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ORIGINAL RESEARCH

Outsourcing with long term contracts: capital structure and product market competition effects

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Abstract This paper analyzes how capital structure and product market competition affect the firms' strategic choice between outsourcing with long term contracts and outsourcing to the spot market. When outsourcing to the spot market firms are exposed to price uncertainty, whereas a long term contract allows them to set in advance the outsourcing price. We show that, to the extent that leverage and uncertainty can lead to financial distress costs in bad states of nature, firms may use long term contracts as a risk management device to hedge input price uncertainty. With a monopoly in the final product market, the outsourcing decision involves a trade-off between a positive convexity effect of input price uncertainty under the spot regime and the option to avoid financial distress costs under the long term contract regime. Moreover, 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 examine the monopolist's outsourcing decision and 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

1 Introduction

Outsourcing has become an important part of today's business as many organizations rely on outsourcing to organize their production modes. In 2002 US manufacturers were outsourcing more than 70 % of their products (Corbert 2004) and in the UK a survey realized in 2000 shows that 68 % of organizations outsource some of their activities (Manpower

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UK Ltd. 2003). In recent years, benefiting from deregulation of emerging economies, increased competition, improvements in information technology and rapid dissemination of the internet, many firms have started to outsource internationally.[1] There has been, however, mixed patterns in the way firms conduct their outsourcing activities. Some firms engage in long term contractual agreements with independent suppliers, while others rely on outsourcing directly to the spot market, without any sort of long term commitment with suppliers.

There are some important differences between these two outsourcing regimes that can potentially affect the firms' profits and market value. Outsourcing to the spot market often involves price uncertainty, whereas outsourcing to independent suppliers, using a long term contract, allows firms to set in advance the outsourcing price for the duration of the contract. This suggests that long term contracts are somehow equivalent to forward contracts, and therefore can be used to rule out price uncertainty. This paper explicitly examines a buyer's strategic choice between outsourcing to the spot market and outsourcing to an independent supplier, using a long term contract, by recognizing that levered firms may use long term contracts for risk management reasons. When exposed to high input price uncertainty, levered firms may experience deadweight losses from financial distress in bad states of nature, and this provides an important incentive to outsource with long term contracts.[2]

Financial distress has been described in the risk management literature as a state where a levered firm incurs additional losses (deadweight costs) because its cash flows are not sufficient to cover debt payments. The papers that have analyzed the importance of risk management to reduce these deadweight costs of financial distress include Smith and Stulz (1985), Froot et al. (1993), Brown and Toft (2002), Fehle and Tsyplakov (2005), Hahnenstein and Röder (2007) and Purnanandam (2008). This literature usually considers three main sources of financial distress costs. First, financial distress costs arise due to the decrease in product-market competitiveness. A financially distressed firm may lose customers, valuable suppliers and key employees because these stakeholders may seek to reduce their long-term dependence on firms with a high likelihood of bankruptcy. Second, a financially distressed firm is more likely to violate its debt covenants or miss coupon/principal payments (Purnanandam 2008). These violations impose deadweight losses in the form of financial penalties, accelerated debt-payments, operations inflexibility and managerial time and resources spent on negotiations with the lenders. Finally, a financially distressed firm may have to forego a positive NPV project due to costly external financing, as in Froot et al. (1993).

By incorporating financial distress costs in our framework, we create an obvious link between our study and this literature. There are, however, important differences in the modeling strategy. The risk management literature focus on hedging with derivatives, whereas we assume that long term contracts can be used as a complement to derivatives to hedge input price risk. Spinler et al. (2003) give the example of polyethylene companies that usually have small margins and cannot afford the high costs of some derivatives. Cohen and Agrawal (1999) and Stulz (1996) refer to the importance of long term contracts

[1] For a survey on the forces driving international outsourcing see Spencer (2005). Kuo and Wang (2005) provide empirical report that during the 1997 Asian financial crisis multinational firms, especially in the IT industry, have substantially used international outsourcing in order to cut costs. Also, Lambrecht et al. (2012) develop a model where they show how firm adjust the outsourcing strategy to the economic cycle.

[2] Of course, there are a number of other motivations for hedging, including taxes, managerial incentives, capital market imperfections and inefficient investment. For a review of the determinants of hedging by corporations see Smith and Stulz (1985) and Froot et al. (1993).

as a risk management instrument for risk averse decision makers, and Li and Kouvelis (1999) provide some examples where the outsourcing of inputs involves substantial price uncertainty such that the use of long term outsourcing contracts is very important (paper, agriculture, electronics, textiles, commodity fibers, petro chemical).

Since financial distress costs play an important role in our model, we are especially concerned with the factors that drive these costs, and ultimately with the effect that these costs have in the outsourcing decision. We start off by examining the outsourcing decision by a monopolist, and subsequently consider an oligopoly. The monopoly framework allows us to focus on the effect of input price uncertainty and leverage on financial distress costs, and consequently on the firm's profits. By expanding the initial model to an oligopoly, we are able to examine the important effect of product market competition on financial distress costs and on the surplus that firms derive from each outsourcing regime. Finally, we also investigate how relevant for the outsourcing decision is the assumption that the independent supplier is somehow more efficient than the spot market in providing the inputs.

With a monopoly in the downstream market, we find that outsourcing to the spot market involves a trade-off between a positive convexity effect of input price uncertainty and a negative effect caused by financial distress costs. The first effect captures the idea that with no deadweight losses associated with bad states of nature, the firm's profits are increasing in input price uncertainty. Given that the buyer can fully adjust capacity for a given input price, he only cares with the upside potential, and therefore takes advantage from price uncertainty.[3] The second effect shows how input price uncertainty can induce deadweight losses when the firm's profit flow in the bad states of nature is not enough to pay out debt. We derive the conditions for which the financial distress costs of the spot regime are positive, and show that they increase as the wedge between debt and the profit flow increases. Therefore, negative demand shocks or an increase in the firm's cost structure causes an increase in financial distress costs as it depresses profits.

Our model predicts that the monopolist always outsources to the spot market if financial distress costs are zero in order to fully benefit from the positive convexity effect of input price uncertainty. Rather, if financial distress costs are positive, the equilibrium depends on how severely are the firm's profits affected by financial distress costs. We derive a measure that captures the sensitivity of these profits to financial distress costs, and show that the long term contract regime holds when there are high financial distress costs associated with the spot regime. By outsourcing with a long term contract the monopolist can perfectly hedge input price uncertainty.

We formalize a bilateral bargaining game between the monopolist and the supplier when the long term contract is in place. The game allows us to make endogenous the proportion of the profit derived by each part, and consequently to make endogenous the outsourcing price. This represents a contribution to the outsourcing literature, in particular to the one that studies the decision to vertically integrate or outsource.[4]

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

[3] This positive convexity effect derives from Jensen's inequality. Since the expected profit is a convex function of input price uncertainty, it follows that the expected value of a convex function of a random variable is greater than the value of the function evaluated at the expected value of the random variable.

[4] Grossman and Helpman (2002), Levy (2006) and Fontenay and Gans (2008) develop an outsourcing model that incorporates a bilateral game between a buyer and a set of suppliers but where the proportion of the surplus collected by each part is exogenous.

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 do 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.[5] We show 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.[6]

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

[5] The analysis is motivated by the findings of Kleindorfer and Wu (2003) and Spinler et al. (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.

[6] 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.

On the other hand, the operations management literature has focused more on the choice between option contracts and the spot market (see Kleindorfer et al. 2002; Spinler et al. 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. In Sect. 2 we set out the basic model and the assumptions for the monopoly structure. Section 3 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 4 concludes and summarizes some empirical predictions of our theory. Proofs of all propositions are detailed in the "Appendix".

