The Value of Transparency in Dynamic Contracting with Entry*

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Abstract

A manufacturer designs a long-term contract with a retailer who is privately informed about demand and faces competition by an entrant in the future. When demand is correlated across periods, information about past sales affects firms’ behavior after entry. We analyze the incentives of the incumbent players to share this information with the entrant and show that the manufacturer and the retailer have diverging objectives: when the retailer wants to disclose information, the manufacturer does not, and vice versa. Although transparency harms consumers and reduces total welfare, incumbent players jointly benefit from selling information to the entrant.

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1 Introduction

In vertically related markets, incumbents facing the threat of future entry may engage in anticompetitive practices like exclusive dealings, limit pricing, most-favoured nation clauses and other forms of vertical restraints that protect their market power. Incumbents may also use information disclosure as a strategic tool against competitors. Although information sharing among firms has been extensively studied in static models of oligopoly (see, e.g., Vives, 2006, for a survey), little is known on firms’ incentives to share information in dynamic environments, where incumbents may strategically disclose or hide information to potential entrants (see, e.g., Bonatti and Cisternas, 2018). Even less is known on the interplay between these incentives and vertical contracting.

Do incumbents want to share their private information with future competitors? How is information sharing affected by vertical contracting? What is the price for this information? What are the effects on final consumers?

To address these questions, we analyze a dynamic vertical contracting environment in which a manufacturer deals with an exclusive retailer for two periods. In the first period the retailer is a monopolist in the downstream market, while in the second period it faces competition by an integrated entrant. The incumbent firms may exchange information about their past sales with the entrant.

The use of multi-period exclusive contacts, entry of integrated competitors and information sharing are common in many industries. For example, in franchise markets contracts are typically exclusive, long lasting and not renegotiable, and new entrants mainly use company-owned outlets rather than independent retailers. Blair and Lafontaine (2011) document that in franchise markets independent retailers coexist with company-owned units and, compared to larger and established franchisors, young franchisors that are still in their adjustment phase tend to rely more on company-owned outlets. Specifically, their data show that new franchise chains almost all begin with few pilots that are 100-percent company-owned. Moreover, competitors in these markets routinely exchange information through buying cooperatives and trade associations, franchising advertising meetings and conventions, and elsewhere (see, e.g., Anderson and Pearce, 2003).

The retailing and food supply chain industries are other notable examples of markets where the main features of the environment that we analyze are present (see, e.g., Yan, 2010, Eksoz et al., 2014, among others). In these markets, a long-term relationship between the incumbent firms often arises because the manufacturer needs to use a retailer with the specific skills to customize a new product, requiring a fixed investment that is not worth paying for one period only. By contrast, an entrant may not need a specialized retailers

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1 Blair and Lafontaine (2011) report that the average duration of a franchise contract is 10.7 years. Azoulay and Shane (2001) find that 142 out of 170 business-franchise systems adopt exclusive contracts (see also Anand and Khanna, 2000). Lafontaine and Shaw (1999) find that 75% of franchisors in their panel never change their terms over a 12-year period.
once the incumbent has developed the product’s characteristics that are more suitable for final consumers. Moreover, in these industries manufacturers and retailers usually share information with their rivals thorough forecasting partnerships, and the disclosure of sales data or sales report — see, e.g., Jin (1994) and Vives (1990). Firms’ incentives to disclose this data is unclear, however. For example, in 2001 Wal-Mart stopped selling its sales data to outside companies, like Information Resources Inc. and ACNielsen, that used to resell them to other retailers — see, e.g., Hays (2004) and Shamir (2012).

We assume that firms compete à la Cournot by selling a homogeneous product whose demand is uncertain and, in every period, is privately observed by the downstream players — i.e., by the retailer in both periods and by the entrant in the second period. The manufacturer designs a long-term contract to elicit the retailer’s private information, specifying the quantity produced by the retailer and the transfer paid to the manufacturer in every period. Since demand is correlated over time, the retailer’s second-period production depends on its report about demand and its production in the first period (that the manufacturer uses to update its beliefs about demand) — i.e., the optimal dynamic contract features memory (e.g., Baron and Besanko, 1984; Laïont and Tirole, 1996; Battaglini, 2005, among others).

We show that firms’ profits depend on the information about first-period production possessed by the entrant. One may wonder why the entrant should care about this information, since it observes demand in the second period, when it chooses production. The reason is that, because the entrant does not observe demand in the first period, past production conveys information on the retailer’s production in the second period, thus affecting firms’ choices and market competition post entry. In other words, the long-term interaction between the incumbent players creates a contractual link between periods, and the role of information sharing hinges on this link.

Our main result is that the manufacturer and the retailer have diverging incentives to share information about past production (or sales). When the downstream firm is willing to disclose this information to entrants, the upstream firm does not want to do so, and vice versa. The reason is that the manufacturer’s profit and the retailer’s information rent are affected by the entrant’s production in opposite ways. Moreover, firms’ incentive to share information depends on the degree of demand uncertainty, which indicates the relevance of information asymmetry.

When uncertainty about demand is small, the retailer wants to inform the entrant about its first-period production, while the manufacturer has no incentive to disclose this information. The reason is that an informed entrant expands production when it expects the incumbent’s production to be distorted — i.e., in a low-demand state — whereby reducing the market price and the profit that the manufacturer can extract from the retailer. This

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Notice that, in contrast to other models of information sharing, in our environment the entrant is only interested in information that signals the quantity produced by the retailer in the second period (like its report or the quantity produced in the first period), rather than information about demand per se.
magnifies the retailer’s standard incentive to report low demand, because in this case the manufacturer requests a lower transfer both because demand is low and because the entrant is (relatively) more aggressive. This competition effect à la Martimort (1996) increases the information rent that the manufacturer pays to the retailer in the second period (compared to a situation without information sharing). In addition, ceteris paribus, the manufacturer’s profit is lower with information sharing because an informed entrant is more aggressive on average: a business stealing effect.3

The opposite incentives arise when uncertainty about demand is large: the manufacturer wants to disclose past production, while the retailer has no incentive to do so. In this case, the distortion featured by the incumbent’s quantity with information sharing becomes of first order magnitude compared to the effect of this decision on the competition effect. Essentially, since the entrant is more aggressive when it is informed, the manufacturer has a stronger incentive to distort production with information sharing than without information sharing, and this incentive magnifies as demand uncertainty increases. As a result, the difference in the incumbent’s quantities have a larger effect on the retailer’s rent and overcome the competition effect, so that the retailer prefers not to share information. Consider now the manufacturer. On the one hand, sharing information reduces the retailer’s information rent; on other hand, however, it makes the entrant a tougher competitor. When uncertainty is sufficiently large, the first effect dominates — i.e., optimally solving internal agency problems becomes more important than softening competition — and the manufacturer prefers to share information.

More generally, our analysis suggests that when information asymmetry is (relatively) strong, internal agency problems are more important than competitive issues. Specifically, a vertical structure characterized by substantial agency problems tends to adopt organizational and contractual arrangements that reduce internal inefficiencies, rather than external competition. By contrast, when the amount of information asymmetry is smaller, agency problems are second order and firms tend to be more concerned with the effects of information on the behavior of competitors.

Interestingly, although the two incumbent firms never agree to disclose information to the entrant at no cost, the entrant is always willing to pay a sufficiently high price to induce incumbents to jointly sell such information. The reason is that information sharing maximizes total firms’ profits in the market. Therefore, a market for information may arise in our environment. (See Bergemann and Bonatti, 2018, for a survey of the recent literature on these types of markets.)

