



Centro de Estudos de  
Economia Aplicada do Atlântico

## **WORKING PAPER SERIES**

**CEEApIA WP No. 20/2011**

### **The Impact of Product Market Competition on the Decision to Outsource With Long Term Contracts**

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**November 2011**

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Universidade dos Açores (DEG e CEEAplA)

Working Paper n.º 20/2011  
Novembro de 2011

## **RESUMO/ABSTRACT**

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This paper analyzes how product market competition affects the firms' choice between outsourcing with long term contracts and outsourcing to the spot market. Product market competition among buyers can lead to an increase in financial distress costs not only for firms outsourcing to the spot market but also for firms outsourcing with a long term contract. We derive the equilibrium for an oligopoly, and show that the equilibrium depends on the magnitude of these costs and on the level of efficiency of the supplier.

**Keywords:** outsourcing, long term contracts, uncertainty, financial distress

**JEL classification:** D81; G32; G33; L23; L24

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# The impact of product market competition on the decision to outsource with long term contracts \*

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This version: 02 November 2011

## Abstract

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\*I thank financial support from Portuguese Foundation for Science and Technology. Any errors remain my responsibility. Comments can be sent to João Teixeira (jteixeira@uac.pt).

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# The impact of product market competition on the decision to outsource with long term contracts

This paper analyzes how product market competition affects the firms' choice between outsourcing with long term contracts and outsourcing to the spot market. Product market competition among buyers can lead to an increase in financial distress costs not only for firms outsourcing to the spot market but also for firms outsourcing with a long term contract. We derive the equilibrium for an oligopoly, and show that the equilibrium depends on the magnitude of these costs and on the level of efficiency of the supplier.

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# 1 Introduction

This paper extends the work by Teixeira (2011) by incorporating the product market competition dimension on the outsourcing decision to outsource with long term contracts. With product market competition in the downstream market, new insights arise with respect to financial distress costs, and consequently to the outsourcing equilibrium. We find that firms outsourcing to the spot market can incur financial distress costs in bad states of nature not only due to higher input prices but also due to the competition in the downstream market of other firms that outsource with a long term contract. As for firms that outsource with a long term contract, although this contract provides them a perfect hedge of input price uncertainty, now their revenue stream is not immune to fluctuations caused by product market competition. Therefore, contrary to the monopoly setting, now they can also incur financial distress costs. We analyze under which conditions these financial distress costs are positive, and how this affects the proportion of firms outsourcing in each regime.

We find that when the independent supplier is as competitive as the spot market, i.e. when the outsourcing price of the long term contract is equal to the expected spot price, two equilibrium scenarios can arise. One where all firms are outsourcing to the spot market and another where all firms are outsourcing with a long term contract. The equilibrium depends on the trade-off between the positive convexity effect of input price uncertainty and the differences in financial distress costs of both regimes. The higher the sensitivity of the buyers' profits to financial distress costs, the higher the possibility of having an equilibrium where all firms outsource with a long term contract in order to avoid these costs.

Next, we derive the outsourcing equilibrium when the independent supplier is able to provide an outsourcing price lower than the expected spot price.<sup>1</sup> We show

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<sup>1</sup>The analysis is motivated by the findings of Kleindorfer and Wu (2003) and Spinler, Huchz-

that this new assumption creates a relative disadvantage of the spot regime and induces, for certain conditions, an asymmetric equilibrium where some firms outsource to the spot market and others to the independent supplier. The equilibrium depends on the relative importance of the positive convexity effect of the spot regime, its cost disadvantage and the differences in financial distress costs of both regimes.

Our predictions about the effect of product market competition on the outsourcing decision are, as far as we know, a novel contribution to the outsourcing literature. Our model also relates to the literature that studies the link between capital structure and product market competition (see Maksimovic (1995) for a review). In particular, our framework incorporates the choice of two equilibrium regimes, and the derivation of the industry equilibrium as in Maksimovic and Zechner (1991). Note, however, that we abstract from any strategic considerations of debt on product market competition.<sup>2</sup>

Before we proceed, we further contrast our analysis with related work in the literature. While we motivate the use of long term contracts as a risk management device, alternative explanations have been examined in the economics and operations management literature. The economics literature builds on the incomplete contracting view of Williamson (1975). This theory argues that, in a context of incomplete contracting, long term contracts provide greater benefits when the products to be outsourced are more specific (specialized or differentiated) and spot transactions are more frequent for standard products. When products are more specific, there is a higher requirement for the parties to make a specific investment but, at the same time, the specific investment can create hold-up problems. With a long term con-

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ermeier, and Kleindorfer (2003). They argue that, in many industries, the supplier can offer an outsourcing price lower than the expected spot price because a long term contract allows the supplier to plan in advance, lowering cost staffing, maintenance and other production costs.

<sup>2</sup>In our model, debt has an impact in the number of firms in equilibrium as it can induce positive financial distress costs and consequently change the incentives for the choice of the equilibrium regime.

tract the parties can mitigate the hold-up problem because they can benefit from a future relationship.

On the other hand, the operations management literature has focused more on the choice between option contracts and the spot market (see Kleindorfer, Wu, and Zhang (2002), Spinler, Huchzermeier, and Kleindorfer (2003) and Kleindorfer and Wu (2005)). Option contracts are common in capital intensive industries where capacity can only be expanded well in advance of output requirements. With these contracts the buyer acquires the option to buy capacity from the supplier. A reservation fee is paid ex-ante and an execution fee is paid if the option is exercised. The choice between the execution of these options and the acquisition of the input from the spot market depends on the balance between the costs involved with the option contract and the level of realized demand in the downstream market.

