And, moreover, the optimal incentive contract, in terms of minimizing payments to the supplier, is $\mu = 0$.

One might consider other organizational arrangements rather than *delegated procurement* to gain clout over the supplier. For instance, the HQ could vertically split the company in two different entities: one owning the retail store being able to obtain revenues $R(q)$ and the other entity owning the factory with costs $C(q)$. Under *Vertical Separation*, or simply VS, the HQ of the former company plays no further role in production and the manager of the factory becomes HQ of the new company, taking over both procurement and production decisions. When the HQ chooses to create two companies assume the HQ cares about total profits of the firm, that is $\Pi(c_1) - T^{VS}(q)$ where $T^{VS}(q)$ is the payment to the supplier in the vertical separation case. In other words, assume perfectly capital markets that allows the HQ from the sale of the factory obtaining a payment that covers exactly the profits of the separated entity.

We use the Shapley Value as a solution concept of the negotiation with three players involved in sharing the rents, the sales company, the factory company and the supplier.[11] In this simple case, the rents of the grand coalition are $\Pi(c_1)$. The supplier is not needed to

[11] Similar results could be obtained if instead of the Shapley value we use simultaneous negotiations

achieve $\Pi(c_2)$ but it becomes as essential as the factory and the sales division to generate the extra rents $\Pi(c_1) - \Pi(c_2)$. Therefore, the profits of the supplier will be $\frac{1}{3}(\Pi(c_1) - \Pi(c_2))$. The allocation of profits can be achieved by a two part tariff with an input price equal to the marginal cost of production c_1 and a fee:

$$F^{VS} = \frac{1}{3}(\Pi(c_1) - \Pi(c_2)) \tag{13}$$

It is immediate from equations (9) and (13)) that payments under vertical separation are lower than under centralized procurement, $F^{VS} < F^{C}$. The intuition for this result is that under centralized procurement, the firm and the supplier equally share the rents generated, $\Pi(c_1) - \Pi(c_2)$ whereas in the separating case, the supplier needs to agree with two other companies making the supplier less determinant to achieve the extra rents.

Then, when comparing delegated procurement and vertical separation, we observe that both organizational structures reduce the fixed payment as compared to the centralized procurement case. Under delegated procurement, some rents are transferred out of the negotiation through a transfer price scheme, whereas, under separation, some of the rents are outside the negotiation since the company is split into two different entities. While under delegated procurement the share of factory's profits with respect the total company's profit depends on the optimal transfer price, that is, $F^{D} = \frac{1}{2}(\Pi_f(c_1) - \Pi_f(c_2))$, under vertical separation, the share retained by the factory remains constant, that is, the supplier always retains $F^{VS} = \frac{1}{3}(\Pi(c_1) - \Pi(c_2))$. Therefore, the preference of one structure over the other depends crucially on the cost/revenue structure.

In the linear demand and quadratic cost case, we can explicitly compare both organizational arrangements. In particular, from equation (11) and (13) we see that which organizational arrangement is more profitable depends on the convexity of the revenue and cost functions: payments are lower under delegation, $F^{VS} > F^{D}$ if and only if $\theta \in \left(0, \frac{2}{3}\right)$ (and $F^{VS} < F^{D}$ if and only if $\theta \in \left(\frac{2}{3}, 1\right)$.

3.1 Transfer Price Commitment

The previous section shows that delegation of procurement when the firm is organized through business units allows the firm to set aside some rents from negotiation. The result is obtained even if the choice of internal pricing is nonstrategic. Could the firm improve this situation by credibly announcing to an observable transfer price? By credibly committing to an observable transfer price, the firm may deviate from efficient considerations (can set $p \neq R'(q(c_1)))$ trying to affect supplier's behavior. However, committing to a transfer

processes. Formally the approach used here to share rents is a cooperative game in which we have $N = 3$ players (the grand coalition) and a characteristic function $v : S \rightarrow R$ from the set of all possible coalitions of players to a set of payments that satisfies $v(\varnothing) = 0$. The Shapley value gives any player i his (average) contribution to a coalition, where the contribution is taken over all possible coalitions to which a player i might belong. More formally, a player's i's share of the rents are given by

$$\Pi_i^{VS} = \sum_{S \subseteq N \backslash \{i\}} \frac{|S|!\,|n - |S| - 1|!}{n!} (v(S \cup i) - v(S)),$$

where n is the total number of players and the sum extends over all subsets S belonging to N not containing player i.

price also implies the firm cannot adapt its transfer price to the outcome of the negotiation stage.[12]

Thus, we can slightly modify the timing on our set-up to account for the possibility that the HQ sets transfer prices strategically: first, HQ announces the allocation of authority over procurement decisions. If the firm centralizes procurement, the game is the same as previously stated but in case the firm delegates procurement, the HQ publicly announces one particular transfer price at which divisions trade. Afterwards, the factory manager bargains with the supplier, and finally produces according to the preciously announced transfer price and the outcome of the bargaining stage. We use H to denote actions and payoffs when the HQ delegates procurement and uses the transfer price strategically.

Under *delegated procurement*, the level of production is chosen optimally according to (2), and the bargaining process leads to efficient production, $w = c_1$. The argument is similar to the one in the nonstrategic situation in Section 2: the supplier prefers to reduce the marginal wholesale price to increase total rents and grab some of those rents through the fixed component, being $F^H(p) = \frac{1}{2}\{\pi^f(p, c_1) - \pi^f(p, c_2)\}$. Thus, when setting the transfer price, HQ chooses p to maximize,

$$\Pi^H(p) = \pi(p, c_1) - F^H(p), \tag{14}$$

where $\pi(p, c_1)$ are the operating profits for a given transfer price p and an input price c_1. The optimal strategic transfer price p^H solves the following first order condition:

$$\underbrace{[R'(q(p, c_1)) - p]\frac{\partial q(p, c_1)}{\partial p}}_{Direct\ effect\ on\ operative\ profits\ \pi(p,c_1)} - \underbrace{\frac{1}{2}\{q(p, c_1) - q(p, c_2)\}}_{Strategic\ effect\ on\ the\ fee\ F^H(p)} = 0. \tag{15}$$

In words, the first term in (15) is the direct effect on rents when transfer price is changed, whereas the second term is the strategic effect of the transfer price on the outcome of the negotiation. The strategic effect is always negative, higher transfer prices affects negatively profits through higher fees since profits of the factory increase at a higher rate when the firm works with the efficient source of the input. The sign of the direct effect depends on the choice of the strategic transfer price: it is positive if $p < R'(q(p, c_1))$ whereas it is negative otherwise. Therefore, the following Proposition states whether it is convenient to distort or not (and how) transfer prices.

Proposition 2 *If HQ can commit to a transfer price* p^H *before bargaining takes place, then the optimal transfer price satisfies* $p^H < R'(q(c_1))$ *and profits under Delegated procurement are higher than in Centralized procurement,* $\Pi^C < \Pi^H(p^H)$.

[12] First, note that in this section we take observability of the transfer price for granted. Existing literature typically justifies observability through two mechanisms: when the firms trades both internally and externally, the recommendation is to set the internal price very similar to the external one (arm's length principle, OECD, 2011) and the second one is related to tax considerations, and the fact that the firms may commit to use the same book for both taxes and evaluation purposes (see Baldenius, 2004 and Dur and Gox, 2011, for a discussion on using one or two set of books). Second, we do not allow the firm to commit to a menu of transfer prices. If the firm were able to do that, the strategic transfer pricing would always dominate the nonstrategic case (note that you could always replicate the nonstrategic transfer prices). However, regulatory bodies may be skeptical when facing a menu of transfer prices since as already stressed by consultants: "alignment of transfer prices with management views of the business can enhance the defensibility of the transfer prices..."(Ernst and Young, 2003). See Arya and Mittendorf (2008) for a further discussion on commitment and observability of the transfer price.

Proposition 2 extends Proposition 1 when transfer prices are strategic; delegating procurement activities to business units provides larger profits than keeping them at the HQ level. In both strategic and nonstrategic transfer pricing, the relevant feature of delegating procurement to the business unit manager is that the factory has more clout than HQ when negotiating the fee with the supplier, because an increase in production costs have less impact on factory profits than on those of the company as a whole. In the strategic situation, committing to a transfer price allows the firm to further reduce the relevance of an agreement in factory profits. Against intuition, however, commitment to a transfer price does not guarantee the firm larger profits (not even to pay a lower fee to the supplier) than in the absence of commitment. The reason is that committing to a transfer price, the firm cannot adapt to the outcome of the negotiation stage.

To see this, note that profits under nonstrategic transfer pricing are those in (12) whereas equation (14) evaluated at $p = R'(q(c_1))$ leads to

$$\Pi^H(p(c_1)) = \Pi(c_1) - \frac{1}{2}\left(\Pi_f(c_1) - \pi_f(p(c_1), c_2)\right) \tag{16}$$

and therefore $\Pi^D > \Pi^H(p(c_1))$, that is, profits under strategic transfer price jump down, not because reduced efficiency in equilibrium but because the alternative becomes less valuable when transfer prices cannot adapt to the true marginal cost of the factory ($\Pi_f(c_2) > \pi_f(p(c_1), c_2)$).[13] In Figures 2 (a) and (b), when the firm commits to the efficient transfer price $p = p(c_1)$, profits jump down from $\Pi^D = \Pi(c_1) - F^D$ in (12) to $\Pi^H(p(c_1))$ as defined in (16). The firm can improve this situation by distorting the transfer price from $p(c_1)$ to p^s, the one solving (2). There are cases in which the jump down in profits is compensated by distorting the transfer price (case (a)) whereas other cases in which the distortion is unable to do so (case (b)).

