MANAGERIAL DELEGATION UNDER CAPACITY COMMITMENT:
A TALE OF TWO SOURCES

Stefano Colombo*, Marcella Scrimitore*

Abstract

The paper discusses the role of delegation to managers in a duopoly in which the optimal decisions upon in-house production and outsourcing may lead make and buy to coexist, namely bi-sourcing to arise at equilibrium. In the benchmark framework of quantity competition, delegation is shown to lead outsourcing to be strategically used under bi-sourcing even when external manufacturing is more costly than in-house production. The role of firms’ strategic incentives to exploit downstream market leadership through outsourcing is shown to be crucial in delivering such a result, as well as to drive the equilibrium firm choices when both delegation is considered endogenous and products are differentiated. The paper, finally, offers some insights into the price competition case.

JEL codes: D43, L11, L21

Keywords: duopoly, outsourcing, capacity commitment, strategic delegation.

Acknowledgements: We wish to thank for their comments and suggestions the participants to the seminars at the University of Pisa, Chukyo University (Japan), University of Crete, Chonnam National University (Gwangju, South Korea) and participants at RCEF 2016 Conference (Waterloo, Canada).

1. Introduction

The crucial role outsourcing strategies plays in sustaining business success has been widely investigated in the economic literature. Within the latter, literature addressing the standard make-or-buy question identifies a substitutability relationship between firm internal and external sourcing of key inputs (Coase, 1937, Williamson, 1975). Most recently, some works have provided arguments

* Università Cattolica del Sacro Cuore, Milano, Largo A. Gemelli 1, I-20123. stefano.colombo@unicatt.it
* Università del Salento, Lecce, Ecotekne, via per Monteroni, I-73100. marcella.scrimitore@unisalento.it
suggesting the existence of a complementarity relationship between the two sources, which have lead the *make-and-buy* concept to arise. By procuring the same input both through purchases from outside suppliers and in-house production, firms are said to engage in bi-sourcing. The latter is getting quite popular in the world of business nowadays. For instance, Nokia combines in-house production of components with the purchase of inputs from a wide network of electronic components (Shy and Stenbacka, 2003), whereas Mattel “made most of its own die-casting molds at a facility in Malaysia, but also outsourced them to firms in Hong Kong” (Johnson, 2007). As argued by Carey and Frangos (2005), US airlines usually adopt bi-sourcing, in the sense that half of overhaul work is done by internal resources, but the remaining part is done by external resources. Similarly, Sony both manufacturers display panels (in-house production) and procures display panels from external suppliers (e.g. AU Optronics) (outsourcing), thus engaging in bi-sourcing (Lin et al., 2016). Other examples of bi-sourcing firms are Du Punt and GMS (Beladi and Mukherjee, 2012).

While the analysis of make-or-buy decisions within economic literature has focused on both cost and strategic advantages of outsourcing when it fully crowds-out the internal input production (see, e.g., Kopel et al., 2016, Chen et al., 2011, Buehler and Haucap, 2006, Shy and Stenbacka, 2003; Arya et al., 2008a and 2008b), a more recent and still scant literature on bi-sourcing has discussed the reasons leading outsourcing to coexist with in-house production.\(^1\) In Du et al. (2006 and 2009) and Stenbacka and Tombak (2012) bi-sourcing is shown to achieve the optimal balance between cost savings of outsourcing and firm bargaining power in bilateral negotiations with external suppliers. The

---

\(^1\) The question on whether single or multiple external sourcing is the optimal procurement strategy also attracts considerable interest among researchers (see, e.g., Burke et al., 2007, Inderst, 2008, Puranam et al., 2013).
preference for combining make and buy over exclusive internal or exclusive external input production has been also demonstrated by Spencer and Raubitschek (1996) in an international scenario in which the optimality of buying inputs from abroad rivals and making inputs internally is determined by price reductions of importing inputs caused by higher competition in the input market. Further literature focuses on bi-sourcing as a strategy adopted to mitigate the problem of capacity utilization (He and Nickerson, 2006), to reduce demand uncertainty (Emons, 1996) and to exploit the complementarity between in-house R&D and external know-how (Veugelers and Cassiman, 1998).\(^2\)

A new rationale for bi-sourcing has been recently provided by Beladi and Mukherjee (2012) in a Cournot duopoly in which profit-maximizing firms commit to in-house production at a pre-play stage and compete downstream, choosing the optimal input levels to outsource. In a framework in which external manufacturing is assumed to be more efficient than the internal one, the role of market power at the upstream stage of competition between suppliers is shown to be crucial in causing bi-sourcing. Indeed, the incentive to reduce the outside over-cost input prices creates a strategic effect pushing towards in-house production; the latter, in turn, trades-off with the cost-efficiency effect of outsourcing, thus determining the optimality of bi-sourcing which occurs under inefficient insourcing.\(^3\)

In the present paper we introduce managerial delegation in the framework of Beladi and Mukherjee (2012), without assuming any a priori cost advantage of external or internal production. According to literature of strategic delegation,

---

\(^2\) See Krzeminska (2009) for a survey on the determinants and management of make-and-buy and Parmigiani (2007) who surveys both economics and management theories, explaining why firms adopt concurrent sourcing, also offering some empirical evidence.

\(^3\) Beladi and Mukherjee (2012) examine the incentives towards bi-sourcing by first assuming a monopoly both downstream and upstream, and then introducing competition at least at one stage, finding that both higher upstream and downstream competition affect bi-sourcing, reducing its extent in equilibrium.
and in the vein of Fershtman (1985) and Fershtman and Judd (1987), we assume that profit-maximizing owners delegate discretion over outsourcing decisions to revenue-interested managers. In such a context, we aim at investigating the implications of delegation on firms’ incentives towards bi-sourcing. In particular, we explore the circumstances under which firms’ owners, by strategically allowing their managers to twist away from profit-maximization, affect firm aggressiveness on the product market and how this affects the optimal balance between both the strategic and cost advantages from committing to internal capacity and the advantages brought by outsourcing.

The above analysis is carried out by solving a Cournot duopoly game in which, at the first stage, each profit-maximizing owner decides upon the optimal capacity and chooses, after observing the input prices set at the second stage by the external suppliers, the optimal degree of discretion to assign to revenue-interested managers at third stage. According to such a delegation scheme, managers compete at the last stage of the game by deciding upon the output produced in outsourcing, thus determining the optimal extent of bi-sourcing. The model is further developed in order to capture the competitive forces driving the endogenous choice of delegation: it is made by firms at a pre-play stage of an extended game in which symmetric delegation and symmetric no-delegation represent two possible outcomes, respectively recovering the

---

4 See also Vickers (1985) and Sklivas (1987) for other seminal works in this literature. For further extensions of the basic models in oligopoly theory see González-Maestre, M., 2000, Saracho, 2002, Scrimitore, 2013 and Ziss, 2001. Contributions of this literature to business and management literature include Bhardwaj, 2001, Bhardwaj and Balasubramanian, 2005 and Kremic et al. 2006, while the most recent survey by Sengul et al. (2012) which integrates strategic delegation theory into strategy and management research. Finally, see the work by Kräkel (2004) combining strategic delegation with agency theory.

5 We assume that all variables are simultaneously chosen by the decision-makers at each stage of the game.
above described managerial model and the Beladi and Mukherjee’s model. The likelihood of bi-sourcing and the outcome of the extended game of delegation are also investigated under product differentiation. The paper, finally, provides some insights on the results obtained from running the model under price competition.