Although we focus on input price uncertainty and assume risk neutrality, our study also relates to the literature on the behavior of the firm under price uncertainty. Prominent contributions by Carlton (1979), Polinsky (1987) and Hubbard and Weiner (1992) examine the buyers' choice between spot sales and sales with a long term contract assuming risk aversion and demand uncertainty.

The remainder of the paper is organized as follows. Section 2 examines the effect of product market competition and cost differences between the independent supplier and the spot market. It extends the basic model to an oligopoly in the downstream market. Section 3 concludes and summarizes some empirical predictions of our theory. Proofs of all propositions are detailed in the Appendix.

## 2 Oligopoly in the downstream market

This section considers an oligopoly structure in market  $A$ . With this extension to the basic model, we examine the effect of product market competition on the choice of the outsourcing regime. First, we derive the equilibrium quantities, profits and prices for the general model. Subsequently, we discuss the equilibrium for two special cases: one where we assume that the outsourcing price provided by the supplier is the same as the expected spot price, and another where we assume that the supplier is somehow more efficient in the production of input  $B$  in the sense that the firm can provide an outsourcing price lower than the expected spot price. By ignoring costs differentials in the first case, we follow the same assumptions of the monopoly model, and therefore focus our analysis exclusively on the additional effect of product market competition. What motivates our investigation of the second case is empirical evidence showing that in many industries long term contracts allow suppliers to plan in advance, lowering cost staffing, maintenance and other production costs (see Kleindorfer and Wu (2003) and Spinler, Huchzermeier, and Kleindorfer (2003)), and therefore are associated with lower outsourcing prices than the spot market.

Let us assume that at time  $t = 1$  a total of  $n$  symmetric and atomistic firms are competing in a Cournot fashion in market  $A$  and, from these,  $n_S$  may be outsourcing to the spot market and  $n_{LT}$  (or  $n - n_S$ ) may be outsourcing to the independent supplier, using a long term contract. We keep the assumption of the previous model that downstream firms have a marginal cost  $c_A$ , a fixed cost  $f_A$  and are due to make a debt payment of  $D$  at time  $t = 1$ . The supplier produces with a marginal cost  $c_B$  and has unlimited capacity.

The decisions made by firms at each time are as follows. At time  $t = 0$ , firms

that decide to outsource with a long term contract (a total of  $n_{LT}$  firms) negotiate with the supplier the terms of the contract. These include the quantity of input  $B$  to be exchanged at time  $t = 1$   $q_{ALT}$  (which equals the quantity of product  $A$ ) and the corresponding outsourcing price  $p_{BLT}$ . Once again, this outsourcing price is the outcome of a Nash bargaining game. Note, however, that, for simplification purposes, we assume that the buyers have all the bargaining power (we set the exogenous bargaining power as  $\eta = 1$ ). This implies that the outsourcing price equals the marginal cost of the supplier ( $p_{BLT} = c_B$ ), such that the supplier derives a zero profit and the buyers derive the total profit under global maximization. In order to determine the outsourcing quantity  $q_{ALT}$ , each buyer and the supplier jointly maximize the individual expected profit under global maximization. Unlike the monopoly model, now this profit is itself a function of the quantities produced by firms outsourcing to the spot market. Therefore, firms that outsource with a long term contract decide at time  $t = 0$  on their outsourcing quantity taking into account the input price uncertainty estimated for the spot market.

At time  $t = 1$ , input price uncertainty is revealed and firms compete in the downstream market  $A$ . Although they all face the same demand function in each state of nature, some of them may be outsourcing to the spot market and others to the independent supplier. As in the previous model, the input price is given by (??) and (??) for the bad and good state, respectively. Buyers that outsource to the spot market decide on their quantities  $q_{AS}^u$  and  $q_{AS}^d$  on the bad and good state by optimizing their profit function, given the realized input prices and also given the quantities committed by other buyers that outsource with a long term contract. The equilibrium quantities are then determined jointly. Now, the quantities outsourced with the long term contract are a function of the spot quantities and the spot quantities are also a function of the quantities of the long term contract.

The downstream demand function in state  $i$ , with  $i \in \{u, d\}$  is:

$$(Q_{ALT} + Q_{AS}^i) = \alpha_A - \beta_A p_A^i \quad (1)$$

where  $Q_{ALT}$  is the sum of the quantities produced by firms that outsource with a long term contract and  $Q_{AS}^i$  is the sum of the quantities produced by firms that outsource to the spot market. It follows that:

$$Q_{ALT} = n_{LT} q_{ALT} \quad (2)$$

$$Q_{AS}^i = n_S q_{AS}^i \quad (3)$$

Before we proceed with the derivation of the equilibrium, let us make some considerations about the effect of product market competition on financial distress costs. At this stage, we know that financial distress costs are positive as soon as the profit flow at time  $t = 1$  is lower than the required debt payment  $D$ . With a monopoly in the downstream market, we showed that only firms outsourcing to the spot market would incur financial distress costs, and this would happen in the bad state ( $u$ ), due to a higher input price. A long term contract provided the buyer a perfect hedge of input price uncertainty and, at the same time, because the buyer was the only competitor in market  $A$ , his profit with the long term contract regime was certain at time  $t = 0$ . We found in proposition 2 that under the long term contract regime the uncertainty measure had no effect on the equilibrium price in market  $A$ .