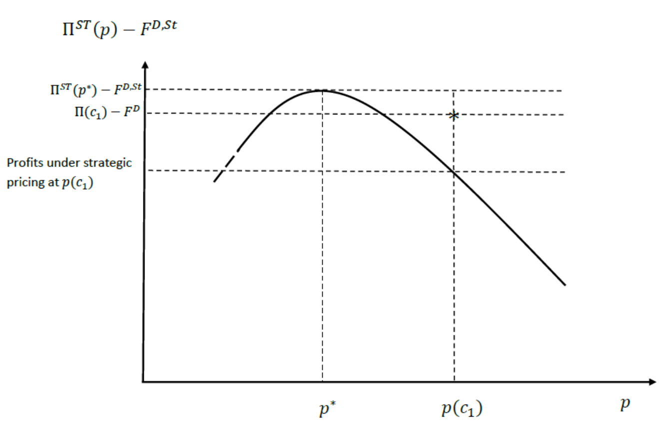

Figure 2 (a)

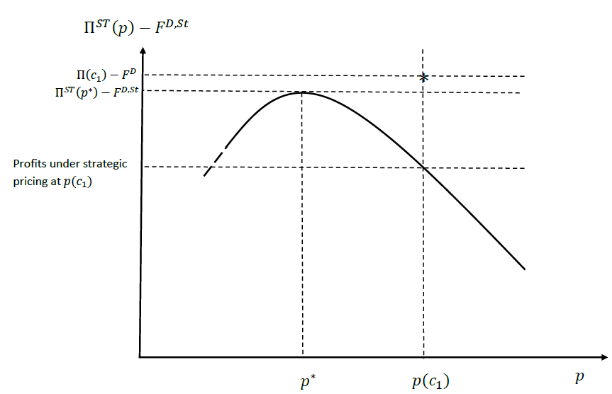

Figure 2 (b)

We first show a case when the distortion of the transfer price can never compensate this (discrete) fall in profits. Moreover, we show that not only profits decrease but the

[13] It should be clear here that if the firm could commit to a menu of transfer prices, there would be no efficiency distortions in equilibrium, and setting the price in case negotiation fail as high as possible so profits off equilibrium be the highest possible. In other words you could always replicate the outcome under nonstrategic transfer pricing, and potentially, the firm would improve that situation.

lack of adaptability also increases fees to be paid to the supplier. To see these effects, we analyze the marginal change of fees when the cost of the alternative changes marginally both under strategic and nonstrategic transfer price. When the price is strategically set

$$\frac{\partial F^H}{\partial c_2} = q(p^H, c_2) + \left(q(p^H, c_1) - q(p^H, c_2)\right) \frac{\partial p^H}{\partial c_2}$$

where p^H solves (15). First, an increase in the cost of the alternative raises the fee due to a reduction on firm's bargaining (first element of the rhs of the previous equation). The firm can reduce the impact of this effect by modifying the transfer price (i.e., by reducing it, $\frac{\partial p^H}{\partial c_2} < 0$), which in turn reduces the quantity to be produced and eventually the fee. Note crucially that the positive impact of the strategic transfer prices on the fee depends on the (different) quantity produced with the supplier and the alternative.

Instead, when prices are nonstrategic, an increase in the cost of the alternative has a different effect on fees:

$$\frac{\partial F^D}{\partial c_2} = q(c_2) - q(c_2)\frac{\partial p(c_2)}{\partial c_2}$$

where $p(c_2) = R'(q(c_2))$ is the nonstrategic transfer price. The first effect accounts for the loss in firm's bargaining power while the second effect is an adaptive effect: the firm modifies the transfer price according to the real marginal cost in case negotiations fail reducing the impact of this increase. The following Lemma compares fees when the alternative is highly efficient, $c_2 = c_1 + \varepsilon$ with ε small.

Lemma 1 *Fees under strategic transfer prices are larger than under nonstrategic transfer pricing when the alternative cost is in a neighborhood of c_1.*

When the alternative is as efficient as the supplier, that is, when $c_1 = c_2$, the strategic and the nonstrategic transfer prices are identical, and the fees paid to the supplier, as well. However, when the cost of the alternative increases (marginally) nonstrategic transfer price adapts the price to the real marginal cost under the alternative. The impact on fees when the firm uses strategic transfer price depends crucially on the quantity produced in equilibrium and under the alternative. When the alternative is as efficient as the supplier this effect is negligible and therefore fees are larger than under nonstrategic transfer pricing.

Therefore, since distorting the optimal transfer price leads to lower operating profits (immediate consequence from Lemma 2) the result in Lemma 1 has immediate consequences on profits under both strategic and nonstrategic transfer pricing

Proposition 3 *Profits under strategic transfer price are lower than under nonstrategic transfer price when the alternative cost is in a neighborhood of c_1.*

In words, committing to a transfer price does not allow the firm to adapt the transfer price to the real marginal cost reducing profits in the alternative (the HQ loses the adaptive effect). The benefit of a transfer price consists in distorting it to reduce the fees and improve profits. When the alternative is highly efficient, it makes no sense to distort transfer prices since there are no gains at the fee level and profits are strictly lower than the nonstrategic case.

When the alternative worsens (when the alternative is not in the neighborhood of c_1), the use of strategic pricing may be beneficial since the jump down due to committing to a transfer price is lower and second distorting the transfer prices has an impact over fees (since $q(p^H, c_1) - q(p^H, c_2) > 0$). We analyze this possibility by means of the linear demand and quadratic cost case and we obtain that committing to a price is profitable in cases in which is crucial to gain leverage at the negotiation stage. The use of strategic transfer prices makes sense when the cost of the alternative is high and/or when firm's cost/revenue structure makes difficult for the firm to reduce factory's profits through nonstrategic transfer prices, that is, for θ large.

We can compare profits and fees both under the strategic and under the nonstrategic transfer pricing when demand is linear generating revenues $R(q) = \left(1 - \frac{b}{2}q\right)q$ costs are quadratic $C(q) = \frac{m}{2}q^2$ and supplier's cost is normalized to cero, $c_1 = 0$ and rewrite $c_2 = c < 1$. We know from Section 3 that delegation under nonstrategic transfer prices leads to fees F^D in (11) and profits Π^D in (12). Under strategic transfer prices, the optimal transfer price is[14]

$$p^H = \begin{cases} \frac{\theta(2-c)}{2} \text{ if } c \leq \frac{2\theta}{2+\theta} \\ \frac{2\theta}{2+\theta} \ otherwise \end{cases}$$

which leads to fees

$$F^H = \begin{cases} c\left(\frac{\theta(2-c)-c}{4m}\right) \text{ if } c \leq \frac{2\theta}{2+\theta} \\ \frac{\theta^2}{m(2+\theta)^2} \ otherwise \end{cases} \tag{17}$$

and profits

$$\Pi^H(p^H) = \begin{cases} \frac{\theta(2-c)^2}{8m} + \frac{c^2}{4m} \text{ if } c \leq \frac{2\theta}{2+\theta} \\ \frac{\theta}{m(2+\theta)} \ otherwise \end{cases} \tag{18}$$

Comparing equations (12) and (18) for profits and equations (11) and (17) for fees lead to the following Proposition

Proposition 4 *In the linear demand and quadratic cost case, fees are lower under strategic transfer prices, $F^H < F^D$, iff $c \geq g(\theta)$, and profits are higher under strategic transfer prices, $\Pi^H(p^H) > \Pi^D$, iff $c \geq f(\theta)$, where*

$$g(\theta) = \begin{cases} 1-\sqrt{\frac{\theta(\theta+4)}{(2+\theta)^2}} \ if\ 0<\theta<\frac{1}{2} \\ \frac{2\theta(1-\theta)}{1+\theta(1-\theta)} \ if\ \frac{1}{2}<\theta<1 \end{cases},\ f(\theta) = \begin{cases} 1-\sqrt{\frac{\theta}{2+\theta}} \ if\ 0<\theta<\frac{2}{3} \\ \frac{4\theta(1-\theta)}{2(1-\theta^2)+\theta} \ if\ \frac{2}{3}<\theta<1 \end{cases} \ and\ g(\theta) < f(\theta).$$

The solid line in Figure 3 represents the combinations of parameters such that above the solid line the firm prefers using strategic transfer prices, while the dashed line represents the combination of parameters such that the fee paid is the same both under strategic and under nonstrategic transfer price. Therefore three regions are obtained, one in which fees and profits are larger under nonstrategic (below the dashed function), the second in which both fees and profits are larger under strategic transfer price (above the solid function) and finally a third region of parameters in which fees are lower under strategic but the firm gets larger profits under nonstrategic. In this last region the reduction of fees does not offset the distortions generated at the production level.

[14] By distorting the transfer price, profits under the alternative may become zero or even negative. We do not allow for these unreasonable cases and we stick to cases in which firm's profit are nonnegative in all scenarios.

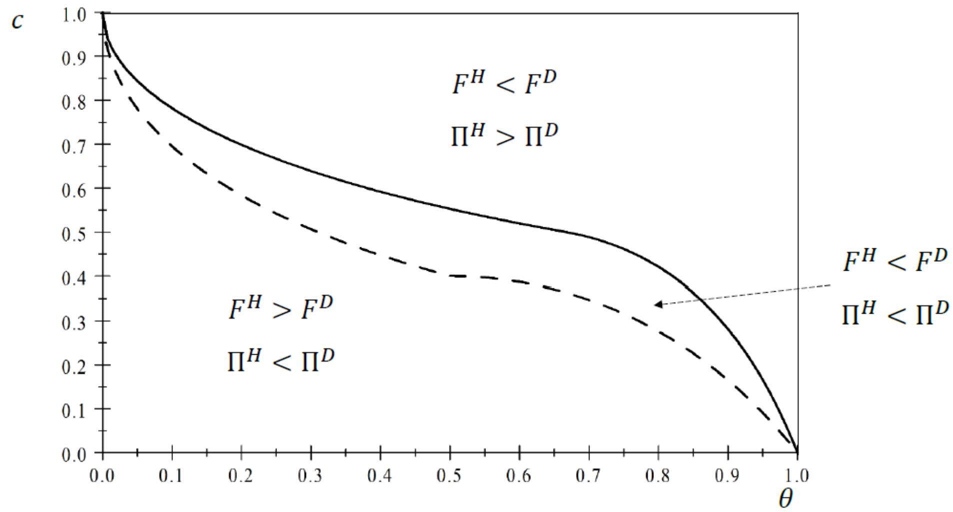

Figure 3: strategic vs nonstrategic transfer prices. Effect on Fees and Profits

We finish this section by studying the linear revenue case: $R(q) = vq$ being $v > 0$. Note that Proposition *1* does not apply for this case, since the result requires revenues to be strictly concave. It is immediate, though, to see that delegation does not improve firm's profit by any means, that is, $\Pi^D = \Pi^C$. When revenues are linear, and prices are nonstrategically set, transfer pricing is constant over negotiating scenarios ($p = v$ both when the factory manager reaches an agreement or not), then the firm is unable to shift profits outside the factory ($R(q) - R'(q)q = 0$ at all scenarios). Thus, it is irrelevant who bargains with the supplier, since the rents at the bargaining stage are always the same. Therefore, the firm cannot take rents away from the negotiation stage and delegation procurement has no impact.

This is not the case when the HQ can use transfer prices strategically. First of all, compared to figures 2a and 2b there is no jump down in profits at $p(c_1)$, that is, $\Pi^D = \Pi^H(p(c_1))$. In other words, committing to the efficient transfer price does not worsen profits under the alternative ($\Pi_f(c_2) = \pi_f(p(c_1), c_2)$), and therefore, the firm can always replicate the outcome of the nonstrategic situation. But note that Lemma *2* still applies and therefore HQ should optimally set a transfer price below the efficient, that is, $p^H < v$, thus shifting profits from the factory to the sales division and taking away some rents from the bargaining stage. The following Proposition summarizes this finding.

Proposition 5 *When revenues are linear, $R(q) = vq$ being $v > 0$, commitment to a transfer price leads always to higher profits, that is, $\Pi^H(p^H) > \Pi^D = \Pi^C$*

4 Economic forces that go against delegation of procurement

Until now, all the effects we consider favor the decentralization of procurement (maybe under the form of vertical separation). In this last section we present two effects that may moderate this result about the preference for delegation. The first one analyzes a case where the factory is not essential for the firm since its activities can be replaced through an external alternative. The second caveat arises when the firm is facing a supplier that may behave strategically, that is, a supplier that may announce and commit to a contract, and therefore may influence firm's behavior.