2 Monopoly in the downstream market

In this section we examine the choice between outsourcing to the spot market and outsourcing to an independent supplier, using a long term contract, when there is a monopoly in the downstream market. We start off with the derivation of the equilibrium prices and profits under each outsourcing regime, and then proceed with the analysis of the monopolist's equilibrium decision.

Consider a monopolist that produces a homogeneous product A and sells this product in market A. One unit of product A requires one unit of input B. The monopolist can outsource input B either to the spot market B or to an independent supplier. For simplification purposes, we assume that the monopolist only operates in market A, and therefore the quantity that he outsources of input B must equal the quantity that he sells of product A.

There are two dates. At time $t = 0$ the monopolist decides which outsourcing regime he will use to acquire input B. If he outsources to the spot market, he faces input price uncertainty as he does not know what price of input B will prevail at the end of the period. At time $t = 1$ uncertainty is resolved and the monopolist decides which quantity to outsource (and to sell in market A) given the observed input prices. Alternatively, if the monopolist outsources input B to the independent supplier, at time $t = 0$ he writes a long term contract (one-period contract) with the supplier which allows him to set in advance the outsourcing price, and consequently the cost of production for the entire period. Contrary to outsourcing to the spot market, outsourcing with a long term contract rules out all input price uncertainty.

Furthermore, in order to examine the effect of the monopolist's capital structure on the outsourcing decision, we assume that he has debt outstanding in the amount D, which is due to be paid at time $t = 1$. We assume that the monopolist is, in some degree, financially constrained, and also needs debt to take advantage of investment opportunities. For simplification purposes, we assume that the independent supplier has no leverage and does not

compete in market B. The supplier produces with unlimited capacity and only incurs the marginal cost c_B.

We model the input price uncertainty of the spot regime as follows. At time $t = 1$ there are two states of nature, each with a probability of 1/2. Input prices of B can either be high or low. We denote the bad state (high input price) and good state (low input price) by u and d, respectively. These prices are a function of the expected spot price m and input price uncertainty, as measured by s, with $s > 0$, and they are defined as:

$$p_B^u = m + s \tag{1}$$

$$p_B^d = m - s \tag{2}$$

In the downstream market, the demand for product A can be defined as:

$$Q_{\mathrm{A}} = \alpha_A - \beta_A p_A \tag{3}$$

In what follows, we denote the regime where the monopolist outsources to the spot market by S and the regime where he outsources to the independent supplier, with a long term contract, by LT. To simplify the exposition, we assume risk neutrality and a zero interest rate.

Next, we derive the equilibrium profits under each regime and discuss the advantages and disadvantages provided by each one. Consider first the case where the monopolist is outsourcing to the spot market. At time $t = 0$ the expected profit of the monopolist, $E(\Pi_{AS})$, is given by:

$$E(\Pi_{AS}) = \frac{1}{2}\overset{u}{\underset{AS}{\Pi}} + \frac{1}{2}\overset{d}{\underset{AS}{\Pi}} \tag{4}$$

where Π_{AS}^u $\left(\Pi_{AS}^d\right)$ is the realized profit when the spot price of input B is p_B^u $\left(p_B^{\mathrm{d}}\right)$. Furthermore, we assume that the monopolist has a marginal cost c_A and a fixed cost f_A. If we denote the inverse demand function by $p_{AS}^i\left(Q_{AS}^i\right)$, with $i \in \{u, d\}$ (when the input price is p_B^u and p_B^d, respectively), and consider linear cost functions, it follows that the realized profit of the monopolist in state i is:

$$\overset{i}{\underset{AS}{\Pi}} = \overset{i}{\underset{ASNFDC}{\Pi}} - \overset{i}{FDC}_s \tag{5}$$

where FDC_S^i are the financial distress costs that the monopolist may incur when outsourcing to the spot market and Π_{ASNFDC}^i is the realized profit when these financial distress costs are zero. Π_{ASNFDC}^i is defined as:

$$\overset{i}{\underset{ASNFDC}{\Pi}} = Q_{AS}^i\left(p_{AS}^i\left(Q_{AS}^i\right) - c_A - p_B^i\right) - f_A \tag{6}$$

Financial distress costs are associated with bad states of nature (see Turetsky and McEwen 2001; Brown and Toft 2002; Fehle and Tsyplakov 2005; Hahnenstein and Röder 2007; and Purnanandam 2008). Our formal definition of these costs is closely related to the one proposed by Fehle and Tsyplakov (2005). The idea is that when the monopolist is outsourcing with a high input price (in our model when p_B^u is realized), the firm's instantaneous profit flow (revenues minus operating costs) may not be sufficient to pay debt. If this happens, the firm is in financial distress and incurs additional losses. These additional cash flow losses arise because customers, suppliers, or strategic partners may not be willing to deal with financially distressed firms. Hence, the magnitude of financial

distress costs is determined by how low the firm's revenue falls relative to the debt payment and production costs. These costs are important because they may be incurred long before bankruptcy, and they provide an incentive to manage risk. Formally, we define the financial distress costs of the spot regime as:

$$FDC_S^i = k\max\left(0, D - \underset{AS\,NFDC}{\overset{i}{\Pi}}\right) \tag{7}$$

where the parameter $k > 0$ is a constant that captures the intensity of financial distress cost and $\Pi^i_{AS\,NFDC}$ is as stated in (6). An increase in k intensifies the value loss caused by financial distress costs.[7] Since financial distress costs are associated with bad states of nature, we assume in this section that they can only occur when the input price is high (p_B^u), i.e. we assume that $FDC_S^u \geq 0$ and $FDC_S^d = 0$.[8]

We are now in a position to derive the equilibrium expressions for the spot regime. The monopolist optimizes his profit flow with respect to Q^i_{AS}, given the realized price p^i_B at which input B is supplied. Substituting the equilibrium quantities and prices into the profit functions gives us the expressions for Π^u_{AS} and Π^d_{AS}. We further present the equilibrium expression of financial distress costs and the set of parameters for which these are positive. Proposition 1 summarizes these results. To simplify our exposition of the equilibrium, we denote by $E(\Pi_{\mathrm{AS}})_{NFDC}$ the expected profit of the monopolist when financial distress costs are zero, i.e. $E(\Pi_{\mathrm{AS}})_{NFDC} = E(\Pi_{\mathrm{AS}})$ if $FDC_S^{\mathrm{u}} = 0$.

Proposition 1 *If market A is a monopoly where a firm faces the demand function (3) for product A and outsources input B to the spot market, then the equilibrium expected profit of this firm at time $t = 0$ is:*

$$E(\Pi_{AS}) = E(\Pi_{AS})_{NFDC} - \frac{1}{2}FDC_S^u \tag{8}$$

where

$$E(\Pi_{AS})_{NFDC} = \frac{[\alpha_A - \beta_A(c_A + m)]^2}{4\beta_A} - f_A + \frac{s^2\beta_A}{4} \tag{9}$$

$$FDC_S^u = k\,max\left[0, D - \left(\frac{[\alpha_A - \beta_A(c_A + m + s)]^2}{4\beta_A} - f_A\right)\right] \tag{10}$$

Given that $k > 0$, the monopolist incurs positive financial distress costs if:

$$s > \frac{\alpha_A - \beta_A(c_A + m) - 2\sqrt{\beta_A(D + f_A)}}{\beta_A} \equiv \hat{s} \tag{11}$$

and zero financial distress costs if otherwise. The realized profits in the bad and good state are, respectively:

[7] The parameter k has an upper bound (see expression in the "Appendix") to ensure that the monopolist's equity value remains positive. Formally, we require that the expression for the firm's profit, net of financial distress costs, as given by (5), is positive.