The introduction of product market competition in the downstream market has important implications for financial distress costs. Now, the possibility of incurring financial distress costs is real not only for firms that outsource to the spot market but also for firms that outsource to the independent supplier. Because they all compete in market  $A$ , input price uncertainty may have an effect on the prices in market  $A$ , and consequently on the revenue stream of firms that outsource with a

long term contract. Therefore, firms that outsource to the spot market can incur financial distress costs in the bad state ( $u$ ) not only due to higher input prices but also due to the competition in market  $A$  of other firms that outsource with a long term contract. On the other hand, firms that outsource with a long term contract can incur financial distress costs in the good state ( $d$ ) due to the competition effect of other firms that outsource to the spot market.<sup>3</sup>

We now derive the equilibrium quantities under each regime. We start with the quantities under the long term contract, and then proceed with the quantities of the spot regime. We present here the key assumptions and steps that support our results. More details of the derivation are given in the Appendix. Under the long term contract regime, each buyer and the supplier jointly optimize the individual expected profit under global maximization  $E(\pi_{GM})$  with respect to the individual quantity  $q_{ALT}$ , taking the total spot quantities  $Q_{AS}^i$  as given. At time  $t = 0$ , the expected profit under global maximization is:<sup>4</sup>

$$E(\pi_{GM}) = \frac{1}{2}\pi_{GM}^u + \frac{1}{2}\pi_{GM}^d \quad (4)$$

where  $\pi_{GM}^u$  and  $\pi_{GM}^d$  are the realized profits under global maximization when the spot price of input  $B$  is  $p_B^u$  and  $p_B^d$ , respectively. If we denote the inverse demand function by  $p_A^i(Q_{ALT}, Q_{AS}^i)$ , with  $i \in \{u, d\}$ , it follows that the realized profits under global maximization at time  $t = 1$  are:

$$\pi_{GM}^i = q_{ALT} (p_A^i(Q_{ALT}, Q_{AS}^i) - c_A - c_B) - f_A - FDC_{GM}^i \quad (5)$$

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<sup>3</sup>Remember that, if we assume no cost difference between the two regimes (in expected terms, i.e.  $m = c_B = p_{BLT}$ ), then in the good state ( $d$ ), firms that outsource to the spot market are more competitive than firms outsourcing with a long term contract as they buy the input  $B$  at a lower price. In this state the input price in the spot market is  $p_B^d = m - s$ , whereas with the long term contract it is  $m = p_{BLT} > p_B^d$ . This cost disadvantage of firms outsourcing with a long term contract may induce these firms to incur financial distress costs. For example, an increase in the number of firms outsourcing to the spot market (more efficient firms in this state) can lead to a decrease in downstream prices, and as a consequence to a depression in the profits of firms outsourcing with the long term contract.

<sup>4</sup>Note that the assumption of  $\eta = 1$  implies that the expected profit under global maximization is equal to the profit each buyer expects from outsourcing with a long term contract, i.e.  $E(\pi_{GM}) = E(\pi_{ALT})$ .

where the financial distress costs in state  $i$  are:

$$FDC_{GM}^i = k \max [0, D - (q_{ALT} (p_A^i (Q_{ALT}, Q_{AS}^i) - c_A - c_B) - f_A)] \quad (6)$$

The optimization of the expected profit under global maximization (4) yields the following individual quantity of the long term contract:

$$q_{ALT} = \alpha_A - \beta_A(c_A + c_B) - Q_{ALT} - \frac{1}{2} (Q_{AS}^u + Q_{AS}^d) \quad (7)$$

In order to obtain the sum of the quantities of all firms outsourcing with a long term contract  $Q_{ALT}$ , we multiply both sides of (7) by  $n_{LT}$  and, given that  $Q_{ALT} = n_{LT} q_{ALT}$ , we solve it for  $Q_{ALT}$ . This yields:

$$Q_{ALT} = \frac{n_{LT} [\alpha_A - \beta_A(c_A + c_B) - \frac{1}{2} (Q_{AS}^u + Q_{AS}^d)]}{1 + n_{LT}} \quad (8)$$

Let us now determine the equilibrium quantities for buyers that outsource to the spot market. At time  $t = 0$ , the expected profit of each buyer that outsources to the spot market is:

$$E(\pi_{AS}) = \frac{1}{2} \pi_{AS}^u + \frac{1}{2} \pi_{AS}^d \quad (9)$$

where the realized profits in state  $i$  are:

$$\pi_{AS}^i = q_{AS}^i (p_A^i (Q_{ALT}, Q_{AS}^i) - c_A - p_B^i) - f_A - FDC_S^i \quad (10)$$

and the corresponding financial distress costs are given by:

$$FDC_S^i = k \max [0, D - (q_{AS}^i (p_A^i (Q_{ALT}, Q_{AS}^i) - c_A - p_B^i) - f_A)] \quad (11)$$

At time  $t = 1$ , the buyers optimize their profits given the realized input price and the total quantity of other firms outsourcing with a long term contract  $Q_{ALT}$ . The optimization of the profits in each state yields the following individual quantities:

$$q_{AS}^i = \alpha_A - \beta_A(c_A + p_B^i) - Q_{ALT} - Q_{AS}^i \quad (12)$$

Given that  $Q_{AS}^i = n_S q_{AS}^i$ , if we multiply both sides of (12) by  $n_S$  and solve for  $Q_{AS}^i$ , it follows that:

$$Q_{AS}^i = \frac{n_S [\alpha_A - \beta_A(c_A + p_B^i) - Q_{ALT}]}{1 + n_S} \quad (13)$$