4.1 Optimal organization when the factory is not essential

In this extension, the firm can shut down the factory and still produce the output externally, achieving profits Π^{ext} that are below those that can be achieved with the efficient use of the factory, $\Pi^{ext} < \Pi(c_1)$.[15] We analyze a set-up where bargaining is efficient and as a consequence in equilibrium the factory is in operation; but we show that the existence of an alternative may have consequences in the organization of procurement.

If procurement is *centralized* the alternative for HQ when it bargains with the supplier is to achieve profits $\widehat{\Pi} = \max\{\Pi(c_2), \Pi^{ext}\}$ in case of disagreement; and the increase in total profits from an agreement is $\min\{\Pi(c_1) - \Pi(c_2), \Pi(c_1) - \Pi^{ext}\}$. The Nash bargaining agreement in which the HQ and the supplier share equally the increase in joint profits can be implemented through a tariff that features a marginal price $w = c_1$ and a fee

$$F^C = \min\{\frac{\Pi(c_1) - \Pi(c_2)}{2}, \frac{\Pi(c_1) - \Pi^{ext}}{2}\}. \tag{19}$$

Therefore whenever $\Pi^{ext} > \Pi(c_2)$ the external alternative improves the bargaining position of HQ under centralized procurement and end up paying a lower fee than the one in (7).

Under *delegated procurement,* the business unit is in charge of negotiations; but HQ must approve the agreement and we assume they are still in time to shut down the factory and produce the output externally. Therefore the fee F^D that the business unit and the supplier agree on must satisfy $\Pi(c_1) - F^D \geq \Pi^{ext}$ for the agreement to be approved by HQ. The outcome of the negotiation between the business unit and the supplier is a tariff that features a marginal price $w = c_1$ and a fee

$$F^D = \min\{\frac{\Pi_f(c_1) - \Pi_f(c_2)}{2}, \Pi(c_1) - \Pi^{ext}\}. \tag{20}$$

When using external production does not bring much benefit, $\Pi^{ext} < \Pi(c_2)$, the bargaining clout of HQ does not improve at all and the fee paid when procurement is centralized is the same as in Section 3, $F^C = \frac{\Pi(c_1)-\Pi(c_2)}{2}$. Therefore the result in Proposition 1 directly applies when $\Pi^{ext} < \Pi(c_2)$: Delegation is then the best way to organize procurement. An attractive external production $\Pi^{ext} > \Pi(c_2)$ will tend to be more useful under centralized procurement, however, since in delegated procurement it only works as an upper limit in the fee that the supplier can charge. As a consequence, the manager of the factory sometimes plays a softer hand than HQ in negotiations. Indeed, whenever the restriction on the fee is binding, $\frac{\Pi_f(c_1)-\Pi_f(c_2)}{2} > \Pi(c_1) - \Pi^{ext}$ and thus $F^D = \Pi(c_1) - \Pi^{ext}$, centralized procurement would allow the firm to pay a lower fee $F^C = \frac{\Pi(c_1)-\Pi^{ext}}{2} < F^D = \Pi(c_1) - \Pi^{ext}$. For intermediate values of the external alternative, i.e. when $\Pi(c_2) < \Pi^{ext} < \Pi(c_1) - \frac{\Pi_f(c_1)-\Pi_f(c_2)}{2}$, the possibility of external production increase the bargaining clout of HQ whereas it doesn't

[15] We consider this alternative to be exogenous and hence we do not model how the firm achieves that level of profits.

affect the fee that a business unit is charged. If we express the profits under external production as $\Pi^{ext} = \alpha\Pi(c_1)$, where $\alpha \in (0,1)$ measures its value, then we can write the fee F^C under centralized procurement as

$$F^C = \begin{cases} \frac{1}{2}(\Pi(c_1) - \Pi(c_2)) \text{ if } \alpha \in \left(0, \alpha^C\right) \\ \frac{1}{2}(1-\alpha)\Pi(c_1) \text{ if } \alpha \in (\alpha^C, 1) \end{cases}$$

where $\alpha^C = \frac{\Pi(c_2)}{\Pi(c_1)}$; and the fee F^D under delegated procurement as

$$F^D = \begin{cases} \frac{1}{2}(\Pi_f(c_1) - \Pi_f(c_2)) \text{ if } \alpha \in \left(0, \alpha^D\right) \\ (1-\alpha)\Pi(c_1) \text{ if } \alpha \in (\alpha^D, 1) \end{cases}$$

where $\alpha^D = 1 - \frac{\Pi_f(c_1) - \Pi_f(c_2)}{2\Pi(c_1)}$. It is immediate to see that a strictly concave revenue function $(R'' < 0)$ implies $\alpha^C < \alpha^D$. We then obtain the following result:

Proposition 6 *The fee paid in centralized procurement is below the one paid in delegated procurement, $F^C < F^D$, whenever $\alpha \in (\alpha^*, 1)$, where $\alpha^* = 1 - \frac{\Pi_f(c_1) - \Pi_f(c_2)}{\Pi(c_1)} \in \left(\alpha^C, \alpha^D\right)$.*

According to this Proposition, we obtain that centralized procurement is the optimal organization when the external alternative is sufficiently attractive, $\alpha \in (\alpha^*, 1)$. Delegated procurement is still chosen for values of the alternative $\alpha \in \left(\alpha^C, \alpha^*\right)$ for which the external alternative improves the bargaining clout of HQ in centralized bargaining; only when this external alternative is sufficiently attractive (and therefore HQ can ask for a low fee) is centralized procurement chosen. Figure 4 illustrates this result by plotting fees obtained under centralized procurement (solid line) and fees obtained under delegated procurement (dashed line) as a function of the external alternative, measured by α.

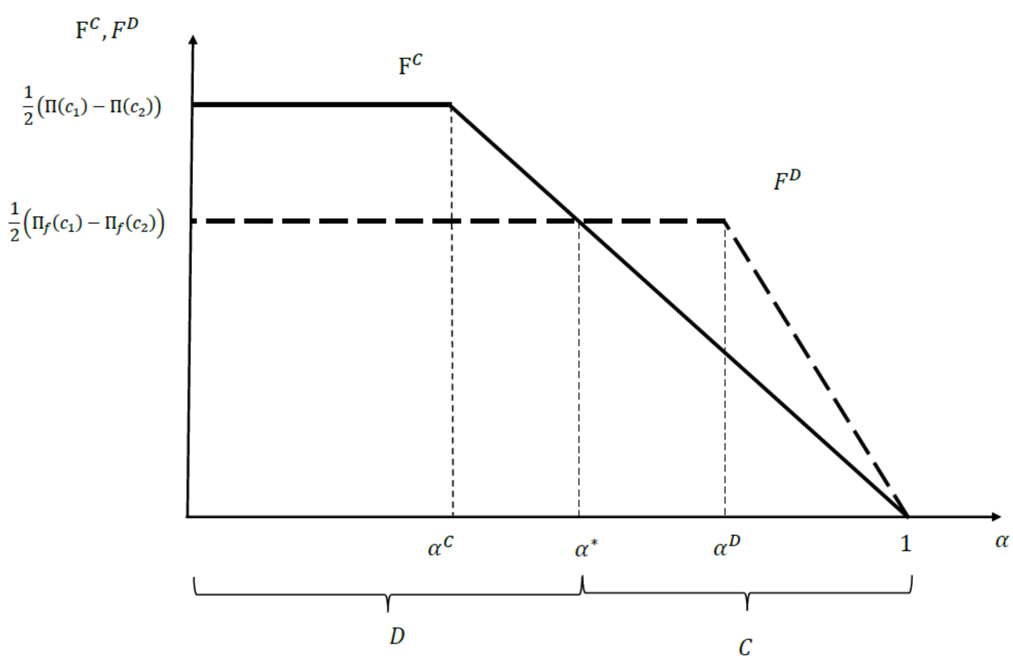

Figure 4. Fees under centralized and delegated procurement when the factory is not essential for the activities of the firm.

As an example of this Proposition, consider the linear demand and quadratic cost function case. The profits of a business unit can be written as $\Pi_f(w) = \theta\Pi(w)$, where $\theta = \frac{m}{b+m} \in (0,1)$. And profits when the factory is used with the inefficient technology are $\Pi(c_2) = \phi\Pi(c_1)$, where $\phi = (\frac{1-c_2}{1-c_1})^2 \in (0,1)$ measures the differences in efficiency of the available suppliers.

We can write the fee under centralized procurement as

$$F^C = \begin{cases} \frac{1}{2}(1-\phi)\Pi(c_1) \text{ if } \alpha \in (0,\phi) \\ \frac{1}{2}(1-\alpha)\Pi(c_1) \text{ if } \alpha \in (\phi,1) \end{cases}$$

and the fee under delegated procurement as

$$F^D = \begin{cases} \frac{1}{2}\theta(1-\phi)\Pi(c_1) \text{ if } \alpha \in \left(0, \frac{2-\theta}{2} + \frac{\theta}{2}\phi\right) \\ (1-\alpha)\Pi(c_1) \text{ if } \alpha \in \left(\frac{2-\theta}{2} + \frac{\theta}{2}\phi, 1\right) \end{cases}$$

For any given values of parameters $\theta, \phi \in (0,1)$ we see that fees are lower under centralized procurement, $F^C < F^D$, when the external alternative is good enough, that is, whenever

$$\alpha \geq \alpha^* = \phi + (1-\theta)(1-\phi),$$

and keeps delegating procurement otherwise. Thus, there are values of the external production $\alpha \in (\phi, \alpha^*)$ such that HQ improve their bargaining position against the efficient suppliers but still prefer to delegate procurement.

4.2 Strategic supplier

The firm is facing a supplier that may behave strategically, that is, a supplier that may announce and commit to a contract, and potentially influencing firm's behavior. A rationale for this case may arise if the supplier is selling the product externally to the firm and internally to other supplier's divisions through the use of transfer pricing (see Arya et al, 2008).

The timing is similar to the benchmark case with the exception that the tariff may play an strategic role. The HQ states who negotiates with the supplier, then either the HQ or the factory bargains with the supplier and *announces a particular tariff* $T(q)$ that will not be renegotiated afterwards, and finally the firm starts production needs. During this section we will use the term S when the HQ delegates procurement and the supplier may behave strategically.

Under *centralized procurement*, the supplier improves nothing by announcing a different tariff from $T^C(q) = F^C + c_1 q(c_1)$. An input price different from the marginal cost of production, that is setting $w \neq c_1$, reduces the quantity to be produced and therefore the rents to bargain with. However, under *delegated procurement*, this is not necessarily the case: by credibly committing to $T(q) \neq T^D(q) = F^D + c_1 q(c_1)$, the supplier may influence the transfer price by setting an input price $w \neq c_1$.

