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Vertical control, opportunism, and risk sharing

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ABSTRACT

A manufacturer who offers secret contracts faces an opportunism problem: She undercuts her own input prices and fails to offset retail competition. I show that this problem diminishes when retailers are risk averse and face demand uncertainty. Risk aversion and uncertainty create a bilateral risk sharing incentive that raises equilibrium input prices above marginal cost. The manufacturer can therefore profit from downstream risk aversion when retail competition is fierce.

1. Introduction

To achieve *vertical control*, manufacturers must restrict output to offset retail competition. A fundamental idea in the vertical restraints literature is that an upstream monopolist can do this by charging per-unit input prices above the marginal cost of production and extract remaining downstream rents by fixed fees (Mathewson and Winter, 1984). This strategy is attractively simple and well within antitrust laws in both the US and the EU. Not surprisingly though, it fails under imperfect information.[1]

For one, the manufacturer cannot commit to these input prices when retailers are unable to observe each other's offers; i.e., when contracts are secret. Instead, an *opportunism* problem arises: The manufacturer cuts the price to one retailer to free ride on the rents of rival retailers, then cuts the price to a second retailer and so forth until all prices equal marginal cost (Hart and Tirole, 1990; O'Brien and Shaffer, 1992; McAfee and Schwartz, 1994). Thus, when contracts shift from observable to secret, the market outcome shifts from one extreme, monopoly, to another, unfettered competition.[2]

Another strand of the literature abstracts from the issue of secret contracting and emphasizes instead a different informational friction, namely demand uncertainty. Although the friction is different the conclusion is similar: uncertainty is a problem because it prevents vertical control. In particular, problems arise when retailers are risk averse because the manufacturer must engage in *risk sharing* to provide insurance against unfavorable market conditions. As shown by Rey and Tirole (1986), this involves designing contracts in a way that distorts pricing incentives and leaves rents for the retailers.[3]

In many real-world markets, we see a combination of the above-mentioned issues:

- *Vertical supply contracting*. A manufacturer offers a new and original product but retailers may behave as risk averse; e.g., due to liquidity constraints or by "inheriting" risk aversion from their owners (Banal-Estañol and Ottaviani, 2006). Supply contracts are typically proprietary information.
- *Franchising*. McDonald's, 7-Eleven, H&R Block, etc., use the franchise model. A franchisee is often a person with "skin in the game" (Fan et al., 2017) who cannot inspect the contracts of rival franchisees nor foresee how many customers she will attract or which products and services they will purchase.
- *Technology licensing*. An innovator (upstream party) pitches a new technology to a risk averse firm (e.g., as in Bousquet et al., 1998). Unless the innovator can commit to an exclusive contract the firm may reasonably worry that also her rivals will obtain the technology, and at lower royalty rates as well.

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1 The strategy may also fail if retailers can exert sales effort, see Mathewson and Winter (1984).

2 There is a strong analogy between this opportunism problem and the Coase-conjecture for durable goods monopoly. Coase's (1972) monopolist, who cannot commit to prices over time, sells at cost from the first period onwards and loses all market power. The manufacturer who cannot commit to contracts across retailers sells at cost to all buyers and retains no vertical control.

3 In addition, retail risk aversion may cause vertical foreclosure (Hansen and Motta, 2020).

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Despite the many examples, I am not aware of any study of an upstream firm's contracting problem in a setting with risk aversion, uncertainty, *and* secret contracts. In this paper, I examine exactly such a model in which one manufacturer offers secret two-part tariffs to several risk averse retailers while consumers' taste for the product is unknown.[4] The analysis contributes to the literature on secret contracting by showing that the presence of retail risk aversion leads to input prices above marginal cost that depend on the risk aversion level and demand curvature in intuitive ways. The model delivers testable predictions and a better understanding of the trade-off between risk sharing and rent extraction. An interesting corollary is that when downstream competition is sufficiently fierce, the manufacturer can actually profit from the retailers' risk aversion because the incentive for risk sharing mitigates the opportunism problem.