Our results mainly point out the circumstances under which: a) in-house production coexists with more efficient outsourcing, since it strategically allows to affect upstream competition by reducing external input prices, as in Beladi and Mukherjee (2012); b) outsourcing coexists with more efficient in-house production, due to the incentive to strategically exploit downstream competition, which identifies a new incentive to engage in bi-sourcing. More particularly, in the benchmark framework of quantity competition, we find that delegation pushes towards greater outsourcing relative to in-house production than under no-delegation, which makes bi-sourcing to arise even when the external production is less efficient than in-house production. The extension of the Cournot framework to product differentiation reveals its role in making bi-sourcing more likely under both delegation and no-delegation. Moreover, the paper demonstrates that, as long as products are homogeneous or slightly differentiated, delegation arises in equilibrium as a symmetric endogenous choice, regardless of the relative efficiency of internal vs. external manufacturing. This is due to the advantage achieved through delegation, which allows firms to expand outsourcing and the output on the downstream market, thus resembling a standard result in the literature of strategic delegation (Sklivas, 1987; Basu, 1995; Scimitore, 2013). Such a result can be reverted in the circumstances under which delegation is associated with more

---

6 The distinction between delegating and non-delegating firms mirrors the difference between profit-maximizing and revenue-maximizing behavior, i.e., owner-managed and managerial firms.
significant capacity commitment and the latter implies a relatively inefficient production technology. This occurs as long as products are homogeneous or slightly differentiated and the relative efficiency of external and internal manufacturing is small enough, case in which an equilibrium with both firms choosing not to delegate coexists with the equilibrium with symmetric delegation. Moreover, symmetric no-delegation is shown to arise as a unique equilibrium when sufficiently high product differentiation favors inefficient insourcing, further reducing the advantage of acting as a delegating firm. Finally, the paper offers some insights on the conditions determining bi-sourcing under price competition and differentiated products, pointing out how in this case, in contrast to the quantity competition case, bi-sourcing under inefficient outsourcing occurs even in the absence of delegation.

The paper is structured in four sections: Section 2 describes the model in a Cournot setting with homogeneous products under both symmetric and unilateral delegation, also solving the endogenous delegation game. Section 3 extends the model to product differentiation and offers some insights on the results obtained in a Bertrand setting. Finally, Section 4 concludes.

2. The model

Consider two final producers, named Firm 1 and Firm 2, competing in a downstream market. The producers need a unique input to produce the final good. For sake of simplicity we assume that one unit of input is sufficient to produce one unit of output. In turn, one unit of labor is sufficient to produce one unit of input. Inputs are transformed into final goods at a constant cost, which is normalized to zero. Furthermore, the cost of labor is assumed to be constant and equal to $c \geq 0$. 
The final producers can buy the input for the final good from two external firm-specific suppliers, named Supplier 1 and Supplier 2. Therefore, we assume that there is no substitutability of suppliers: Supplier 1 (2) serves only Firm 1 (2). This may be due for technological reasons. The cost of the input for the external suppliers is equal to $d \geq 0$. Therefore, the marginal cost of production of the input is equal to $c$ if the final producer adopts in-house production, whereas it is equal to $d$ if it buys the input from the external supplier. Supplier $J = 1, 2$ charges a price equal to $w_J$ per any input it sells to the final producers.

We assume an inverse demand function for Firm $J = 1, 2$ of this kind:
\[ p_J = 1 - Q_J - Q_{-J}, \]
where $Q_J$ is the total quantity of Firm $J = 1, 2$. Therefore, we assume that firms produce homogenous goods. Furthermore, we assume that firms may delegate market (thus outsourcing) decisions to their own managers, by choosing the appropriate incentive contract to assign them. In particular, following Fertshman (1985), we assume that the manager objective function is given by
\[ O_J = \alpha_J (\pi_J + \lambda_J R_J), \quad (J = 1, 2), \]
where $\alpha_J$ is a scaling parameter, $\pi_J$ and $R_J = p_J Q_J$ are respectively Firm $J$’s profits and revenues, and $\lambda_J$ is the managerial incentive parameter, with $\lambda_J \geq 0$. While $\lambda_J = 0$ implies pure profit-maximization, $\lambda_J \neq 0$ captures the distortion from pure profit maximization, which suggests that managers can be allowed to overestimate revenues ($\lambda_J > 0$) or can be ‘taxed’ for input expenditures ($\lambda_J < 0$), being respectively induced to behave more or less aggressively on the product market. Indeed, by choosing the optimal incentive contract for her own manager, i.e. the optimal $\lambda_J$, the profit-maximizing owner of a delegating (managerial) firm decides upon the extent of discretion on market decisions to give her manager, while she directly

---

7 Note that this rules out the possibility to adopt outsourcing decisions with the purpose to increase the upstream price for the rival, as in Arya et al. (2008) and Lin et al. (2016).
8 The case of differentiated goods is discussed in Section 3.
9 See Fershtman and Judd (1987, p. 938) in this regard.
makes market decisions within a non-delegating (profit-maximizing) firm.\textsuperscript{10}

The game proceeds as follows. Following Beladi and Mukherjee (2012), we assume that in the first stage each owner chooses a capacity level $k_j$, $J = 1, 2$, for in-house production and hires the workers it needs to meet the in-house production level. In the second stage, each supplier determines the input price $w_j$, $J = 1, 2$. In the third stage, each owner decides the delegation parameter, $\lambda_j$. In the last stage each manager decides how much to produce accordingly to his objective function.\textsuperscript{11}

As in Beladi and Mukherjee (2012), after that Firm $J = 1, 2$ has build up a capacity level $k_j$ for in-house production, it will produce up to this point, as it has already sustained the costs for input production by hiring workers. However, if Firm $J$ wants to produce more than $k_j$, it needs to buy extra inputs from the external suppliers. Let us indicate by $q_j$ the quantity that Firm $J$ wants to produce in addition to the in-house production, $k_j$. With this in mind, we can write the profits function of Firm $J$ as follows: $\pi_j = (p_j - c)k_j + (p_j - w_j)q_j$. The total quantity of Firm $J$ is then given by $Q_j = k_j + q_j$. Finally, the profits function of the supplier of Firm $J$ are given by $\omega_j = (w_j - d)q_j$.

\textsuperscript{10} Strategic delegation allows firms to exploit the differences in the objectives pursued by firms’ owners and managers to gain market leadership. Delegation, indeed, turns out to be a strategic device used by owners to commit to a more profitable course of actions which leads, in a framework under quantity competition, to a more aggressive behavior on the product market.

\textsuperscript{11} In a setting without capacity commitment, Park (2002) investigates the effects of the vertical externality caused by the presence of an upstream monopoly on the incentive schemes offered by owners to downstream competing managers. Given this aim, owners are assumed to decide upon the delegation scheme prior to the monopolist’s optimal choice, thus showing how they design managerial incentives according to the attempt to affect downstream competition, thus the demand of inputs, and that to extract the rent accruing to the upstream monopolist. By contrast, the sequence of moves assumed in our setting is consistent with the aim of explaining on how managerial delegation, by altering downstream competition, affects the incentive to commit to in-house production vs. outsourcing.
2.1. Symmetric delegation

In this section we consider the case where both firms adopt a delegation strategy and solve the game by backward induction to derive the subgame perfect Nash equilibrium.

In the fourth stage of the game, each manager, by maximizing her own objective function $q_J$, decides how much to produce, given the degree of discretion assigned by her owner, the in-house capacity level and the price of the input set by the external supplier. Therefore, the quantity level is obtained by solving the following system: $\frac{\partial O_1}{\partial q_1} = 0$, $\frac{\partial O_2}{\partial q_2} = 0$, which yields the following optimal quantity for Firm $J = 1, 2$:

$$q_J = \frac{(1 + \lambda_J)[w_J + (1 - 3k_J)(1 + \lambda_J)] - 2w_J(1 + \lambda_J)}{3(1 + \lambda_J)(1 + \lambda_J)}$$ (1)

Note that the higher is the capacity level $k$ for in-house production, the lower is outsourced production. Indeed, the higher is $k$, the greater is the price reduction induced by a certain increase of $q$. Therefore, when $k$ is high, the incentive to out-source production is low.

