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RISK SHARING MITIGATES OPPORTUNISM IN VERTICAL CONTRACTING

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Risk sharing mitigates opportunism in vertical contracting*

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Abstract

I study one manufacturer that contracts secretly with two risk averse retailers that face uncertain demand. The need for risk sharing limits the manufacturer's scope for opportunistic deviations. If retail competition is fierce, the manufacturer's profit increases with the levels of risk aversion and uncertainty, i.e., there is no trade-off between risk sharing and industry efficiency. The results are consistent with stylized facts from empirical and experimental research on vertical relations, including the negative correlation between vertical integration and uncertainty.

1 Introduction

This paper considers a market with one manufacturer and several competing retailers, in which the manufacturer offers simple, bilateral and *secret* contracts to the retailers. Several influential papers, e.g., Hart and Tirole (1990), O'Brien and Shaffer (1992) and McAfee and Schwartz (1994), show that the manufacturer's ability to exercise market power in this situation is severely limited by an *opportunism problem*.[1] The crux of the

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[1] The term 'opportunism' reflects that the manufacturer engages in contractual opportunism, as introduced by Williamson (1975). The problem is similar to the conjecture of Coase (1972) about the durable goods monopolist that loses market power when unable to commit to future prices.

problem is that the manufacturer cannot commit to secret contracts. Instead of restricting output at the first-best monopoly level, the manufacturer gives each retailer a discount to free-ride on the rival retailers' rents. In equilibrium, the manufacturer sells at marginal cost and retailers buy and resell quantities as in Cournot or Bertrand oligopolies.

I analyze a simple extension of the secret-contracting model in which final demand is *uncertain* at the time of contracting, and retailers are *risk averse*. The paper's main message is that *the manufacturer's scope for opportunism is limited by the retailers' need for risk sharing*. My results are consistent with empirical and experimental evidence from vertical markets, and have implications for managerial strategy and antitrust policy.

Risk aversion is an unusual feature in the vertical contracting literature, and the main treatment of risk averse retailers can still be found in the seminal paper by Rey and Tirole (1986) (discussed below). However, it is now theoretically and empirically well-established that small or specialized retailers—say independent shoe stores or local bicycle shops—can behave as risk averse because of liquidity constraints, risk-averse owners or limited hedging abilities.[2] In addition, large retailers can become risk averse by making investment decisions while facing credit constraints (Nocke and Thanassoulis 2014). The next paragraph explains the key effect of risk aversion in my model.

Suppose that the manufacturer offers each retailer a two-part tariff, i.e., a wholesale price and a fixed fee. Can the manufacturer offer, as in earlier secret-contracting models, to sell at marginal cost in exchange for a large fixed fee? The answer is clearly 'no', because such contracts would put all the demand uncertainty on the risk averse retailers. Instead, to secure the retailers' participation, the manufacturer must take part in risk sharing. With two-part tariffs, risk is shared by setting wholesale prices above cost, which reduces the retailers' margins and the variance of their flow profits. In turn, this double marginalization leads the retailers to buy and resell quantities below the fully competitive level. I conclude that the combination of risk aversion and uncertainty restores some of the manufacturer's market power.

In contrast, the conventional view in principal-agent theory is that risk aversion and uncertainty distort the contracting outcome and reduce the principal's payoff. This view comes from the classic risk-incentive trade-off, which says that risk sharing comes at

[2] See Banal-Estañol and Ottaviani (2006) and Asplund (2002) for excellent discussions and references to empirical work on these factors.

the expense of bilateral trade efficiency (Holmström 1979; Shavell 1979). In my model, as explained above, this trade-off takes the form of double marginalization and reduced quantities which prevents the manufacturer from maximizing the *bilateral* profit with each retailer. However, this is only half the story. Because of the opportunism problem, quantities are too high to maximize the *total* profit with both retailers. The overall profit effect of risk aversion and uncertainty is decided by the relative strength of these effects.

Opportunism is a big problem when retailers are close substitutes.[3] In this case, the benefit of curbing opportunism outweighs the cost of sharing risk, and the manufacturer is better off with (than without) risk aversion and uncertainty. Furthermore, in any equilibrium in which quantities are above the monopoly level, *more* risk aversion pushes equilibrium quantities toward the monopoly level. Thus, if retailers are close substitutes, the manufacturer's equilibrium profit *increases* with the retailers' level of risk aversion, and there is no trade-off between risk sharing and total efficiency. The economic principle at heart of this result is Lipsey and Lancaster's (1956) general theory of second best: if one distortion (here: secret offers) precludes the first-best, a second distortion (here: risk aversion and uncertainty) can alleviate the situation. Under certain assumptions, an analogous result holds for the uncertainty level. This gives rise to an interesting empirical application.

The correlation between the frequency of vertical integration and the level of market uncertainty is a well-known puzzle in the principal-agent literature. On one hand, standard agency theory predicts a positive correlation, because integration is a way to share risk. On the other hand, there is compelling empirical evidence in support of a negative correlation.[4] In the present model, a negative correlation can be natural. The manufacturer can use vertical integration to escape the opportunism problem, as first suggested by Hart and Tirole (1990). However, by the argument in the previous paragraph, a high uncertainty level curbs opportunism *without* integration. If retail competition is fierce, more uncertainty can give a higher profit. Thus, the possible benefit of integration can be small when the level of uncertainty is high, which is consistent with the data.

[3] In the terminology of Segal (1999), the opportunism problem is a negative contracting externality that is strong when retailers are close substitutes and fierce competitors.