Finally, the effects of information sharing on consumer surplus and total welfare depend on its impact on the overall efficiency of the industry. Sharing information reduces the in-
cumbent’s production because, other things being equal, it induces the entrant to increase production when the incumbent distorts it for rent extraction reasons. On balance, however, aggregate production is lower with information sharing because, holding constant the incumbent’s production, the entrant’s production decision is always efficient regardless of its information (since the entrant equalizes marginal revenue to marginal cost). In other words, although information sharing rebalances production between the incumbent and the entrant, it reduces market efficiency because it increases the retailer’s rent via the competition effect. Therefore, consumer surplus and welfare are always lower with information sharing in our model and, contrary to what is commonly believed, a welfare maximizing policy should reduce transparency and forbid incumbents to disclose information to entrants.

Of course, there are other reasons why information sharing may affect welfare (see, e.g., Vives, 2006, for a survey). For example, the existing literature on information sharing in static oligopoly models shows that firms want to share demand or cost information when this increases efficiency.4 Moreover, the literature on collusion highlights the anticompetitive effect of sharing information about past prices — see, e.g., Green and Porter (1984). We chose to neglect these channels in order to focus on the effects of information sharing in dynamic environments with vertically separated firms. The novel insight of our analysis is that disclosing information about past production to entrants does not necessarily increase competition and consumer surplus, when taking into account the effect of disclosure on retailers’ rents. Hence, from a normative point of view, welfare may actually be reduced by mandatory disclosure rules forcing firms in vertical relationships to adopt transparency standards that reveal information to potential entrants.

The rest of the paper is organized as follows. After discussing the existing literature, Section 2 describes the baseline model and Section 3 discusses benchmarks without asymmetric information and without entry in the second period. Section 4 provides the equilibrium analysis with and without information sharing. In Section 5, we describe the incumbents’ incentives to share information and analyze a market for information. Welfare is discussed in Section 6. The last section concludes. All proofs are in the Appendix. The working paper version of this article, Karakoç et al. (2018), contains additional material and analyzes various extensions under the assumption of small uncertainty.

Related Literature. We build on and contribute to three strands of literature. First, our paper relates to the literature on dynamic contracting with types correlated over time and full commitment by the principal. Baron and Besanko (1984) first characterized optimal contracts in a two-period environment. Laffont and Tirole (1996) applied dynamic contracting with adverse selection to the regulation of pollution rights and provided an interpretation of the optimal mechanisms in terms of markets with options. More recently, 

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4Some of the effects highlighted in this literature would also emerge in our framework if we had demand uncertainty after entry (like in many standard models). We chose to eliminate these additional channels in order to focus on our new main effects.
stemming from Battaglini (2005), the literature has evolved to multi-period models (both with discrete and continuous types) to investigate the memory and complexity of optimal dynamic contracts after long histories, convergence to efficiency, the effects of learning by doing, risk aversion and renegotiation, the limits of the ‘first-order’ approach, the impact of dynamics and enforcement risk on the contract incompleteness and stationarity (Arve and Martimort, 2016; Battaglini and Coate, 2008; Battaglini and Lamba, 2015; Garrett and Pavan, 2012; Gennaioli and Ponzetto, 2017; Esó and Szentes, 2017; Martimort et al., 2017; Pavan et al., 2014).5 In our two-period model, most of these technical issues are not present: we chose to analyze a simple contracting environment to focus on the relationship between dynamics, transparency and product market competition.

Second, our analysis is related to the IO literature on information sharing in oligopoly. This literature shows that firms’ incentives to share information about their common demand function (Novshek and Sonnenschein, 1982; Clarke, 1983; Vives, 1984; Gal-Or, 1985) or about their private costs of production (Fried, 1984; Gal-Or, 1986; Shapiro, 1986) depend on the nature of competition. Raith (1996) rationalizes the results of this vast literature in a unified framework. In contrast to our model, this literature typically assumes that firms are ex ante symmetric and play simultaneously. By studying dynamic incentives and sequential entry, we introduce an endogenous asymmetry between firms that depends on the incumbent’s contract and information sharing decision, which affect the entrant’s behavior.6 Hence, the novel and key feature of our environment is vertical contracting, which creates an endogenous relationship between information and competition. Without the contracting dimension, information sharing would play no role in our model since firms’ production in every period would only depend on current demand, which is observed by the entrant.

Jin (1994) also analyzes a dynamic environment with common demand uncertainty which firms share information about past sales, but does not consider vertical contracting. In a two-period model, he shows that without sales reports firms manipulate rivals’ perception about the market by distorting first-period decisions. By contrast, sales reports eliminate firms’ incentive to do so. In a Cournot industry, firms are better off with sales reports, while consumer surplus and welfare are reduced by this form of communication. Our paper complements this work by focusing on the effects of information sharing on sales reports through the contracting channel only.

Finally, we contribute to the literature on communication between vertical hierarchies, with endogenous information that principals have to obtain from privately informed retailers. Calzolari and Pavan (2006a) were the first to study this problem in a sequential contracting environment where principals may share the information obtained by contracting with a common agent (see also Calzolari and Pavan, 2006b, for a model with resale). They show

5See Bergemann and Pavan (2015) for a survey of the dynamic contracting literature.
6While in most of the existing literature on information sharing firms symmetrically exchange information and reciprocally learn about each other’s characteristics, in our model the decision to share information is unilaterally taken by the incumbent, who has perfect information about the entrant.
how the information disclosed by one principal affects the contractual relationships between other players and analyze when a principal wants to offer full privacy to the agent.\textsuperscript{7} When contracts are exclusive, Piccolo and Pagnozzi (2013) show that sharing information affects contracting within competing organizations and induces agents’ strategies to be correlated through the distortions imposed by principals to obtain information.\textsuperscript{8} In this environment, the incentives to share information depend on the nature of upstream externalities between principals and the correlation of agents’ information.\textsuperscript{9} In contrast to our model, both these papers focus on one-period relationships. More recently, Bonatti and Cisternas (2018) study a dynamic model where firms sequentially share information about a long-lived consumer. Because firms do not compete to attract the consumer (who buys in every period from one ‘monopolistic’ firm), information about past sales is only used to update beliefs about the consumer’s preferences and set prices optimally.

\section{The Model}

\textbf{Players and Environment.} Two incumbent players, a manufacturer $M$ and its exclusive retailer $R$, contract for two periods. The manufacturer supplies a fundamental input to the retailer, which is used to produce a final good. We assume that there is a constant marginal cost of production, that we normalize to zero. In the first period $\tau = 1$, $R$ is a monopolist in the downstream market. In the second period $\tau = 2$, an integrated firm $E$ enters the market and firms compete by choosing quantities.\textsuperscript{10} There are no entry costs.\textsuperscript{11}

For example, our model is consistent with actual franchise markets, that are characterized by exclusive and long-lasting contracts, as well as new entry by manufacturer-owned outlets (Blair and Lafontaine, 2011). More generally, in contrast to later entrants, an incumbent manufacturer may have to use long-term contracts whenever it needs a retailer with the specific abilities to customize and market a new product.

The inverse demand function in period $\tau = 1, 2$ is

\[ P(\theta_\tau, Q_\tau) \triangleq \max \{0, \theta_\tau - Q_\tau\}, \]

where $Q_1$ is $R$’s production in the first period and $Q_2 \triangleq q_2 + q_E$ is aggregate production in the second period — i.e., the sum of $R$’s second-period production $q_2$ and $E$’s production $q_E$. The parameter $\theta_\tau \in \Theta \triangleq \{\underline{\theta}, \overline{\theta}\}$ is a measure of the magnitude of demand, with $\Delta \theta \triangleq \overline{\theta} - \underline{\theta} > 0$.