2. Model

There is one manufacturer, M, and $n \geq 2$ retailers. (I use feminine pronouns for all firms.) N is the set of retailers. M has constant marginal cost of production, $c \geq 0$. I normalize all other costs to zero. There are two stages. In the first stage, M makes take-it-or-leave-it contract offers to the retailers. Contract offers are secret, and retailers never observe each other's terms throughout the game. The offer to retailer $i \in N$ is a two-part tariff, $T_i(q_i) = F_i + w_i q_i$, with fixed fee F_i, input price w_i, and quantity q_i. Each retailer then accepts or rejects her offer. In the second stage, retailers with accepted offers place their orders, pay the tariffs, and compete à la Cournot in the final market.

A stochastic variable θ, with bounded support on $(\underline{\theta}, \overline{\theta})$, captures the "taste" for M's product among final consumers. The value of θ is unknown throughout the first stage. At the beginning of the second stage, nature picks θ upon which it becomes observable to all active firms. This timing, which I borrow from Rey and Tirole (1986), implies that retailers are unable to predict perfectly their revenues from reselling M's product when considering her supply terms.

The solution concept is perfect Bayesian equilibrium (PBE) given the passive beliefs refinement. With passive beliefs, a retailer does not update her beliefs about the rivals' offers in the event that she receives an unexpected (i.e., out-of-equilibrium) offer.[5] I focus on symmetric equilibria.

The inverse demand faced by retailer i is $P_i(q_i, \mathbf{q}_{-i}, \theta)$, where $\mathbf{q}_{-i}$ is the vector of quantities of all other retailers. Inverse demand functions are symmetric. For any θ and n-dimensional vector of input prices, I assume that the downstream Cournot game has a stable, unique, and interior equilibrium. Finally, I assume that the function P_i is thrice continuously differentiable with the following properties, $\forall i \neq k$:

$$\frac{\partial P_i}{\partial q_i} \leq \frac{\partial P_i}{\partial q_k} < 0, \quad 2\frac{\partial P_i}{\partial q_i} + \frac{\partial^2 P_i}{\partial q_i^2} q_i < 0, \quad \frac{\partial P_i}{\partial \theta} > 0,$$
$$\frac{\partial^2 P_i}{\partial q_i \partial \theta} > 0, \quad 3\frac{\partial^2 P_i}{\partial q_i^2} + \frac{\partial^3 P_i}{\partial q_i^3} q_i < 0.$$

Starting left, I call the first condition A1, etc. Then, A1 says that consumers see retailers as substitutes; A2 implies that retail marginal revenue functions are decreasing in q_i; A3 says that, all else equal, a retailer can charge a higher price if consumers are more receptive to M's product; A4 implies that retail marginal revenue functions are increasing in θ; and A5 ensures that M's second order condition holds.

Finally, let $u(\pi_i)$ be the utility that retailer i derives from earning a profit of $\pi_i = [P_i(q_i, \mathbf{q}_{-i}, \theta) - w_i] q_i - F_i$. Here, u is a von Neumann-Morgenstern utility function with $u(0) = 0$, $u' > 0$, and $u'' < 0$: the retailers are risk averse. M is risk neutral.

3. Analysis

3.1. Deriving the main result

At the second stage, retailer i sets q_i to maximize her profit given the observed state θ. The first order condition equates retailer i's marginal revenue and marginal cost:

$$\frac{\partial \pi_i}{\partial q_i} = 0 \iff \frac{\partial P_i(q_i, \mathbf{q}_{-i}, \theta)}{\partial q_i} q_i + P_i(q_i, \mathbf{q}_{-i}, \theta) = w_i. \tag{1}$$

In equilibrium, (1) holds $\forall i$. Let $q_i(w_i, \mathbf{w}_{-i}, \theta)$ be retailer i's equilibrium quantity where $\mathbf{w}_{-i}$ is the vector of all other retailers' input prices, and let

$$\widetilde{\pi}_i(w_i, \mathbf{w}_{-i}, \theta) \equiv [P_i(q_i(w_i, \mathbf{w}_{-i}, \theta), \mathbf{q}_{-i}(\mathbf{w}_{-i}, w_i, \theta), \theta) - w_i] \times q_i(w_i, \mathbf{w}_{-i}, \theta)$$

be her flow profit as a function of θ and input prices.