[4] See Prendergast (2002) and, in particular, Lafontaine and Slade (2007).

Related literature. This paper bridges the gap between two strands of the vertical contracting literature that looks at one upstream firm and competing downstream firms: the strand on secret contracts and the strand on risk aversion and uncertainty.

Secret contracts are studied by Hart and Tirole (1990), O'Brien and Shaffer (1992), McAfee and Schwartz (1994), Segal (1999), Rey and Vergé (2004), Gabrielsen and Johansen (2014) and Montez (2015). All these papers show, in various settings, that retailers sell quantities as in Cournot or Bertrand oligopolies when the manufacturer makes secret offers. My model builds particularly on the work of McAfee and Schwartz (1994) and Rey and Vergé (2004). I use the same supply contracts, retail competition form and equilibrium concept as these papers, but add retail risk aversion and demand uncertainty.

In a model with perfectly competitive and risk averse retailers, Rey and Tirole (1986) find that the manufacturer's two targets—exploiting market power and sharing risk—are conflicting. I find the exact opposite result if competition is sufficiently fierce, namely that the manufacturer can exploit more market power if retailers require more risk sharing. The reason for this difference in predictions is that Rey and Tirole (1986) look at public contracts, whereas I look at secret contracts.

After Rey and Tirole (1986), there has been surprisingly little work on vertical contracting with risk aversion and uncertainty. Dewatripont and Sekkat (1991) find that contract renegotiation and the ex post exclusion or entry of new retailers can smooth retail profits, and act as an insurance device. This topic is very different from what I study, and Dewatripont and Sekkat use public contracts that can be made contingent on the number of retailers. More recently, Hansen and Motta (2015) assume that retailers are privately informed about local cost shocks. They show that the manufacturer may want to exclude one retailer to remove the other retailer's fear of facing a more efficient rival, and, thus, to avoid paying a risk premium. Hansen and Motta also look at public contracts, so there is no opportunism problem in their model.

In a more general paper, Dequiedt and Martimort (2015) study informational opportunism under asymmetric information, i.e., the manufacturer's incentive to manipulate one retailer's cost report when making a public contract offer to a rival retailer. This issue is different from the opportunism caused by secret contracts, although Dequiedt and Martimort also extend their analysis to the case with secret offers. However, risk sharing is not part of their theory.

Structure of the paper. Section 2 sets up the formal model and derives two benchmark outcomes. Section 3 contains my main analysis and results. Section 4 discusses empirical and experimental evidence. Section 5 concludes. Appendix A contains a few proofs.

2 The model

A manufacturer (female) makes a product at constant marginal cost $c \geq 0$. She can sell the product to two symmetric and differentiated retailers $i = 1, 2$ (male), who compete à la Cournot when reselling the product to final consumers.[5] The manufacturer is risk neutral, whereas the retailers are risk averse: for any level of monetary profit π_i (defined below), retailer i gets utility $u(\pi_i)$, where u is a twice continuously differentiable von Neumann-Morgenstern utility function with $u' > 0$ and $u'' < 0$.

The inverse demand function for the manufacturer's product at retailer i is $P_i(q_i, q_j, \theta)$. Here, q_i is the quantity sold by retailer i, q_j is the quantity sold by his rival and θ is a stochastic variable with bounded support on $(\underline{\theta}, \overline{\theta})$ that represents the state of demand. I assume that $P_i(0, 0, \underline{\theta}) \geq c$ so that there is scope for trade for any realization of θ, and that the support $(\underline{\theta}, \overline{\theta})$ is such that any retail Cournot equilibrium is interior $\forall \theta \in (\underline{\theta}, \overline{\theta})$. The function P_i is twice continuously differentiable in all three arguments and satisfies:

$$\frac{\partial P_i}{\partial q_i} \leq \frac{\partial P_i}{\partial q_j} < 0; \qquad \frac{\partial^2 P_i}{\partial q_i^2} q_i + 2\frac{\partial P_i}{\partial q_i} < 0; \qquad \frac{\partial P_i}{\partial \theta} > 0; \qquad \frac{\partial^2 P_i}{\partial q_i \partial \theta} q_i + \frac{\partial P_i}{\partial \theta} > 0.$$

These conditions state, respectively, that retailers are substitutes, that their revenue functions are concave, and that both inverse demand and retailers' marginal revenues are monotonically increasing in θ (I explain the effect of the last point in Section 3.1). In addition, I assume that the standard conditions for the existence and uniqueness of Cournot equilibria are satisfied.[6]

Now, let us look at the contracting game. Note first that θ is hidden information to all firms at the outset of the game. Play then takes place in three stages:

1. The manufacturer makes a contract offer to each retailer on a take-it-or-leave-it basis. Retailers accept or reject without observing the rival's offer.

[5] The extension to the case with $n > 2$ retailers, as in McAfee and Schwartz (1994), is straightforward.

[6] These conditions are $\frac{\partial^2 P_i}{\partial q_i^2} q_i < 0$, $\frac{\partial^2 P_i}{\partial q_i \partial q_j} q_i > 0$ and $\frac{\partial^2 P_i}{\partial q_i^2} q_i > \left| \frac{\partial^2 P_i}{\partial q_i \partial q_j} q_i \right|$.