Consider now the third stage of the game, where each firm designs the incentive structure for its manager by choosing the delegation variable $\lambda$. After plugging (1) into $\pi_J$, $J = 1, 2$, we need to solve the system $\frac{\partial \pi_1}{\partial \lambda} = 0$, $\frac{\partial \pi_2}{\partial \lambda} = 0$, which yields the optimal delegation level for Firm $J = 1, 2$, that is:

$$\lambda_J = \frac{1 + 3w_{-j} - 3w_J}{8w_J - 1 - 2w_{-j}}$$ (2)
Note that $\frac{\partial \lambda_j}{\partial w_j} < 0$. Therefore, when the price of its own external input increases, the firm’s owner reduces the manager aggressiveness in the downstream market (i.e. $\lambda_j$ is lower) in order to reduce the purchase of external inputs.

We can now move to the second stage of the game, where the external suppliers choose simultaneously and non-cooperatively the price of the input by anticipating the delegation parameter as derived in (2) and the quantity produced in the downstream market as derived in (1). Therefore, after inserting (1) and (2) into the profits function of the suppliers, we solve the system

$$\begin{cases} \frac{\partial \omega_j}{\partial w_1} = 0 \\ \frac{\partial \omega_j}{\partial w_2} = 0 \end{cases}$$

which yields the following optimal input price for the external Supplier $J = 1, 2$, that is:

$$w_j = \frac{8 + 24d - 5(3k_j + k_{-j})}{32} \tag{3}$$

Finally, we move to the first stage of the game, where the owners choose simultaneously the capacity level $k_j$ for in-house production. After plugging (1), (2) and (3) into $\pi_j$, $J = 1, 2$, we solve the system

$$\begin{cases} \frac{\partial \pi_j}{\partial k_1} = 0 \\ \frac{\partial \pi_j}{\partial k_2} = 0 \end{cases}$$

which yields the equilibrium level of in-house production:

$$k_j^{DD} = \frac{2(61 - 160c + 99d)}{315} \tag{4}$$

where the superscript $DD$ refers to the situation where both firms delegate. Therefore, by using (1) into (2), (3) and (4), we can write the equilibrium
variables as function of the exogenous parameters $c$ and $d$. We have:

$$q_{j}^{DD} = \frac{1 + 80c - 81d}{105}, \quad w_{j}^{DD} = \frac{1 + 80c + 45d}{126} \quad \text{and} \quad \lambda_{j}^{DD} = \frac{25 - 16c - 9d}{54d + 96c - 24}, \quad J = 1, 2.$$

We are now in the position to write the necessary conditions for bi-sourcing to occur, that is, $k_{j}^{DD} > 0$ and $q_{j}^{DD} > 0$, $J = 1, 2$. We have:

**Proposition 1.** Suppose that both firms delegate market decisions to managers. Bi-sourcing emerges in equilibrium if and only if

$$\max[0, \frac{4 - 16c}{9}, \frac{-61 + 160c}{99}] < d < \frac{1 + 80c}{81}.$$

**Proof.** Note that $q_{j}^{DD} > 0$ requires that $d < \frac{1 + 80c}{81}$. On the other hand, $k_{j}^{DD} > 0$ requires that $d > \frac{-61 + 160c}{99}$. Moreover, the necessary condition for delegation to occur, i.e. $\lambda_{j}^{DD} > 0$, is that $\frac{4 - 16c}{9} < d < \frac{25 - 16c}{9}$. Note that $\frac{25 - 16c}{9} > \frac{-61 + 160c}{99}$. Finally, note that $w_{j}^{DD} > d$ is satisfied.

**Figure 1:** the parameter space for bi-sourcing in a symmetric delegation game
Figure 1 illustrates the parameter space, indicated by the grey area, where bi-sourcing emerges in a situation where both firms delegate. The black areas indicate the parameter space under where $\lambda_j^D < 0$. It can be observed that if $d$ is high ($d > \frac{1+80c}{81}$), the input supplier is too inefficient. Therefore, in this case complete in-house production emerges in equilibrium. On the other hand, when $d$ is sufficiently low ($d < \frac{-61 + 160c}{99}$), the manufacturer is highly inefficient with respect to the external supplier. Therefore, in this case complete outsourcing emerges in equilibrium. Finally, for a moderate input supplier’s marginal cost, both internal and external furnishing of inputs emerges in equilibrium: that is, we observe bi-sourcing.

From Proposition 1 we can derive the following corollary:

**Corollary of Proposition 1.** When both firms delegate, bi-sourcing may emerge even if the input supplier is less efficient than the manufacturer, i.e. $d > c$.

For example, observe that $c = 0.251$ and $d = 0.26$ satisfy the condition for bi-sourcing to occur as stated in Proposition 1, thus implying that bi-sourcing may emerge even if the input supplier is less efficient than the manufacturer. Therefore, Proposition 1 shows the existence of an interesting implication of delegation on the make-and-buy decision. Namely, we show that the condition that the external input supplier is more efficient than the manufacturer is not necessary for bi-sourcing to occur, as argued in the literature (see for example
Indeed, the manufacturer may procure the input from an external supplier even if this is less efficient than the manufacturer. In order to explain the above results, we need to compare the case of symmetric delegation with the case of symmetric no-delegation. In the latter case, no owner delegates to managers. Basically, this amounts to re-run our model by assuming \( \lambda_j = 0, \quad J = 1, 2 \). Note that this model coincides with Beladi and Mukherjee (2012). Therefore, we can directly apply their results which are included in the following lemma.

**Lemma 1** (from Beladi and Mukherjee, 2012).

Suppose that no firm delegates. The equilibrium variables, respectively the optimal levels of in-house production, input prices and outsourced production, are the following:

\[
\begin{align*}
k_j^{NN*} &= \frac{73 - 135c + 62d}{201}, & q_j^{NN*} &= \frac{810c - 36 - 774d}{1809}, & w_j^{NN*} &= \frac{45c + 24d - 2}{67},
\end{align*}
\]

Given the above equilibrium variables, bi-sourcing emerges in equilibrium if and only if \( \max[0, \frac{135c - 73}{62}] < d < \frac{45c - 2}{43} \).

Proof. See Proposition 3 in Beladi and Mukherjee (2012).

By comparing the equilibrium input price and the in-house and outsourced production equilibrium levels under symmetric delegation (DD) and under symmetric no-delegation (NN), we obtain:

---

12 In particular, Beladi and Mukherjee (2012, p.213) state that “if \( c \leq d \), there is no reason for outsourcing to firm I, since the price charged by firm I is higher than Firm I’s in-house input production”.

13 It can be shown that, in contrast with the common wisdom, social welfare is higher when firms outsource part of the overall production to a less efficient supplier rather than producing overall inputs in-house. In such circumstances, indeed, the output expansion induced by higher managers’ aggressiveness compared to profit-maximizer owners impacts positively welfare more than hurts it through the negative effect of outsourcing inefficiency.
Indeed, due to the presence of more aggressive managers at the downstream stage, firms are induced to expand output through greater outsourcing than under no-delegation. In a framework without capacity commitment, thus in the absence of bi-sourcing, such a higher demand of external inputs would let the external suppliers set lower prices than under no-delegation, in the attempt to keep managers’ aggressiveness high and foster their demand of inputs. This is in contrast with what is observed under capacity pre-commitment. In this case, indeed, delegation to managers, by positively impacting the leadership effect on the downstream market, alters the incentive to use in-house production vs. outsourcing: in particular, it favors the latter and weakens the incentive to commit to in-house production to reduce the upstream prices, which turn out to be lower compared to the no-delegation case.