Consider now M's choice of input prices and fixed fees at the first stage. To derive M's objective function, note first that, with passive beliefs, each retailer anticipates that her rivals face the (symmetric) equilibrium input price w^*. Setting $\mathbf{w}_{-i} = \mathbf{w}^*$, M's expected profit can be written as

$$\pi_M = E\left[\sum_{i \in N} \left[(w_i - c) q_i\left(w_i, \mathbf{w}^*, \theta\right) + F_i\right]\right],$$

where $E[.]$ is the expectation operator for θ. Furthermore, retailers will accept their offers if and only if the proposed terms promise a nonnegative expected utility. This gives the following ex ante participation constraints:

$$E\left[u\left(\widetilde{\pi}_i\left(w_i, \mathbf{w}^*, \theta\right) - F_i\right)\right] \geq 0, \quad \forall i \in N.$$

M's objective function is therefore

$$\mathcal{L}_M = E\left[\sum_{i \in N} \left[(w_i - c) q_i\left(w_i, \mathbf{w}^*, \theta\right) + F_i - \lambda_i\left[u\left(\widetilde{\pi}_i\left(w_i, \mathbf{w}^*, \theta\right) - F_i\right)\right]\right]\right],$$

where in which λ_i is the multiplier for retailer i's participation constraint. M maximizes $\mathcal{L}_M$ with respect to F_i and w_i, $\forall i \in N$. Hereafter, I drop all functional arguments to simplify the exposition. The first order conditions can be written as

$$\frac{\partial \mathcal{L}_M}{\partial F_i} = E\left[1 - \lambda_i\left[-u'\right]\right] = 0, \tag{2}$$

$$\frac{\partial \mathcal{L}_M}{\partial w_i} = E\left[q_i + (w_i - c)\frac{dq_i^*}{dw_i} - \lambda_i\left[u'\left[\frac{dq_i^*}{dw_i}\left(\frac{\partial P_i}{\partial q_i} q_i + P_i - w_i\right) - q_i\right]\right]\right] = 0, \tag{3}$$

where q_i^* is short for retailer i's equilibrium quantity.

To proceed, let us note two things about (3). First, inside the brackets after u' we have in parentheses the derivative of retailer i's profit with respect to q_i. By (1), this equals zero in

[4] Abstracting from second-order differences, the model can be seen either as Rey and Tirole (1986) with secret contracts or, equivalently, McAfee and Schwartz (1994) with risk aversion and uncertainty.

[5] Passive beliefs is the standard assumption in the secret contracts literature (e.g., McAfee and Schwartz, 1994; Aghadadashli et al., 2016). These beliefs are similar in spirit to the market-by-market conjectures in Hart and Tirole (1990) and the contract equilibrium in O'Brien and Shaffer (1992). Note also that passive beliefs coincide with so-called wary beliefs under retail Cournot competition (Rey and Vergé, 2004). Thus, my main result holds also with wary beliefs.

equilibrium. By the envelope theorem, therefore, only the direct effect $\partial\pi_i/\partial w_i = -q_i$ remains. Second, after the input margin $(w_i - c)$ we have the term dq_i^*/dw_i, which is the pass-through rate of retailer i's input price to her equilibrium quantity. We can get an explicit formula for this pass-through rate by evaluating (1) at the equilibrium quantities (when $\mathbf{w}_{-i} = \mathbf{w}^*$), differentiating with respect to w_i, and then solving for dq_i^*/dw_i. This yields the following (expected value of the) pass-through rate, which I denote by ρ_i:

$$\rho_i = \frac{1}{E\left[2\left(\partial P_i/\partial q_i\right) + \left(\partial^2 P_i/\partial q_i^2\right) q_i\right]} < 0,$$

where the sign follows from A2. These observations allow us to rewrite (3) as

$$E\left[q_i\right] + (w_i - c)\,\rho_i + \lambda_i E\left[u' q_i\right] = 0. \tag{4}$$