2. Retailers learn the value of θ.[7]

3. Retailers buy from the manufacturer, and then compete à la Cournot.

To pin down the information structure at Stage 1 of the game, I assume that retailers have *passive beliefs*. This means that retailer 1 continues to believe that the manufacturer has offered retailer 2 an equilibrium contract in the event that retailer 1 gets an out-of-equilibrium-offer, and vice versa. I use perfect Bayesian equilibrium as solution concept.[8]

Note that θ is a common variable. This implies that retailers do not have private information about demand at the end of Stage 2, which simplifies the analysis of the Cournot game at Stage 3.[9] Because retailers are symmetric and sell the same product in the same market, it is reasonable that they face similar demand conditions.

Finally, the manufacturer offers retailer i a two-part tariff (w_i, F_i) where w_i is a wholesale price and F_i is a fixed fee. Thus, the manufacturer's profit is

$$\Pi = (w_1 - c)\, q_1 + (w_2 - c)\, q_2 + F_1 + F_2 \tag{1}$$

and the profit of retailer i is

$$\pi_i = (P_i\,(q_i, q_j, \theta) - w_i)\, q_i - F_i. \tag{2}$$

Remark: Supply contracts. With two-part tariffs, the analysis is tractable and my results are easily comparable with those in the received literature. There is also compelling evidence about the frequent use of two-part tariffs and other simple supply contracts in real-world markets.[10] However, I emphasize that my insights are not driven by this assumption. Under risk aversion and ex ante uncertainty, there are bilateral distortions (i.e.,

[7] Note that because the manufacturer does not observe θ at Stage 2, state-contingent contracts are not feasible. A less crude assumption that achieves the same result is that θ is unverifiable by a third party.

[8] Passive beliefs are used by, e.g., McAfee and Schwartz (1994), Segal (1999) and Rey and Vergé (2004). A perfect Bayesian equilibrium with passive beliefs is similar to other equilibrium refinements that focus on bilateral optimality: Crémer and Riordan's (1987) contract equilibrium; Hart and Tirole's (1990) market-by-market conjectures; and McAfee and Schwartz's (1995) pairwise-proof requirement.

[9] In particular, retailers need not form beliefs about the rival's demand conditions as in Myatt and Wallace (2014), and can gain nothing from sharing demand information, as studied by Hviid (1989). This is not a critical assumption, and my main points are valid also for correlated or independent shocks.

[10] See Lafontaine and Slade (2010), Blair and Lafontaine (2005) and Villas-Boas (2007).

quantities below the bilateral first-best level for some realizations of the state variable), also with more general, bilateral payment schemes.[11] However, I do not consider 'multilateral' contracts such as industry-wide resale price maintenance and territorial restrictions. Such contracts can be prohibitively costly to enforce, and may violate antitrust laws.

2.1 Two benchmarks

In the above model, as made clear in the Introduction, the manufacturer has incentives for both opportunism and risk sharing (i.e., two 'distortions'). My analytical strategy is to derive the equilibrium wholesale prices of that model, and compare those with two sets of benchmark wholesale prices. The benchmarks I see as most interesting are the wholesale prices from a model with (*i*) opportunism, but no risk sharing (i.e., one 'distortion'), and (*ii*) neither opportunism nor risk sharing (i.e., no 'distortions'). Of course, these situations are well-known in the vertical contracting literature.

Opportunism, no risk sharing. Rey and Vergé (2004, p. 731) study a model with Cournot competition between two retailers, secret two-part tariffs and passive beliefs, i.e., the same model that I study, except for risk aversion and demand uncertainty. Rey and Vergé show that the unique perfect Bayesian equilibrium in that model has wholesale prices equal to marginal cost (their Proposition 1). This result reflects the manufacturer's opportunism problem with secret contracts. I use this as my first benchmark, and denote these wholesale prices by $w_1^o = w_2^o = c$.

No opportunism, no risk sharing. Mathewson and Winter (1984) show that the manufacturer can earn the monopoly profit when she offers public two-part tariffs to competing retailers. The intuition is that, by setting wholesale prices that restrict retail competition, the manufacturer can fully internalize that one retailer's sale reduces the rival's revenue and payment. To represent such a monopoly benchmark in my model, I use the wholesale prices set with public contract offers and risk neutral retailers.[12]

[11] See Katz (1991) for a discussion, and Salanié (1990) and Laffont and Martimort (2002, Section 2.12.2) for formal analyses.

[12] Risk sharing could also be ruled out from this benchmark by assuming deterministic demand. However, by keeping θ in P_i, the monopoly benchmark has the same expected demand and retail revenue as the main model; this permits direct comparison of the two pairs of wholesale prices.

Let us formally derive these wholesale prices. With public contract offers, subgame perfect equilibrium is the appropriate solution concept, and the game can be solved by backward induction. This method gives the following wholesale price for $i \neq j = 1, 2$:

$$w_i = c - E\left[\frac{\partial R_j}{\partial q_i}\right]. \tag{3}$$

Here, E is the expectation operator over θ and $\frac{\partial R_j}{\partial q_i} \equiv \frac{\partial P_j}{\partial q_i} q_j(w_j; \theta)$, in which $q_j(w_j; \theta)$ is the quantity set by retailer j at Stage 3 after observing θ. Because $\frac{\partial P_j}{\partial q_i}$ is negative, it follows that $\frac{\partial R_j}{\partial q_i}$ is negative and that the right hand side of (3) is larger than c as expected from the intuition in the previous paragraph. I label the wholesale prices that satisfy (3) by w_1^m and w_2^m, and refer to these as monopoly wholesale prices.

3 Main analysis

I start the analysis by solving the full model outlined in Section 2, in which the manufacturer's contract offers are secret and the retailers are risk averse.