The stronger incentive towards outsourcing induced by delegation also causes: a) its strategic effect to trades-off with higher cost efficiency of in-house production even in the interval $d > c$, thus explaining the result highlighted in Corollary 1 that outsourcing occurs under bi-sourcing when the supplier is less efficient than internal manufacturing; b) bi-sourcing to be less likely than in the no-delegation case. Indeed, let us denote by $I_{DD} = \frac{1 + 80c}{81} - \frac{-61 + 160c}{99}$ and $I_{NN} = \frac{45c - 2}{43} - \frac{135c - 73}{62}$ the interval of bi-sourcing in which both firms delegate and both firms do not delegate, respectively. It can be immediately noted that

---

14 See Fershtman and Judd (1987) for a discussion in this point.

15 Indeed, when there is no possibility of pre-commitment to the capacity level, namely when $k_j = 0$ ($j = 1, 2$), we obtain in equilibrium $q_{jDD}^* \leq q_{jNN}^*$, where the symbol "*" is used here and later to identify the case of no-commitment to in-house production.
\[ I^{NN} \geq I^{DD} \]. Also, note that \( \frac{-61 + 160c}{99} \geq \frac{135c - 73}{62} \) and \( \frac{1 + 80c}{81} \geq \frac{45c - 2}{43} \), that is, the interval of bi-sourcing shifts upward when moving from a symmetric no-delegation to a symmetric delegation, with the parameter space with complete outsourcing enlarging and that with complete in-house production shrinking. This is due to the greater outsourcing occurring at any efficiency level under symmetric delegation which negatively impacts the incentive to use strategically capacity when \( d \) is sufficiently low and positively affects the incentive to outsource strategically inputs when \( d \) is sufficiently high. Since the former effect dominates the latter, bi-sourcing turn out to be less likely than under no-delegation.\(^{16}\)

Let us consider now the equilibrium profits under symmetric delegation. By using the equilibrium values of the relevant variables, we get:

\[
\pi_j^{DD} = \frac{3247 + 16000c^2 + 3438d + 9315d^2 - 4c(2483 + 5517d)}{39690}
\]  

(5)

Note that, within the parameter space where bi-sourcing occurs, the profits are U-shaped both in \( c \) and in \( d \). Therefore, even one might expect that profits decrease with marginal costs (and indeed this happens under complete

\(^{16}\) While delegation is shown to affect the incentives toward outsourced vs. in-house production, pushing toward the former regardless of their relative efficiency, the latter is shown to play a role when the above scenario with a duopolistic upstream market is compared to that with a monopoly external supplier (see the online Appendix for details). Indeed, it can be shown that higher upstream market concentration, by inducing a higher wholesale price, enhances the need to reduce it through higher capacity commitment also when \( d \) is sufficiently low and cost reasons motivate outsourcing. By also relaxing market competition, it also enhances the incentive to strategically procure inputs from outside when more costly outsourced production (i.e., sufficiently high \( d \)) amplifies the advantage from competing downstream relative to that from in-house production. The above incentives, by extending bi-sourcing to both lower and higher values of \( d \) than under duopoly (also to values in the interval \( d > c \)), make it more likely, thus resembling the result obtained in the same context without delegation by Beladi and Mukherjee (2012, p.216).
outsourcing and under complete in-house production), this is not the case under bi-sourcing. Indeed, as long $c$ or $d$ is low enough, firm profits are decreasing due to the standard negative cost-effect on profits which dominates a positive effect on profits due to the incentive to substitute the less efficient manufacturing with the more efficient one under bi-sourcing. Conversely, the latter dominates the former when the relative inefficiency of internal or external manufacturing becomes more relevant (i.e., for high levels of $c$ or $d$), thus determining the U-shape relationship between the marginal cost and the equilibrium profits.

By contrast, when delegation is not possible, the equilibrium profits are:

$$\pi_{jN}^* = \frac{1441 + 3645c^2 + 524d + 1680d^2 - 2c(1703 + 1942d)}{13467}$$  \hspace{1cm} (6)

It can be easily checked that $\pi_{jN}^* \geq \pi_{jD}^*$. It is well-known (see for example Fershtman and Judd, 1987, p. 933) that delegation tends to reduce the profits in equilibrium with respect to the no-delegation case. Indeed, delegation to managers increases fierceness of competition in the downstream market, as managers are biased toward revenues. This reduces the equilibrium price and lowers firms’ profits. It can be easily checked that consumer surplus and external suppliers’ profits are higher under symmetric delegation than under symmetric no-delegation, the former being positively affected by higher overall output induced by delegation and the latter positively affected by higher input prices and higher input demand.\(^\dagger\) These positive effects outweigh the reduction of delegating firms’ profits induced by managers’ aggressiveness, causing higher total welfare under delegation.

\(^\dagger\) Calculations are available upon request.
Results in Lemma 1 and the above discussion can be summarized in the following proposition:

**Proposition 2.** Regardless of the relative efficiency of internal vs. external manufacturing, under symmetric delegation outsourcing is larger and in-house production is smaller than under no-delegation. With respect to this case, the input prices charged from external suppliers, as well as their profits, increase; moreover, consumers’ and social surplus increases. Finally, delegation makes bi-sourcing less likely than under no-delegation.

### 2.2. Unilateral delegation

In this section, we consider the case of unilateral delegation, which will be crucial to investigate the endogenous firm choice of delegation as a solution of the game in Section 3. In particular, we assume that Firm 1 delegates market and thus outsourcing decisions to managers, whereas Firm 2 does not. The last stage optimal quantities are then obtained by inserting $\lambda_2 = 0$ in (1), which yields the last stage optimal quantities:

\[
q_i = \frac{(1 + \lambda_i)(1 + w_2 - 3k_i) - 2w_i}{3(1 + \lambda_i)} \quad (7)
\]

\[
q_2 = \frac{(1 + \lambda_i)(1 - 2w_2 - 3k_2) + w_i}{3(1 + \lambda_i)} \quad (8)
\]

In the third stage, only Firm 1 chooses the delegation parameter, by anticipating the optimal quantities (7) and (8). By solving $\partial \pi_i / \partial \lambda_i = 0$, we get:
\[ \lambda_i = \frac{1 + w_2 - 2w_i}{6w_i - w_2 - 1} \] (9)

Consider now the second stage of the game. The two suppliers choose simultaneously the input prices. By solving \[ \begin{cases} \frac{\partial \omega_1}{\partial w_1} = 0 \\ \frac{\partial \omega_2}{\partial w_2} = 0 \end{cases}, \] we get:

\[ w_i = \frac{7 + 15d - 12k_1 - 4k_2}{22} \] (10)
\[ w_2 = \frac{3 + d - 2k_1 - 8k_2}{11} \] (11)

Finally, in the first stage, the two firms decide the capacity level. By solving \[ \begin{cases} \frac{\partial \pi_i}{\partial k_i} = 0 \\ \frac{\partial \pi_2}{\partial k_2} = 0 \end{cases}, \] we get:

\[ k_1^{DN} = \frac{240 - 517c + 277d}{559} \] (12)
\[ k_2^{DN} = \frac{703 - 1540c + 837d}{2236} \] (13)

where the superscript DN indicates that Firm 1 delegates, while Firm 2 does not delegate. Therefore, in equilibrium the outsourced quantities are

\[ q_1^{DN} = \frac{15 + 352c - 367d}{559} \text{ and } q_2^{DN} = \frac{3(-19 + 374c - 355d)}{2236} \] for the delegating firm and the non-delegating firm, respectively. On the other hand, the equilibrium input prices are \[ w_1^{DN} = \frac{15 + 352c + 192d}{559} \text{ and } w_2^{DN} = \frac{-19 + 374c + 204d}{559}, \] whereas the equilibrium delegation parameter of Firm 1 is

\[ \lambda_1^{DN} = \frac{15(17 - 11c - 6d)}{-223 + 869c + 474}. \]
We can now derive the necessary conditions for bi-sourcing to occur in the unilateral delegation model, that is, $k_1^{DN} > 0$, $k_2^{DN} > 0$, $q_1^{DN} > 0$ and $q_2^{DN} > 0$. We can state the following proposition:

**Proposition 3.** Suppose that only one firm delegates. Bi-sourcing emerges in equilibrium if and only if $\max[0, \frac{225-869c}{474}, -\frac{703+1540c}{837}] < d < -\frac{19+374c}{355}$.