[8] The expression for the set of parameters for which $FDC_S^{\mathrm{u}} \geq 0$ is presented in Proposition 1.

$$\prod_{AS}^{u} = \frac{[\alpha_A - \beta_A(c_A + m + s)]^2}{4\beta_A} - f_A - FDC_S^u \tag{12}$$

$$\prod_{AS}^{d} = \frac{[\alpha_A - \beta_A(c_A + m - s)]^2}{4\beta_A} - f_A \tag{13}$$

The equilibrium output prices for product A in the bad and good state are, respectively:

$$p_{AS}^u = \frac{\alpha_A + \beta_A(c_A + m + s)}{2\beta_A} \tag{14}$$

$$p_{AS}^d = \frac{\alpha_A + \beta_A(c_A + m - s)}{2\beta_A} \tag{15}$$

Proposition 1 states that expected profit of the monopolist when outsourcing to the spot market (expression (8)) consists of the expected profit when financial distress costs are zero minus the value of financial distress costs that can arise from outsourcing at a high input price p_B^u (this latter component is multiplied by the probability of reaching the bad state). Hence, it is obvious from this expression the negative effect of financial distress costs on the monopolist's expected profit. Let us now discuss in detail what influences the value of each of these components of the expected profit, particularly the effect of input price uncertainty, leverage, demand shocks and the monopolist's cost structure.

First, consider the case where financial distress costs are zero. The expected profit is given by (9), which we decompose in two components. The first, $\frac{[\alpha_A - \beta_A(c_A + m)]^2}{4\beta_A} - f_A$, only incorporates demand and cost parameters, whereas the second, $\frac{s^2\beta_A}{4}$, provides the additional effect of input price uncertainty. The first component of the expected profit shows how positive demand shocks, like an increase in the size of market A (measured by α_A) or a reduction in the buyer's variable and fixed production costs (c_A and f_A, respectively) affects positively the firm's profit flow. Furthermore, the monopolist benefits from a decrease in the expected spot price from outsourcing (as measured by m). The second component of the expected profit represents the important positive convexity effect of uncertainty (as measured by s) on profits. If financial distress costs are zero ($s \leq \hat{s}$, with $\hat{s}$ defined in (11)), there is no cost associated with the bad state of nature since the monopolist can fully adjust capacity and care exclusively with the upside potential (outsourcing at a lower input price). In this case, higher input price uncertainty always increases the advantage of the spot regime.[9]

Input price uncertainty can also have, however, a negative effect on the monopolist's expected profit when there are financial distress costs caused by the firm's leverage. Before we discuss the overall effect of input price uncertainty on this expected profit, let us analyze what exactly determines the magnitude of these financial distress costs. From (10), one can see that these costs depend positively on the parameter k associated with the intensity of financial distress costs and also on the positive wedge between debt (D) and the profit flow realized in the bad state of nature ($\frac{[\alpha_A - \beta_A(c_A + m + s)]^2}{4\beta_A} - f_A$). All else equal, an

[9] As noted earlier, this positive convexity effect derives from Jensen's inequality.

increase in the uncertainty measure s in the bad state of nature induces a higher input price p_B^u, and as a consequence an increase in financial distress costs.[10]

Therefore, there are two opposite effects of an increase in input price uncertainty on the monopolist's expected profit from outsourcing to the spot market: the positive convexity effect versus the negative effect caused by financial distress costs. We show that the intensity of financial distress costs, as measured by k, plays an important role in the overall effect of uncertainty as:

$$\frac{\partial E(\Pi_{AS})}{\partial s} > (<) 0 \text{ if } k < (>) \frac{4\beta_A s}{\alpha_A - \beta_A(c_A + m + s)} \equiv k^* \tag{16}$$

The intuition behind condition (16) is that if the intensity of financial distress costs is low ($k < k^*$), the positive convexity effect dominates and an increase in s increases the monopolist's expected profit. Hence, even with positive financial distress costs the monopolist may benefit from increased uncertainty in the spot market. Conversely, if the intensity of financial distress costs is high ($k > k^*$), the financial distress cost effect dominates and the monopolist has an incentive to avoid outsourcing to the spot market.

Next, we consider the case where the monopolist outsources the production of input B to the independent supplier, using a long term contract. We assume that the negotiation process in the long term contract is formalized as Nash bargaining, where the bargaining power is split between the monopolist and the supplier.[11] The distribution of the bargaining power is given exogenously and is described by the parameter $\eta \in [0, 1]$, where η is defined as the monopolist's bargaining power. As a result of bargaining, each side receives a fraction of the total profit under global maximization.[12] We start off with the determination of the total profit under global maximization, and subsequently derive the optimal sharing rule and the firms' profits.

If we denote the inverse demand function by $p_{ALT}(Q_{ALT})$, it follows that the total profit under global maximization, Π_{GM}, is:

$$\Pi_{GM} = Q_{ALT}(p_{ALT}(Q_{ALT}) - c_A - c_B) - f_A \tag{17}$$

Let w be the outcome of the Nash bargaining process such that the monopolist receives a fraction w of the total profit under global maximization and the supplier receives $1 - w$, with $w \in [0, 1]$. The proportion of the total profit received by each side depends on the value of the firms' outside options. These are the profits the parties would make in case they decide to quit the negotiation. We assume that the monopolist's outside option consists of outsourcing to the spot market, and therefore its value is given by the profit expression$E(\Pi_{AS})$, previously stated in Proposition 1 (Eq. (8)). For simplification purposes, we assume that the supplier has no outside option. Therefore, the fraction received by the monopolist must be the solution to the Nash bargaining game (maximization with respect to w):

$$\max_w [w\Pi_{GM} - E(\Pi_{AS})]^{\eta}[(1 - w)\Pi_{GM} - 0]^{1-\eta} \tag{18}$$

[10] When the condition for positive financial distress costs (11) is satisfied, we show that financial distress costs depend positively on s as $\frac{\partial FDC_s^u}{\partial s} = k\frac{\alpha_A - (c_A + m + s)}{2} > 0$.

[11] The game in is modeled as in Fan and Sundaresan (2000). In order to focus on the role of financial distress on the outsourcing decision, we ignore repeated interactions between the buyer and the supplier (see Dawid and Kopel 2003 and Hadlock and Lewis 2003 for a dynamic model of bargaining in subcontracting).

[12] This is the maximum profit the parties can make together if negotiation is possible, where they act jointly as a global optimizer.

It follows that the optimal sharing rule is[13]:

$$w = \frac{\eta[\Pi_{GM} - E(\Pi_{AS})] + E(\Pi_{AS})}{\Pi_{GM}} \tag{19}$$

These results show that if the monopolist's outside option is zero ($E(\Pi_{AS}) = 0$), he receives a fraction of the total profit under global maximization equal to his exogenous bargaining power ($w = \eta$). Alternatively, if the expected profit from outsourcing to the spot market equals the total profit that is possible to generate with the long term contract ($E(\Pi_{AS}) = \Pi_{GM}$), he is able to collect the full surplus of the long term contract as $w = 1$. Expression (19) also shows another important result concerning the effect of input price uncertainty on the proportion of the profits collected by each firm, and as a consequence on the profits they realize with the long term contract. Given that the magnitude of input price uncertainty (as measured by s) has effect on the monopolist's expected profit from outsourcing to the spot market ($(E(\Pi_{AS}))$), the proportion that he derives with the long term contract is naturally affected by this uncertainty.