Solving the system of equations (8) and (13) for  $Q_{ALT}$  and  $Q_{AS}^i$ , and setting  $n_{LT} = n - n_S$ , gives us the final expressions for the total quantities in equilibrium. Moreover, if we divide these quantities by the number of firms we obtain the individual quantities in equilibrium. Finally, substituting the equilibrium quantities into the profit functions gives us the expressions for the equilibrium profits. Analogously to the monopoly model, we denote by  $E(\pi_{AS})_{NFDC}$  the expected profit of each buyer outsourcing to the spot market when financial distress costs are zero, i.e.  $E(\pi_{AS})_{NFDC} = E(\pi_{AS})$  if  $FDC_S^u = 0$  and by  $E(\pi_{ALT})_{NFDC}$  the expected profit of each buyer outsourcing to the independent supplier, also when financial distress costs are zero, i.e.  $E(\pi_{ALT})_{NFDC} = E(\pi_{ALT})$  if  $FDC_{GM}^d = 0$ .<sup>5</sup> The same notation applies to the realized profits in each state of nature,  $\pi_{AS}^i_{NFDC}$  and  $\pi_{ALT}^i_{NFDC}$ . Proposition 1 summarizes the equilibrium profits and prices for the oligopoly equilibrium.<sup>6</sup>

**Proposition 1** *Assume that market A is an oligopoly where  $n$  symmetric firms face the demand function (1) for product A. Further, assume that  $n_S$  firms outsource input B to the spot market and  $n_{LT}$  firms outsource input B to an independent supplier, using a long term contract, with  $n = n_S + n_{LT}$ . The expected profit of those firms that outsource to the spot market is:*

$$E(\pi_{AS}) = E(\pi_{AS})_{NFDC} - \frac{1}{2}FDC_S^u \quad (14)$$

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<sup>5</sup>Note that, as we discussed earlier, it follows from the model that both the financial distress costs in the good state of firms outsourcing to the spot market ( $FDC_S^d$ ) and the financial distress costs in the bad state of firms outsourcing to the independent supplier ( $FDC_{GM}^u$ ) are zero.

<sup>6</sup>The expressions for the equilibrium quantities and for the realized profits in each state of nature when financial distress costs are zero,  $\pi_{AS}^i_{NFDC}$  and  $\pi_{ALT}^i_{NFDC}$ , are presented in the Appendix.

where

$$E(\pi_{AS})_{NFDC} = \frac{[\alpha_A - \beta_A(c_A + m + (n - n_S)(m - c_B))]^2}{\beta_A(1 + n)^2} - f_A + \frac{s^2\beta_A}{(1 + n_S)^2} \quad (15)$$

$$FDC_S^u = k \max[0, D - (\pi_{AS}^u)_{NFDC}] \quad (16)$$

Conversely, the expected profit of those firms that outsource to the independent supplier, using a long term contract, is:

$$E(\pi_{ALT}) = E(\pi_{ALT})_{NFDC} - \frac{1}{2} FDC_{GM}^d \quad (17)$$

where

$$E(\pi_{ALT})_{NFDC} = \frac{[\alpha_A - \beta_A(c_A + c_B - n_S(m - c_B))]^2}{\beta_A(1 + n)^2} - f_A \quad (18)$$

$$FDC_{GM}^d = k \max[0, D - (\pi_{ALT}^d)_{NFDC}] \quad (19)$$

Finally, the equilibrium prices in market A in the bad and good state are, respectively:

$$p_A^u = \frac{\alpha_A + \beta_A[n(c_A + c_B) + n_S(m - c_B)]}{\beta_A(1 + n)} + s \frac{n_S}{1 + n_S} \quad (20)$$

$$p_A^d = \frac{\alpha_A + \beta_A[n(c_A + c_B) + n_S(m - c_B)]}{\beta_A(1 + n)} - s \frac{n_S}{1 + n_S} \quad (21)$$

Having derived the equilibrium profits and prices when there is an oligopoly in market A, we are now in a position to discuss the choice of the outsourcing regime. This analysis is developed in the next section.

## 2.1 Equilibrium in the oligopoly model

We discuss the equilibrium using the following outline. We first start with the case where the outsourcing price provided by the supplier is the same as the expected spot price ( $p_{BLT} = m$ ), and then introduce the possibility of the supplier being more efficient, in the sense that it provides an outsourcing price lower than the expected spot price ( $p_{BLT} < m$ ). The first case allows us to isolate the effect

of uncertainty and product market competition on the choice of the outsourcing regime, whereas the second brings us new insights on the empirical evidence that some suppliers might be able to provide a more competitive price than the spot market. For example, Kleindorfer and Wu (2003) and Spinler, Huchzermeier, and Kleindorfer (2003) argue that in many industries (capital intensive industries) the supplier can offer an outsourcing price lower than the expected spot price because a long term contract allows the supplier to plan in advance, lowering cost staffing, maintenance and other production costs.