\textsuperscript{7}See also Bennardo \textit{et al.} (2015) and Maier and Ottaviani (2009) for common agency models with moral hazard and communication.

\textsuperscript{8}Guo \textit{et al.} (2011), Hamir and Shin (2015) and Zhou and Zhu (2010) analyze similar models by taking a cheap talk approach rather than a mechanism design perspective.

\textsuperscript{9}See also Piccolo \textit{et al.} (2015) for a model with moral hazard and communication between competing hierarchies.

\textsuperscript{10}Karakoç \textit{et al.} (2018), the working paper version of this article, considers entry by a non-integrated firm.

\textsuperscript{11}In Section 6, we discuss the implications of introducing (fixed) entry costs.
The assumption of a linear demand function is standard in the literature on information sharing but it is not necessary for most of our results.

Demand is correlated across periods. We assume that \( \Pr [\theta_1 = \bar{\theta}] = \frac{1}{2} \), and let

\[
\Pr [\theta_2 = \bar{\theta} | \theta_1 = \bar{\theta}] = \Pr [\theta_2 = \bar{\theta} | \theta_1 = \theta] \equiv \nu.
\]

The parameter \( \nu \in \left[ \frac{1}{2}, 1 \right] \) measures the degree of demand persistency: a higher \( \nu \) makes it more likely that demand in the second period is equal to demand in the first period.\(^{12}\)

In every period, \( R \) privately observes \( \theta_\tau \) while the manufacturer does not. The entrant observes \( \theta_2 \), but not \( \theta_1 \).

**Contracts.** We assume that \( M \) commits to a long-term contract with \( R \). Following the literature — e.g., Baron and Besanko (1984) — we define a long term contract as a menu

\[
\{ q_1 (m_1), t_1 (m_1), q_2 (m_2, m_1), t_2 (m_2, m_1) \},
\]

where, for every period \( \tau, m_\tau \in \Theta \) is \( R \)'s report about \( \theta_\tau \); while \( q_\tau (\cdot) \) is the quantity produced by \( R \) and \( t_\tau (\cdot) \) the transfer paid by \( R \) to \( M \), both contingent on \( R \)'s current and past reports. In practice, this contract can be implemented through non-linear transfers \( t_1 (q_1) \) and \( t_2 (q_2, q_1) \), such that the second-period transfer depends on the first-period production.\(^{13}\)

\( R \) is protected by limited liability in both periods, which avoids full surplus extraction by \( M \) in the second period (see, e.g., Laffont and Martimort, 2002).

**Communication.** The contract between \( M \) and \( R \) is secret, so that \( E \) cannot directly observe it. However, the incumbent players can disclose the first-period quantity \( q_1 \) to \( E \) before market competition takes place in the second period. Following the literature — e.g., Vives (1984) and Raith (1996) among many others — we consider a ‘all-or-nothing’ disclosure policy \( d \in \{ S, N \} \): either \( q_1 \) is fully disclosed to \( E \) (\( d = S \)) or it remains private information of \( R \) and \( M \) (\( d = N \)).\(^{14}\)

Incumbents disclosing first-period production to the entrant is a natural and realistic form of communication, since quantities are usually verifiable, and firms may disclose sales reports (Jin, 1994).\(^{15}\) By contrast, it may not be possible for the manufacturer to credibly

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\(^{12}\)Karakoç et al. (2018), the working paper version of this article, analyzes a more general stochastic structure, where demand persistency in the second period depends on demand in the first period, and demand may be negatively correlated across periods.

\(^{13}\)We do not consider more complex franchise contracts, like resale price maintenance (RPM), in order to avoid full extraction of \( R \)'s surplus by \( M \) — see, e.g., Gal-Or (1991). For example, RPM contracts cannot be enforced when prices are too costly to verify. Even with RPM, however, information rents may still emerge if adverse selection is coupled with a moral hazard problem à la Laffont and Tirole (1986).

\(^{14}\)Karakoç et al. (2018), the working paper version of this article, considers more general (stochastic) disclosure rules.

\(^{15}\)Given that, in practice, long-term contracts consist of menus that specify production in a period as a function of production in previous periods, disclosing information about quantity simply amounts to disclosing the contractual terms implemented by \( M \) and \( R \).
communicate the retailer’s report \( m_1 \). Notice that assuming that firms can only share information about \( q_1 \) is without loss of generality in our framework, because of the contractual link between \( R \)'s first-period report \( m_1 \) and its first-period and second-period production. On the other hand, the entrant is not interested in information about \( \theta_1 \) per se, because the incumbent’s production in the second period only depends on \( R \)'s report on first-period demand. Of course, disclosing information about \( R \)'s report or production in the second period has no effect since \( E \) directly observes \( \theta_2 \).

As standard in the literature, we also assume that once an information sharing decision has been announced, it cannot be renegotiated after uncertainty about \( \theta_1 \) and \( \theta_2 \) realizes. Commitment requires, for instance, the presence of a third party (such as a certification intermediary) that verifies communication. We discuss the effects of secret renegotiations in Remark 1. Moreover, rather than assuming that a specific incumbent player chooses whether or not to share information with the entrant, we first characterize the equilibrium under each disclosure policy, and then analyze the incumbents’ private and joint incentives to share or sell information.

**Timing and Profits.** The timing of the game is as follows.

1. **First period.**
   - A disclosure policy \( d \in \{S, N\} \) is announced.
   - \( R \) observes \( \theta_1 \).
   - \( M \) offers a contract. If \( R \) accepts it, it reports \( m_1 \) to \( M \).
   - Production occurs, and \( t_1 \) is paid.

2. **Second period.**
   - \( E \) enters.
   - \( q_1 \) is disclosed if and only if \( d = S \) and \( E \) updates its beliefs about \( \theta_1 \).
   - \( R \) and \( E \) observe \( \theta_2 \).
   - \( R \) reports \( m_2 \) to \( M \).
   - Production occurs, and \( t_2 \) is paid.

All players are risk neutral and \( M \) and \( R \) discount future profit at a common discount factor \( \delta \in (0, 1) \). This can be interpreted as a measure of the length of the period before entry occurs. Hence, \( R \)'s intertemporal payoff is

\[
\sum_{\tau=1,2} \delta^{\tau-1} \left[ P(\theta_\tau, Q_\tau) q_\tau - t_\tau \right],
\]
and $M$’s intertemporal payoff is
\[ \sum_{\tau=1,2} \delta^{\tau-1} t_\tau. \]

$E$’s profit is $P(\theta_2, Q_2) q_E$.

**Equilibrium.** The solution concept is Perfect Bayesian Equilibrium (PBE). We focus on separating equilibria in which: (i) $M$ offers an incentive compatible contract; (ii) $R$ accepts the contract and truthfully reports demand; (iii) quantity produced by firms in the second period are mutual best responses; (iv) when the incumbent shares information, the entrant correctly learns $m_1$ and therefore the quantity produced by the incumbent in the second period — i.e., $q_2(\theta_2, m_1)$. We impose passive beliefs off equilibrium path, so that whenever $R$ is offered an unexpected contract, it believes that $E$ still follows its equilibrium strategy. This is a natural assumption since $M$’s offer should not convey any information about $E$’s behavior.

The following assumption guarantees that in the equilibrium quantities are always positive — i.e., there is never shut down of production.