3.1 An equilibrium with less opportunism

At Stage 3, each retailer sets the quantity that maximizes his profit given his wholesale price and the state of demand θ. Because retailers' utility functions are monotonically increasing in profits, profit maximization implies expected utility maximization. Furthermore, as retailers do not know each other's supply contracts, they must form a belief about the rival's quantity. Let q_j^e be the quantity that retailer i expects retailer j to set. Taken together with the profit function in (2), we have that retailer i chooses:

$$q_i^w \equiv \arg\max_{q_i} \left\{ \left(P_i\left(q_i, q_j^e, \theta\right) - w_i\right) q_i - F_i \right\}. \tag{4}$$

Consider now Stage 1. The manufacturer makes contract offers to maximize her expected profit, while, at the same time, securing that wholesale prices and fixed fees satisfy the retailers' participation constraints. These constraints require that retailers' *expected utility* of Stage 3 profits is nonnegative, and reflect that retailers are cautious about making high payments ex ante when uncertain about whether these expenses can be covered ex post. By using the manufacturer's profit in (1), retailer i's profit in (2) and the Stage 3 quantity in (4), we can write the manufacturer's problem as:

$$\max_{w_1,w_2,F_1,F_2} \{E[(w_1 - c)\, q_1^w + (w_2 - c)\, q_2^w + F_1 + F_2]\}$$

subject to, for $i \neq j = 1, 2$:

$$E\left[u\left(\left(P_i\left(q_i^w, q_j^e, \theta\right) - w_i\right) q_i^w - F_i\right)\right] \geq 0.$$

Remark: Existence of equilibrium. The possible nonexistence of perfect Bayesian equilibria in models with secret contract offers is a well-known concern in the literature.[13] However, this is not a problem in the present model. The reason is the same as in the Cournot model of Rey and Vergé (2004), namely that the manufacturer's problem is *separable* in her contract offers. Separability here means that the wholesale price offered to retailer 1 does not directly affect the manufacturer's income from retailer 2, and vice versa. Thus, a candidate pair of equilibrium contracts that is robust to bilateral deviations (i.e., a passive beliefs equilibrium) is also robust to any multilateral deviations.

I solve the manufacturer's problem with Lagrange's method (see Appendix A for the formal proof), and find that her equilibrium wholesale prices are given by

$$w_i^* = c + \delta, \tag{5}$$

in which

$$\delta \equiv \underbrace{\frac{cov\left(u', q_i^w\right)}{E\left[u'\right]}}_{\text{'Marginal risk premium'}} \times \underbrace{E\left[\frac{\partial q_i^w}{\partial w_i}\right]^{-1}}_{\text{'Pass-through rate'}}.$$

Let us sign and interpret δ. The first term of δ is negative because the covariance is negative: a realization of θ that gives a high quantity also gives a high flow profit (because of the assumption that inverse demand and marginal revenue increase with θ), and a low marginal utility under risk aversion. This term is familiar from Baron (1970, equation 14)

[13] Equilibria can fail to exist if the number of retailers is large (McAfee and Schwartz 1995, Theorem 1; Segal 1999, Proposition A.1), if upstream marginal cost is nondecreasing (Segal and Whinston 2003, Proposition 8) or if retailers are fierce Bertrand competitors (Rey and Vergé 2004, Proposition 2).

and Asplund (2002, equation 1), and represents the per-unit risk premium as an addition to marginal cost that retailer i requires. The second term of δ is also negative because retailer i's quantity is a decreasing function of w_i. This term represents the 'pass-through' rate from the intermediate market to the final market. To summarize, because both terms in δ are negative, we have $\delta > 0$ and $w_i^* > c$.

Proposition 1. *In the unique perfect Bayesian equilibrium with risk averse retailers and uncertain demand, the manufacturer sets wholesale prices above her marginal cost.*

This result says that the retailers' need for risk sharing restores some of the manufacturer's market power with secret contracts compared with the opportunism benchmark. Note that both risk aversion and uncertainty are needed to obtain this result. Indeed, with either risk neutral retailers (constant marginal utility) or deterministic demand, the covariance and δ equal zero so that (5) gives $w_i^* = c = w_i^o$. Note also that a smaller absolute value of the pass-through rate causes δ and w_i^* to increase. Intuitively, a smaller pass-through rate makes the manufacturer's perceived demand curve less elastic, which makes her set higher wholesale prices.

Remark: Retailers' beliefs. Proposition 1 is derived with passive beliefs, which are known in the literature to make retailers 'naive' and receptive to opportunistic deviations. To explain why the manufacturer's scope for opportunism may be limited, previous work has thus instead focused on alternative belief specifications. However, these alternatives are not without problems.[14] In contrast, passive beliefs are intuitively appealing when retailers compete à la Cournot (Rey and Tirole 2007). Furthermore, because Rey and Vergé (2004) show that passive and wary beliefs coincide under Cournot competition, Proposition 1 and subsequent results would hold also with wary beliefs.

[14] I have in mind here the symmetric beliefs from McAfee and Schwartz (1994), and the wary beliefs introduced by McAfee and Schwartz (1994) and formalized by Rey and Vergé (2004). Symmetric beliefs require the manufacturer to make offers that are not sequentially rational, whereas wary beliefs reduce opportunism only under Bertrand competition. See Rey and Tirole (2007) for a good discussion of these matters. Also, Avenel (2012) finds that the opportunism problem disappears with 'full capacity beliefs' under an upstream capacity constraint, but only if the constraint is binding exactly at the monopoly level or if production is costless.