### 2.1.1 Equilibrium assuming that the outsourcing price provided by the supplier is the same as the expected spot price

Analogously to the monopoly section, we first examine the outsourcing decision assuming zero financial distress costs, and subsequently consider positive financial distress costs. From proposition 1, it follows that when financial distress costs are zero, the expected profit of firms outsourcing to the spot market,  $E(\pi_{AS})$ , and to the independent supplier,  $E(\pi_{ALT})$ , simplifies to:

$$E(\pi_{AS}) = \frac{[\alpha_A - \beta_A(c_A + m)]^2}{\beta_A(1+n)^2} - f_A + \frac{s^2\beta_A}{(1+n_S)^2} \quad (22)$$

$$E(\pi_{ALT}) = \frac{[\alpha_A - \beta_A(c_A + c_B)]^2}{\beta_A(1+n)^2} - f_A \quad (23)$$

Since we are assuming that the buyers have all the bargaining power ( $\eta = 1$ ) and the supplier only incurs marginal costs  $c_B$ , it follows immediately that if the outsourcing price is equal to the expected spot price ( $p_{BLT} = m$ ), then the marginal cost of the supplier is also equal to the expected spot price ( $c_B = m$ ), such that the firm makes zero profit. Using this assumption, one can show that the advantage of the spot regime becomes:

$$Surplus \equiv E(\pi_{AS}) - E(\pi_{ALT}) = \frac{s^2\beta_A}{(1+n_S)^2} \geq 0 \quad (24)$$

and the equilibrium is the one stated in proposition 2 below.<sup>7</sup> From now on we denote the equilibrium number of firms outsourcing to the spot market by  $n_S^*$ .

**Proposition 2** *Assume that the expected spot price is the same as the outsourcing price provided by the supplier ( $m = p_{BLT}$ ). If the level of input price uncertainty is such that each firm competing in market A has zero financial distress costs, the oligopoly equilibrium consists of all firms outsourcing to the spot market.*

In equilibrium, all firms outsource to the spot market in order to benefit from the positive convexity effect of input price uncertainty, as given by the surplus expression  $\frac{s^2\beta_A}{(1+n_S)^2}$ . Note, however, that there is a difference between this expression and the one derived for the monopoly,  $\frac{s^2\beta_A}{4}$ . Now, the positive convexity effect is adjusted for the number of firms outsourcing to the spot market, and this illustrates the additional effect of product market competition. An increase in product market competition (an increase in  $n_S$ ) causes an obvious reduction on the firms' surplus from outsourcing. Figure 2.2 provides an illustration of this product market competition effect and also depicts the above equilibrium.<sup>8</sup> It shows that the expected profit of firms outsourcing to the spot market,  $E(\pi_{AS})$ , decreases as the number of firms in this regime increase but, given that financial distress costs are zero, this profit is always higher than the expected profit of firms outsourcing to the independent supplier,  $E(\pi_{ALT})$ . Therefore, in equilibrium, all firms outsource to the spot market in order to take advantage of the positive convexity effect of input price uncertainty.

(Insert Figure 2.2 here)

Next, we examine the equilibrium assuming that financial distress costs can be

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<sup>7</sup>The expressions for the set of parameters that ensure zero financial distress costs are presented in the Appendix.

<sup>8</sup>The figure is generated using the following parameter values.  $m = c_B = 20$ ,  $\alpha_A = 120$ ,  $\beta_A = 1$ ,  $c_A = 20$ ,  $f_A = 0$ ,  $s = 6$ ,  $k = 5$ ,  $n = 12$ , and  $D = 0$ .

positive. Given the equilibrium expressions from proposition 1, one can show that the surplus from the spot market regime is now given by:

$$Surplus = \frac{s^2\beta_A}{(1+n_S)^2} - \frac{1}{2} (FDC_S^u - FDC_{GM}^d) \quad (25)$$

where the expressions for  $FDC_S^u$  and  $FDC_{GM}^d$  are given by (16) and (19), respectively. The advantage from the spot regime now depends on the balance between the positive convexity effect of input price uncertainty and the difference in financial distress costs of both regimes, this last term adjusted for the probability associated with each state of nature. This result allows us to make the following prediction.<sup>9</sup>

**Proposition 3** *Assume that the expected spot price is the same as the outsourcing price provided by the supplier ( $m = p_{BLT}$ ). If the level of input price uncertainty is such that each firm competing in market A can incur positive financial distress costs, the oligopoly equilibrium is as follows: all firms outsource to the spot market if  $\frac{s^2\beta_A}{(1+n_S^*)^2} > \frac{1}{2} (FDC_S^u - FDC_{GM}^d)$  and all firms outsource to the independent supplier if otherwise. The financial distress costs expressions  $FDC_S^u$  and  $FDC_{GM}^d$  were previously stated in proposition 5.*

Proposition 3 shows that firms outsource to the spot market in order to take advantage of the positive convexity effect of input price uncertainty,  $\frac{s^2\beta_A}{(1+n_S)^2}$ , but only when this advantage compensates the differences in financial distress costs of both regimes,  $\frac{1}{2} (FDC_S^u - FDC_{GM}^d)$ .

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<sup>9</sup>Once again, the expressions for the set of parameters that ensure positive financial distress costs are presented in the Appendix.

### 2.1.2 Equilibrium assuming that the outsourcing price provided by the supplier is lower than the expected spot price

In this section we derive the equilibrium assuming the additional cost differential effect between the spot market and the supplier, i.e. we consider that the supplier is able to provide an outsourcing price lower than the expected spot price ( $p_{BLT} < m$ ). Given our assumption that the buyers have all the bargaining power,  $\eta = 1$ , this is equivalent to assume that the difference between the expected spot price and the supplier's marginal cost is positive ( $m - c_B > 0$ ). Analogously to the previous section, we start with the version of the model that ignores financial distress costs, and subsequently introduce these costs.