Next, denote the buyer's and the supplier's profit with the long term contract by Π_{ALT} and Π_{BLT}, respectively. Given the assumption above, these profits sum up to the profit under global maximization, $\Pi_{GM} = \Pi_{ALT} + \Pi_{BLT}$, and can be defined as $\Pi_{ALT} = w\Pi_{GM}$ and $\Pi_{BLT} = (1 - w)\Pi_{GM}$. Also, if we denote the agreed input price of the long term contract by p_{BLT}, and assume, as before, that $Q_{ALT} = Q_{BLT}$, it follows that these profits are given by:

$$\Pi_{ALT} = w\Pi_{GM} = Q_{ALT}(p_{ALT}(Q_{ALT}) - c_A - p_{BLT}) - f_A \tag{20}$$

$$\Pi_{BLT} = (1 - w)\Pi_{GM} = Q_{ALT}(p_{BLT} - c_B) \tag{21}$$

With these results, we can easily determine the equilibrium outsourcing price agreed for input B under the long term contract. It is obtained by solving any of these profit functions for p_{BLT} (Eqs. (20) or (21)), after substituting the proportion w by the expression previously derived in (19). It follows that the outsourcing input price is given by:

$$p_{BLT} = \frac{(1 - \eta)[\Pi_{GM} - E(\Pi_{AS})]}{Q_{ALT}} + c_B \tag{22}$$

As expected, in both scenarios where the monopolist is able to collect the whole surplus from the long term contract (as discussed earlier, when the profit under global maximization equals the outside option, $\Pi_{GM} = E(\Pi_{AS})$, or when $\eta = 1$), the outsourcing price converges to the marginal cost of the supplier, and the supplier makes a zero profit.

We are now in a position to determine the equilibrium quantities, prices and profits under the long term contract regime. The equilibrium quantities Q_{ALT} are derived by optimizing the total profit under global maximization defined in Eq. (17). By substituting this quantity into the demand function (3), we obtain the equilibrium prices in market A, p_{ALT}. Finally, by substituting these quantities and prices into the profit functions (20) and (21), we determine the expressions for the equilibrium profits of the monopolist and the supplier, respectively. These results are summarized in Proposition 2.

Proposition 2 *If market A is a monopoly where a firm faces the demand function (3) for product A and outsources input B to an independent supplier, using a long term contract,*

[13] The optimization problem is solved only for the relevant case where the monopolist's outside option is lower than the total profit under global maximization, i.e. $E(\Pi_{AS}) \leq \Pi_{GM}$.

then the equilibrium profit under global maximization that is possible to generate with the contract is:

$$\Pi_{GM} = \frac{[\alpha_A - \beta_A(c_A + c_B)]^2}{4\beta_A} - f_A \tag{23}$$

The equilibrium profits of the monopolist and the supplier are, respectively:

$$\Pi_{ALT} = E(\Pi_{AS}) + \eta[\Pi_{GM} - E(\Pi_{AS})] \tag{24}$$

$$\Pi_{BLT} = (1 - \eta)[\Pi_{GM} - E(\Pi_{AS})] \tag{25}$$

where Π_{GM} is given by (23) and $E(\Pi_{AS})$ is the value of the monopolist's outside option as given by (8). The equilibrium output price for product A is:

$$p_{ALT} = \frac{\alpha_A + \beta_A(c_A + c_B)}{2\beta_A} \tag{26}$$

Proposition 2 shows that input price uncertainty, as measured by s, has no effect on the downstream price of product A, and consequently on the profit under global maximization. As to be expected, the long term contract allows the monopolist to perfectly hedge input price uncertainty by setting in advance the outsourcing price. If there are relevant reasons for hedging input price uncertainty, then long term contracts can represent an important tool for risk management. We discuss next, under which circumstances the use of long term contracts can create value for the firm.

2.1 Monopolist's choice of the outsourcing regime

We now examine the monopolist's choice of the outsourcing regime at time $t = 0$. The monopolist compares the expected profit from outsourcing to the spot market with the profit under global maximization from outsourcing with the long term contract and chooses the regime with the highest expected profit. Let us denote the extra profit or surplus from outsourcing to the spot market by:

$$Surplus = E(\Pi_{AS}) - \Pi_{GM} \tag{27}$$

In order to focus our discussion of the equilibrium on the effect of input price uncertainty and financial distress costs, we ignore any cost differences between the two regimes, i.e. we assume that the expected input price from the spot market is the same as the supplier's marginal cost ($m = c_B$). Under this assumption, one can show that the surplus from the spot market regime is given by:

$$Surplus = \frac{s^2\beta_A}{4} - k\,max\left[0, D - \left(\frac{[\alpha_A - \beta_A(c_A + m + s)]^2}{4\beta_A} - f_A\right)\right] \tag{28}$$

Expression (28) states that the advantage of the spot market regime relies on the trade-off between a positive convexity effect of uncertainty (first term of (28)) and a negative effect caused by financial distress costs (second term of (28)). This result has several interesting implications, which we state in the following two propositions. Proposition 3

summarizes the equilibrium if financial distress costs are zero, whereas Proposition 4 considers positive financial distress costs.

Proposition 3 *Assume that the expected spot price is the same as the supplier's marginal cost ($m = c_B$) and consider the input price uncertainty level $\hat{s}$ as stated previously in (11). If $0 < s \leq \hat{s}$ such that financial distress costs are zero, the monopolist always outsources to the spot market.*

This proposition shows that if the level of input price uncertainty is not enough to cause any financial distress costs, the monopolist has no deadweight losses associated with the spot regime, and thus chooses this regime in order to benefit from the positive convexity effect of uncertainty. He derives a surplus from outsourcing given by $\frac{s^2\beta_A}{4}$.

Now, let us assume that the level of uncertainty is such that financial distress costs from outsourcing to the spot regime are positive, i.e. $s > \hat{s}$, with $\hat{s}$ once again as given by the right hand side of (11). In that case, one can show that the surplus expression (28) can be rearranged and expressed as:

$$Surplus(FDC > 0) = \frac{s^2\beta_A}{4} - \frac{1}{2}k(D + f_A) + \frac{1}{2}k\frac{[\alpha_A - \beta_A(c_A + m + s)]^2}{4\beta_A} \tag{29}$$

The surplus from outsourcing is a quadratic function of s, which means that if we solve this function for s, there are two levels of the uncertainty measure where the monopolist is indifferent between one regime and the other. We denote these levels by s_j^*, with $j \in [1, 2]$ and $s_1^* < s_2^*$.[14] One can show that s_j^* is given by:

$$s_{1,2}^* = \frac{k[\alpha_A - \beta_A(c_A + m)] \pm \sqrt{2}\beta_A\sqrt{2(D + f_A)\beta_A(2 + k)k - k[\alpha_A - \beta_A(c_A + m)]^2}}{\beta_A(2 + k)} \tag{30}$$

These levels of the uncertainty measure play an important role in the derivation of the outsourcing equilibrium, as we summarize in Proposition 4 below.

Proposition 4 *Assume that the expected spot price is the same as the supplier's marginal cost ($m = c_B$) and consider the two levels of the input price uncertainty measure s_1^* and s_2^* given by (30), for which the monopolist is indifferent between outsourcing to the spot market and outsourcing with a long term contract. Furthermore, consider the input price uncertainty level $\hat{s}$ as stated previously in (11). If $s > \hat{s}$ such that financial distress costs are positive, the outsourcing choice represents a trade-off between the positive convexity effect associated with uncertainty and the level of financial distress costs. It consists of one of the following three cases:*

A) *If $\hat{s} < s < s_1^*$ the monopolist outsources to the spot market as the positive convexity effect dominates.*
B) *If $s_1^* < s < s_2^*$ the monopolist outsources with a long term contract as the negative effect of financial distress costs associated with the spot regime dominates.*
C) *If $s > s_2^*$ the monopolist outsources to the spot market as the positive convexity effect associated with uncertainty dominates.*

[14] Note, however, that there is an upper bound for s_1^* as it has to ensure positive input prices ($0 < s_j^* < m$) and positive quantities in the bad state of nature $\left(0 < s_j^* < \frac{\alpha_A - \beta_A(c_A + m)}{\beta_A}\right)$. See proof of Proposition 4 for this derivation.