3.2 The manufacturer's profit with risk sharing

The focus of this section is the manufacturer's profit in the equilibrium derived above. In particular, I address two important questions: (*i*) When is the equilibrium profit with risk sharing greater than the profit in the opportunism benchmark? and (*ii*) How does the equilibrium profit vary with the amount of risk sharing needed?

I start with some notation and a few technical remarks. Let Π^*, Π^o and Π^m be the manufacturer's profit from, respectively, setting the equilibrium prices (w_1^*, w_2^*), opportunism prices (w_1^o, w_2^o) and monopoly prices (w_1^m, w_2^m), and note that $\Pi^o < \Pi^m$ due to the opportunism problem. As shown in Appendix A, w_i^* is derived by substituting the first-order condition for F_i into the first-order condition for w_i. This method implies that, for any change in w_i^*, the equilibrium fee F_i^* must also be adjusted to satisfy retailer i's participation constraint. For Π^o and Π^m, it was implicitly assumed that F_i is set to make the retailers' participation constraints binding. These observations tell us that the manufacturer's profit is equal to the total expected industry profit in all three cases, and that we can compare profit levels simply by comparing wholesale prices.

When is Π^* larger than Π^o? The inequality $\Pi^* > \Pi^o$ holds if the difference between w_i^* and w_i^m is smaller than the difference between w_i^o and w_i^m. Here, it is important to note that w_i^* can take any value greater than c, i.e., that w_i^* can be both *smaller and larger* than w_i^m. If w_i^* is smaller than w_i^m, i.e., $w_i^o < w_i^* < w_i^m$, then w_i^* is always the wholesale price closest to w_i^m. If w_i^* is larger than w_i^m, the difference between w_i^* and w_i^m is still smaller than the difference between w_i^o and w_i^m as long as $w_i^* < w_i^m + (w_i^m - w_i^o) = 2w_i^m - w_i^o$. Taken together, we have that $\Pi^* > \Pi^o$ if and only if $w_i^o < w_i^* < 2w_i^m - w_i^o$. To gain more intuition, we can use the wholesale price formulas to write this compound inequality as

$$c < c + \delta < c - 2E\left[\frac{\partial R_j}{\partial q_i}\right].$$

By dropping c from each part of the above inequality and rearranging, we get:

$$-E\left[\frac{\partial R_j}{\partial q_i}\right] > \frac{1}{2}\delta. \tag{6}$$

This gives the following result.

Proposition 2. *The manufacturer's equilibrium profit* Π^* *is larger (smaller) than her opportunism profit* Π^o *if condition* (6) *is satisfied (not satisfied).*

To understand this result, consider the left-hand side of (6). Here, the derivative $\frac{\partial R_j}{\partial q_i}$ represents the negative impact of retailer i's sales on retailer j's revenue, i.e., the intensity of retail competition. Competition is weak if $\frac{\partial R_j}{\partial q_i}$ is close to zero, and fierce if the absolute value of $\frac{\partial R_j}{\partial q_i}$ is large. We know from equation (3) in Section 2.1 that the monopoly price w_i^m is close to c if retail competition is weak. In this case, there is little scope for risk aversion and uncertainty to increase the manufacturer's profit vis-a-vis in the opportunism equilibrium, and condition (6) is not likely to be satisfied. On the other hand, if retailers are competing fiercely, w_i^m can be much larger than c, and there is much scope for condition (6) to hold.

Hence, the intuition for Proposition 2 is that the manufacturer is most likely to benefit from setting (w_1^*, w_2^*) instead of (w_1^o, w_2^o) when retail competition is fierce. The opportunism problem is a serious concern when competition is fierce, and many different levels of risk sharing (i.e., positive values of δ) can make Π^* larger than Π^o in such cases.

How does Π^* vary with the need for risk sharing? To answer this question, we must first decide how w_i^* varies with the need for risk sharing, or, more specifically, with the levels of risk aversion and uncertainty. Intuitively, we should expect that w_i^* increases with these levels, because more risk aversion or more uncertainty makes risk sharing more important.

However, it is not straightforward to fully confirm this intuition from equation (5). A general and unambiguous result can be obtained only for a marginal increase in risk aversion, in which case δ and w_i^* always increase. For a marginal increase in uncertainty, the effect on w_i^* depends on how 'more uncertainty' is defined, as well as on the sign and size of the third derivative of the utility function u'''.[15] For more specific assumptions about θ and risk preferences, we can show that w_i^* increases with the uncertainty level.[16]

[15] These are well-known issues in the literature, studied at least since Rothschild and Stiglitz (1970). See Eeckhoudt et al. (1995) for a good treatment in the context of the risk averse newsboy problem, and once again Asplund (2002) for the case with oligopolistic firms.

[16] Take, for example, the linear inverse demand $P_i(q_i, q_j, \theta) = 1 + \theta - q_i - q_j$, in which θ is uniformly distributed on $[-\Delta, \Delta]$. The greater is Δ, the greater the uncertainty. If retailers are infinitely risk averse (i.e., they require nonnegative profit for $\theta = -\Delta$), solving the game yields $w_i^* = c + \Delta$.

For the rest of this section however, I focus on marginal changes in risk aversion:

Corollary 1. *The equilibrium wholesale prices are increasing in the retailers' level of risk aversion.*

Proof. See Appendix A.

Given Corollary 1, the rest of this argument is best done in a figure. Figure 1 illustrates $\widetilde{\Pi} \equiv \Pi\left(q_1\left(w_1^*\right), q_2\left(w_2^*\right)\right)$, i.e., the manufacturer's profit as a function of the retailers' equilibrium quantities defined over the range of wholesale prices.