Proof. Note that $q_2^{DN} > 0$ requires that $d < -\frac{19+374c}{355}$. Moreover, $q_2^{DN} > 0$ implies $q_1^{DN} > 0$. On the other hand, $k_2^{DN} > 0$ requires that $d > -\frac{703+1540c}{837}$. Moreover, $k_2^{DN} > 0$ implies $k_1^{DN} > 0$. The necessary condition for delegation to occur, i.e. $\lambda_1^{DN} > 0$, is that $\frac{225-869c}{474} < d < -\frac{17-11c}{6}$. Note that $\frac{17-11c}{6} > -\frac{19+374c}{355}$. Finally, note that $w_1^{DN} > d$ and $w_2^{DN} > d$ is satisfied. ■

**Figure 2:** the parameter space for bi-sourcing in a unilateral delegation game
Figure 2 illustrates the parameter space under where bi-sourcing emerges in a situation where only one firm delegates. In particular, bi-sourcing emerges when $c$ and $d$ are in the grey area. Black areas indicate those situations where Firm 1 has no incentive to delegate in equilibrium (i.e. $x_{i}^{DN*} \leq 0$). The parameter space supporting complete outsourcing, as well as the parameter space supporting complete in-house production are represented in the same figure.

Note that $\frac{-703+1540c}{837} < \frac{-61+160c}{99}$ and $\frac{-19+374c}{355} < \frac{1+80c}{81}$, that is, the interval of bi-sourcing shifts downward when passing from symmetric delegation to unilateral delegation, since the latter is characterized by a lower incentive to strategically use outsourcing (because of the higher input prices charged to the delegating firm and the profit-maximizing behavior of the non-delegating firm). It derives that complete outsourcing (in-house production) becomes less (more) likely. By contrast, $\frac{-703+1540c}{837} > \frac{135c-73}{62}$ and $\frac{-703+1540c}{837} > \frac{135c-73}{62}$ imply that the interval of bi-sourcing shifts upward when passing from symmetric no-delegation to unilateral delegation, since the presence of a delegating firm in a market pushes toward greater outsourcing. This implies that complete outsourcing (in-house production) becomes more (less) likely under unilateral delegation. Moreover, note that $I^{NN} > I^{DN} > I^{DD}$, where $I^{DN} \equiv \frac{-19+374c}{355} - \frac{-703+1540c}{837}$ denotes the interval of bi-sourcing under unilateral delegation, which is shown to be more likely with respect to the case of symmetric delegation, but less likely with respect to the case of symmetric no-delegation (outsourcing to an inefficient supplier does not arise in such a context).

Consider now the equilibrium downstream quantities and the equilibrium input prices. We have that $q_{i}^{DN*} \geq q_{2}^{DN*}$ and $w_{1}^{DN*} \geq w_{2}^{DN*}$. Indeed, unilateral
delegation implies that the delegating firm acts as a Stackelberg leader and chooses the optimal quantity over the reaction function of the rival (see Vickers, 1985, pp. 139-141): it follows that in equilibrium the downstream quantity of Firm 1 is higher than the downstream quantity of Firm 2. The output expansion by the delegating firm also induces it to choose to produce in-house larger input volumes than the rival’s, i.e., \( k_{1}^{DN} \geq k_{2}^{DN} \), as a consequence of the higher incentive to reduce, through in-house production, the upstream price induced by its larger input demand.

Let us now consider the equilibrium profits in the case of unilateral delegation. They are:

\[
\pi_{1}^{DN} = \frac{3[24075 + 80421c^2 + 18190d + 38156d^2 - 2c(33170 + 47251d)]}{624962} \quad (14)
\]

\[
\pi_{2}^{DN} = \frac{9[10108 + 36509c^2 + 5985d + 20416d^2 - c(26201 + 46817d)]}{1249924} \quad (15)
\]

Observe that, under the necessary condition for bi-sourcing (Proposition 3), we have that \( \pi_{1}^{DN} > \pi_{2}^{DN} \). Indeed, delegation by Firm 1 allows it to act as a Stackelberg leader, thus getting higher profits in equilibrium.\(^{18}\) Second, we observe a U-shape relationship between the marginal costs and the equilibrium profits which is similar to the case of symmetric delegation, with the exception that the profits of the delegating firm are strictly decreasing in the marginal costs of internal manufacturing, \( c \). In order to explain such relationships, we remind from the previous section that symmetric delegation implies a substitution effect of the less efficient technology with the more efficient one.

\(^{18}\) However, in Section 3, we show that this result can be reverted in the case of differentiated products.
which impacts positively on profits, causing a U-shape pattern of profits with respect to a $c$ and $d$ under bi-sourcing. With respect to symmetric delegation, unilateral delegation implies that a lower outsourced production trades-off with in-house production when the latter becomes less efficient and outsourcing causes higher input prices charged to the delegating firm. Such a relatively lower profitability of outsourced production, indeed, limits its use relative to in-house production even when the latter is more inefficient, which determines a decreasing pattern of the delegating firm’s profits with respect to $c$.

2.3. The endogenous choice of delegation

In this section we develop the game in which Firm 1 and Firm 2 non-cooperatively decide whether to delegate or not, namely to act as a delegating (managerial) firm or a non-delegating (profit-maximizing) firm, before competing as in above frameworks. This amounts to consider the following 2x2 matrix:\textsuperscript{19}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
 & B & D \tabularnewline
\hline
D & $\pi_1^{DD}$*, $\pi_2^{DD}$* & $\pi_1^{DN}$*, $\pi_2^{DN}$* \tabularnewline
\hline
N & $\pi_1^{ND}$*, $\pi_2^{ND}$* & $\pi_1^{NN}$*, $\pi_2^{NN}$* \tabularnewline
\hline
\end{tabular}
\caption{the pay-off matrix in the endogenous delegation game}
\end{table}

\textsuperscript{19} Due to symmetry, it must be: $\pi_1^{ND}$* = $\pi_2^{DN}$* and $\pi_2^{ND}$* = $\pi_1^{DN}$*.
Let us denote
\[
d_1 = \frac{-203707051 - 37453(1-c)\sqrt{4320037 + 685311447c}}{491604396}
\]
(16)
\[
d_2 = \frac{-203707051 + 37453(1-c)\sqrt{4320037 + 685311447c}}{491604396}
\]
(17)

We can state the following proposition:

**Proposition 5.** If \( d \leq d_1 \cup d \geq d_2 \), the unique Nash equilibrium is \( DD \): that is, delegation emerges as the endogenous choice by both firms; if \( d \in [d_1,d_2] \), there are two Nash equilibria: \( DD \) and \( NN \), the latter implying that no-delegation is endogenously chosen by both firms.