Using the equilibrium expressions derived in proposition 1, we show that if financial distress costs are zero, the expected profits of firms that outsource to the spot market and to the independent supplier are, respectively:

$$E(\pi_{AS}) = \frac{[\alpha_A - \beta_A(c_A + m + (n - n_S)(m - c_B))]^2}{\beta_A(1 + n)^2} - f_A + \frac{s^2\beta_A}{(1 + n_S)^2} \quad (26)$$

$$E(\pi_{ALT}) = \frac{[\alpha_A - \beta_A(c_A + c_B - n_S(m - c_B))]^2}{\beta_A(1 + n)^2} - f_A \quad (27)$$

These profit expressions can be directly compared with the ones where there was no cost differential between the two outsourcing regimes ((22) and (23), respectively). The difference relies on the first term of each expression that has now the extra component related with the cost difference ( $m - c_B$ ), and this component is either multiplied by the number of firms outsourcing to the independent supplier ( $n - n_S$  for  $E(\pi_{AS})$ ) or by the number of firms outsourcing to the spot market ( $n_S$  for  $E(\pi_{ALT})$ ). Before we proceed to the investigation of the outsourcing equilibrium, we discuss the intuition behind this new effect.

To support our discussion, we derive the comparative statics of the expected profits with respect to the number of firms outsourcing to the spot market  $n_S$ . The comparative statics of  $E(\pi_{AS})$  is:

$$\frac{\partial E(\pi_{AS})}{\partial n_S} = \frac{\partial \left[ \frac{[\alpha_A - \beta_A(c_A + m) + (n - n_S)(m - c_B)]^2}{\beta_A(1+n)^2} \right]}{\partial n_S} + \frac{\partial \left[ \frac{s^2 \beta_A}{(1+n_S)^2} \right]}{\partial n_S} \quad (28)$$

where

$$\frac{\partial \left[ \frac{[\alpha_A - \beta_A(c_A + m) + (n - n_S)(m - c_B)]^2}{\beta_A(1+n)^2} \right]}{\partial n_S} > 0 \quad (29)$$

$$\frac{\partial \left[ \frac{s^2 \beta_A}{(1+n_S)^2} \right]}{\partial n_S} < 0 \quad (30)$$

The results show that an increase in the number of firms outsourcing to the spot market has two opposite on the expected profit of firms outsourcing to the spot market. The derivative (30) illustrates the dilution of the positive convexity effect that occurs when there is an increase in product market competition (same as in previous section). On the other hand, the derivative (29) captures the idea that an increase in  $n_S$  represents an increase in the number of less efficient firms (less efficient in comparison with firms that outsource to the independent supplier given that  $m - c_B > 0$ ), leading to an upward move on the prices in market  $A$  and therefore to a positive effect on the expected profits of firms that outsource to the spot market. Hence,  $E(\pi_{AS})$  is decreasing or increasing in  $n_S$  depending on the balance between these two effects. The more efficient is the supplier when compared to the spot market (the larger is the wedge  $m - c_B$ ), the stronger is the cost differential effect given by (29) and the higher are the changes that  $E(\pi_{AS})$  is increasing in  $n_S$ . Moreover, it follows immediately from (27) that an increase in the number of firms outsourcing to the spot market has a positive effect on the expected profit under the long term contract regime, i.e.  $\partial E(\pi_{ALT}) / \partial n_S > 0$ . This is due to the positive effect that an increase in  $n_S$  has on the prices in market  $A$ .

Having discussed the effect on the expected profits of product market competition and differences in costs, we are now in a position to examine the surplus from the spot market regime, and consequently the choice of the equilibrium regime. The surplus from the spot regime is:

$$Surplus = \frac{s^2 \beta_A}{(1 + n_S)^2} - (B - A) \quad (31)$$

where

$$A \equiv \frac{[\alpha_A - \beta_A (c_A + m + (n - n_S) (m - c_B))]^2}{\beta_A (1 + n)^2} \quad (32)$$

$$B \equiv \frac{[\alpha_A - \beta_A (c_A + c_B - n_S (m - c_B))]^2}{\beta_A (1 + n)^2} \quad (33)$$

The second term in the surplus expression  $(B - A)$  represents the cost disadvantage of the spot market regime due to the cost differential effect discussed earlier. Given our assumption that  $m - c_B > 0$ , one can show that  $B - A > 0$ . Hence, the overall surplus from the spot regime depends on the balance between this negative cost differential effect and the positive effect induced by input price uncertainty (as given by the first term). Proposition 4 summarizes the equilibrium under these assumptions.

**Proposition 4** *If the level of input price uncertainty is such that financial distress costs are zero and the outsourcing price provided by the supplier is lower than the expected spot price ( $p_{BLT} < m$  or  $m - c_B > 0$ ), the oligopoly equilibrium is as follows: all firms outsourcing to the independent supplier if  $\frac{s^2 \beta_A}{(1 + n_S^*)^2} - (B - A) < 0$  or an asymmetric equilibrium where some firms outsource to the spot market and others outsource to the independent supplier if  $\frac{s^2 \beta_A}{(1 + n_S^*)^2} - (B - A) = 0$ .*

An asymmetric equilibrium still has to ensure positive quantities for those firms outsourcing to the spot market. The problem is that as the cost difference  $(m - c_B)$  becomes very high, meaning that the supplier's outsourcing price is much more

competitive than the one expected from the spot market, we are likely to not satisfy the condition of positive spot quantities in the bad state. In this case, the equilibrium would consist of all firms outsourcing to the independent supplier.