Furthermore, we have from (2) that

$$\lambda_i = -\frac{1}{E\left[u'\right]}. \tag{5}$$

By substituting (5) into (4), we obtain

$$\begin{aligned} E\left[q_i\right] + (w_i - c)\,\rho_i - \frac{E\left[u' q_i\right]}{E\left[u'\right]} &= 0 \\ &\Updownarrow \\ E\left[u'\right](w_i - c)\,\rho_i &= E\left[u' q_i\right] - E\left[u'\right] E\left[q_i\right] \\ &\Updownarrow \\ E\left[u'\right](w_i - c)\,\rho_i &= Cov(u', q_i), \end{aligned}$$

where the last equivalence uses the definition of covariance which applies because u' and q_i are random variables at the first stage. Importantly, we have $Cov(u', q_i) < 0$ for a risk averse retailer: A change in θ that raises q_i will, under A3 and A4, also raise π_i and thereby reduce u' because $\left(u'\right)' = u'' < 0$. Let

$$\mu_i \equiv \frac{Cov(u', q_i)}{E\left[u'\right]} < 0,$$

such that the first order condition for w_i can be rewritten one more time as

$$(w_i - c)\,\rho_i = \mu_i. \tag{6}$$

It is easy to verify that M's second order condition holds.[6] In a symmetric equilibrium with $w_i = w^*$, $\forall i$, we have $\rho_i = \rho$ and $\mu_i = \mu$, $\forall i$, because inverse demand and utility functions are symmetric. By solving (6), we get the main result:

Proposition 1. *In the symmetric PBE with passive beliefs, M sets the input price to each retailer above marginal cost:*

$$w^* - c = \frac{\mu}{\rho} > 0. \tag{7}$$

On the one hand, the manufacturer behaves opportunistically because she sees her relationship with each retailer in isolation, and thereby neglects the multilateral nature of her contracting problem and the need to internalize competition between channels. In the terminology of Segal (1999), this is a contracting externality which exerts downward pressure on input prices. On the other hand, the manufacturer finds it bilaterally optimal to raise each retailer's input price (and lower the fixed fee) to reduce the variance of retail flow profits and thereby provide insurance against the event that consumers dislike the product. This creates a vertical externality akin to double marginalization which counteracts the contracting externality by exerting upward pressure on input prices. In equilibrium, the manufacturer sets an input price that balances the two incentives.[7] Risk sharing is therefore a novel explanation for why secret contracting need not cause marginal cost pricing.[8]

The equilibrium input price, w^*, rises with the retailers' risk aversion level. This follows because the absolute value of μ increases with the risk aversion level, that is with the degree of concavity of u (see Asplund, 2002). Intuitively, a more risk averse retailer places more weight on low demand states and the risk of monetary losses when considering M's offer. To provide such a retailer with better insurance, M should raise the input price. Consequently, (higher levels of) retail risk aversion also unambiguously reduces output and consumer surplus in this model.

Moreover, w^* falls in the absolute value of ρ, that is in the "strength" of pass-through. Stronger pass-through means that M faces a more elastic derived demand curve, which, all else equal, calls for a price cut. Pass-through, in turn, depends on demand curvature. For instance, consider the case in which consumers see retailers as perfect substitutes. The market-wide inverse demand is $P(Q, \theta)$ with $Q = q + (n-1)\,q^*$ for each retailer. This yields $\rho = 1/\left[P'\left(2 + \eta\kappa\right)\right] < 0$ where $\eta \equiv P''Q/P'$ is the curvature of $P(Q, \theta)$ and $\kappa = 1/n$ is the retail sector's conduct parameter.[9] Note that $\eta\kappa > -2$ by A2. From (7) we get $w^* - c = \mu P'\left(2 + \eta\kappa\right) > 0$ which, all else equal, is higher (lower) the more concave (convex) is inverse demand.

3.2. Relationship to commitment solution

Another important question is how the price given by (7) compares to the price that M would choose if she could in fact commit to input prices because her contract offers were publicly observable. With public contracts, we generally know that upstream firms can seek vertical control by raising input prices in accordance with the intensity of retail competition. When the incentive for competition dampening coexists with the incentive for risk sharing, M would therefore get an extra push to increase her margins. Consequently, we should expect that a move from public to secret contracts tends to reduce input prices and expand output, just as in models without risk aversion and uncertainty (e.g., Hart and Tirole, 1990; McAfee and Schwartz, 1994).