*Proof.* Note that \( \pi_i^{DD^*} \geq \pi_i^{ND^*} \), whereas \( \pi_1^{NN^*} \geq (\leq) \pi_1^{DN^*} \) if \( d \in [d_1,d_2] \) \((d \leq d_1 \cup d \geq d_2)\). Due to firms’ symmetry, the proposition follows. ■

In Figure 3 only the interval where bi-sourcing emerges in each delegation policy situation is represented. Within this parameter space, the light grey area represents the parameter space where multiple equilibria emerge, whereas the dark grey area represents the parameter space where only a symmetric delegation equilibrium emerges.
Figure 3: The Nash equilibria in the endogenous delegation game

An explanation of the results in Proposition 5 is as follows. The firm decision to delegate or not is mainly driven by the incentive to gain a leadership through the output expansion induced downstream by higher managers’ aggressiveness. Such an ‘outsourcing effect’ trades-off, in a context of bi-sourcing, with an ‘in-house production effect’ which captures the incentive to use capacity to affect upstream competition and get lower wholesale prices. The outsourcing effect is the only effect playing a role when capacity commitment is not possible, which causes an equilibrium with symmetric delegation to arise, as underlined in strategic delegation literature (Sklivas, 1987; Basu, 1995; Scrimitore, 2013). In our framework, however, the incentive toward in-house production may lead, when it is highly inefficient, delegation not to be optimal anymore. More particularly, when the rival chooses to delegate, the firm’s best-reply is delegation, regardless of the relative efficiency of internal vs. external manufacturing. Indeed, if the firm does not delegate when the rival delegates,

20 We easily recover that standard result by setting in our framework $k_j = 0$, $J = 1, 2$: the equilibrium profits would be as follows: $\bar{\pi}_1^{NN} = \bar{\pi}_2^{NN} = \frac{4(1-d)^2}{81}$, $\bar{\pi}_1^{DD} = \bar{\pi}_2^{DD} = \frac{9(1-d)^2}{200}$, $\bar{\pi}_1^{DN} = \bar{\pi}_2^{VD} = \frac{49(1-d)^2}{968}$ and $\bar{\pi}_1^{VD} = \bar{\pi}_2^{DN} = \frac{81(1-d)^2}{1936}$. It can be easily checked that $\bar{\pi}_1^{DN} \geq \bar{\pi}_1^{NN} \geq \bar{\pi}_1^{DD} \geq \bar{\pi}_1^{VD}$ and, similarly, $\bar{\pi}_2^{VD} \geq \bar{\pi}_2^{NN} \geq \bar{\pi}_2^{DD} \geq \bar{\pi}_2^{DN}$, which allows to state that the unique Nash equilibrium is $DD$.  


the non-delegating firm behaves like a low-producing follower on the downstream market, gaining lower profits than under symmetric delegation. Delegation, therefore, turns out to be the optimal strategy since it allows the firm to expand the output through higher outsourcing, which leads symmetric delegation to arise as a prisoner-dilemma-type equilibrium (due to $\pi^*_j \geq \pi^*_j$, as shown in Section 2.1). It should be stressed how such a result holds for any $d$ in the considered interval, due to the fact that symmetric delegation limits capacity commitment with respect to the no-delegation case, thus allowing the outsourcing effect to prevail on the in-house production effect also when the former is relatively less efficient.

The above result differs from that obtained when the rival is assumed not to delegate. In this case, indeed, delegation represents the best-reply to the rival’s strategy of not delegating only if $d$ is sufficiently low or sufficiently high, while no-delegation turns out to be the best-reply when $d$ is intermediate. This is due to the fact that delegation is not profitable in a unilateral delegation context with respect to no-delegation when it entails a more relevant investment in capacity (i.e. when $d$ is sufficiently high) and when capacity is inefficient enough compared to external manufacturing (i.e., $d$ is not too high). In such circumstances, namely when $d \in [d_1, d_2]$, the higher cost of inefficient in-house production negatively impacts the delegating firm’s profits more than it raises the advantage achieved through higher outsourcing. Therefore, mimicking the no-delegation choice of the rival turns out to be optimal, which leads a Nash equilibrium with symmetric no-delegation to coexist with the equilibrium with

\[ k_1^{DN*} \geq k_1^{NN*} \text{ when } d \geq (28452c - 7433)/21019 \text{, that is, the need for reducing the input prices through strategic in-house production is higher under unilateral delegation than symmetric no-delegation, provided that } d \text{ is sufficiently high. Indeed, when } d \text{ is low, highly efficient outsourcing is the most profitable channel for gaining a leadership in a unilateral delegation context, thus } k_1^{DN} \text{ is low relative to } k_1^{NN}, \text{ while outsourcing needs to be combined with increasing in-house production when it is less efficient, i.e. } d \text{ is higher.} \]
symmetric delegation. In contrast with the literature on strategic delegation, which shows that a symmetric choice of delegation emerges as a Pareto-inferior equilibrium, we demonstrate that under capacity commitment a prisoner dilemma is not an inevitable outcome. Indeed, both firms choosing no-delegation implicitly coordinate on a higher profits situation, since \( \pi_{NN}^* \geq \pi_{DD}^* \).

Conversely, the firm chooses delegation as a dominant strategy when the external supplier is strongly more efficient than the manufacturer (i.e., \( d \leq d_1 \)), with the outsourcing effect dominating the in-house production effect (becoming the only effect playing a role in the area of complete outsourcing), or is weakly more efficient than the manufacturer (i.e., \( d \geq d_2 \)), and the in-house production effect dominates the outsourcing effect (becoming the only effect in the area of complete in-house production). In both the intervals, firms choose to delegate at equilibrium and a prisoner dilemma emerges.\(^{22}\)

3. Extensions

In this section we consider two extensions of the basic model. In the first, we consider differentiated goods; in the second, we discuss the implications of the model developed by assuming that firms compete with respect to prices.

3.1. Differentiated products

Suppose that the two firms produce differentiated goods. The demand function of Firm \( J = 1,2 \) is now given by \( p_J = 1 - Q_J - \gamma Q_{-J} \), where \( \gamma \in [0,1] \) measures the degree of product substitutability: when \( \gamma = 0 \) product differentiation is maximal, whereas when \( \gamma = 1 \) the products are perfect substitutes (see Dixit, 1979, and Singh and Vives, 1984). The model can be

\(^{22}\) Note that the external supplier cannot be less efficient than the internal manufacturer, otherwise bi-sourcing would not occur in the unilateral delegation situation and in the situation where both firms do not delegate.
solved as in Section 2. We simply report the relevant propositions, which extend, with some differences, the results obtained in the basic model.

**Proposition 6.** Regardless of the presence of symmetric delegation, symmetric no-delegation or unilateral delegation, increasing product differentiation widens the extent of bi-sourcing. It raises the incentive to use strategically in-house production under more efficient outsourcing, as well as the incentive to use strategic outsourcing under more efficient in-house production, the latter only when product substitutability is sufficiently high in the symmetric delegation case. In the limit, when $\gamma \to 0$, bi-sourcing always occurs for $d < c$.

*Proof.*

Bi-sourcing emerges in equilibrium if and only if:

- $\frac{\partial d_I}{\partial \gamma} < 0$ when $0 < \gamma \leq 0.8214$, while $\frac{\partial d_I}{\partial \gamma} > 0$ when $0.8214 < \gamma \leq 1$.
- $\frac{\partial d_N}{\partial \gamma} > 0$ when $0 < \gamma \leq 0.8214$, while $\frac{\partial d_N}{\partial \gamma} < 0$ when $0.8214 < \gamma \leq 1$.
- $\frac{\partial J}{\partial \gamma} < 0$ when $0 < \gamma \leq 0.8214$, while $\frac{\partial J}{\partial \gamma} > 0$ when $0.8214 < \gamma \leq 1$.

where the expressions of $d_I$ and $d_N$ (with $I = DD, NN, DN$) are included in the Appendix. We obtain:

Moreover, by denoting by $f_I^{DD}$, $f_I^{NN}$ and $f_I^{DN}$ the intervals in which bi-sourcing occurs in the three cases, we get: $\frac{\partial J^{DD}}{\partial \gamma} < 0$; $\frac{\partial J^{NN}}{\partial \gamma} < 0$; $\frac{\partial J^{DN}}{\partial \gamma} < 0$.