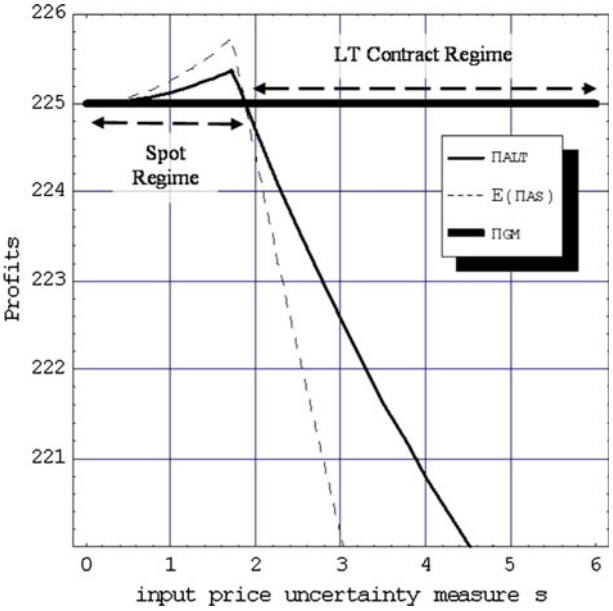

Fig. 1 Monopolist's optimal decision. Expected profit of the monopolist under the spot regime, $E(\Pi_{AS})$, profit of the monopolist under the long term contract regime, Π_{ALT}, and total profit under global maximization, Π_{GM}, as a function of the input price uncertainty measure s. The expected profit under the spot regime is increasing (decreasing) when financial distress are zero (positive). The spot regime dominates if $E(\Pi_{AS}) > \Pi_{GM}$, and the long term contract regime dominates if otherwise

In case A, the monopolists outsources to the spot market because although financial distress costs have been triggered, they are not high enough to offset the positive convexity effect of input price uncertainty. Case B is the opposite case where the monopolist is outsourcing to the independent supplier in order to avoid the deadweight losses associated with financial distress costs. Finally, we are likely to end up in case C when there is a combination of high uncertainty and low intensity of financial distress costs (low k), such that the positive convexity effect of uncertainty dominates.

Figure 1 illustrates an example of the monopolist's optimal choice of the outsourcing regime. It depicts the expected profit of the monopolist when outsourcing to the independent supplier and to the spot market, Π_{ALT} and $E(\Pi_{AS})$, respectively, and the total profit under global maximization with the long term contract, Π_{GM}, as a function of our measure of input price uncertainty s.[15] It shows that for low values of the input price uncertainty measure ($s \leq 1.72$), the expected profit of the monopolist under the spot regime $E(\Pi_{AS})$ is increasing because financial distress costs have not been triggered. Once these costs are positive, the expected profit from the spot regime starts decreasing. There is a small range for which this profit is decreasing but is still higher than the profit of the long term contract. This means that although financial distress costs are positive, there are not high enough to offset the positive effect of input price uncertainty, and therefore the monopolist outsources

[15] The set of input parameters used is as follows: monopolist's bargaining power $\eta = 0.5$, expected spot price $m = 20$, marginal cost of the supplier $c_B = 20$, size of market A $\alpha_A = 70$, slope of demand function $\beta_A = 1$, marginal cost of monopolist $c_A = 20$, fixed cost of monopolist $f_A = 0$, debt $D = 200$ and intensity of financial distress costs parameter $k = 0.8$. In the example it follows that only s_1^* exists.

to the spot market. Then, as the input price uncertainty measure increases, the expected profit of the spot regime is more severely affected by financial distress costs such that it is below the profit of the long term contract. When this occurs the long term contract regime dominates.

Up to this point, we have mainly discussed the effect of uncertainty on financial distress costs, and consequently on the choice of the outsourcing regime. We should note, however, that what drives these costs is the existence of debt on the firm's capital structure. Next, we determine the debt level D^* that makes the monopolist indifferent between the two regimes. This is obtained by solving equation $E(\Pi_{AS}) - \Pi_{GM} = 0$ for D. It follows that:

$$D^* = \frac{1}{2}\frac{s^2\beta_A}{k} + \frac{[\alpha_A - \beta_A(c_A + m + s)]^2}{4\beta_A} - f_A \tag{31}$$

This indifference level can be interpreted as the maximum debt the monopolist can afford if outsourcing to the spot market. For any debt level above D^* the surplus from the spot regime is negative, and therefore the monopolist chooses to outsource to the independent supplier in order to avoid financial distress costs. A change in the parameters that increase the profit flow, as an increase in the size of market A (α_A) or a decrease in the operational costs (c_A, m and f_A), increases this indifference level, which means that the monopolist can afford to use more debt when outsourcing to the spot market.

Furthermore, from expression (31) one can see that the effect of the uncertainty measure s on D^* depends on the parameter k associated with the intensity of financial distress costs. We show that $\frac{\partial D^*}{\partial s} > (<) 0$ if $k < (>) k^*$ where k^* is as previously defined in (16). This suggests that if we combine high intensity of financial distress costs and high input price uncertainty, firms tend to reduce their debt level in order to stay in the spot regime or, alternatively, they prefer to outsource with long term contracts. This prediction captures Froot et al. (1993) idea that when long term contracts are used as a risk management device they can be seen as a mean of increasing debt capacity.

3 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 et al. 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_A 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. 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 (1) and (2) 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:

$$Q_{ALT} + Q_{AS}^i = \alpha_A - \beta_A p_A^i \tag{32}$$

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:

$$Q_{ALT} = n_{LT} q_{ALT} \tag{33}$$

$$Q_{AS}^i = n_S q_{AS}^i \tag{34}$$

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.[16]

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 given by[17]:

$$E(\pi_{GM}) = \frac{1}{2}\pi_{GM}^{u} + \frac{1}{2}\pi_{GM}^{d} \tag{35}$$

where π_{GM}^{u} and π_{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:

$$\pi_{GM}^{i} = q_{ALT}\left(p_A^i\left(Q_{ALT}, Q_{AS}^i\right) - c_A - c_B\right) - f_A - FDC_{GM}^{i} \tag{36}$$

where the financial distress costs in state i are:

$$FDC_{GM}^{i} = k\,max\left[0, D - \left(q_{ALT}\left(p_A^i\left(Q_{ALT}, Q_{AS}^i\right) - c_A - c_B\right) - f_A\right)\right] \tag{37}$$

The optimization of the expected profit under global maximization (35) yields the following individual quantity of the long term contract:

$$q_{ALT} = \alpha_A - \beta_A(c_A + c_B) - Q_{ALT} - \frac{1}{2}\left(Q_{AS}^{u} + Q_{AS}^{d}\right) \tag{38}$$

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 (38) by n_{LT} and, given that $Q_{ALT} = n_{LT}q_{ALT}$, we solve it for Q_{ALT}. This yields:

$$Q_{ALT} = \frac{n_{LT}\left[\alpha_A - \beta_A(c_A + c_B) - \frac{1}{2}\left(Q_{AS}^{u} + Q_{AS}^{d}\right)\right]}{1 + n_{LT}} \tag{39}$$

[16] 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.

[17] 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. $E(\pi_{GM}) = E(\pi_{ALT})$.