**Assumption 1.** Demand uncertainty is not too large — i.e., $\Delta \theta \leq \overline{\Delta \theta} \triangleq \frac{3\nu-1}{4} \theta$.

Moreover, we also assume that $\delta$ is not too large in order to ensure that intertemporal rents are positive — i.e., that in the first period $R$ has an incentive to mis-report only when demand is high (see Laffont and Martimort, 2002).\(^{16}\)

### 3 Benchmarks

Consider two useful benchmarks. First, suppose that, in every period, $\theta_\tau$ is common knowledge. Then $M$ fully extracts $R$’s surplus and the optimal contract implements the monopoly outcome in the first period — i.e., $q^*(\theta_1) \triangleq \frac{\theta_1}{2}$ — and the symmetric Cournot outcome in the second period — i.e., both firms produce $q^C(\theta_2) \triangleq \frac{\theta_2}{3}$.

Second, suppose that there is no entry in the second period. Assume that in each period only the incentive compatibility constraint of the high-demand retailer matters,\(^{17}\) and let $U_1(\cdot)$ be $R$’s equilibrium rent in the first period. Using a standard change of variables (e.g., Laffont and Martimort, 2002), $M$ offers the contract that solves the following intertemporal problem:

\[ \max_{q_1(\cdot), q_2(\cdot), U_1(\cdot)} \mathbb{E} \left[ \sum_{\tau=1,2} \delta^{\tau-1} P(\theta_\tau, q_\tau(\cdot)) q_\tau(\cdot) \right] - \sum_{\theta_1} \Pr[\theta_1] \left[ U_1(\theta_1) + \delta \Pr[\theta_2 = \overline{\theta}|\theta_1] \Delta \theta q_2(\theta, \theta_1) \right], \]

\(^{16}\)This is a sufficient condition that does not affect the main results of the analysis since only second-period outputs matter to determine the incentives to share/sell information, and the welfare effects of this choice.

\(^{17}\)It can be shown that this is always the case under Assumption 1.
subject to $U_1 (\vartheta) \geq 0$ and

$$U_1 (\vartheta) \geq U_1 (\vartheta) + \Delta \vartheta q_1 (\vartheta) + \delta \nu \Delta \vartheta [q_2 (\vartheta, \vartheta) - q_2 (\vartheta, \vartheta)].$$

(1)

It can be verified that both these constraints bind and that, in the optimal dynamic contract, first-period quantities are

$$q^M_1 (\vartheta) = q^* (\vartheta), \quad \text{and} \quad q^M_1 (\vartheta) = q^* (\vartheta) - \frac{\Delta \vartheta}{2},$$

while second-period quantities are

$$q^M_2 (\vartheta, \vartheta) = q^M_1 (\vartheta) - \frac{\Delta \vartheta}{2\nu},$$

and $q^M_2 (\vartheta, \vartheta) = q^* (\vartheta)$ in all other states $(\vartheta, \vartheta), (\vartheta, \vartheta)$, and $(\vartheta, \vartheta)$.

Hence, $R$ always produces the monopoly quantity $q^* (\cdot)$ in a period in which demand is high — i.e., there is ‘no distortion at the top’. Moreover, second-period production when demand is high in the first period and low in the second period is also not distorted. The reason is that, in this case, although reducing second-period production reduces $R$’s incentive to under-report demand in the second period, it also increases its incentive to under-report demand in the first period, and the two effects perfectly balance each other.

In the first period, there is a standard (static) downward distortion of production when demand is low, because of $R$’s incentive to under-report demand. By contrast, production in the second period is distorted only when demand is low in both periods and, in this case, compared to a static environment there is an additional intertemporal distortion. This distortion arises because a higher quantity in state $(\vartheta, \vartheta)$ makes it more attractive for $R$ to report low demand both in the second and in the first period, ceteris paribus.

The intertemporal distortion decreases with $\nu$ because a high probability of low demand in the second period following low demand in the first period reduces $M$’s willingness to distort production for efficiency reasons, since it makes state $(\vartheta, \vartheta)$ relatively more likely.

4 Equilibrium Analysis

In Section 4.1 we analyze $E$’s behavior in the second period and in Section 4.2 we derive $R$’s second-period rent. We then characterize the optimal contract offered by $M$ without information sharing in Section 4.3 and with information sharing in Section 4.4.
4.1 Entrant’s Behavior

Information sharing affects $E$’s production since $R$’s second-period production $q_2(\cdot)$ depends on its first-period report $m_1$ and, hence, on its first-period production.

Consider an equilibrium in which $R$ truthfully reports demand in the first period — i.e., such that $m_1 = \theta_1$ — and $E$ expects $R$ to produce $q_2(\theta_2, \theta_1)$ in the second period. With information sharing, $E$ learns $\theta_1$ and hence solves

$$\max_{q_E \geq 0} P(\theta_2, q_E + q_2(\theta_2, \theta_1))q_E.$$  

The solution to this problem yields a downward-sloping reaction function (that depends on $R$’s production)

$$q_E(\cdot) = \frac{\theta_2 - q_2(\theta_2, \theta_1)}{2}, \quad \forall (\theta_2, \theta_1) \in \Theta^2.$$  

(2)

By contrast, with no information sharing, $E$ must form a belief about $\theta_1$ (which is equal to $m_1$ in equilibrium), given $\theta_2$. Bayes’ rule implies that $E$’s posterior beliefs about $\theta_1$ are

$$\Pr[\theta_1 = \theta | \theta_2 = \overline{\theta}] = \Pr[\theta_1 = \theta | \theta_2 = \overline{\theta}] = \nu.$$  

Hence, given $\theta_2$, $E$’s problem is

$$\max_{q_E \geq 0} \sum_{\theta_1} \Pr[\theta_1 | \theta_2] P(\theta_2, q_E + q_2(\theta_2, \theta_1))q_E,$$

whose solution yields a downward-sloping reaction function (that depends on $R$’s expected production)

$$q_E(\cdot) = \frac{\theta_2 - \sum_{\theta_1} \Pr[\theta_1 | \theta_2] q_2(\theta_2, \theta_1)}{2}, \quad \forall \theta_2 \in \Theta.$$  

(3)

The slope of this function depends on the degree of demand intertemporal correlation: the higher is the correlation, the more ‘accurate’ is $E$’s inference on $\theta_1$ given $\theta_2$ and, hence, its estimate of $R$’s second-period production.

4.2 Second-Period Rents

For $d \in \{N, S\}$ let $\Delta q^d$ denote the difference between $E$’s equilibrium production with high and low demand in the second period — i.e., with a slight abuse of notation

$$\Delta q^d \equiv \begin{cases} 
\Delta q^N = q^N_E(\overline{\theta}) - q^N_E(\theta) & \text{if } d = N, \\
\Delta q^S(\theta, m_1) = q^S_E(\overline{\theta}, m_1) - q^S_E(\theta, m_1) & \text{if } d = S.
\end{cases}$$

With information sharing, $E$’s equilibrium production depends both on demand in the second period and on the actual quantity produced by $R$ in the second period, which is determined by $m_1$ through the contract chosen by $M$ (that $E$ correctly expects in equilibrium). By contrast,
without information sharing $E$ does not observe $m_1$ and can only form an expectation of the quantity produced by $R$.