Under *delegated procurement*, the production stage leads to optimal decisions. Given the transfer price p and the input price w the factory chooses $q(p(w), w)$ according to (2) and the HQ can achieve, given w, the optimal production by setting $p(w) = R'(q(p(w), w))$ (optimality is still conditional on the right expectations over w). At the bargaining stage and in case negotiations fail, the input price rises up to c_2 and the factory obtains $\Pi_f(c_2)$. When the factory and the supplier bargain, they choose the tariff $T(q) = F + wq$ that maximize joint profits in (6). Since this is simply a two-part tariff any agreement between the supplier and the factory manager should feature the restriction that the marginal wholesale price cannot be set above c_2. Because otherwise, if the input price is set above c_2, then the factory manager could always trade with the alternative paying a lower per unit price.[16]

When this constraint is not binding ($w < c_2$), the optimal input price w^S solves the following first-order condition,

$$(w - c_1)\frac{\partial q(p(w), w)}{\partial w} + \frac{\partial p}{\partial w}q(p(w), w) = 0. \tag{21}$$

The first element, *the direct effect*, is the effect of the input price on the quantity produced by the factory while the second element, *the strategic effect*, is the effect that the input price has on the internal price set by the HQ. The sign of the direct effect depends on the choice of the input price: it is negative if $w > c_1$ and positive otherwise. Instead, the strategic effect is always positive, since the HQ should optimally increase the transfer price to respond to higher marginal costs (in this case, the input cost).

The following Lemma specifies the tariff, production decisions and firm's profits under S. It is instructive to define the following threshold $\delta(c_1) \equiv c_1 - R\text{"}(q(w^S))q(w^S) \geq 0$ where w^S solves (21),[17] since the exact shape of the contract depends on the relative efficiency of the supplier and the alternative. We say that the alternative is efficient when when $c_2 \in (c_1, \delta(c_1))$ and inefficient otherwise.

Lemma 2 *Under S, the optimal contract displays the following characteristics:*
(a) When $c_2 \in (c_1, \delta(c_1))$, the contract is $F^S = -\frac{1}{2}(c_2 - c_1)q(c_2)$ and $w^S = c_2$, production $q = q(c_2)$, and firm's profits are $\Pi^S = \Pi(c_2) + \frac{1}{2}(c_2 - c_1)q(c_2)$
(b) When $c_2 > \delta(c_1)$, the contract is $F^S = \frac{1}{2}\left[\Pi_f(w^S) - \Pi_f(c_2)\right] - \frac{1}{2}(w^S - c_1)q(w^S)$ and $w^S \in (c_1, c_2)$, production $q = q(w^S) < q(c_1)$, and firm's profits are $\Pi^S = \Pi(w^S) - F^S$

First of all, the tariff between the factory and the supplier always leads to inefficient production, $w > c_1$. When the strategic effect was absent setting $w = c_1$ was indeed optimal. Now, in this framework, when $w = c_1$, the first order condition in (21) is still positive, $\frac{\partial p}{\partial c_1}q(p(c_1), c_1) > 0$. Thus, both the supplier and the factory benefit by distorting input prices so as to influence transfer prices even though this comes at the cost of producing inefficiently. By increasing the input price, the transfer price is set according to the real marginal cost, and joint profits increase. The supplier reaps some of those extra profits through the bargaining process.

The exact value of the distortion depends on the relative efficiency of the alternative and the supplier. When the alternative is efficient (case (a) in Lemma 2) the input price

[16] In other words, the contract between the factory manager and the supplier is a non-exclusive dealing. We could assume the HQ delegates to the factory manager the decision to sign an exclusive dealing with the supplier, that is, a two-part tariff including an exclusivity clause; a clause forcing the firm to buy the input at the supplier. Including this clause into contracts implies that agreements featuring an input $w > c_2$ may be perfectly the solution of factory and manager's joint profits. By the end of this section we briefly discuss the consequences of allowing the factory manager to sign exclusive contracts. We do so by assuming two cases: one in which exclusive dealing is subject to the approval of the HQ and a second one in which the decision to sign exclusive dealing is completely delegated.

[17] For instance, for a linear demand case in which $R(q) = (1 - \frac{b}{2}q)q$ and $C(q) = \frac{m}{2}q^2$ $\delta(c_1) = \frac{(1-\theta)+c_1}{2-\theta}$

is set at its maximum level, $w = c_2$, and the firm thus produces at its lowest level of production, $q(c_2)$. Instead, when the alternative is more inefficient (case (b) in Lemma 2), the input price is set at an intermediate unit price, $w \in (c_1, c_2)$, but still the production is inefficiently low.

It is worth mentioning that the fix component F^D may take negative values; it is the supplier who pays the firm (the factory, indeed) for accepting the terms of the contract. The intuition of this negative fix component may be seen in the following way. When the alternative is inefficient, both the factory and the manager agrees on setting the largest marginal wholesale price possible, $w = c_2$. Net of fixed payments, the factory gets exactly $\Pi_f(c_2)$ (the same amount obtained under the alternative). Since the rents generated under this agreement rises up to $(c_2 - c_1)\, q(c_2)$, the factory reaps half of those rents; rents that can only be satisfied through the fix component.[18]

We now focus on supplier's profits when the supplier can commit to the contract stated in Lemma *2*, and we relate supplier's profits to the ones obtained under D and under C. Let us define by the subscript Π^i_{sup} the profits of the supplier for a specific way of organizing procurement activities $i \in \{C, S, D\}$. It is immediate to see from Proposition 1 that $\Pi^C_{\text{sup}} = F^C > \Pi^D_{\text{sup}} = F^D$. The following result allows us to state that supplier's profit under S remain between profits of D and S.

Lemma 3 *When the supplier behaves strategically, if $R'' < 0$ then $\Pi^S_{\text{sup}} \in \left(\Pi^D_{\text{sup}}, \Pi^C_{\text{sup}}\right)$*

First, as compared to the delegated procurement case, the supplier gets larger profits by setting a distorted input price $w^S > c_1$. Note that, unlike the HQ behaving strategically, the supplier can always replicate the efficient contract, setting $w = c_1$ and grabbing rents through the fee F^D. By distorting the input price, the supplier can manage to effectively influence the transfer pricing, increasing joint profits and eventually grabbing some of those extra profits. Second, as compared to the centralized procurement case, the supplier achieves lower profits than the centralized situation: the loss of efficiency caused by the distortion of the input price, $w^S > c_1$, is always larger than the increase in supplier's profits due to the commitment effect.

Given this potential unwanted production levels, the HQ may prefer to centralize procurement activities. Centralizing it raises production up to its efficient level, $q(c_1)$, and hence profits (net of fixed payment) increases, as well. However, centralizing does reduce firm's bargaining strength increasing the fix component and reducing firm's profits (see Proposition 1). The next proposition shows a case where the firm always centralizes procurement.

Proposition 7 *When firm's alternative is efficient that is, when $c_2 \in (c_1, \delta(c_1))$, HQ centralizes procurement.*

This result states that, anticipating supplier's strategic behavior, the firm should centralize procurement if there are no substantial differences between the two sources of the input. The distortions generated by delegating activities, i.e., producing $q(c_2)$ instead of $q(c_1)$, cannot be compensated by the positive fee paid by the supplier. This cutoff $\delta(c_1)$

[18] This could be seen potentially as an slot allowance or even as a bribe from the supplier to the factory manager. In this model, we assume that the negative fix component is returned to the firm and not kept privately in hands of the factory's manager (see Troya-Martinez and Wren-Lewis, 2016 for a model in which corrupt intermediaries may exist).

should be seen as lower bound since, as long as $w = c_2 > c_1$, profits under centralized are strictly larger than delegated procurement when the supplier behaves strategically.

When the alternative is inefficient (the optimal solution of the contract is an interior solution) distortions are not so pronounced and the firm may prefer to delegate procurement. The difference of profits between centralized and delegated procurement can be rearranged in the following way:

$$\Pi^C - \Pi^D = \left(\frac{1}{2}\Pi(c_1) - \Pi(w^S) + \frac{1}{2}\Pi_f(w^S) - \frac{1}{2}(w^S - c_1)q(w^S)\right) + \frac{1}{2}\left(\Pi(c_2) - \Pi_f(c_2)\right).$$

First, centralizing procurement provides more profits than delegating it because profits obtained under the alternative are always larger, $\frac{1}{2}\left(\Pi(c_2) - \Pi_f(c_2)\right) > 0$ but this effect is reduced the lower the efficiency of the alternative, that is, $\frac{\partial\left(\Pi(c_2)-\Pi_f(c_2)\right)}{\partial c_2} \leq 0$. In the limiting case when there is no alternative, i.e., the best case scenario for delegated procurement, the firm may still centralize procurement. To be this true, the first element of the former equation should be positive, that is, delegation never takes place if, after rearranging,

$$\Pi(c_1) - \left(\Pi(w^S) + (w^S - c_1)q(w^S)\right) \geq \Pi(w^S) - \Pi_f(w^S),$$

the gains of producing efficiently are larger than the gains of paying less at the bargaining stage.

The sign of this inequality is not conclusive for general functions but we can compare different organizational structures when the demand is linear generating revenues $R(q) = \left(1 - b\frac{q}{2}\right)q$ and cost are quadratic $C(q) = m\frac{q^2}{2}$. We know from Section 3 that *centralized procurement* leads to $w = c_1$ and a fee F^C in (9) and profits Π^C in (10). Under S, the optimal contract leads to a two part tariff with the following fee F^S and unit price w^S:

$$F^S = \begin{cases} -\frac{\theta(c_2-c_1)(1-c_2)}{2m} \text{ if } c_2 \in (c_1, \delta(c_1)) \\ \frac{\theta(3\theta-2)(1-c_1)^2}{4m(2-\theta)^2} - \frac{\theta^2(1-c_2)^2}{4m} \text{if } c_2 \in (\delta(c_1), 1) \end{cases} \quad \textit{and } w^S = \begin{cases} c_2 \text{ if } c_2 \in c_2 \in (c_1, \delta(c_1)) \\ \frac{(1-\theta)+c_1}{2-\theta} \text{ if } c_2 \in (\delta(c_1), 1) \end{cases}$$

Then the supplier's profits are

$$\Pi^S = \begin{cases} \frac{(1-c_1)(1-c_2)\theta}{2m} \text{ if } c_2 \in c_2 \in (c_1, \delta(c_1)) \\ \frac{\theta(4-3\theta)(1-c_1)^2}{4m(2-\theta)^2} + \frac{\theta^2(1-c_2)^2}{4m} \text{ if } c_2 \in (\delta(c_1), 1) \end{cases} \tag{22}$$

where the exact shape of the contract depends on the constraint $w \leq c_2$ being binding or not (see Lemma (2)) where the cutoff $\delta(c_1) = \frac{(1-\theta)+c_1}{2-\theta} \in (c_1, 1)$ when the demand is linear and costs are quadratic. Comparing equations (22) and (10) for profits leads to the following result.