To illustrate this point, let us consider the following example (inspired by Banal-Estañol and Ottaviani (2006)). Suppose that inverse demand is $P_i\left(q_i, Q_{-i}, \theta\right) = a + \theta - q_i - bQ_{-i}$, $\forall i \in N$. The parameter $b \in [0, 1]$ measures consumers' willingness to substitute across retail outlets and $Q_{-i} = \Sigma_{k \neq i}^{n-1} q_k$ is the total output of retailers $k \neq i$. Let $\alpha \equiv a - c > 0$ be the effective market size. Suppose also that θ has mean 0 and variance $\sigma^2 > 0$

6 The second order condition holds if and only if $\mathcal{L}_M$ is concave. First, it can be shown that $(w_i - c)\,q_i$ is concave if and only if

$$\begin{aligned} &\frac{d\left[q_i + (w_i - c)\,\rho_i\right]}{dw_i} \\ &= 2\rho_i + \frac{(w_i - c)\left[3\left(\partial^2 P_i/\partial q_i^2\right) + \left(\partial^3 P_i/\partial q_i^3\right) q_i\right]}{-\left[2\left(\partial P_i/\partial q_i\right) + \left(\partial^2 P_i/\partial q_i^2\right) q_i\right]^3} < 0, \end{aligned}$$

which holds by A5 as long as $w_i \geq c$. Second, the term $-\lambda_i\left[u(.)\right]$ is concave because $u'' < 0$ if and only if $\lambda_i < 0$ which follows from (5). Thus, $\mathcal{L}_M$ is concave.

7 This result and the underlying intuition is robust. In particular, expressions similar to (7) can be derived also if retailers compete in prices, if there are idiosyncratic demand shocks or uncertainty about per-unit retailing costs, if there is upstream competition, or if the manufacturer uses other (non-linear) contracts. Proofs are available from the author upon request.

8 Also Pinopoulos (2019) finds that a manufacturer who offers secret contracts sets input prices above cost. However, the result is perhaps less surprising in his model as he restricts attention to inefficient linear contracts without fixed fees.

9 See Adachi and Ebina (2014) and Gaudin (2016) for more on pass-through in vertical relationships.

and that retailers have mean–variance preferences over profits, $u(\pi_i) = E[\pi_i] - (r/2)\,Var[\pi_i]$, where $r \geq 0$ is the coefficient of risk aversion. As is well known, such preferences can be obtained from utility functions with constant absolute risk aversion and normally distributed uncertainty. For clarity, I assume that the product $r\sigma^2$ is not too large.[10] Under these assumptions, M's equilibrium margin with secret contracts (corresponding to (7)) is

$$w^* - c = \frac{\alpha r\sigma^2}{\tau + r\sigma^2}, \tag{8}$$

where $\tau \equiv 2 + (n-1)\,b > 0$. With public contracts, the symmetric equilibrium[11] price can instead be written as

$$\overline{w} - c = \frac{(\alpha b/4)\,(n-1)\,\tau^2 + \alpha r\sigma^2}{(1/2)\,(1 + b\,(n-1))\,\tau^2 + r\sigma^2}. \tag{9}$$

In line with the above intuition, it is straightforward to verify from (8) and (9) that the difference $\Delta w \equiv \overline{w} - w^*$ is strictly positive for all n and $b > 0$ and zero when retailers serve independent markets ($b = 0$). Relatedly, note that $w^* > c$ if and only if $r\sigma^2 > 0$ whereas $\overline{w} > c$ even if $r\sigma^2 = 0$. Finally, it is worth noting that retail substitutability has opposite effects on $\overline{w}$ and w^*: Whereas $\overline{w}$ rises with b because M puts more weight on relaxing competition, w^* falls with b because retailers pay smaller franchise fees and therefore require less insurance.

3.3. Upstream profits and downstream risk aversion

Proposition 1 has a striking managerial implication: A manufacturer who offers secret contracts can raise her profit by targeting risk averse retailers if downstream competition is fierce enough (that is, assuming risk preferences can be inferred).