By slightly abusing notation, let $U_2(\cdot)$ be $R$’s equilibrium rent in the second period. Following Martimort (1996), we first assume that $R$ only has an incentive to deviate from equilibrium by under-reporting demand and then verify this conjecture ex post. For any disclosure policy $d \in \{S, N\}$, in the second period $R$’s relevant incentive compatibility constraint is

$$U_2(\bar{\theta}, m_1) \geq U_2(\bar{\theta}, m_1) + (\Delta \bar{\theta} - \Delta q^d) q_2(\bar{\theta}, m_1), \quad \forall m_1 \in \Theta,$$

while its relevant participation constraint is

$$U_2(\bar{\theta}, m_1) \geq 0, \quad \forall m_1 \in \Theta.$$

Limited liability implies that $U_2(\bar{\theta}, m_1) = 0$ for every $m_1$. Therefore, in order to be induced to truthfully report demand to $M$ in the second period, $R$ obtains a rent equal to

$$U_2(\bar{\theta}, m_1) \triangleq \frac{\Delta \theta q_2(\bar{\theta}, m_1)}{\text{Information rent}} - \frac{\Delta q^d q_2(\bar{\theta}, m_1)}{\text{Competition effect}}, \quad \forall m_1 \in \Theta. \quad \text{(4)}$$

This expression embeds two contrasting effects. First, when demand is high in the second period, $R$ has a standard incentive to report low demand in order to pay a lower transfer. Other things being equal, this secures $R$ an information rent which is increasing in the quantity produced when demand is low — see, e.g., Mussa and Rosen (1978) and Maskin and Riley (1985).

Second, since $R$’s rent is also affected by $E$’s production, there is a competition effect (see, e.g., Martimort, 1996, and Gal-Or, 1999). Specifically, $R$’s incentive to under-report demand depends on $\Delta q^d$, which reflects the wedge between $R$’s transfer when it under-reports demand, as determined by $M$’s belief about $E$’s production following a report $m_1 = \bar{\theta}$, and the actual market price which instead reflects $E$’s true production when demand is high.

When $\Delta q^d > 0$, competition in the downstream market reduces $R$’s information rent, and makes it less costly for $M$ to elicit truthful information from $R$. The reason is that, when $R$ under-reports demand in the second period, it knows that $E$ produces a relatively large quantity (since demand is actually high), thus reducing the market price and $R$’s profit (compared to a market without entry). The transfer requested by $M$, however, does not take this effect into account, since $M$ expects $E$ to produce a (relatively) low quantity based on $R$’s report. Hence, $R$’s (off-equilibrium) incentive to under-report demand is weaker than without entry.

By contrast, when $\Delta q^d < 0$ competition in the downstream market increases $R$’s information rent, and makes it more costly for $M$ to elicit truthful information from $R$. The reason is that, in this case, $E$ produces a higher quantity with low demand than with high de-
mand.\textsuperscript{18} Therefore, $M$ requests a lower transfer (compared to a case without entry) when $R$ under-reports demand because it expects $E$ to produce more than what it actually does, thus reducing the market price. Hence, $R$’s (off-equilibrium) incentive to under-report demand is stronger than without entry.

As we will show, the competition effect plays a key role in our analysis: since the decision to share information affects $E$’s production, it also affects $R$’s second-period rents, and hence (ceteris paribus) $M$’s intertemporal profit.

### 4.3 No Information Sharing

Assume that incumbents do not share information. Let $R$’s rent in the first period be

$$U_1(\theta_1, m_1) \equiv P(\theta_1, q_1(m_1))q_1(m_1) - t_1(m_1),$$

and $U_1(\theta_1) \equiv U_1(\theta_1, m_1 = \theta_1)$, $\forall m_1 \in \Theta$. Taking into account its rent in the second period — i.e., equation (4) for $d = N$ — $R$’s intertemporal incentive compatibility constraint, which ensures that $R$ truthfully reports demand in the first period, is

$$U_1(\theta_1) + \delta \Pr[\theta_2 = \bar{\theta}|\theta_1] (\Delta \theta - \Delta q^N) q_2(\theta, \theta_1) \geq U_1(\theta_1, m_1) + \delta \Pr[\theta_2 = \bar{\theta}|\theta_1] (\Delta \theta - \Delta q^N) q_2(\theta, m_1), \quad \forall \theta_1, m_1 \in \Theta.$$

Assuming that this constraint only binds when demand is high,\textsuperscript{19} the relevant first-period incentive compatibility constraint is

$$U_1(\bar{\theta}) \geq U_1(\theta) + \Delta \theta q_1(\theta) + \delta \nu (\Delta \theta - \Delta q^N) [q_2(\theta, \theta) - q_2(\theta, \bar{\theta})], \quad \text{(5)}$$

while the relevant first-period participation constraint is $U_1(\bar{\theta}) \geq 0$.

The incentive compatibility constraint depends on two terms: the static rent of a single-period relationship and the intertemporal rent that $R$ obtains when demand is high in both periods, which happens with probability $\nu$. The sign of this second term depends on how the first-period report affects production in the second period when demand is low. If $q_2(\theta, \theta) > q_2(\theta, \bar{\theta})$, $R$’s second-period rent is higher when it reports low rather than high demand in the first period, since this increases the quantity produced in the second period when demand is low. In this case, $R$ has a stronger incentive to under-report demand in the first period and eliciting truthful information is more costly than in a static environment. By contrast, when $q_2(\theta, \theta) < q_2(\theta, \bar{\theta})$, it is less costly for $M$ to elicit truthful information because $R$ has a weaker incentive to under-report demand in the first period. Of course, as

\textsuperscript{18}This may actually happen in equilibrium because $E$ expects $R$’s quantity to be distorted when second-period demand is low, but not when second-period demand is high.

\textsuperscript{19}In the Appendix we check that under Assumption 1 this conjecture is verified in equilibrium.
\[ \Delta q^N \text{ increases and the competition effect becomes stronger, } R \text{'s second-period rent decreases and the difference } q_2(\theta, \theta) - q_2(\theta, \bar{\theta}) \text{ has a weaker effect on } R \text{'s first-period rent.} \]

### 4.3.1 Optimal Long Term Contract

After a standard change of variables, \( M \)’s intertemporal (relaxed) maximization problem is

\[
\max_{q_1(\cdot), q_2(\cdot); U_1(\cdot)} \mathbb{E} \left[ \sum_{\tau=1,2} \delta^{\tau-1} P(\theta_{\tau}, Q_{N}^N(\cdot)) q_{\tau}(\cdot) \right] + \\
- \sum_{\theta_1} \Pr[\theta_1] U_1(\theta_1) + \delta \Pr[\theta_2 = \bar{\theta}|\theta_1] \left( \Delta \theta - \Delta q^N \right) q_2(\theta, \theta_1) ,
\]

where

\[
Q_{N}^N(\theta_2, \theta_1) \triangleq q_2(\theta_2, \theta_1) + q_E^N(\theta_2),
\]

subject to incentive compatibility constraint (5) and the participation constraint \( U_1(\theta) \geq 0 \).

Since both constraints bind at the optimum, it can be shown that first-period production is as in a market without entry, with no distortion at the top and downward distortion at the bottom — i.e., using the superscript \( N \) to denote the optimal quantities chosen by the manufacturer, \( q_1^N(\bar{\theta}) = q^* (\bar{\theta}) \) and \( q_1^N(\theta) = q^* (\theta) - \frac{\Delta \theta}{2} \).