Proposition 8 *HQ centralizes procurement if* $c_2 \in (c_1, \beta(c_1))$*, where* $\beta(c_1) = \frac{2-\left(\theta+\sqrt{\theta}\right)+\sqrt{\theta}c_1}{2-\theta}$*, and delegates otherwise.*

The former Proposition shows a case where, in some cases, it is more convenient to centralize whereas in others delegating procurement is the optimal way to organize procurement activities. When the alternative is efficient, centralize procurement emerges as the optimal organization; the argument is similar to Proposition 7, efficiency distortions are larger than potential gains at the bargaining stage. Moreover, it is easy to see that $\beta(c_1) > \delta(c_1)$: HQ centralizes procurement beyond stated in proposition 7, confirming the idea that the cutoff $\delta(c_1)$ is a lower bound on centralizing procurement activities. When the efficiency of the alternative worsens, the firm is in a weaker position and being tougher at the bargaining stage becomes more relevant than efficiency considerations.

A final comment concerns the assumption on the characteristics of the contract signed between the supplier and the factory manager. We have imposed a restriction on the input price w; a restriction well justified if the contract is a non-exclusive deal. Assume though that the factory manager and the supplier may sign a two part tariff including an exclusive clause and assume the HQ delegates such decision to the factory manager. The basic difference between these two cases arises when the restriction $w \leq c_2$ under non-exclusive deals is active. Under exclusive deals, the optimal tariff avoid the restriction $w \leq c_2$; the tariff is simply the solution to (21), implying an input price featuring $w^S > c_2$ if $c_2 \in (c_1, \delta(c_1))$. It is immediate to see that the unconstrained joint profit maximization leads to higher profits to both the supplier and the factory, but since $w > c_2 > c_1$ then overall profits generated by this agreement are even lower, $\Pi^S(w^S) + \Pi^S_{\text{sup}}(w^S) < \Pi^S(c_2) + \Pi^S_{\text{sup}}(c_2)$. Given these two observations, firm's profits under non-exclusive are always larger than under exclusive deals (or the same level of profits when the restriction is not active). Anticipating this, the HQ centralizes procurement if $w^S > c_2$. by a similar argument provided in Proposition 7.

Another possibility would be to allow the factory manager to sign contracts subject to HQ's approval. In this case the factory manager and the supplier maximize joint profits subject to the constraint that the agreement must be at least as good as the alternative, that is, $\Pi^S(w^S) - F \geq \Pi^S(c_2)$. Even if we add this restriction, the agreement obtained can never provide larger profits than under non-exclusive deals. When it is optimal to set $w^S > c_2$ either the HQ would block the agreement and the supplier and the factory manager set precisely $w^S = c_2$ or it does not block the agreement and the firm sets a larger input price. In either case, profits the HQ anticipates this inefficient behavior and prefers to centralize procurement.

Finally, given that $\Pi^S_{\text{sup}} \in (\Pi^D_{\text{sup}}, \Pi^C_{\text{sup}})$ as stated in Lemma 3 and the fact that the firm may recover procurement decisions (as discussed in Propositions 7 and 8), the supplier always improves profits as compared to the delegated situation (Section 3). This improvement comes from two different channels: (a) if the HQ delegates procurement the supplier distorts the input price, setting $w^S > c_1$, thus increasing profits. The second mechanism arises when the HQ, anticipating a high distortion of input prices, may take control over procurement decisions leading to an improvement of supplier's profit (since $\Pi^C_{\text{sup}} = F^C > \Pi^D_{\text{sup}} = F^D$).

Proposition 9 *Committing to a contract always improves supplier's profit. When the alternative is efficient, announcing a distorting contract deters delegation of procurement.*

The next figure graphically represents the former result. We graphically represent supplier's profits as a function of the alternative efficiency c_2. First, the dotted line represents supplier's profits under D, the benchmark case; the dashed line represents supplier's profits under C, that is, when the supplier bargains with the HQ and finally the light dashed line represents supplier's profits under S, that is, profits obtained if the contract signed was the one defined in Lemma 2. The solid line represents supplier's profits when HQ's decisions to either centralize or delegate procurement are taking into account. When strategic considerations were absent, it was optimal to delegate decisions to the factory manager (Proposition 1), leading to low supplier's profits (the dotted line). When the supplier behaves strategically, it may happen that the HQ is forced to take over procurement decisions leading to an increase of supplier's profits (from dotted to dashed) or it allows the factory to bargain even if it leads to inefficient production choices. Still, the supplier improves profits by distorting input prices since it is able to influence transfer price (from dotted to light dashed line)

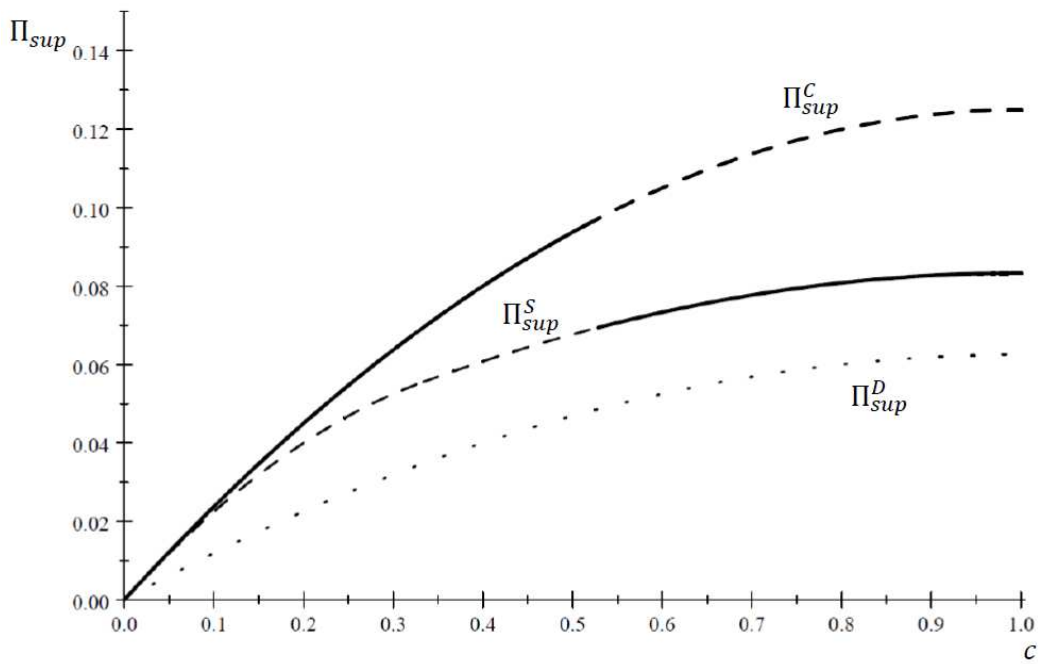

Figure 5. Supplier's profits linear demand, quadratic cost example $\theta = \frac{1}{2}$

5 Concluding remarks

The main goal of this paper is to understand the benefits of delegating procurement to a business unit in charge of production. We show conditions under which the delegation of this activity improves firm's bargaining against suppliers. The benefits arises as long, by delegating, factory's profits are lower than firm's profits which improves firm's bargaining positioning. We show, unlike Arya (2007), the existence of those benefits both under strategic and non-strategic transfer prices. Further, we show that the use of strategic transfer prices does not necessarily improve firm's profits and they may be counterproductive. Alternative organizational arrangements such as vertical separation may be an alternative but not superior way to organize procurement activities. We extend the initial framework by introducing other aspects that may moderate the decision to decentralize firm's procurement. First, the firm owns an external alternative that allows to shut down the factory. Second, the factory and the supplier privately negotiate the input price. In both cases, we obtain situations in which still the firm prefers firms' procurement to be in factory's hands.

The model presented in this paper aims to characterize an industry structure in which the firm needs to acquire an input from an external source to produce a good, and then the sales division markets the good. This industry structure naturally captures situations in which a divisionalized firm needs to interact with key suppliers or engages negotiations with union labours at the factory level. As a consequence, the agent in charge of leading procurement negotiations must be the one with the adequate expertise, that is, the agent in charge of production decisions or the HQ. Our result on delegation is not necessarily restricted to this particular industry structure and can be extended to other industries in which production decisions fall on the agent in charge of marketing the product and where our results remain essentially unchanged. A potential example of this industry structure can be captured by the broadband industry. In this industry, the firm owns a technology able to send content at a high speed but it also need to distribute content in order to satisfy its final consumer. In this case, the sales division, having a superior knowledge of consumer's preferences, should be the one leading procurement negotiations with content producers, deciding which set of products are of interest.

Finally, there are at least two natural extensions. First, the multiplant case: note that in this case, the firm can use the organizational structure to increase firm's bargaining positioning, but it can also shift production to increase its positioning. When the firm owns several factories, it may not always be optimal to keep decentralization at the factory level, and the firm partly centralize firm's procurement by building a new layer, namely, a central purchasing. Second, the introduction of uncertainty at the demand's side. In that framework, the sales manager knows the true realization of the demand but cannot communicate it to the HQ or to the factory (following Weitzman, 1974). Thus, the problem faced by the HQ is to whom provide authority over quantity; to the sales division and taking advantage of the local information knowledge or to the factory and reinforce the bargaining position against the supplier.

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6 Appendix A

Below we show the outcomes of bargaining when procurement is centralized and when it is delegated

6.1 Bargaining under centralised procurement

The optimal contract between the supplier and the headquarter is the solution to the following problem

$$\max_{\{F,w\}} \left[\Pi(w) - F - \Pi(c_2)\right]^{\frac{1}{2}} \left[F + (w - c_1)q(w)\right]^{\frac{1}{2}}$$

Let us first take logs to convert the program into

$$\max_{\{F,w\}} \frac{1}{2} \ln\left[\Pi(w) - F - \Pi(c_2)\right] + \frac{1}{2} \ln\left[F + (w - c_1)q(w)\right]$$

and the first order conditions are

$$\begin{aligned} \frac{\partial}{\partial F} &= 0 \Longleftrightarrow -\frac{\frac{1}{2}}{\Pi(w) - F - \Pi(c_2)} + \frac{\frac{1}{2}}{F + (w - c_1)q(w)} = 0 \\ \frac{\partial}{\partial w} &= 0 \Longleftrightarrow \frac{\frac{1}{2}\frac{\partial \Pi(w)}{\partial w}}{\Pi(w) - F - \Pi(c_2)} + \frac{\frac{1}{2}\left((w - c_1)\frac{\partial q(w)}{\partial w} + q(w)\right)}{F + (w - c_1)q(w)} = 0 \end{aligned}$$