Finally, we observe that: $\lim_{\gamma \to 0} f_I^I = 3(1 - c)$ ($I = DD, NN, DN$).

$\blacksquare$
Proposition 6 shows that increasing product differentiation, by strengthening the incentive to enhance upstream competition through larger capacity commitment, extends bi-sourcing to progressively lower values of $d$, independently of the presence of delegation or not. Moreover, by also relaxing competition on the downstream market, it positively affects the strategic incentive to expand the output through outsourcing when the latter is less efficient, thus monotonically extending bi-sourcing to progressively higher values of $d$ both in the symmetric no-delegation case and in the unilateral delegation case. In the symmetric delegation case, however, increasing product differentiation raises the strategic incentive to exploit the downstream leadership relative to the need of enhancing upstream competition, only when the latter is fiercer, i.e., when product substitutability is high enough, which also keeps managers’ aggressiveness high. In this case, bi-sourcing extends to progressively higher values of $d$, becoming more likely in the interval $d > c$ (see also Corollary of Proposition 1). By contrast, when upstream competition is scarce and also limits managers’ aggressiveness, i.e. when product substitutability is low enough, increasing differentiation causes the incentive toward in-house production to dominate the incentive toward outsourcing. This makes bi-sourcing less likely in the interval $d > c$. When, in the limit, $\gamma$ approaches zero, delegation does not affect the relative incentives of the two sources and bi-sourcing arises for all $d$ in the interval $d < c$ in the three considered cases. That is, under the hypothesis of independent goods, bi-sourcing always occurs under more efficient outsourcing, while complete in-house production is always observed under more efficient in-house production, regardless of the presence of delegation or not.\textsuperscript{23} This reflects the fact that, in

\textsuperscript{23} Note that $\lim_{\gamma \to 0} \lambda_i = 0$, i.e., when $\gamma \to 0$, all firms maximize profits, which makes the three frameworks perfectly equivalent.
such circumstances, outsourcing is used only for cost advantages (there is no need to strategically orient firm behavior in the absence of downstream competition), also allowing in-house production to be always combined with more efficient outsourcing for strategic reasons and exclusively used for cost advantages.

The next proposition shows how product differentiation plays a role in defining the relative advantage of the delegating and the non-delegating firms under unilateral delegation.

**Proposition 7**. When products are sufficiently differentiated and $d$ is sufficiently low (high), the profits of the non-delegating firm under unilateral delegation are higher (lower) than the profits of the delegating firm.24

*Proof*. See the online Appendix.

Indeed, it can be observed that, regardless of product differentiation and the relative efficiency of external vs. internal input production, $\bar{q}_{1}^{DN} > \bar{q}_{2}^{DN}$ and $\bar{w}_{1}^{DN} > \bar{w}_{2}^{DN}$ (where the symbol “~” is used here and later to indicate the case of differentiated products).25 That is, since the delegating firm is more aggressive than the rival in the downstream market, the higher demand of inputs to the external supplier induces its own external supplier to charge it with a higher input price with respect to the rival’s. However, $d$ and $\gamma$ turn out to matter in the comparison between the capacity choices of the two competing firms and their profits. Indeed, we find that $\bar{k}_{1}^{DN} > \bar{k}_{2}^{DN}$, provided that $\gamma$ and $d$ are sufficiently

---

24 Due to the equivalence between unilateral delegation and a Stackelberg leadership (Vickers, 1985, Scrimitore, 2013), this amounts to saying that the first-mover advantage is reverted in favor of the second-mover, thus contrasting to previous results in the literature (Gal-Or, 1985).

25 See the online Appendix for the equilibrium values of market outcomes in such a framework.
high. In other words, unilateral delegation by Firm 1 induces its in-house production to be higher than that of the non-delegating rival when such a production is relatively efficient and products are homogeneous or slightly differentiated. In such circumstances, the output expansion due to higher outsourcing and in-house production by the delegating firm always allows it to gain an advantage over the non-delegating firm, despite the higher input prices charged by the external suppliers and the cost associated to higher inefficient in-house production. Such a result is reversed in favor of the non-delegating firm when sufficiently high product differentiation (i.e., low $\gamma$) and sufficiently low costs of external manufacturing (i.e., low $d$) weaken Firm 1’s aggressiveness on the downstream market and its incentive to expand capacity relative to the rival, leading Firm 2’s leadership to emerge.

Finally, Proposition 8 discusses the endogenous choice of delegation in the presence of product differentiation.

**Proposition 8.** Suppose that the products are sufficiently differentiated (i.e., $\gamma$ is sufficiently low). If $d$ is low, the unique equilibrium is $NN$; if $d$ is intermediate, there are two equilibria, $NN$ and $DD$; if $d$ is high, the unique equilibrium is $DD$.

*Proof.* See the online Appendix.

---

26 The negative impact of increasing product differentiation on Firm 1’s manager aggressiveness and its last-stage equilibrium quantity $q_1 = \frac{1 - Bk_1}{B} - \frac{2w_1}{AB(1 + \lambda_1)} + \frac{\gamma w_2}{AB}$ (where $A = 2 - \gamma$ and $B = 2 + \gamma$) is captured by the fact that $\frac{\partial^2 q_1}{\partial \lambda \partial \gamma} = \frac{4w_1\gamma}{(4 - \gamma^2)^2(1 + \lambda_1)} \geq 0$.

27 If products are scarcely differentiated, the results replicate those in Proposition 5.
Proposition 8 shows that, when products are highly differentiated, it is possible that a situation where no firm delegates emerges as a unique equilibrium, whereas the same equilibrium always coexists with an equilibrium with symmetric delegation when products are scarcely differentiated or, as shown in Section 2.3., homogeneous. While the same forces as those highlighted in the homogeneous product case are at work when \( d \) is high (\( DD \) emerges as the unique equilibrium) and when \( d \) assumes intermediate values (a multiplicity of equilibria arises), product differentiation alters the results obtained with homogenous products when \( d \) is very low. In this case, indeed, increasing product differentiation, by strengthening the strategic incentives toward in-house production, leads bi-sourcing to occur more likely, ruling out complete outsourcing when \( \gamma \) tends to zero. By positively impacting the in-house production effect and, moreover, negatively impacting the outsourcing effect due to decreasing firm aggressiveness, increasing product differentiation makes delegation less profitable than no-delegation in the interval of values of \( d \) in which in-house production is very inefficient. This occurs both under symmetric and unilateral delegation, which lets the choice of not delegating be the optimal one regardless of whether the rival delegates or not, and the equilibrium in dominant strategies \( NN \) arise as the unique Nash equilibrium.