Differentiating the objective function with respect to \( q_2(\bar{\theta}, \theta_1) \) yields

\[
P_{q_2}(\bar{\theta}, Q_{2}^N(\bar{\theta}, \theta_1)) q_2(\bar{\theta}, \theta_1) + P(\bar{\theta}, Q_{2}^N(\bar{\theta}, \theta_1)) = 0, \quad \forall \theta_1 \in \Theta,
\]

where \( P_{q_2}(\cdot) \) denotes the partial derivative of the demand function with respect to \( q_2 \). Hence, when demand is high in the second period, \( R \)’s production is not distorted (compared to the benchmark with complete information, where \( \theta_1 \) is common knowledge) regardless of the level of demand in the first period — i.e., \( q_2^N(\bar{\theta}, \theta_1) = q^C(\bar{\theta}) \) for every \( \theta_1 \) — so that \( E \)’s best response is \( q_E^N(\bar{\theta}) = q^C(\bar{\theta}) \).

Differentiating the objective function with respect to \( q_2(\theta, \bar{\theta}) \) yields

\[
P_{q_2}(\theta, Q_{2}^N(\theta, \bar{\theta})) q_2(\theta, \bar{\theta}) + P(\theta, Q_{2}^N(\theta, \bar{\theta})) = 0.
\]

Hence, as without entry, if demand is high in the first period, the optimal dynamic contract does not distort production (for rent-extraction reasons) in the second period even if demand is low.

Finally, differentiating the objective function with respect to \( q_2(\theta, \theta) \) yields

\[
P_{q_2}(\theta, Q_{2}^N(\theta, \theta)) q_2(\theta, \theta) + P(\theta, Q_{2}^N(\theta, \theta)) = \frac{\Delta \theta - \Delta q^N}{\nu}.
\]

As without entry, the intertemporal distortion arises because increasing the second-period production in state \( (\theta, \theta) \) has two effects: a higher \( q_2(\theta, \theta) \) increases both \( R \)’s second-period
rent when demand is high in the second period and low in the first period, and \( R \)'s intertemporal rent when demand is high in the first period. Both these effects make it more profitable for \( R \) to under-report demand in the first period in order to enjoy a higher future rent, and hence induce \( M \) to distort production. In the presence of entry, however, the intertemporal distortion is reduced because of the competition effect.

Substituting \( q_N^2(\theta, \theta_1) = q_E^N(\overline{\theta}) = q^C(\overline{\theta}) \) into (3), (8), (9) yields the following result.

**Proposition 1** Without information sharing, \( q_N^2(\theta, \theta) < q_N^2(\theta, \overline{\theta}) < q^C(\theta) < q_E^N(\theta) = q^C(\overline{\theta}) \), so that \( \Delta q^N = 0 \).

Hence, \( M \) distorts production downward (compared to a benchmark without incomplete information) when demand is low in both periods in order to optimally trade off efficiency and rent extraction. This distortion induces \( E \) to increase production when demand is low, because \( E \) expects \( R \) to under-produce with positive probability. As a consequence, \( R \) faces a more aggressive competitor when demand is low in the second period, regardless of first-period demand, which induces \( M \) to reduce production even in state \((\theta, \overline{\theta})\).

Notice that \( E \) produces the same quantity in the second period, regardless of demand — i.e., \( q_E^N(\theta) = q_E^N(\overline{\theta}) \). The intuition is the following. On the one hand, other things being equal, \( E \) has an incentive to produce relatively more when demand is high in the second period, because the market is larger. On the other hand, however, when demand is low \( E \) has an incentive to increase production (compared to the complete information benchmark) because \( R \)'s production is distorted. These two effects perfectly balance. A relevant implication is that (in the equilibrium) there is no competition effect without information sharing.\(^{20}\)

### 4.4 Information Sharing

Assume now that incumbents share information. From equation (4), \( R \)'s second-period rent is

\[
U_2(\overline{\theta}, m_1) = (\Delta \theta - \Delta q^S(m_1)) q_2(\theta, m_1).
\]

Hence, \( R \)'s intertemporal incentive compatibility constraint is

\[
U_1(\theta_1) + \delta \Pr[\theta_2 = \overline{\theta}|\theta_1] [\Delta \theta - \Delta q^S(\theta_1)] q_2(\theta, \theta_1) \geq U_1(\theta_1, m_1) + \delta \Pr[\theta_2 = \overline{\theta}|\theta_1] [\Delta \theta - \Delta q^S(m_1)] q_2(\theta, m_1), \quad \forall \theta_1, m_1 \in \Theta.
\]

\(^{20}\)In the working paper version of this article, we show that when demand persistency depends on first-period demand, \( E \)'s production does depend on demand in the second period. All our qualitative results also hold in this case.
Assuming (and verifying ex post) that \( R \) only has an incentive to mis-report demand when demand is high, the relevant first-period incentive compatibility constraint is

\[
U_1(\bar{\theta}) \geq U_1(\theta) + \Delta \theta q_1(\theta) + \delta \nu \left[ (\Delta \theta - \Delta q^S(\bar{\theta})) q_2(\theta, \bar{\theta}) - (\Delta \theta - \Delta q^S(\bar{\theta})) q_2(\theta, \bar{\theta}) \right],
\]

(10)

while the relevant first-period participation constraint is \( U_1(\bar{\theta}) \geq 0 \).

Other things being equal, \( R \)'s intertemporal rent is increasing in \( \Delta q^S(\bar{\theta}) \) and decreasing in \( \Delta q^S(\bar{\theta}) \). The reason is the following. First, an increase in \( \Delta q^S(\bar{\theta}) \) reduces \( R \)'s rent in the second period, through the competition effect, when demand is high in the first period and \( R \) truthfully reports it (i.e., on the equilibrium path). This makes it more costly for \( M \) to induce \( R \) to truthfully report \( \theta_1 \). Second, an increase in \( \Delta q^S(\bar{\theta}) \) reduces \( R \)'s rent in the second period, through the competition effect, when it under-reports demand (i.e., off the equilibrium path). This makes it less attractive for \( R \) to deviate from equilibrium, and less costly for \( M \) to induce \( R \) to truthfully report \( \theta_1 \).

### 4.4.1 Optimal Long Term Contract

After a standard change of variables, \( M \)'s intertemporal (relaxed) maximization problem is

\[
\max_{q_1(\cdot), q_2(\cdot), U_1(\cdot)} \mathbb{E} \left[ \sum_{\tau=1,2} \delta^{\tau-1} P(\theta_\tau, Q^S_\tau(\cdot)) q_\tau(\cdot) \right] + \sum_{\theta_1} \Pr[\theta_1] \left[ U_1(\theta_1) + \delta \Pr[\theta_2 = \bar{\theta}|\theta_1] (\Delta \theta - \Delta q^S(\theta_1)) q_2(\theta, \theta_1) \right],
\]

(11)

where

\[
Q^S_2(\theta_2, \theta_1) \triangleq q_2(\theta_2, \theta_1) + q^S(\theta_2, \theta_1),
\]

subject to the incentive compatibility constraint (10) and the participation constraint \( U_1(\bar{\theta}) \geq 0 \). Since both constraints bind at the optimum, it is easy to show that first-period production is the same as without information sharing, and that in the second period there is no distortion at the top regardless of the level of demand in the first period — i.e., using the superscript \( S \) to denote the optimal quantities with information sharing, \( q^S_2(\bar{\theta}, \theta_1) = q^S(\bar{\theta}, \theta_1) = q^C(\bar{\theta}) \) for every \( \theta_1 \).