Note first that from $\frac{\partial}{\partial F} = 0$ we obtain the fixed component F^C

$$F^C = \frac{1}{2}\left[\Pi(w) - \Pi(c_2)\right] - \frac{1}{2}(w - c_1)q(w)$$

By plugging $F^C(w)$ into $\frac{\partial}{\partial w} = 0$, we obtain

$$\begin{aligned} \frac{\frac{1}{2}\frac{\partial \Pi(w)}{\partial w}}{\frac{1}{2}\left(\Pi_f(w) - \Pi_f(c_2) - (w - c_1)q(w)\right)} + \frac{\frac{1}{2}\left((w - c_1)\frac{\partial q(w)}{\partial w} + q(w)\right)}{\frac{1}{2}\left(\Pi_f(w) - \Pi_f(c_2) - (w - c_1)q(w)\right)} &= 0 \Longleftrightarrow \\ \frac{\partial \Pi_f(w)}{\partial w} + (w - c_1)\frac{\partial q(w)}{\partial w} + q(w) &= 0 \end{aligned}$$

Note that by applying the envelope theorem $\frac{\partial \Pi_f(w)}{\partial w} = -q(w)$ which means that

$$\frac{\partial}{\partial w} = 0 \Longleftrightarrow (w - c_1)\frac{\partial q(w)}{\partial w} = 0$$

which holds if and only if $w = c_1$ since $\frac{\partial q(w)}{\partial w} = \frac{1}{R'' - C''} < 0$. Thus, $w = c_1$ and $F^C = \frac{1}{2}\left[\Pi(c_1) - \Pi(c_2)\right]$

6.2 Bargaining under delegated procurement

The optimal contract between the supplier and the factory is the solution to the following problem

$$\max_{\{F,w\}} \left[\Pi^f(w) - F - \Pi_f(c_2)\right]^{\frac{1}{2}} \left[F + (w - c_1)q(w)\right]^{\frac{1}{2}}$$

Let us first take logs to convert the program into

$$\max_{\{F,w\}} \frac{1}{2} \ln\left[\Pi_f(w) - F - \Pi_f(c_2)\right] + \frac{1}{2} \ln\left[F + (w - c_1)q(w)\right]$$

and the first order conditions derived from the lagrangian are

$$\begin{aligned}
\frac{\partial L}{\partial F} &= 0 \Longleftrightarrow -\frac{\frac{1}{2}}{\Pi_f(w) - F - \Pi_f(c_2)} + \frac{\frac{1}{2}}{F + (w - c_1)q(w)} = 0 \\
&\Longleftrightarrow \frac{1}{2}\left[F + (w - c_1)q(w)\right] = \frac{1}{2}\left[\Pi_f(w) - F - \Pi_f(c_2)\right] \\
\frac{\partial L}{\partial w} &= 0 \Longleftrightarrow \frac{\frac{1}{2}\frac{\partial \Pi_f(w)}{\partial w}}{\Pi_f(w) - F - \Pi_f(c_2)} + \frac{\frac{1}{2}\left((w - c_1)\frac{\partial q(w)}{\partial w} + q(w)\right)}{F + (w - c_1)q(w)} = 0
\end{aligned}$$

Note first that from $\frac{\partial L}{\partial F} = 0$ we obtain

$$F^D(w) = \frac{1}{2}\left[\Pi_f(w) - \Pi_f(c_2)\right] - \frac{1}{2}(w - c_1)q(w)$$

By plugging $F^D(w)$ into $\frac{\partial}{\partial w} = 0$, we obtain

$$\begin{aligned}
\frac{\frac{1}{2}\frac{\partial \Pi_f(w)}{\partial w}}{\frac{1}{2}\left(\Pi_f(w) - \Pi_f(c_2) - (w - c_1)q(w)\right)} + \frac{\frac{1}{2}\left((w - c_1)\frac{\partial q(w)}{\partial w} + q(w)\right)}{\frac{1}{2}\left(\Pi_f(w) - \Pi_f(c_2) - (w - c_1)q(w)\right)} &= 0 \Longleftrightarrow \\
\frac{\partial \Pi_f(w)}{\partial w} + (w - c_1)\frac{\partial q(w)}{\partial w} + q_f(w) &= 0 \Longleftrightarrow \\
(w - c_1)\frac{\partial q_f(w)}{\partial w} &= 0
\end{aligned}$$

where the last equivalence is obtained by noting that $\frac{\partial \Pi_f(w)}{\partial w} = -q(w)$. Finally, since $\frac{\partial q(w)}{\partial w} < 0$, $w = c_1$. Finally, plug $w = c_1$ to obtain the payment $F^D = \frac{1}{2}\left[\Pi_f(c_1) - \Pi_f(c_2)\right]$.

7 Appendix B. Proofs.

Proof of Proposition 1. We want to show that if $R'' < 0$, then $F^D < F^C$. First, we know that production levels are always $q(c_1)$ if negotiations succeed and $q(c_2)$ otherwise. Second, according to the expressions of the fees F^C in (7) and F^D in (8) $F^D < F^C \iff \frac{1}{2}(\Pi_f(c_1) - \Pi_f(c_2)) < \frac{1}{2}(\Pi(c_1) - \Pi(c_2)) \iff R'(q(c_1))q(c_1) - R'(q(c_2))q(c_2) < R(q(c_1)) - R(q(c_2))$ and rearranging

$$F^D < F^C \iff R(q(c_2)) - R'(q(c_2))q(c_2) < R(q(c_1)) - R'(q(c_1))q(c_1).$$

where $R(q(c_i)) - R'(q(c_i))q(c_i) > 0$ $i = 1, 2$, since $R'' < 0$. Let us define the function $f(q) = R(q) - R'(q)q$. This function is increasing in q since $\frac{df(q)}{dq} = -R''(q)q > 0$ and $f(0) = 0$. To prove the result it is left to remind that $q(c_1) > q(c_2)$, since $\frac{\partial q}{\partial w} = \frac{1}{R''-C''} < 0$. QED ■

Proof of Proposition 2. We first see that at the transfer price that maximizes total surplus, $p(c_1) = R'(q(c_1))$, profits under Delegated procurement are larger: In equilibrium total surplus is $\Pi(c_1)$, the supplier charges a fee $F^H(p(c_1)) = \frac{1}{2}\{\Pi_f(c_1) - \pi^f(p(c_1), c_2)\}$ and the firm have profits $\Pi(c_1) - F^H(p(c_1))$. Thus these profits are higher than under Centralized procurement if the fee $F^H(p(c_1))$ is lower than the fee under Centralized procurement $F^C = \frac{1}{2}(\Pi(c_1) - \Pi(c_2))$. Indeed, $F^H(p(c_1)) = \frac{1}{2}\int_{c_1}^{c_2} q(p(c_1), w)dw < F^C = \frac{1}{2}\int_{c_1}^{c_2} q(w)dw$ since $q(p(c_1), w) < q(w)$ if $w > c_1$. But HQ can obtain even higher profits setting a lower transfer price, since at $p = R'(q(p, c_1))$, the first order condition in (15) becomes $-\frac{1}{2}\{q(p, c_1) - q(p, c_2)\} < 0$. QED ■

Proof of Lemma 1. Differentiating fees under strategic transfer price w.r.t c_2 leads to

$$\frac{\partial F^H}{\partial c_2} = q(p^H, c_2) + \left(q(p^H, c_1) - q(p^H, c_2)\right)\frac{\partial p^H}{\partial c_2}$$

where p^H solves (15).

Differentiating fees under strategic transfer price w.r.t c_2 leads to:

$$\frac{\partial F^D}{\partial c_2} = q(c_2) - q(c_2)\frac{\partial p(c_2)}{\partial c_2}$$

$p(c_2) = R'(q(c_2))$ is the nonstrategic transfer price. Now, note that when $c_2 = c_1$ $p^H = R'(q(c_1))$, which implies that $q(p^H, c_2) = q(c_1) = q(c_2)$ and therefore $F^D = F^H$. Note that $\frac{\partial F^H}{\partial c_2} = q(p^H, c_2) > \frac{\partial F^D}{\partial c_2} = q(c_2) - q(c_2)\frac{\partial p^{NS}(c_2)}{\partial c_2} > 0 \iff R'' < 0$ and the stated result is obtained. QED ■

Proof of Proposition 3.

First, firm's profits when the transfer price is not strategic are $\Pi^D = \Pi(c_1) - \frac{1}{2}(\Pi_f(c_1) - \Pi_f(c_2))$ and differentiating (and applying envelope theorem) with respect to c_2, we get

$$\frac{\partial \Pi^D}{\partial c_2} = \frac{1}{2}\left(-q(c_2) + R''(q(c_2))q(c_2)\frac{\partial q(c_2)}{\partial c_2}\right)$$

rearranging and noting that $\frac{\partial q(c_2)}{\partial c_2} = \frac{1}{R''-C''} < 0$, we obtain

$$\frac{\partial \Pi^D}{\partial c_2} = \frac{1}{2}\frac{C''(q(c_2))}{R''(q(c_2)) - C''(q(c_2))}q(c_2) < 0$$

Second, firm's profits when the transfer price is strategic are $\Pi^H = \Pi(p^H, c_1) - \frac{1}{2}\left(\Pi^f(p^H, c_1) - \Pi^f(p^H, c_2)\right)$ where p^H solves (15), and differentiating (and applying envelope theorem) with respect to c_2, we get

$$\frac{\partial \Pi^{Str}}{\partial c_2} = -\frac{1}{2} q(p^H, c_2) < 0$$

Now, note that when $c_2 = c_1$ $p^H = R'(q(c_1))$, which implies that $q(p^H, c_2) = q(c_1) = q(c_2)$ and therefore $\Pi^D = \Pi(c_1) = \Pi^H$. Note that $\left.\frac{\partial \Pi^D}{\partial c_2}\right|_{c_2=c_1} = \frac{1}{2}\frac{C''(q(c_1))}{R''(q(c_1)) - C''(q(c_1))} q(c_1)$ while $\frac{\partial \Pi^H}{\partial c_2} = -\frac{1}{2} q(c_1)$. Since $\frac{C''(q(c_1))}{R''(q(c_1)) - C''(q(c_1))} < 1 \iff R'' < 0$ the stated result is obtained. QED ■

Proof of Proposition 4. First, we find fees and profits when the transfer price is strategic, and then we compare profits under strategic and under nonstrategic. First, under strategic transfer price, it is still true that efficient production can be achieved by means of a two part tariff, that is, the optimal quantity of the factory is $q(p, 0) = \frac{p}{m}$ under the supplier and $q(p, c) = \frac{p-c}{m}$ under the alternative, which in turn implies profits $\Pi_f(0) = \frac{p^2}{2m}$ and $\Pi_f(c) = \frac{(p-c)^2}{2m}$, and therefore

$$F^H(p) = \frac{1}{2}\left(\Pi_f(p, 0) - \Pi_f(p, c)\right) = \frac{1}{4m}\left(p^2 - (p-c)^2\right)$$

Since prices are strategic, profits under the alternative might be negative. We do not allow for that and assume that if the optimal strategic transfer price is $p \leq c$ then $\Pi_f(c) = 0$. Thus, $F^H(p) \in \left\{\frac{1}{4m} c(2p - c), \frac{p^2}{4m}\right\}$ where the second case arises whenever $p \leq c$. Thus, the optimal strategic price is the solution to

$$\max_{\{p\}} R(q(p, 0)) - C(q(p, 0) - F^H(p) = \left(1 - \frac{bq(p, 0)}{2}\right) q(p, 0) - \frac{mq(p, 0)^2}{2} - F^H(p) = \left(1 - \frac{p}{2\theta}\right)\frac{p}{m} - F^H(p)$$