If, however, the condition is satisfied, the profit functions intersect each other as we increase  $n_S$ . The intersection point  $n_S^*$  is the equilibrium number of firms outsourcing to the spot market (the number of firms outsourcing to the independent supplier would be  $n - n_S^*$ ). This result is very intuitive. When the supplier is able to provide an outsourcing price much lower than the expected spot price, it is very difficult to find a firm willing to outsource to the spot market as the positive convexity effect of the spot regime cannot compensate this cost disadvantage. Rather, when the cost disadvantage is low, some firms will be willing to outsource to the spot market.

Finally, we derive the equilibrium when the outsourcing price provided by the supplier is lower than the expected spot price, and there is the possibility that at least in one regime financial distress costs are positive. One can show that the surplus expression is extended with an extra term related with the differences in financial distress costs,  $1/2 (FDC_S^u - FDC_{GM}^d)$ , as we had in the previous section. It follows that:

$$Surplus = \frac{s^2 \beta_A}{(1 + n_S)^2} - (B - A) - \frac{1}{2} (FDC_S^u - FDC_{GM}^d) \quad (34)$$

where the expressions for  $A$  and  $B$  are given by (32) and (33), respectively, and the expressions for  $FDC_S^u$  and  $FDC_{GM}^d$  were previously stated in proposition 1. Therefore, the surplus from the spot regime now depends on the trade-off between the sum of the positive convexity effect of input price uncertainty (first term) and the negative effect of cost differentials (second term) and the differences in financial distress costs that can occur in both regimes (third term). Proposition 5 summarizes the new equilibrium under this assumptions.

**Proposition 5** *If the level of input price uncertainty is such that firms can incur positive financial distress costs, and the outsourcing price provided by the supplier is lower than the expected spot price ( $p_{BLT} < m$  or  $m - c_B > 0$ ), the oligopoly equilibrium is as follows:*

A) *If  $FDC_{GM}^d = 0$  and  $\frac{s^2\beta_A}{(1+n_S^*)^2} - (B - A) - \frac{1}{2}FDC_S^u < 0$  all firms outsource to the independent supplier.*

B) *If  $FDC_{GM}^d = 0$  and  $\frac{s^2\beta_A}{(1+n_S^*)^2} - (B - A) - \frac{1}{2}FDC_S^u = 0$  there is an asymmetric equilibrium where some firms outsource to the spot market and others outsource to the independent supplier.*

C) *If  $\frac{s^2\beta_A}{(1+n_S^*)^2} - (B - A) - \frac{1}{2}(FDC_S^u - FDC_{GM}^d) > 0$  all firms outsource to the spot market.*

Proposition 5 has several interesting implications. First, if the outsourcing price provided by the supplier is much lower than the expected spot price, such that the cost disadvantage of the spot regime dominates, then all firms are likely to outsource to the independent supplier (equilibrium A). Second, as this cost disadvantage is reduced ( $p_{BLT} = c_B$  approaches  $m$ ), then it may be optimal for some firms to outsource to the spot market as by doing it they can benefit from the positive convexity effect of input price uncertainty. They may do so even incurring financial distress costs (equilibrium B). Finally, if we combine a low cost advantage of the long term contract regime with increased product market competition of firms outsourcing to the spot market, firms outsourcing to the independent supplier may start incurring deadweight losses induced by this competition effect, and this can lead to an equilibrium where they all outsource to the spot market (equilibrium C). This last equilibrium shows how important can be financial distress costs for the choice of the outsourcing regime. Due to the product market competition effect in the down-

stream market, firms may have to avoid the use of a long term contract as it can also induce positive financial distress costs.

### 3 Conclusions

This paper develops a model that examines a firm's choice between outsourcing to an independent supplier, using a long term contract, and outsourcing to the spot market, by incorporating an important dimension of the problem: product market competition.

The oligopoly structure brings new insights with respect to the outsourcing decision. We find that product market competition can also induce positive financial distress costs as it affects downstream prices. Therefore, firms that outsource to the spot market can incur financial distress costs not only due to higher input prices but also due to higher competition of other firms outsourcing with a long term contract. This competition effect can also trigger positive financial distress costs for firms that outsource with a long term contract. We derive the set of parameters that induce these costs, and show that the outsourcing equilibrium depends on the balance between the positive convexity effect of the spot regime and the differences in financial distress costs of both regimes. When financial distress costs are zero for firms that outsource to the spot market, all firms choose the spot market regime, whereas if financial distress costs are high, they all outsource to the independent supplier.

Finally, we examine the effect on the equilibrium of assuming that the independent supplier is more efficient than the spot market, in the sense that it can provide an outsourcing price lower than the expected spot price. This obviously adds a disadvantage to the spot market regime. We find that, under some circumstances,

this can lead to an asymmetric equilibrium, where some firms outsource to the spot market and others to the independent supplier. The more efficient is the supplier, the higher is the proportion of firms willing to switch from the spot regime to the long term contract regime.