Differentiating the objective function with respect to \( q_2(\theta, \bar{\theta}) \) yields

\[
P_{q_2}(\theta, Q^S(\theta, \bar{\theta})) q_2(\theta, \bar{\theta}) + P(\theta, Q^S(\theta, \bar{\theta})) = 0.
\]

(12)

Hence, with information sharing, since \( E \)'s output depends on first-period demand, neither firm distorts production when demand is high in the first period and low in the second — i.e., \( q^S_2(\theta, \bar{\theta}) = q^S(\theta, \bar{\theta}) = q^C(\theta) \).
Differentiating the objective function with respect to $q_2 (\theta, \overline{\theta})$ yields
\[
P_{q_2} (\theta, Q_2^S (\theta, \overline{\theta})) q_2 (\theta, \overline{\theta}) + P (\theta, Q_2^S (\theta, \overline{\theta})) = \frac{\Delta \theta - \Delta q^S (\theta)}{\nu}.
\] (13)

Hence, the effects of the intertemporal distortions on production when demand is low in both periods are as in the case of no information sharing (see condition (9)).

Substituting $q_2^S (\theta_1, \overline{\theta}) = q_E^S (\theta_1, \overline{\theta}) = q_C^S (\theta_1)$ and $q_2^S (\theta, \overline{\theta}) = q_E^S (\theta, \overline{\theta}) = q_C^S (\theta)$ into (12) and (13), and solving jointly with $E$’s first-order condition (2) yields the following result.

**Proposition 2** With information sharing, $q_2^S (\theta, \overline{\theta}) < q_C^S (\theta, \overline{\theta}) < q_E^S (\theta, \overline{\theta})$. Moreover, $\Delta q^S (\theta) < 0 < \Delta q^S (\overline{\theta})$.

As intuition suggests, $E$ produces more than $R$ when demand is low in both periods because $M$ distorts production downward to reduce $R$’s intertemporal rent. By contrast, firms produce the same quantities because $M$ does not distort production when: (i) demand is high in the second period or (ii) demand is high in the first period and low in the second period.

Notice that, in contrast to the case of no information sharing, with information sharing $E$’s production depends on demand in the second period, so that the competition effect arises in equilibrium. As we will show, this has a crucial effect on the incumbents’ incentive to share information. Interestingly, $\Delta q^S (\theta) < 0$. Therefore, with low demand in both periods, $E$ produces more than $R$ (as without information sharing) and also more than with high demand in the second period. The reason is that, when demand is low in both periods, $M$ distorts production both for static and for dynamic reasons (see condition (13)), which induces $E$ to increase production above $q_C^S (\overline{\theta})$ when it is informed.

By contrast, $\Delta q^S (\overline{\theta}) > 0$. The reason is that $M$ does not distort production when demand is high in the first period and, hence, $E$ produces more when demand is high than when demand is low in the second period. Specifically, the two firms produce the same Cournot quantity $q_C^S (\cdot)$ in the second period when $\theta_1 = \overline{\theta}$.

**Remark 1.** So far we have assumed that $E$ correctly learns $m_1$ in equilibrium, so that it infers the incumbent’s second-period production $q_2 (\theta_2, m_1)$ perfectly. One may wonder, however, if the incumbent(s) have an incentive to deceive the entrant by producing in the first period a quantity that is suboptimal from a static point of view, but that induces the entrant to wrongly update its beliefs. For example, when $\theta_1 = \overline{\theta}$, by producing the ‘inefficient quantity’ $q_1^M (\overline{\theta})$ in the first period, the incumbent(s) may convince $E$ to reduce its production since $q_2^S (\theta_2, \overline{\theta})$ is not distorted (compared to $q_2^S (\theta_2, \overline{\theta})$). This strategy is clearly costly because it distorts the incumbent first period production, but it may create a competitive advantage in the second period by reducing the entrant’s production. However, the first effect always dominates the second when $\delta$ is not too large, as we assume, because
in this case the incumbents place a relatively higher weight on first-period profit, than on second-period profit.

5 Incentives to Share Information

To analyze the effects of information sharing on the manufacturer’s and the retailer’s expected profits, we start by comparing $E$’s production with and without information sharing. Since production is never distorted when demand is high, we can focus on the quantity produced by $E$ when demand is low.\footnote{Notice that while we consider information about past production, similar effects arise with information about the retailer’s cost. In fact, information about $q_1$ allows the entrant to learn whether $R$’s production will be distorted in the second period, which is analogous to knowing whether a competitor has high or low cost of production.}

**Proposition 3** When demand is low in the second period, $E$’s production is higher (lower) with information sharing than without information sharing if demand is low (high) in the first period — i.e., $q_{SE}^S(\theta, \theta) < q_{NE}^S(\theta, \theta) < q_{SE}^N(\theta, \theta)$. Moreover, $E$’s average production is higher with information sharing than without — i.e., $\mathbb{E}_{\theta_1} \left[ q_{SE}^S(\theta, \theta_1) \right] > q_{NE}^N(\theta)$.

With information sharing, $E$ knows the quantity that $R$ produces in the second period. When demand is low in both periods, $R$’s second-period production is distorted for rent extraction reasons and, since reaction functions are downward sloping, this induces $E$ to produce more when it is informed. By contrast, when demand is low in the second period and high in the first period, $R$’s second-period production is not distorted and this induces $E$ to produce less when it is informed. Therefore, with information sharing $R$ faces tougher (weaker) competition from $E$ when demand is low (high) in the first period.

Without information sharing, $E$ is uncertain about $R$’s production and produces an intermediate quantity, between $q_{SE}^S(\theta, \theta)$ and $q_{SE}^N(\theta, \theta)$. In expectation, information sharing increases $E$’s production since the first effect discussed above dominates, so that the entrant obtains a larger expected market share when it is informed.

To analyze players’ incentives to share information, we now compare $R$’s expected rents and $M$’s expected profits with and without information sharing.

**Proposition 4** There exist two thresholds $\Delta \theta_R(\nu)$ and $\Delta \theta_M(\nu)$, with $\Delta \theta_R(\nu) > \Delta \theta_M(\nu)$, such that $R$ wants to share information if and only if $\Delta \theta \leq \Delta \theta_R(\nu)$, while $M$ wants to share information if and only if $\Delta \theta \geq \Delta \theta_M(\nu)$. Moreover, both thresholds are increasing in $\nu$.

Two effects determine $R$’s incentive to share information. First, holding constant $R$’s second-period production, sharing information impacts $E$’s production and hence $R$’s rent through the competition effect. Second, other things being equal, information sharing
changes $R$’s second-period production and thus its (expected) information rent (see equation (4)).

When $\Delta \theta$ is small, the competition effect of information sharing on the $R$’s rent dominates, while the effect on $R$’s production is second-order. In fact, as discussed before, while the competition effect is absent without information sharing, when $R$’s first-period production is disclosed (ceteris paribus) the competition effect increases $R$’s second-period rent when demand in the first period is low (since $\Delta q^S(\bar{\theta}) < 0$) and reduces $R$’s second-period rent when demand in the first period is high (since $\Delta q^S(\bar{\theta}) > 0$). In expected terms, however, the first effect dominates because production is distorted only when demand in the first period is low: in this case the competition effect counterbalances the rent reduction due to the intertemporal distortion. By contrast, production is not distorted when demand in the first period is high, so that the negative effect of the competition effect on $R$’s rent is less relevant. Hence, behind a veil of ignorance, $R$ prefers to face an informed rather than an uninformed competitor in the second period.\footnote{The fact that the retailer prefers to disclose information is in line with the literature finding that with Cournot competition firms want to exchange information about their stochastic costs (see, e.g., Shapiro, 1986).}

On the other hand, when $\Delta \theta$ is large $R$ prefers not to share information. The reason is that, in the case, information sharing has a large effect on $R$’s production when demand is low in both periods — i.e., $q^R_2(\bar{\theta}, \bar{\theta}) < q^N_2(\bar{\theta}, \bar{\theta})$ — and hence a large effect on $R$’s information rent. Therefore, the difference in the incumbent’s quantities has a stronger effect than the difference in $E$’s quantities on $R$’s rent, and this overcomes the competition effect (see equation (4)).