To see this in the general model, consider the case in which retail outlets are perfect substitutes and suppose for a moment that the retailers were risk neutral. In this case, M would sell at marginal cost (as $u'' = \mu = 0$) and extract each retailer's (expected) flow profit by a fixed fee. She would therefore earn the full industry profit, which coincides with the aggregate profits in a Cournot oligopoly where all firms have constant marginal cost c. Under A1, these profits vanish as n goes to infinity (see Amir, 2002). Against this benchmark, what would be the impact on M's expected profit of making retailers slightly risk averse? There are two opposing effects. On the one hand, input prices would rise above cost which would raise the industry profit. On the other hand, M could no longer extract this entire profit. Specifically, a risk averse retailer requires a nonnegative certainty equivalent, which equals her expected profit less a risk premium (which is typically increasing in the risk aversion level). Thus, the fixed fee can at most equal the retailer's expected flow profit less the risk premium. In other words, M gets a smaller slice of a larger pie when retailers go from risk neutral to slightly risk averse.[12] But when n becomes sufficiently large and the profit under risk neutrality sufficiently small, the benefit of higher input prices dominates and M prefers risk averse retailers.[13]

[10] If $r\sigma^2$ is very large relative to b and n, then M may give insurance also through negative fixed fees. She would then have to raise per-unit input prices also for pure rent extraction purposes, which would muddle the interplay between risk sharing and competition dampening that I want to emphasize.

[11] The appropriate solution concept for the public offers game is subgame perfect Nash equilibrium.

[12] The same logic applies to any further increase in the risk aversion level as long as the resulting input price is not "too high" in the sense that it induces retailers to buy less than the industry-profit maximizing quantity.

[13] An analogous argument implies that M could profit by making a product whose base demand is uncertain instead of certain (for given expected demand) or by creating more uncertainty (e.g., raising σ^2) about the demand for her product.

This logic carries over to the case of differentiated retailers in the above-mentioned example. By using (8), we find that M's expected equilibrium profit with secret contracts is

$$E[\pi_M] = \frac{\left(2 + r\sigma^2\right)\alpha^2 + \left(\sigma^2/2\right)\left(\tau + r\sigma^2\right)^2}{(2/n)\left(\tau + r\sigma^2\right)^2},$$

where $dE[\pi_M]/dr > 0$ whenever $n > (1/b)\left(2 + b + r\sigma^2\right)$. Note that a higher (lower) value of b, indicating more (less) retail substitutability, reduces (raises) the threshold number of retailers above which M profits from downstream risk aversion.

3.4. Empirical implications

The model yields several empirical predictions. First, it is natural to think that small retailers may be more risk averse than large retailers; e.g., because small retailers face tighter liquidity constraints or because large retailers have more diversified product portfolios. In that case, Proposition 1 suggests that small retailers will pay higher input prices. Furthermore, the pricing rule in Proposition 1 illustrates how the demand structure and the retail pass-through rate can affect per-unit input prices even when firms use non-linear vertical contracts.[14]

Finally, the model offers an explanation for the inverse empirical relationship between product market risk and the incidence of vertical integration (see Lafontaine and Slade, 2007). This relationship is widely seen as a puzzle because a classic agency model with a risk neutral principal and one risk averse agent predicts that the principal should attain *more* vertical ownership when outcomes become more uncertain. However, the evidence is consistent with an alternative theory of vertical integration, based on supplier opportunism. To see this, we can start from the observation that vertical integration is a way for an upstream firm to regain commitment power and raise profits (Hart and Tirole, 1990). In my model, however, upstream profits may be positively correlated to product market risk in the form of demand uncertainty, which together with downstream risk aversion enables the manufacturer to raise her input prices. (With deterministic demand, $Cov\left(u', q_i\right) = \mu = w^* - c = 0$.) Put differently, product market risk may limit the value of vertical integration as a tool to combat the opportunism problem, which is consistent with the data.

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[14] Miller et al. (2017) study the US cement industry and estimate pass-through rates above one, which is consistent with log-convex demand.

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