3.2. The price competition case

The extension of the above model to price competition has been considered in a framework of differentiated products, the analytics of which is included in the online Appendix. The analysis shows that, under almost perfect substitutability, and regardless of the presence of delegation or not, tougher price competition at the market stage and between suppliers always lets the
most cost-saving source emerge as the exclusive optimal strategy. In this case bi-sourcing does not arise, since neither inefficient insourcing nor inefficient outsourcing can be used for strategic purposes, namely there is no need of enhancing upstream competition to be charged with lower input prices or exploiting more favorable downstream competition. Both in a context of symmetric delegation and symmetric no-delegation, increasing product differentiation affects the above incentives, leaving room for bi-sourcing. More particularly, by relaxing competition between the external suppliers, it induces firms to strategically produce part of the inputs in-house even when such a production is relatively less efficient than the external source, thus extending monotonically bi-sourcing to progressively lower values of $d$. Moreover, increasing product differentiation also leads firms to exploit the advantage of softer downstream competition by strategically out-sourcing part of input production when such a manufacturing is less efficient than internal manufacturing. In this case, however, it extends bi-sourcing to progressively higher values of $d$ in the interval $d > c$, as long as product substitutability is sufficiently high, case in which the incentive to exploit softer downstream competition through strategic outsourcing is higher than the need to enhance less favorable upstream competition. The latter in-house effect, by contrast, dominates the former outsourcing effect when product substitutability is sufficiently low and increasing differentiation further reduces upstream competition through more relaxed market competition. This shrinks the area of bi-sourcing over the interval $d > c$ where complete in-house production becomes optimal under independent goods, i.e. $\gamma$ approaching zero. In such circumstances downstream product (upstream input) market has the most (less) favorable characteristics and bi-sourcing arises over the entire interval $d < c$: outsourcing is therefore used only for cost advantages and in-house production
for both strategic and cost reasons, being always combined to more efficient outsourcing when $d < c$ (capacity choices are not affected by any strategic incentive to exploit downstream competition in this case, which makes bi-sourcing optimal for any $d$ in such an interval), and exclusively used when $d > c$.

By investigating price competition under delegation, our analysis shows that delegation to managers, by causing a collusive-like outcome on the downstream market, is associated with a profitable output contraction, and thus lower outsourced production, with respect to the no-delegation case. The higher capacity levels chosen by firm owners relative to outsourcing cause lower input prices set by the external suppliers than under no-delegation, regardless of the degree of product differentiation. The latter, however, is shown to affect the likelihood of bi-sourcing as follows. While the higher in-house effect induced by delegation trades-off with the outsourcing effect at progressively lower values of $d$ regardless of the degree of product substitutability, when $d > c$ it is still high relative to the latter, provided that product substitutability is low enough. In this latter case, due to the higher need to enhance softer competition between upstream suppliers through insourcing, strategic outsourcing decreases with respect to the no-delegation case and the area of complete insourcing enlarges. Anyway, such a negative effect on bi-sourcing in the interval $d > c$ is dominated by the positive effect caused by higher strategic insourcing in the interval $d < c$, which makes overall bi-sourcing more likely than under no-delegation. By contrast, when product substitutability is high enough and upstream competition is sufficiently fierce, the advantage from capacity commitment becomes low relative to the

---

28 See Fershtman and Judd (1987) and Sklivas (1987) for analyses of equilibrium incentives under price competition.

29 This contrasts with the case without capacity commitment in which delegation, by relaxing downstream competition, is shown to reduce input prices with the aim to enhance managers’ aggressiveness and foster their input demand. See in this regard the discussion after Lemma 1 for a parallelism with the quantity competition case.
advantage of competing downstream, which leads bi-sourcing to become more likely also when $d > c$.

Finally, the analysis of the equilibrium choice in the extended Bertrand game of delegation reveals that a symmetric firm choice to delegate arises as a unique dominant strategy equilibrium, regardless of whether products are differentiated or not. An economic intuition of this result is as follows. Indeed, delegation under price competition benefits firms both under symmetric and unilateral delegation with respect to a context without delegation. It causes, on the one hand, a more profitable competitive environment due to higher downstream prices and, on the other hand, a cost advantage due to lower input prices caused by higher in-house production and lower outsourcing. Such effects allow firms to coordinate on a symmetric delegation choice as the most profitable (unique) equilibrium of the game.\(^\text{30}\)

4. Concluding remarks

This paper has examined the extent to which firms source inputs both internally and externally under managerial delegation. The model highlights the circumstances under which delegation affects, with respect to the no-delegation case, the optimal extent of bi-sourcing, which is shown to be driven by the interplay between the strategic effects of both capacity commitment and outsourcing and the cost-saving effect of using the more efficient source. By assuming no \textit{a priori} efficiency difference between internal and external manufacturing, we find that managerial delegation under quantity competition alters the trade-off between in-house and outsourced production, pushing towards the latter in order to exploit a market leadership effect. Such a strategic

\(^{30}\) This contrasts with the quantity competition case in which delegation may lead to both a prisoner-dilemma-type equilibrium with symmetric delegation and a Pareto improving equilibrium with symmetric no-delegation.
effect of outsourcing arises to a lesser extent than that caused by strategic capacity commitment (yielding a reduction of the external input prices), which makes bi-sourcing less likely than under no-delegation. The role of increasing product differentiation has been also investigated in such a Cournot framework, showing how it makes bi-sourcing more likely by positively affecting both the incentive to commit to in-house production to reduce external input prices and the incentive to strategically exploit, through outsourcing, more profitable downstream competition.

The above analysis, as well as its extension to price competition, has allowed us to show the circumstances under which outsourcing emerges under bi-sourcing even when in-house production is more efficient than external production, thus identifying a source of bi-sourcing not highlighted in previous literature conversely focusing on the strategic effects played by in-house production (Beladi and Mukherjee, 2012). Moreover, our paper has pointed out how the in-house effect interacts with the outsourcing effect in determining both the relative advantage of a delegating firm over the non-delegating rival and the endogenous choice of delegation. The latter effect is shown to dominate the former effect in a Cournot framework with homogeneous products, which gives an advantage to the delegating firm over its non-delegating rival, whatever the relative efficiency of internal vs. external manufacturing. As far as the endogenous choice of delegation is concerned, we have demonstrated that each firm is induced: a) to choose delegation as a dominant strategy, as long as external manufacturing is either highly more efficient or scarcely more efficient relative to in-house production, which causes a prisoner-dilemma-type Nash equilibrium with symmetric delegation to arise;31 b) to mimic the rival’s choice, as long as the relative efficiency of external and in-house production is small, on

31 A Nash equilibrium with symmetric delegation also arises in the correspondent Bertrand game, where delegation is shown to be a dominant strategy for each firm.
the one hand with the aim to exploit the strategic advantage of symmetric
delegation, on the other hand with the aim to avoid the cost of more relevant
and inefficient capacity commitment under unilateral delegation. In case b), a
symmetric Pareto improving Nash equilibrium with no delegation has been
shown to coexist with the symmetric equilibrium with delegation. Sufficiently
high product differentiation has been finally shown both to revert the
advantage of the delegating firm in favor of its rival and to recover the
equilibrium with symmetric no-delegation as the unique solution of the
endogenous delegation game, provided that in-house manufacturing is highly
inefficient.

Considerations on efficiency-driven and market-driven reasons for
outsourcing have been brought forward in this study. Their crucial importance
is also underlined by Deloitte in its 2016 survey (Deloitte Consulting, 2016) that
highlights the advantages of outsourcing in delivering business value beyond
cost savings, in particular value driven through innovation. Future research
should aim to examine the interplay between internal and external sources of
innovation, trying to identify the circumstances under which it may lead to bi-
sourcing.

References

decision in the presence of a rival: strategic outsourcing to a common
vertical integration, and price vs. quantity competition,” *International Journal
of Industrial Organization*, 26, 1–16.
- Beladi, H. and A. Mukherjee, 2012, “Market structure and strategic bi-
sourcing Hamid Beladi,” *Journal of Economic Behavior & Organization*, 82,
210–219


Deloitte Consulting LLP, 2016, “Global Outsourcing Survey”.


Kopel, M. Löffler, C. and T. Pfeiffer, 2016, “Sourcing strategies of a multi-