Figure 1 here (see p. 21 of this document).

Suppose that the contracting game leads to an equilibrium in which the wholesale price w_i^* is *less* than w_i^m. Any point on the solid part of the graph in Figure 1 has this property. Then, all else equal, a marginal increase in w_i^* toward w_i^m would cause $\widetilde{\Pi}$ to move toward Π^m. Because Π^m is the maximal profit level by construction, this change in $\widetilde{\Pi}$ would be positive, i.e., a profit increase. By Corollary 1, this is equivalent to stating that $\widetilde{\Pi}$ would marginally increase upon a marginal increase in risk aversion. More risk aversion calls for higher wholesale prices and lower quantities, which leads to higher profit if quantities are above the monopoly level. On the other hand, if w_i^* is *greater* than w_i^m (but still less than $2w_i^m - w_i^o$), the opposite argument is true. At any point on the dashed part of the graph in Figure 1, quantities are already less than the monopoly level. Thus, it is only in the lower half of the wholesale price interval in which $\Pi^* > \Pi^o$ that $\widetilde{\Pi}$ increases in the risk aversion level. I summarize the above discussion in the following result:

Proposition 3. *The manufacturer's equilibrium profit given by $\widetilde{\Pi}$ increases (decreases) with the retailers' level of risk aversion if $w_i^* < w_i^m$ $(w_i^* > w_i^m)$.*

From the manufacturer's perspective, there is no trade-off between risk sharing and overall efficiency if equilibrium quantities are above the monopoly level. An interesting way to interpret this result goes through the two externalities that influence her profit. Risk sharing creates double marginalization, which is a negative, bilateral externality. Greater risk aversion exacerbates the vertical externality and gives a negative profit effect. The opportunism problem is a negative, multilateral contracting externality. Greater risk aversion counteracts the contracting externality and gives a positive profit effect.[17] If the contracting externality is strong relative to the vertical externality, the latter positive effect outweighs the first negative effect. This relative magnitude of the two externalities is likely to arise, e.g., for high intensities of retail competition or low levels of uncertainty. In such cases, the manufacturer's equilibrium profit is likely to be increasing in the risk aversion level, in which case she would prefer to deal with more risk averse retailers to further limit the opportunism problem.[18]

4 Empirical and experimental evidence

This section discusses three sources of evidence in the literature that support the model and the results above.

Vertical integration and uncertainty. As stated in the Introduction, there is tension between theory and evidence on the relationship between vertical integration and uncertainty. Whereas standard theory predicts a positive correlation, surveys of empirical studies by Prendergast (2002) and Lafontaine and Slade (2007) point to a negative correlation. In the theory model developed in the present paper, a negative correlation can be natural. The following two paragraphs explain why.

The argument builds on the seminal work of Hart and Tirole (1990). They show that forward vertical integration can help a manufacturer that offers secret contracts to escape the opportunism problem. Integration can be used for this purpose because the manufacturer internalizes the negative effect of an opportunistic deviation on her affiliated retailer. Now, in the model in Section 2, suppose that the manufacturer can, as an alternative to contracting with both retailers, integrate with one retailer at Stage 1. In terms of the uncertainty level, when is she likely to choose integration over separation?

The answer follows from two observations. First, assuming that the manufacturer

[17] Interestingly, while risk aversion curbs the contracting externality in my 'common supplier' model, Bernheim and Whinston (1998, Section V) find that retail risk aversion creates a contracting externality in their 'common agency' model.

[18] In a model in which a principal-agent pair competes in prices against an independent principal, Katz (1991) notes that the agent's risk aversion can soften competition and increase channel profits. However, whereas Katz's argument is reversed with quantity competition, the basic idea of my theory applies in both cases.

claims the entire profit of the integrated firm, this expected profit level does not depend on the uncertainty level. Second, suppose that retail competition is relatively fierce. Then, as shown in Section 3, a high uncertainty level reduces the opportunism problem and gives the manufacturer a relatively large profit under vertical separation. By summarizing, we get the key point: if retailers are close substitutes, the potential gain of vertical integration is small when the uncertainty level is high. Moreover, integration can in itself involve costs. A direct example is a fixed cost, and a more subtle example is the manufacturer's incentive to restrict supply to the nonintegrated retailer, which may reduce demand and the available industry profit when retailers are differentiated.[19] Such issues can tip the scale in favor of separation, in particular when the level of uncertainty is high.

Several alternative theories to explain the negative correlation exist in the literature. The most popular one is probably due to Prendergast (2002). In a model with one principal and one agent, he shows that if the agent can gather payoff-relevant information about market conditions, more noisy information calls for stronger incentives, i.e., less integration. Prendergast's (2002) theory is very different from my story, in which integration is not a tool for affecting bilateral incentives, but for regaining multilateral control. Thus, my argument is less suited to settings in which integration is measured, e.g., as pay-for-performance sensitivity. However, it is interesting that the strongest evidence of a negative correlation comes from franchising industries (see Lafontaine and Slade 2007, Table 1), in which both opportunism and risk sharing are relevant concerns.

Experimental studies of opportunism. We have two direct tests of secret, vertical contracting: Martin et al. (2001) and Möllers et al. (2014). These authors study the market situation known from the theoretical literature (i.e., without risk aversion and uncertainty) experimentally, with participants playing the roles of manufacturer and retailers. In the treatments with simple, nonlinear contracts, both studies find that the manufacturer supplies quantities greater than the monopoly level, but less than the Cournot level. This result confirms the relevance of opportunism, but rejects the main hypothesis of the theoretical literature. Martin et al. (2001, p. 478) write that:

[19] In Hart and Tirole's (1990) model with homogeneous retailers, the nonintegrated retailer is excluded from the market with no loss. With differentiated retailers, the equilibrium may involve partial foreclosure; see Rey and Tirole (2007, p. 43) and Reisinger and Tarantino (2015, Section 4) on this.