There are some ways of extending the study theoretically. First, incorporate the possibility of partial outsourcing where the buyers could outsource a proportion of the input to the spot market and another proportion to the independent supplier. Second, allow for an outside option of the supplier and consider some capacity constraints in production such that this production is not enough to satisfy all buyers. Finally, introduce product market competition in the spot market in order to study the effect of demand shocks in the upstream market. This could help us to explore in more detail the cost differential effect considered in the last part of our model.

## 4 Appendix

### Proof of proposition 1

The proof is given in the main text. The expressions for the individual equilibrium quantities of firms outsourcing to the spot market in state  $u$  and  $d$  and for firms outsourcing to the independent supplier are, respectively:

$$q_{AS}^u = \frac{\alpha_A - \beta_A (c_A + m + (n - n_S) (m - c_B))}{(1 + n)} - \frac{s\beta_A}{1 + n_S} \quad (35)$$

$$q_{AS}^d = \frac{\alpha_A - \beta_A (c_A + m + (n - n_S) (m - c_B))}{(1 + n)} + \frac{s\beta_A}{1 + n_S} \quad (36)$$

$$q_{ALT} = \frac{\alpha_A - \beta_A [c_A + c_B - n_S (m - c_B)]}{1 + n} \quad (37)$$

Moreover, the expressions of the realized profit with zero financial distress costs of firms that outsource to the spot market are:

$$\pi_{AS\ NFDC}^u = \frac{\{(1 + n_S) [\alpha_A - \beta_A (c_A + m + (n - n_S) (m - c_B))] - s\beta_A (1 + n)\}^2}{\beta_A (1 + n)^2 (1 + n_S)^2} - f_A \quad (38)$$

$$\pi_{AS\ NFDC}^d = \frac{\{(1 + n_S) [\alpha_A - \beta_A (c_A + m + (n - n_S) (m - c_B))] + s\beta_A (1 + n)\}^2}{\beta_A (1 + n)^2 (1 + n_S)^2} - f_A \quad (39)$$

Finally, the expressions of the realized profit with zero financial distress costs of firms that outsource to the independent supplier are:

$$\begin{aligned} \pi_{ALT\ NFDC}^u &= \frac{[\alpha_A - \beta_A (c_A + c_B - n_S (m - c_B))]^2}{\beta_A (1 + n)^2} \\ &+ \frac{s [\alpha_A - \beta_A (c_A + c_B - n_S (m - c_B))] n_S}{(1 + n) (1 + n_S)} - f_A \end{aligned} \quad (40)$$

$$\begin{aligned} \pi_{ALT\ NFDC}^d &= \frac{[\alpha_A - \beta_A (c_A + c_B - n_S (m - c_B))]^2}{\beta_A (1 + n)^2} \\ &- \frac{s [\alpha_A - \beta_A (c_A + c_B - n_S (m - c_B))] n_S}{(1 + n) (1 + n_S)} - f_A \end{aligned} \quad (41)$$

## Proof of proposition 2

The proof is given in the main text. The expressions that state the set of parameters for which financial distress costs are zero are derived as follows. We first derive the condition for positive financial distress costs and then assume that the condition for zero financial distress costs is the opposite. As noted earlier, it is assumed that firms outsourcing to the spot market can only incur positive financial distress costs in the bad state, whereas firms that outsource to the independent supplier can only incur these costs in the good state. Let us start with the condition for positive financial distress costs of those firm that outsource to the spot market ( $FDC_S^u > 0$  with  $FDC_S^u$  given by (16)). We solve  $FDC_S^u > 0$  for the input price uncertainty measure  $s$ . It follows that  $FDC_S^u = 0$  if

$$s < (1 + n_S) \frac{[\alpha_A - \beta_A (c_A + m + (n - n_S) (m - c_B))] - (1 + n) \sqrt{\beta_A (D + f_A)}}{\beta_A (1 + n)} \quad (42)$$

and positive if otherwise. As for the condition for positive financial distress costs of those firms outsourcing to the independent supplier ( $FDC_{GM}^d > 0$  with  $FDC_{GM}^d$  given by (19)), we solve  $FDC_{GM}^d > 0$  for  $s$  and it follows that  $FDC_{GM}^d = 0$  if

$$s < \frac{[\alpha_A - \beta_A (c_A + c_B - n_S (m - c_B))] (1 + n_S)}{\beta_A (1 + n) n_S} - \frac{(D + f_A) (1 + n) (1 + n_S)}{[\alpha_A - \beta_A (c_A + c_B - n_S (m - c_B))] n_S} \quad (43)$$

and positive if otherwise.

Given our assumption in this section that ( $m = c_B$ ), the condition for  $FDC_S^u = 0$  and  $FDC_{GM}^d = 0$  simplify to (44) and (45), respectively:

$$s < (1 + n_S) \frac{[\alpha_A - \beta_A (c_A + m)] - (1 + n) \sqrt{\beta_A (D + f_A)}}{\beta_A (1 + n)} \quad (44)$$

$$s < \frac{[\alpha_A - \beta_A (c_A + c_B)] (1 + n_S)}{\beta_A (1 + n) n_S} - \frac{(D + f_A) (1 + n) (1 + n_S)}{[\alpha_A - \beta_A (c_A + c_B)] n_S} \quad (45)$$

## Proof of proposition 3

The proof is given in the main text.

#### **Proof of proposition 4**

The proof is given in the main text.

#### **Proof of proposition 5**

The proof is given in the main text. The set of parameters for which financial distress costs are positive was previously derived in the proof of proposition 2.

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