When profits under the alternative are positive, then the FOC is $\frac{1}{m} - \frac{p}{\theta m} - \frac{c}{2m} = 0$, that is, $p^H = \frac{\theta(2-c)}{2}$. Therefore the fee and profits are to be paid is

$$F^H\left(p^H\right) = c\left(\frac{\theta(2-c) - c}{4m}\right); \Pi^H = \frac{\theta(2-c)^2}{8m} + \frac{c^2}{4m}$$

When profits under the alternative are negative, then $F^H(p) = \frac{p^2}{4m}$ and the FOC is $\left(1 - \frac{p}{\theta}\right) p - \frac{p}{2} = 0$ which leads to $p^H = \frac{2\theta}{2+\theta}$. Therefore, fee and profits are

$$F^H\left(p^H\right) = \frac{\theta^2}{m(2+\theta)^2}; \Pi^H = \frac{\theta}{m(2+\theta)}$$

Finally it is left to see that whenever $p^H = \frac{\theta(2-c)}{2} \leq c \iff c \geq \frac{2\theta}{2+\theta}$ profits under the alternative become negative. Thus, the solution to this problem leads to the following fees and profits:

$$F^H\left(p^H\right) = \begin{cases} c\left(\frac{\theta(2-c)-c}{4m}\right) \text{ if } c \leq \frac{2\theta}{2+\theta} \\ \frac{\theta^2}{m(2+\theta)^2} \; otherwise \end{cases}; \Pi^H = \begin{cases} \frac{\theta(2-c)^2}{8m} + \frac{c^2}{4m} \text{ if } c \leq \frac{2\theta}{2+\theta} \\ \frac{\theta}{m(2+\theta)} \; otherwise \end{cases}$$

Finally, the optimal piecewise nonstrategic price is

$$p^H = \begin{cases} \frac{\theta(2-c)}{2} \text{ if } c \leq \frac{2\theta}{2+\theta} \\ \frac{2\theta}{2+\theta} \; otherwise \end{cases}$$

It is left to compare fees and profits both under D and under H. We first compare profits, that is, Π^D and Π^H (a piecewise function). Note that $\Pi^D = \theta\left(\frac{2-\theta(2-c)c}{4m}\right)$ from equation (12). We first compare Π^D and Π^H when profits under the alternative are positive. Thus $\Pi^H = \frac{\theta(2-c)^2}{8m} + \frac{c^2}{4m}$, and

$$\Pi^D \geq \Pi^H \iff \theta\left(\frac{2-\theta(2-c)c}{4m}\right) \geq \frac{\theta(2-c)^2}{8m} + \frac{c^2}{4m}$$

which is true when $c \leq \frac{4\theta(1-\theta)}{2(1-\theta^2)+\theta}$. Note that $\frac{4\theta(1-\theta)}{2(1-\theta^2)+\theta} \leq \frac{2\theta}{2+\theta} \iff \theta \geq \frac{2}{3}$. Second, we compare Π^D and Π^H when profits under the alternative are cero. Thus, $\Pi^H = \frac{\theta}{m(2+\theta)}$, and

$$\Pi^D \geq \Pi^H \iff \left(\frac{2\theta-\theta^2(2-c)c}{4m}\right) \geq \frac{\theta}{m(2+\theta)}$$

which is true when $c \leq 1-\sqrt{\frac{\theta}{2+\theta}}$ and $1-\sqrt{\frac{\theta}{2+\theta}} \geq \frac{2\theta}{2+\theta} \iff \theta \geq \frac{2}{3}$. Thus, the following threshold function for profits

$$f(\theta) = \begin{cases} 1-\sqrt{\frac{\theta}{2+\theta}} \text{ if } 0 < \theta < \frac{2}{3} \\ \frac{4\theta(1-\theta)}{2(1-\theta^2)+\theta} \text{ if } \frac{2}{3} < \theta < 1 \end{cases}$$

states that strategic transfer prices provide larger profits if $c \geq f(\theta)$ (and nonstrategic transfer prices leads to larger profits otherwise).

We do a similar exercise for fees, comparing F^D with F^H (a piecewise function). Note that $F^D = \frac{\theta^2(2-c)c}{4m}$ from equation (11). We first compare F^D and F^H when profits under the alternative are positive. In this case, $F^H = c\left(\frac{\theta(2-c)-c}{4m}\right)$, and

$$F^D \geq F^H \iff \frac{\theta^2(2-c)c}{4m} \geq c\left(\frac{\theta(2-c)-c}{4m}\right)$$

which is true when $c < \frac{2\theta(1-\theta)}{\theta-\theta^2+1}$. Note that $\frac{2\theta(1-\theta)}{\theta-\theta^2+1} \leq \frac{2\theta}{2+\theta} \iff \theta \geq \frac{1}{2}$.Otherwise, compare F^D and F^H when profits under the alternative are cero. Thus, $F^H = \frac{\theta^2}{m(2+\theta)^2}$, and

$$F^D \geq F^H \iff \frac{\theta^2(2-c)c}{4m} \geq \frac{\theta^2}{m(2+\theta)^2}$$

which is true when $c < 1-\sqrt{\frac{\theta(\theta+4)}{(2+\theta)^2}}$and $1-\sqrt{\frac{\theta(\theta+4)}{(2+\theta)^2}} > \frac{2\theta}{2+\theta} \iff \theta < \frac{1}{2}$.Thus, the following threshold function for fees

$$g(\theta) = \begin{cases} 1-\sqrt{\frac{\theta(\theta+4)}{(2+\theta)^2}} \text{ if } 0 < \theta < \frac{1}{2} \\ \frac{2\theta(1-\theta)}{1+\theta(1-\theta)} \text{ if } \frac{1}{2} < \theta < 1 \end{cases}$$

states that strategic transfer prices leads to lower payments if $c \geq g(\theta)$ (and nonstrategic transfer prices leads to lower payments otherwise).

Finally, it is left to show that $f(\theta) \geq g(\theta)$. First, it is almost straightforward to see that $f(\theta) \geq g(\theta)$ when $\theta > \frac{2}{3}$ and when $\theta < \frac{1}{2}$ When $\theta \in \left(\frac{1}{2}, \frac{2}{3}\right)$ we need to show that $1 - \sqrt{\frac{\theta}{2+\theta}} > \frac{2\theta(1-\theta)}{1+\theta(1-\theta)}$. On the one hand, $f(\theta) = 1 - \sqrt{\frac{\theta}{2+\theta}}$ is a strictly decreasing convex function. Since $\theta \in \left(\frac{1}{2}, \frac{2}{3}\right)$ this function takes minimum value when $\theta = \frac{2}{3}$ and $f(\frac{2}{3}) = \frac{1}{2}$. On the other hand, $g(\theta)$ is a strictly concave function with a local maximum in $\theta = \frac{1}{2}$ and $g(0) = g(1) = 0$ and $g\left(\frac{1}{2}\right) = \frac{2}{5}$. Therefore since $f\left(\frac{2}{3}\right) > g\left(\frac{1}{2}\right)$, this implies that $f(\theta) \geq g(\theta)$ holds in this interval. QED ■

Proof of Proposition 5. First, we show that (a) $\Pi^D = \Pi^C$ when revenues are linear and then we show that (b) $\Pi^H > \Pi^D$. To prove (a), under nonstrategic transfer pricing quantities are efficient both under delegated and under centralized procurement and we want to prove that

$$\Pi^D = \Pi^C \Longleftrightarrow F^D = F^C \Longleftrightarrow \frac{1}{2}\left(\Pi(c_1) - \Pi(c_2)\right) = \frac{1}{2}\left(\Pi_f(c_1) - \Pi_f(c_2)\right)$$

The efficient transfer price is $p = R'(q(w)) = v$ when revenues are linear. Note that $\Pi(w) = \Pi_f(w) \Longleftrightarrow R(q(w)) - (C(q(w) + wq(w)) = R'(q(w))q(w) - (C(q(w) + wq(w))$ which is true if revenues are linear. Thus, $\Pi^D = \Pi^C$. To prove (b), if the firm sets $p = v$, then $\pi^H(p) = \Pi^D$, which is true as long as $\Pi_f(c_2) = \pi_f(p, c_2)$. The last comparison holds because $p = v$ maximizes profits under the alternative. Finally, it is left to see that by Lemma 2, $\left.\frac{\partial \pi^H(p)}{\partial p}\right|_{p=v} < 0$. Hence, $\Pi^H > \Pi^D$. QED ■

Proof of Lemma 2. The optimal contract between the supplier and the factory is the solution to the following problem

$$\max_{\{F,w\}} \left[\Pi_f(w) - F - \Pi_f(c_2)\right]^{\frac{1}{2}} \left[F + (w - c_1)q(w)\right]^{\frac{1}{2}} \; s.t \; w \leq c_2$$

Let us first take logs to convert the program into

$$\max_{\{F,w\}} \frac{1}{2} \ln\left[\Pi_f(w) - F - \Pi_f(c_2)\right] + \frac{1}{2} \ln\left[F + (w - c_1)q(w)\right] \;\; s.t \quad w \leq c_2$$

and the first order conditions derived from the Lagrangian are

$$\begin{aligned} \frac{\partial}{\partial F} &= 0 \Longleftrightarrow -\frac{\frac{1}{2}}{\Pi_f(w) - F - \Pi_f(c_2)} + \frac{\frac{1}{2}}{F + (w - c_1)q(w)} = 0 \\ &\Longleftrightarrow \frac{1}{2}\left[F + (w - c_1)q(w)\right] = \frac{1}{2}\left[\Pi_f(w) - F - \Pi_f(c_2)\right] \\ \frac{\partial}{\partial w} &= 0 \Longleftrightarrow \frac{\frac{1}{2}\frac{\partial \Pi_f(w)}{\partial w}}{\Pi_f(w) - F - \Pi_f(c_2)} + \frac{\frac{1}{2}\left((w - c_1)\frac{\partial q(w)}{\partial w} + q(w)\right)}{F + (w - c_1)q(w)} - \lambda = 0 \end{aligned}$$

where $\lambda \geq 0$ is the lagrange multiplier associated to the constraint $w \leq c_2$. Note first that from $\frac{\partial}{\partial F} = 0$ we obtain the fixed component F^S

$$F^S(w) = \frac{1}{2}\left[\Pi_f(w) - \Pi_f(c_2)\right] - \frac{1}{2}(w - c_1)q(w)$$