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:

$$E(\pi_{AS}) = \frac{1}{2}\pi^{u}_{AS} + \frac{1}{2}\pi^{d}_{AS} \tag{40}$$

where the realized profits in state i are:

$$\pi^{i}_{AS} = q^{i}_{AS}\left(p^{i}_{A}\left(Q_{ALT}, Q^{i}_{AS}\right) - c_A - p^{i}_{B}\right) - f_A - FDC^{i}_{S} \tag{41}$$

and the corresponding financial distress costs are given by:

$$FDC^{i}_{S} = k\,max\left[0, D - \left(q^{i}_{AS}\left(p^{i}_{A}\left(Q_{ALT}, Q^{i}_{AS}\right) - c_A - p^{i}_{B}\right) - f_A\right)\right] \tag{42}$$

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:

$$q^{i}_{AS} = \alpha_A - \beta_A\left(c_A + p^{i}_{B}\right) - Q_{ALT} - Q^{i}_{AS} \tag{43}$$

Given that $Q^{i}_{AS} = n_S q^{i}_{AS}$, if we multiply both sides of (43) by n_S and solve for Q^{i}_{AS} it follows that:

$$Q^{i}_{AS} = \frac{n_S\left[\alpha_A - \beta_A\left(c_A + p^{i}_{B}\right) - Q_{ALT}\right]}{1 + n_S} \tag{44}$$

Solving the system of Eqs. (39) and (44) for Q_{ALT} and Q^{i}_{AS}, 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 $FDC^{u}_{S} = 0$ 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 $FDC^{d}_{GM} = 0.FDC^{d}_{S}FDC^{d}_{GM}$ The same notation applies to the realized profits in each state of nature, $\pi^{i}_{AS\,NFDC}$ and$\pi^{i}_{ALT\,NFDC}$. Proposition 5 summarizes the equilibrium profits and prices for the oligopoly equilibrium.[18]

Proposition 5 *Assume that market A is an oligopoly where n symmetric firms face the demand function (32) 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:*

$$E(\pi_{AS}) = E(\pi_{AS})_{NFDC} - \frac{1}{2}FDC^{u}_{S} \tag{45}$$

where

[18] The expressions for the equilibrium quantities and for the realized profits in each state of nature when financial distress costs are zero, $\pi^{i}_{AS\,NFDC}$ and $\pi^{i}_{ALT\,NFDC}$, are presented in the "Appendix".

$$E(\pi_{AS})_{NFDC}=\frac{[\alpha_A-\beta_A(c_A+m+(n-n_S)(m-c_B))]^2}{\beta_A(1+n)^2}-f_A+\frac{s^2\beta_A}{(1+n_S)^2} \tag{46}$$

$$FDC_S^u=k\,max\left[0,D-\left(\pi_{ASNFDC}^u\right)\right] \tag{47}$$

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

$$E(\pi_{ALT})=E(\pi_{ALT})_{NFDC}-\frac{1}{2}FDC_{GM}^d \tag{48}$$

where

$$E(\pi_{ALT})_{NFDC}=\frac{[\alpha_A-\beta_A(c_A+c_B-n_S(m-c_B))]^2}{\beta_A(1+n)^2}-f_A \tag{49}$$

$$FDC_{GM}^d=kmax\left[0,D-\left(\pi_{ALTNFDC}^d\right)\right] \tag{50}$$

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

$$p_A^u=\frac{\alpha_A+\beta_A[n(c_A+c_B)+n_S(m-c_B)]}{\beta_A(1+n)}+s\frac{n_S}{1+n_S} \tag{51}$$

$$p_A^d=\frac{\alpha_A+\beta_A[n(c_A+c_B)+n_S(m-c_B)]}{\beta_A(1+n)}-s\frac{n_S}{1+n_S} \tag{52}$$

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.

3.1 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 et al. (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.

3.1.1 *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 5, 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:

$$E(\pi_{AS}) = \frac{[\alpha_A - \beta_A(c_A + m)]^2}{\beta_A(1+n)^2} - f_A + \frac{s^2\beta_A}{(1+n_S)^2} \tag{53}$$

$$E(\pi_{ALT}) = \frac{[\alpha_A - \beta_A(c_A + c_B)]^2}{\beta_A(1+n)^2} - f_A \tag{54}$$

Since we are assuming that the buyers have all the bargaining power ($\eta = 1$) and the supplier only incurs marginal costs c_B, if 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:

$$Surplus \equiv E(\pi_{AS}) - E(\pi_{ALT}) = \frac{s^2\beta_A}{(1+n_S)^2} \geq 0 \tag{55}$$

and the equilibrium is the one stated in Proposition 6 below.[19] From now on we denote the equilibrium number of firms outsourcing to the spot market by n_S^*.

Proposition 6 *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 provides an illustration of this product market competition effect and also depicts the above equilibrium.[20] 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.

[19] The expressions for the set of parameters that ensure zero financial distress costs are presented in the "Appendix".

[20] 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 $D = 0$.

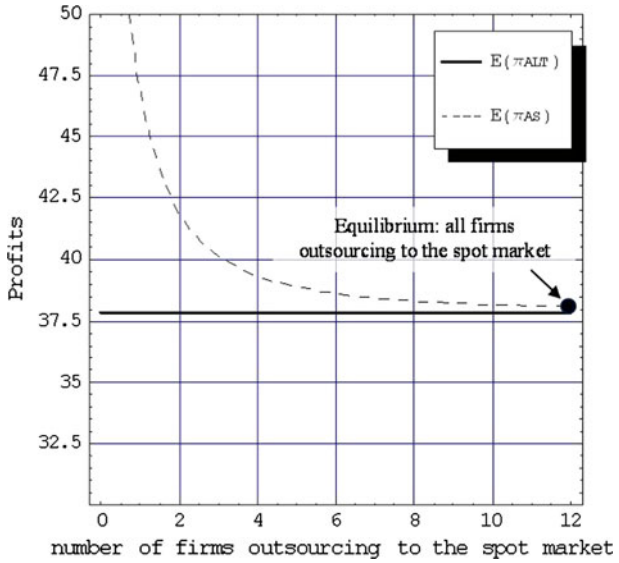

Fig. 2 Oligopoly equilibrium with zero financial distress costs. Expected profit of each buyer under the spot regime, $E(\pi_{AS})$, and under the long term contract regime, $E(\pi_{ALT})$, as a function of the number of firms outsourcing to the spot market, if financial distress costs are zero, and assuming that the outsourcing price provided by the supplier is the same as the expected spot price, $p_{BLT} = m$. In equilibrium, all firms outsource to the spot market as $E(\pi_{AS})$, is always greater than $E(\pi_{ALT})$

Next, we examine the equilibrium assuming that financial distress costs can be positive. Given the equilibrium expressions from Proposition 5, one can show that the surplus from the spot market regime is now given by:

$$Surplus = \frac{s^2\beta_A}{(1+n_S)^2} - \frac{1}{2}\left(FDC_S^u - FDC_{GM}^d\right) \tag{56}$$

where the expressions for FDC_S^u and FDC_{GM}^d are given by (47) and (50), 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.[21]

Proposition 7 *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* $\frac{s^2\beta_A}{\left(1+n_S^*\right)^2} > \frac{1}{2}\left(FDC_S^u - FDC_{GM}^d\right)$ *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.*

[21] Once again, the expressions for the set of parameters that ensure positive financial distress costs are presented in the "Appendix".

Proposition 7 shows that firms outsource to the spot market in order to take advantage of the positive convexity effect of input price uncertainty, $\frac{s^2\beta_A}{\left(1+n_S^*\right)^2}$, but only when this advantage compensates the differences in financial distress costs of both regimes, $\frac{1}{2}\left(FDC_S^u - FDC_{GM}^d\right)$.