> 'Factors not accounted for by the theory seem to allow U [the manufacturer] to exercise greater commitment power than expected'.

The present paper points to risk sharing as a factor that restores commitment power. Martin et al. (2001) suggest that their findings may be explained by heterogeneity in retailers' beliefs, i.e., that some retailers have passive beliefs and some have symmetric beliefs. In the present paper, we get less opportunism even if all retailers have passive beliefs, which are more plausible than symmetric beliefs in the Cournot setting.

Furthermore, my analysis gives a prediction that could be tested experimentally: for high levels of retailer substitutability, more uncertainty leads to lower quantities and higher profits. In an experimental setting, in which each retailer is controlled by a single test subject ('the owner'), retailers' strategies may well display risk aversion.

Picking franchisees. Kaufmann and Lafontaine (1994) study the business strategy of the McDonald's Corporation. One of their main findings (see pp. 441–444) is that McDonald's deliberately hires liquidity-constrained franchisees. For example, McDonald's asks owner-operators to provide large shares of start-up capital, while, at the same time, restricting (by contract) the operators' access to alternative sources of income. Kaufmann and Lafontaine argue that McDonald's uses this strategy to leave franchisees with ex ante rents, which can be used to pay for ex post sales effort that increases industry profits.

My analysis indicates that such a strategy may also be used to restore market power and profits in the face of an opportunism problem. As discussed by Banal-Estañol and Ottaviani (2006), liquidity-constrained firms are likely to behave as risk averse. As suggested by my Proposition 3, risk averse firms can be attractive trading partners because they are less receptive to secret discounts. Hence, the financial flexibility of downstream firms may affect the profit of upstream firms, even in cases where downstream sales effort is of little importance.

5 Conclusion

This paper pairs Rey and Tirole's (1986) risk sharing model with Rey and Vergé's (2004) opportunism model. I find that risk sharing mitigates opportunism in vertical contracting, and that the manufacturer profits from more risk aversion if retail competition is fierce. I now discuss a few implications of these results.

Whereas the manufacturer in my model uses only two-part tariffs, the literature on secret contracts emphasizes that vertical restraints can solve the opportunism problem. This is an important point for antitrust policy, because this role of restraints is anti-competitive. For example, O'Brien and Shaffer (1992) show that monopoly prices can be restored with maximum resale price maintenance. This solution would not work in my model because the expected industry profit is reduced if retailers cannot adjust their prices to fit demand conditions.[20] The present paper thus takes the view that upstream firms in volatile markets with risk averse (say, small or specialized) downstream firms may not find it worthwhile or feasible to curb opportunism with restraints.

Another potentially interesting policy point is that more risk aversion gives less opportunism and higher retail prices. This result indicates that factors that make retailers behave as risk averse can reduce consumer surplus. Also Nocke and Thanassoulis (2014) reach this conclusion. In their model, the retailer becomes risk averse because of credit constraints. Moreover, credit constraints can arise because of various imperfections in the credit market, for example due to asymmetric information (see e.g. Greenwald and Stiglitz 1990). The present paper and that of Nocke and Thanassoulis (2014) thus point to a potential link between credit market policies and the antitrust policy of vertical markets.

Although my formal analysis focuses on second-best solutions, it follows directly from Section 3 that the manufacturer earns the first-best, monopoly profit with two-part tariffs if the monopoly wholesale price coincides with the equilibrium wholesale price.[21] Yet, because both these prices are fully determined by exogenous factors, such an outcome would merely be a stroke of luck. One way to extend the simple model studied here could be to let the manufacturer affect some of the factors that determine w_i^*, e.g., by picking retailers with a certain risk aversion level.

Finally, a more general statement of this paper's main message is that risk aversion and

[20] See Rey and Tirole (1986) for a discussion of vertical restraints under risk aversion and uncertainty. Note also that Rey and Vergé (2004, p. 739) show that O'Brien and Shaffer's solution for contract equilibria and Bertrand competition does not transfer to the case with passive beliefs equilibria and Cournot competition.

[21] More formally, we know from equations (3) and (5) that $w_i^m = w_i^*$ if $E\left[\frac{\partial R_j}{\partial q_i}\right] = \delta$.

uncertainty can mitigate negative, multilateral contracting externalities.[22] Such externalities are found in a variety of economic settings, many of them discussed in Segal (1999). One example is Bizer and DeMarzo's (1992) model of 'sequential banking', in which a borrower (principal) cannot commit to not lend money from multiple banks (agents). The borrower's lack of commitment creates a negative externality across banks because of a higher default probability, to which banks respond with higher interest rates. As a result, the borrower's surplus is reduced. In that context, a possible application of my intuition is that the borrower's surplus and total welfare could be higher if banks faced tighter credit constraints.

[22] A related point (without the contracting dimension) is made by Bramoullé and Treich (2009) in the context of global pollution with risk averse countries. They show that a higher variance of each country's damage from total emissions can increase total welfare by inducing countries to pollute less.

Appendix A

This appendix contains the derivation of the equilibrium wholesale price w_i^* in equation (5) (leading up to Proposition 1) and the proof of Corollary 1.