First, take the case $\lambda = 0$, which implies that $w < c_2$. By plugging $F^S(w)$ into $\frac{\partial}{\partial w} = 0$, we obtain

$$\begin{aligned}\frac{\frac{1}{2}\frac{\partial \Pi_f(w)}{\partial w}}{\frac{1}{2}\left(\Pi_f(w) - \Pi_f(c_2) - (w - c_1)q(w)\right)} + \frac{\frac{1}{2}\left((w-c_1)\frac{\partial q(w)}{\partial w} + q(w)\right)}{\frac{1}{2}\left(\Pi_f(w) - \Pi_f(c_2) - (w - c_1)q(w)\right)} &= 0 \Longleftrightarrow \\ \frac{\partial \Pi_f(w)}{\partial w} + (w-c_1)\frac{\partial q(w)}{\partial w} + q(w) &= 0 \Longleftrightarrow \\ \frac{\partial p(w)}{\partial w}q(w) + (w-c_1)\frac{\partial q^f(w)}{\partial w} &= 0\end{aligned}$$

because $\frac{\partial \Pi(w)}{\partial w} = \frac{\partial p(w)}{\partial w} - q(w) + (p(w) - w - C'(q(w)))\frac{\partial q(w)}{\partial w} = \frac{\partial p(w)}{\partial w} - q(w)$. Knowing that $\frac{\partial p(w)}{\partial w} = R''\left(q(w)\right)\frac{\partial q(w)}{\partial w} < 0$ the first order condition can be rewritten as

$$\begin{aligned}\frac{\partial p(w)}{\partial w}q(w) + (w-c_1)\frac{\partial q(w)}{\partial w} &= 0 \Longleftrightarrow \\ \frac{\partial q(w)}{\partial w}\left(R''\left(q(w)\right)q(w) + (w-c_1)\right) &= 0\end{aligned}$$

and $\frac{\partial q(w)}{\partial w} < 0$ implies $w^S = c_1 - R''\left(q(w\left(c_1\right))\right)q(w\left(c_1\right)) = \delta\left(c_1\right) > c_1$. Note that this implies that $w = c_1$ cannot be a local optimum and therefore $w \in (c_{1,}c_2)$. Now, take the case $\lambda > 0$, which implies that $w = c_2$ and $F^S(w)$ becomes $F^S(c_2) = -\frac{1}{2}(c_2 - c_1)q(c_2) < 0$. Finally, the restriction is active when $c_2 \in (c_1, \delta\left(c_1\right))$ and inactive otherwise. QED ■

Proof of Lemma 3. We want to show that $\Pi^C_{\text{sup}} > \Pi^S_{\text{sup}} > \Pi^D_{\text{sup}}$. First, $\Pi^S_{\text{sup}} > \Pi^D_{\text{sup}}$ it is a direct implication of (21): it is optimal to distort the contract, and set $w^S > c_1$ (although the supplier can always set $w = c_1$), thus, joint profits, and as a consequence supplier's profits, are not maximized at c_1. Second, we show that $\Pi^C_{\text{sup}} > \Pi^S_{\text{sup}}$. We show this in two parts depending on whether the constraint $w \leq c_2$ is binding or not. First, note that $\Pi^C_{\text{sup}} = F^C = \frac{1}{2}\left(\Pi(c_1) - \Pi(c_2)\right)$. If $c_2 \in (c_1, \delta\left(c_1\right))$, the supplier obtains $\Pi^S_{\text{sup}} = \frac{1}{2}\left(c_2 - c_1\right)q(c_2)$ under delegation. Note that

$$\begin{aligned}\Pi^C_{\text{sup}} &> \Pi^S_{\text{sup}} \Longleftrightarrow \Pi(c_1) > \Pi(c_2) + \left(c_2 - c_1\right)q(c_2) \\ &\Longleftrightarrow \Pi(c_1) > R(q(c_2)) - c_1 q(c_2) - C(q(c_2))\end{aligned}$$

which is true since $q(c_2)$ is not the optimal production for $w = c_1$. If $c_2 > \delta\left(c_1\right)$, the supplier obtains $\Pi^S_{\text{sup}} = \left(w^S - c_1\right)q\left(w^S\right) + F^S$ under delegation, where $F^S = \frac{1}{2}\left[\Pi_f(w^S) - \Pi_f(c_2)\right] - \frac{1}{2}(w^S - c_1)q(w^S)$ and $w^S \in (c_1, c_2)$. Thus, we want to prove that

$$\Pi^S_{\text{sup}} = \frac{1}{2}\left(\Pi_f(w^S) + (w^S - c_1)q(w^S) - \Pi_f(c_2)\right) < \Pi^C_{\text{sup}} = F^C = \frac{1}{2}\left(\Pi(c_1) - \Pi(c_2)\right).$$

First, $\Pi^S_{\text{sup}} < \Pi^C_{\text{sup}}$ if

$$\Pi_f(w^S) + (w^S - c_1)q(w^S) - \Pi_f(c_2) < \Pi(c_1) - \Pi(c_2).$$

Second, under w^S the whole firm achieves profits $\Pi(w^S)$,which is larger than the profits of the factory $\Pi_f(w^S)$ since $\Pi(w^S) - \Pi_f(w^S) = R(q(w^S)) - R'(q(w^S))q(w^S) > 0$ if $R" < 0$. Besides, if $w^S < c_2$, we know that $\Pi_f(w^S) - \Pi_f(c_2) < \Pi(w^S) - \Pi(c_2)$. Therefore, adding $(w^S - c_1)q(w^S)$ to both sides of the former inequality

$$\Pi_f(w^S) + (w^S - c_1)q(w^S) - \Pi_f(c_2) < \Pi(w^S) + (w^S - c_1)q(w^S) - \Pi(c_2).$$

Finally, note that $\Pi(w^S)+(w^S-c_1)q(w^S)<\Pi(c_1)$ since $q\left(w^S\right)$ is not the optimal production for $w=c_1$. Therefore, $\Pi_f(w^S)+(w^S-c_1)q(w^S)-\Pi_f(c_2)<\Pi(c_1)-\Pi(c_2)$ implying that $\Pi_{\text{sup}}^S<\Pi_{\text{sup}}^C$. QED ■

Proof of Proposition 7. Under centralized procurement, there are no distortions on wholesale prices, and the firm achieves profits $\Pi^C=\Pi(c_1)-T^C=\Pi(c_1)-\frac{1}{2}[\Pi(c_1)-\Pi(c_2)]$, whereas under delegated procurement profits are $\Pi^S=\Pi(c_2)+\frac{1}{2}(c_2-c_1)q(c_2)$. Then

$$\begin{aligned}\Pi^C &> \Pi^D \Longleftrightarrow \Pi(c_1)-\frac{1}{2}[\Pi(c_1)-\Pi(c_2)]>\Pi(c_2)+\frac{1}{2}(c_2-c_1)q(c_2)\Longleftrightarrow\\ \Pi(c_1) &> \Pi(c_2)+(c_2-c_1)q(c_2)=R(q(c_2))-C(q(c_2))-c_1q(c_2),\end{aligned}$$

which is always true since $q(c_2)$ is not the optimal quantity at marginal costs of the input c_1. QED ■

Proof of Proposition 8. We need to compare Π^C with Π^S. On the one hand, $\Pi^C=\frac{1}{2}\left(\Pi\left(c_1\right)-\Pi\left(c_2\right)\right)$, and when the demand is linear and costs are quadratic, we have previously derived optimal quantity, $q\left(w\right)=\frac{\theta(1-w)}{m}$, and operating profits, $\Pi\left(w\right)=\frac{\theta(1-w)^2}{2m}$. Thus,

$$\Pi^C=\frac{1}{2}\left(\Pi\left(c_1\right)-\Pi\left(c_2\right)\right)=\frac{\theta}{4m}\left(\left(1-c_1\right)^2+\left(1-c_2\right)^2\right).$$

On the other hand, Π^S is defined in (22). Now, let us make the following change of variable that simplifies calculus: $d_1=\left(1-c_1\right)^2>0$ and $d_2=\left(1-c_2\right)^2>0$.

(a) If $c_2\in\left(c_1,\delta\left(c_1\right)\right)$ then $\Pi^C>\Pi^S\Longleftrightarrow$

$$\begin{aligned}\frac{\theta\left(d_1+d_2\right)}{4m} &> \frac{\sqrt{d_1}\sqrt{d_2}\theta}{4m}\Longleftrightarrow d_1+d_2-\sqrt{d_1}\sqrt{d_2}>0\\ &\Longleftrightarrow \left(\sqrt{d_1}-\sqrt{d_2}\right)^2+\sqrt{d_1}\sqrt{d_2}>0\\ &\Longleftrightarrow \left(c_2-c_1\right)^2+\sqrt{\left(1-c_1\right)}\sqrt{\left(1-c_2\right)}>0,\end{aligned}$$

therefore, $\Pi^C\geq\Pi^D\Longleftrightarrow c_2\in\left(c_1,\delta\left(c_1\right)\right)$.

(b) If $c_2\in\left(\delta\left(c_1\right),1\right)$, then $\Pi^S>\Pi^C\Longleftrightarrow$

$$\frac{\theta\left(4-3\theta\right)d_1}{4m\left(2-\theta\right)^2}+\frac{\theta^2 d_2}{4m}>\frac{\theta\left(d_1+d_2\right)}{4m}\Longleftrightarrow d_1\leq\frac{\left(2-\theta\right)^2}{\theta}d_2.$$

Reordering this inequality for c_1 and c_2 we obtain that $\Pi^C\geq\Pi^D\Longleftrightarrow c_2\in\left(\frac{(1-\theta)+c_1}{2-\theta},1-\left(1-c_1\right)\frac{\sqrt{\theta}}{2-\theta}\right)$ which can be rewritten as $\Pi^C\geq\Pi^D\Longleftrightarrow c_2\in\left(\frac{(1-\theta)+c_1}{2-\theta},\frac{2-\left(\theta+\sqrt{\theta}\right)+c_1\sqrt{\theta}}{2-\theta}\right)$. Finally, (a) and (b) together imply that $\Pi^C\geq\Pi^D\Longleftrightarrow c_2\in\left(c_1,\beta\left(\theta\right)\right)$ where $\beta\left(\theta\right)=\frac{2-\left(\theta+\sqrt{\theta}\right)+c_1\sqrt{\theta}}{2-\theta}$. QED ■

Proof of Proposition 9. Direct observation from Lemma 3 and Propositions 7 and 8. First, Lemma 3 allows us to rank supplier's profits, $\Pi_{\text{sup}}^S\in\left(\Pi_{\text{sup}}^D,\Pi_{\text{sup}}^C\right)$, that is, the efficient supplier prefers procurement to be centralized rather than delegated, and in the case it is delegated, it obtains higher profits by distorting input prices. Second, the *HQ* anticipating supplier's behavior may decide to centralize procurement or to delegate it to the factory manager; when the alternative is efficient the *HQ* always centralizes procurement (Proposition 7) and when the alternative is very inefficient the firm may prefer to delegate procurement and allow for distorted input prices (as in the example summarized in Proposition 8). In either case, supplier's improves profits if we compare it to the delegation without distortions of the input price. The second part exists whenever the HQ decides to centralize procurement, which happens when the alternative is efficient. QED ■