3.1.2 *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 5, 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:

$$E(\pi_{AS}) = \frac{\left[\alpha_A - \beta_A(c_A + m + (n - n_S)(m - c_B))\right]^2}{\beta_A(1+n)^2} - f_A + \frac{s^2\beta_A}{(1+n_S)^2} \tag{57}$$

$$E(\pi_{ALT}) = \frac{\left[\alpha_A - \beta_A(c_A + c_B - n_S(m - c_B))\right]^2}{\beta_A(1+n)^2} - f_A \tag{58}$$

These profit expressions can be directly compared with the ones where there was no cost differential between the two outsourcing regimes ((53) and (54), 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 $E(\pi_{AS})$ are:

$$\frac{\partial E(\pi_{AS})}{\partial n_S} = \frac{\partial\left[\frac{\left[\alpha_A - \beta_A(c_A + m + (n - n_S)(m - c_B))\right]^2}{\beta_A(1+n)^2}\right]}{\partial n_S} + \frac{\partial\left[\frac{s^2\beta_A}{(1+n_S)^2}\right]}{\partial n_S} \tag{59}$$

where

$$\frac{\partial\left[\frac{\left[\alpha_A - \beta_A(c_A + m + (n - n_S)(m - c_B))\right]^2}{\beta_A(1+n)^2}\right]}{\partial n_S} > 0 \tag{60}$$

$$\frac{\partial\left[\frac{s^2\beta_A}{(1+n_S)^2}\right]}{\partial n_S} < 0 \tag{61}$$

The results show that an increase in the number of firms outsourcing to the spot market has two opposite effects on the expected profit of firms outsourcing to the spot market.

The derivative (61) 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 (60) 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 (60) and the higher are the chances that $E(\pi_{AS})$ is increasing in n_S. Moreover, it follows immediately from (58) 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:

$$Surplus = \frac{s^2\beta_A}{(1+n_S)^2} - (B - A) \tag{62}$$

where

$$A \equiv \frac{[\alpha_A - \beta_A(c_A + m + (n - n_S)(m - c_B))]^2}{\beta_A(1+n)^2} \tag{63}$$

$$B \equiv \frac{[\alpha_A - \beta_A(c_A + c_B - n_S(m - c_B))]^2}{\beta_A(1+n)^2} \tag{64}$$

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 8 summarizes the equilibrium under these assumptions.

Proposition 8 *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, $1/2\left(FDC_S^u - FDC_{GM}^d\right)$, as we had in the previous section. It follows that:

$$Surplus = \frac{s^2\beta_A}{(1+n_S)^2} - (B-A) - \frac{1}{2}\left(FDC_S^u - FDC_{GM}^d\right) \tag{65}$$

where the expressions for A and B are given by (63) and (64), respectively, and the expressions for FDC_S^u and FDC_{GM}^d were previously stated in Proposition 5. 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 9 summarizes the new equilibrium under this assumptions.

Proposition 9 *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 $\frac{s^2\beta_A}{\left(1+n_S^*\right)^2} - (B-A) - \frac{1}{2}FDC_S^u < 0$ all firms outsource to the independent supplier.*

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

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

Proposition 9 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 downstream market, firms may have to avoid the use of a long term contract as it can also induce positive financial distress costs.

4 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. It incorporates two important dimensions of the problem: capital structure and product market competition. The main difference between the two outsourcing regimes relies on the uncertainty associated with the outsourcing price. Outsourcing to the spot market involves input price uncertainty, whereas outsourcing with a long term contract allows the buyer to set in advance this price and rule out uncertainty. We first investigate the outsourcing decision by a monopolist, where we focus on the effect of leverage and uncertainty on financial distress costs, and then examine the effect of product market competition by extending the basic model to an oligopoly. The main conclusions and empirical implications of the paper are discussed below.

We find that outsourcing to the spot market involves a trade-off between a positive convexity effect of input price uncertainty and a negative effect derived from financial distress costs. If the level of debt and input price uncertainty is not sufficient to induce positive financial distress costs in the bad state of nature, the monopolist chooses to outsource to the spot market in order to take advantage of the positive effect of uncertainty on profits. The monopolist's profits increase with input price uncertainty because he can fully adjust capacity for a given input price, and therefore focuses on the upside potential of the spot regime.

However, to the extent that leverage and input price uncertainty can induce financial distress costs in bad states of nature, there is an incentive for the monopolist to outsource with a long term contract. A long term contract provides a perfect hedge of input price uncertainty, and consequently creates value by eliminating these costs. We find that the equilibrium depends on how severely the firm's profits are depressed by financial distress costs, and derive a measure that captures the sensitivity of the firm's profits to these costs. Our model predicts that these costs are positively related with leverage, input price uncertainty, negative demand shocks and the buyer's marginal and fixed costs. This result is in line with Opler and Titman (1994) as they show that during industry downturns more highly levered firms experience higher drops in equity values than less levered firms. We model the long term contract regime as a Nash bargaining game between the monopolist and the supplier, which allows us to make endogenous the outsourcing price and the proportion of the surplus each firm derives.

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.

Our theory provides new predictions that can be empirically testable. In the monopoly section we derive the level of debt that makes the monopolist indifferent between outsourcing to the spot market and outsourcing to the independent supplier. We show that in the presence of financial distress costs, firms that outsource to the spot market have limited debt capacity as they need to avoid these costs. Thus, our model predicts that firms outsourcing with long term contracts have greater debt capacity and that firms outsourcing to the spot market may be underlevered. Moreover, our model predicts that product market competition can induce higher financial distress costs in levered firms when they outsource to the spot market. This suggests that, in order to avoid these costs, buyers of more competitive industries tend to outsource with long term contracts.

Further research could be aimed at testing empirically some of our predictions. There are also 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.

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Appendix

Proof of Proposition 1

In order to determine the equilibrium profits in each state, we first derive the equilibrium quantities and prices in market A. The monopolist optimizes the profit flow (5) with respect to Q^i_{AS}, and this for a given price p^i_B at which input B is supplied. We further assume that financial distress costs are zero in the good state, i.e. FDC^d_S. It follows that the equilibrium quantities in state u and d are, respectively:

$$Q^u_{AS} = \frac{\alpha_A - \beta_A(c_A + m + s)}{2} \tag{66}$$

$$Q^d_{AS} = \frac{\alpha_A - \beta_A(c_A + m - s)}{2} \tag{67}$$

Substituting these quantities into the corresponding demand functions gives us the expressions for the equilibrium prices (14) and (15) as stated in the proposition. The expressions for the equilibrium profits in each state (12) and (13) are then obtained by substituting these equilibrium quantities and prices into the profit expression (5). The expression for the monopolist's equilibrium expected profit is derived as follows. First, we denote the component of the equilibrium profit Π^u_{AS} that is not affected by financial distress costs by $\Pi^u_{AS\,NFDC}$, i.e. we define $\Pi^u_{AS\,NFDC}$ as:

$$\Pi^u_{ASNFDC} = \frac{[\alpha_A - \beta_A(c_A + m + s)]^2}{4\beta_A} - f_A \tag{68}$$

It follows from (12) that Π^u_{AS} can be expressed as $\Pi^u_{AS} = \Pi^u_{ASNFDC} - FDC^u_S$. Second, we show that the expression of the monopolist's expected profit $E(\Pi_{AS}) = \frac{1}{2}\Pi^u_{AS} + \frac{1}{2}\Pi^d_{AS}$ simplifies to $E(\Pi_{AS}) = \frac{1}{2}\left[\Pi^u_{AS\,NFDC} - FDC^u_S\right] + \frac{1}{2}\Pi^d_{AS}$. Third, denoting by $E(\Pi_{AS})_{NFDC}$ the component of the monopolist's expected profit that do not depends on financial distress costs, it follows immediately that the equilibrium expected profit is given by:

$$E(\Pi_{AS}) = E(\Pi_{AS})_{NFDC} - \frac{1}{2}FDC^u_S \tag{69}$$

where

$$E(\Pi_{AS})_{NFDC} = \frac{1}{2}\Pi^u_{AS\,NFDC} + \frac{1}{2}\Pi^d_{AS} \tag{70}$$

After expanding the expressions for $\Pi^u_{AS\,NFDC}$ and Π^d_{AS} and rearranging some terms we obtain the equilibrium expression $E(\Pi_{AS})_{NFDC}$ as given by (9).