Deriving equation (5)**.** The Lagrangian function corresponding to the manufacturer's problem is defined by:

$$\mathcal{L} = E\left[\sum_{i=1,2}\left\{(w_i - c)\, q_i^w + F_i - \lambda\left[u\left(\left(P_i\left(q_i^w, q_j^e, \theta\right) - w_i\right) q_i^w - F_i\right)\right]\right\}\right].$$

The first-order condition of $\mathcal{L}$ with respect to w_i is

$$E\left[q_i^w + (w_i - c)\frac{\partial q_i^w}{\partial w_i} - \lambda\left[u' \times \left(-q_i^w + \underbrace{\frac{\partial P_i}{\partial q_i^w}\frac{\partial q_i^w}{\partial w_i} q_i^w + \left(P_i\left(q_i^w, q_j^e, \theta\right) - w_i\right)\frac{\partial q_i^w}{\partial w_i}}_{=0}\right)\right]\right] = 0.$$

The last term in the large parenthesis is equal to zero due to the envelope theorem: when retailer i has optimized π_i with respect to q_i (i.e., $\frac{\partial \pi_i}{\partial q_i} = 0$), only the direct effect of w_i on π_i matters (i.e., $\frac{\partial \pi_i}{\partial w_i} = -q_i^w$). Rewrite the first-order condition for w_i as

$$E\left[q_i^w\right] + (w_i - c)\, E\left[\frac{\partial q_i^w}{\partial w_i}\right] + \lambda E\left[u' q_i^w\right] = 0. \tag{A1}$$

The first-order condition of $\mathcal{L}$ with respect to F_i is

$$E\left[1 - \lambda\left(u' \times (-1)\right)\right] = 0 \iff \lambda = -\frac{1}{E\left[u'\right]} < 0. \tag{A2}$$

The sign of λ implies that $\mathcal{L}$ is concave. Substitute λ from $(A2)$ into $(A1)$:

$$E\left[q_i^w\right] + (w_i - c)\, E\left[\frac{\partial q_i^w}{\partial w_i}\right] - \frac{1}{E\left[u'\right]} E\left[u' q_i^w\right] = 0.$$

Multiply this equation by $E\left[u'\right]$ and use the identity $cov(u', q_i^w) \equiv E\left[u' q_i^w\right] - E\left[u'\right] E\left[q_i^w\right]$. Solve for w_i to get (5). ■

Proof of Corollary 1. Rewrite (5), to which w_i^* is the solution, as

$$(w_i - c)\, E\left[\frac{\partial q_i^w}{\partial w_i}\right] = \frac{cov\,(u', q_i^w)}{E\,[u']}. \tag{A3}$$

Define $\widehat{u} \equiv k\,(u)$ with $k' > 0$ and $k'' < 0$. Thus, a retailer is more risk averse with $\widehat{u}$ than with u. An equivalent expression to $(A3)$ with $\widehat{u}$ is

$$(w_i - c)\, E\left[\frac{\partial q_i^w}{\partial w_i}\right] = \frac{cov\,(\widehat{u}', q_i^w)}{E\,[\widehat{u}']}. \tag{A4}$$

Let $\widehat{w}_i^*$ be the solution to $(A4)$. By Proposition 1 in Asplund (2002), the absolute value of the right-hand side in $(A4)$ is larger than in $(A3)$. Because $\frac{\partial q_i^w}{\partial w_i} < 0$, this property implies that $\widehat{w}_i^* > w_i^*$. ■

Figures

Figure 1 (to be inserted at page 13).

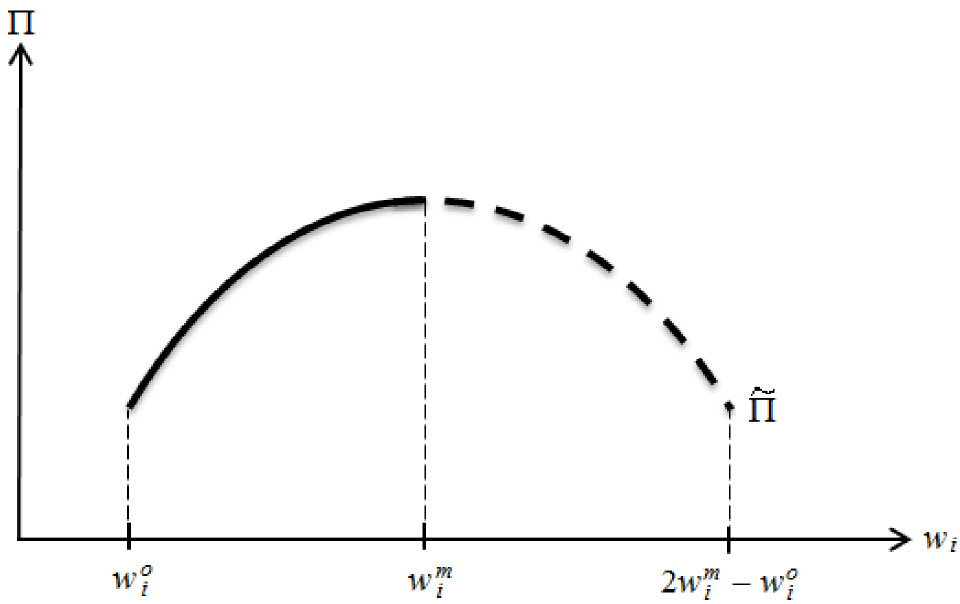

Figure 1: $\widetilde{\Pi}$ increases (decreases) in the risk aversion level if $w_i^* < w_i^m$ ($w_i^* > w_i^m$).

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