Inequality (11) is derived by solving the *RHS* of the financial distress costs expression (10) for the input price uncertainty measure s, such that $FDC^u_S > 0$.

Finally, to ensure that the monopolist's equity value remains positive, we derive an upper bound for k. Formally, we require that the expression for the firm's profit, net of financial distress costs, as given by (5), is positive. Solving $\Pi^i_{AS} \geq 0$ for k gives:

$$k \leq 2\frac{[\alpha_A - \beta_A(c_A + m + s)]^2 - f_A}{4\beta_A(D + f_A) - [\alpha_A - \beta_A(c_A + m + s)]^2} \tag{71}$$

Derivation of inequality (16)

We start with Eq. (8) that defines $E(\Pi_{AS})$. It follows that:

$$\frac{\partial E(\Pi_{AS})}{\partial s} = \frac{\partial E(\Pi_{AS})_{NFDC}}{\partial s} - \frac{1}{2}\frac{\partial FDC^u_S}{\partial s} \tag{72}$$

where

$$\frac{\partial E(\Pi_{AS})_{NFDC}}{\partial s} = \frac{1}{2}s\beta_A > 0 \tag{73}$$

$$\frac{\partial FDC^u_S}{\partial s} = k\frac{\alpha_A - \beta_A(c_A + m + s)}{2} > 0 \tag{74}$$

Thus, the total derivative is positive if the following inequality holds: $\frac{1}{2}s\beta_A - \frac{1}{2}k\frac{\alpha_A-\beta_A(c_A+m+s)}{2} > 0$ and negative, if otherwise. Solving this inequality for k, gives us the condition:

$$\frac{\partial E(\Pi_{AS})}{\partial s} > (<)0 \; if \; k<(>)\frac{4\beta_A s}{\alpha_A - \beta_A(c_A+m+s)} \equiv k^*$$

.

Proof of Proposition 2

The global optimizer maximizes the profit under global maximization (17) with respect to the optimal quantity Q_{ALT}. This quantity is also the one that will prevail with the long term contract. It follows that the equilibrium quantity is:

$$Q_{ALT} = \frac{\alpha_A - \beta_A(c_A + c_B)}{2} \tag{75}$$

Substituting this quantity into the demand function we obtain the equilibrium price in market A as given by (26). Finally, by substituting this quantity and price into the profit function of the global optimizer we obtain the equilibrium profit as stated in the proposition.

The expressions for the equilibrium profit of the buyer and the supplier are derived by substituting the expression of the proportion of the surplus captured by the buyer w, given by (19), into the profits expressions (20) and (21), respectively.

Proof of Proposition 3

The monopolist chooses to outsource to the spot market if the surplus from outsourcing under this regime, as given by (28), is positive, and to the independent supplier if otherwise. Further, we know from Proposition 1 that if $0<s\leq\hat{s}$, where $\hat{s} \equiv \frac{\alpha_A-\beta_A(c_A+m)-2\sqrt{\beta_A(D+f_A)}}{\beta_A}$, the financial distress costs from outsourcing to the spot market are zero. Therefore, for this set of parameters, the surplus from outsourcing to the spot market is always positive ($\frac{s^2\beta_A}{4} > 0$) and this regime always dominates.

Proof of Proposition 4

Given the two zeros s_1^* and s_2^* (expression (30)), we know that the surplus from the spot market regime is negative for $s_1^*<s<s_2^*$ and positive if otherwise. Hence, the long term contract regime holds if $s_1^*<s<s_2^*$ and the spot market regime if otherwise.

The upper bound on s_j^* is necessary to ensure two conditions. First, positive input prices in the good state $p_B^d > 0$, or equivalently $m - s_j^* > 0$, which gives $s_j^* < m$. Second, positive quantities in the bad state $Q_{AS}^u = \frac{\alpha_A-\beta_A\left(c_A+m+s_j^*\right)}{2} > 0$, or equivalently $s_j^* < \frac{\alpha_A-\beta_A(c_A+m)}{\beta_A}$.

Proof of Proposition 5

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:

$$q_A^u = \frac{\alpha_A - \beta_A[c_A + m + (n - n_S)(m - c_B)]}{1 + n} - \frac{s\beta_A}{1 + n_S} \tag{76}$$

$$q_A^d = \frac{\alpha_A - \beta_A[c_A + m + (n - n_S)(m - c_B)]}{1 + n} + \frac{s\beta_A}{1 + n_S} \tag{77}$$

$$q_{ALT} = \frac{\alpha_A - \beta_A[c_A + c_B - n_S(m - c_B)]}{1 + n} \tag{78}$$

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

$$\pi_{ASNFDC}^u = \frac{\{(1 + n_S)[\alpha_A - \beta_A[c_A + m + (n - n_S)(m - c_B)]] - s\beta_A(1 + n)\}^2}{\beta_A(1 + n)^2(1 + n_S)^2} - f_A \tag{79}$$

$$\pi_{AS\,NFDC}^d = \frac{\{(1 + n_S)[\alpha_A - \beta_A[c_A + m + (n - n_S)(m - c_B)]] + s\beta_A(1 + n)\}^2}{\beta_A(1 + n)^2(1 + n_S)^2} - f_A \tag{80}$$

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

$$\pi_{ALT\,NFDC}^u = \frac{[\alpha_A - \beta_A[c_A + c_B - n_S(m - c_B)]]^2}{\beta_A(1 + n)^2} + \frac{s[\alpha_A - \beta_A[c_A + c_B - n_S(m - c_B)]]n_S}{(1 + n)(1 + n_S)} - f_A \tag{81}$$

$$\pi_{ALTNFDC}^d = \frac{[\alpha_A - \beta_A[c_A + c_B - n_S(m - c_B)]]^2}{\beta_A(1 + n)^2} - \frac{s[\alpha_A - \beta_A[c_A + c_B - n_S(m - c_B)]]n_S}{(1 + n)(1 + n_S)} - f_A \tag{82}$$

Proof of Proposition 6

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 firms that outsource to the spot market ($FDC_S^u > 0$ with FDC_S^u given by (47)). We solve $FDC_S^u > 0$ for the input price uncertainty measure s. It follows that $FDC_S^u = 0$ if

$$s < (1 + n_S)\frac{[\alpha_A - \beta_A[c_A + m + (n - n_S)(m - c_B)]] - (1 + n)\sqrt{\beta_A(D + \beta_A)}}{\beta_A(1 + n)} \tag{83}$$

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 (50)), we solve $FDC_{GM}^d > 0$ for s and it follows that $FDC_{GM}^d = 0$ if

$$s < \frac{[\alpha_A - \beta_A[c_A + c_B - n_S(m - c_B)]](1 + n_S)}{\beta_A(1 + n)n_S} - \frac{(D + \beta_A)(1 + n)(1 + n_S)}{[\alpha_A - \beta_A[c_A + c_B - n_S(m - c_B)]]n_S} \tag{84}$$

and positive if otherwise.

Given our assumption in this section that $m = c_B$, the condition for $FDC_S^u = 0$ and $FDC_{GM}^d = 0$ simplifies to (85) and (86), respectively:

$$s < (1 + n_S)\frac{[\alpha_A - \beta_A(c_A + m)] - (1 + n)\sqrt{\beta_A(D + \beta_A)}}{\beta_A(1 + n)} \tag{85}$$

$$s < \frac{[\alpha_A - \beta_A(c_A + c_B)](1 + n_S)}{\beta_A(1 + n)n_S} - \frac{(D + \beta_A)(1 + n)(1 + n_S)}{[\alpha_A - \beta_A(c_A + c_B)]n_S} \tag{86}$$

Proof of Proposition 7

The proof is given in the main text.

Proof of Proposition 8

The proof is given in the main text.

Proof of Proposition 9

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 6.

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