Consider now $M$’s incentive to share information. There are again two main effects that determine whether $M$ is willing to share information. Sharing information not only affects $R$’s information rent, but it also makes the entrant a tougher competitor. These two effects are not always aligned.

When there is small uncertainty, disclosing $q_1$ to $E$ has two negative effects on $M$’s profit. First, since $q^N_1(\bar{\theta}) < \mathbb{E}_{\theta_1}[q^S_E(\theta, \theta_1)]$, the entrant is (on average) more aggressive with information sharing and, hence, the incumbents obtain a lower total surplus when $E$ is informed about first-period production: a business stealing effect. Second, holding revenues constant, sharing information is detrimental to $M$ because it increases $R$’s expected rent. If $\Delta \theta$ is sufficiently large, however, $M$ prefers to share information because $R$’s rent is higher without information sharing, as discussed above. In this case, reducing $R$’s rent is more important than facing a less aggressive entrant.

Summing up, the incumbent firms’ incentive to share information is always misaligned — when $M$ wants to share information, $R$ does not want to do so, and vice versa. This highlights a conflict of interest between upstream and downstream firms in vertical relations facing entry: whether information is shared with entrants depends on which player owns...
privacy rights in a vertical hierarchy, and is accordingly entitled to disclose information. For intermediate values of \( \Delta \theta \), however, both \( M \) and \( R \) prefer not to share information. Therefore, whether transparency arises in our environment depends on: (i) whether the decision to share information is taken by the downstream or the upstream incumbent, and (ii) the magnitude of \( \Delta \theta \), which is a measure of the agency conflict between incumbents.

Finally, notice that since \( \Delta \theta_R (\nu) \) and \( \Delta \theta_M (\nu) \) are both increasing, higher demand correlation increases the retailer’s incentive to share information since the competition effect becomes stronger, while it reduces the manufacturer’s incentive to share information because it increases the retailer’s rent when first-period production is disclosed.

We now consider the effect of information sharing on the (expected) joint profit of \( M \) and \( R \), to analyze whether their conflict of interest can be solved by ex ante contracting. Can \( M \) and \( R \) jointly agree to an information sharing policy with compensation for the damaged party, before demand realizes?\(^{23}\)

**Proposition 5** The ex ante joint profit of \( M \) and \( R \) is lower with information sharing than without information sharing.

Hence, the manufacturer and the retailer jointly gain by not sharing information with the entrant. When ex ante contracting is not possible, however, either because firms are capital constrained or because privacy rights cannot be easily transferred, it is unlikely that the party that is willing to share information with \( E \) can be prevented from doing so.

Finally, since the entrant can always (commit to) disregard the information received by the incumbent and implement the same outcome as without information sharing, we have the following result.

**Proposition 6** \( E \) obtains higher profit with information sharing than without information sharing.

**Remark 2.** We assumed that the incumbent players can commit ex-ante to an information disclosure rule. Even if commitment is a standard hypothesis in the existing literature on information sharing (see, e.g., Vives, 2006, for a survey of this literature), one may wonder whether our results are robust to the possibility that the incumbent players (secretly) renege on their ex ante commitment to share or not information.

Assume, for example, that at the beginning of period 2 — i.e., before learning \( \theta_2 \) — the incumbent players can renege on the information sharing decision, but not on the terms of the optimal long term contract. It can be shown then that the equilibrium with information sharing characterized in Section 4.4 is robust to ex post renegotiation, while the equilibrium without information sharing is not.\(^{24}\)

\(^{23}\)This is equivalent to analyzing whether \( M \) and \( R \) can agree, behind the veil of ignorance, to a system of ex ante transfers that harmonizes their interests, with \( R \) paying \( M \) to disclose \( m_1 \) to \( E \), or vice versa. Of course, in order for this agreement to be feasible, players must not be capital constrained.

\(^{24}\)A similar result obtains when renegotiation occurs before \( \theta_2 \) realizes.
The reason why the equilibrium with information sharing is robust to ex-post renegotiation of the information sharing decision is straightforward. Consider an equilibrium in which the incumbent players commit to share information and $M$ offers the long term contract characterized in Section 4.4. First, $M$ has no incentive to renege on this commitment since players cannot modify the contractual terms and, hence, by refusing to share information $M$ cannot increase the second-period transfer. But then $R$ has no profitable deviation either, since the optimal long term contract is incentive compatible. By contrast, the equilibrium without information sharing is not robust to ex-post renegotiation because $R$ has a unilateral incentive to disclose information when demand in the first period is high. In fact, other things being equal, this reduces $E$’s production and increases $R$’s revenue.

5.1 Market for Information

The previous analysis shows that information about the retailer’s first-period production is valuable and the entrant is willing to pay for it. Do incumbent players have any incentive to sell information to the entrant, rather than simply share it at no cost? Coherently with our full commitment assumption, in order to address this question we assume that incumbents can commit at the outset of the game to a price that the entrant has to pay in order to acquire information.\textsuperscript{25}

Proposition 7 $M$ and $R$ have an incentive to jointly sell information to $E$.

Trading information is jointly profitable for the incumbents and the entrant because it maximizes total profit in the industry: it allows firms to extract more surplus from consumers (as we show in the next section), and it rebalances production from a less efficient firm (the incumbent who faces agency costs) to a more efficient one (the entrant who faces no agency costs and, on average, produces more when it is informed).

6 Welfare

Since first-period production is the same with and without information sharing, to analyze the welfare effects of information sharing we focus on how the incumbent’s decision to disclose information impacts aggregate production in the second period.

Proposition 8 Expected aggregate production is lower with information sharing than without information sharing.

Information sharing reduces the incumbent’s production and allows $E$ to increase production when the incumbent distorts it. On balance, however, aggregate production is lower.

\textsuperscript{25}See Bergemann and Bonatti (2018) for a survey of the literature on markets for information.
than without information sharing because, holding constant the incumbent’s production, $E$’s decision is always efficient regardless of its information (since it equalizes marginal revenue to marginal costs). In other words, information reduces market efficiency because it increases $R$’s information rent via the competition effect, whereby reducing the incumbent’s overall efficiency.

**Proposition 9** Consumer surplus and total welfare are lower with information sharing than without information sharing.

This suggests that information sharing about past production between incumbents and new entrants should not necessarily be allowed. Hence, our analysis highlights a potential drawback of imposing transparency about past performance to incumbents.\(^{26}\)

Notice that the result in Proposition 9 hinges on the absence of a fixed cost of entry. With a sufficiently high entry cost, not sharing information may foreclose entry, which always harms consumers. With a stochastic entry cost, however, the net effect of information sharing on consumer surplus depends on the relative likelihood of entry being blocked without information sharing.

**Remark 3.** So far we have considered an integrated entrant. Do our results change when the entrant is a vertical hierarchy rather than an integrated firm — i.e., when in period 2 a new manufacturer enters the market and sells through its exclusive retailer, who is privately informed about $\theta_2$ but does not know $\theta_1$? In this more complex framework information sharing has a new effect that tends to increase the entrants’ efficiency. In fact, since demand is correlated over time, information sharing reduces the information rent of the entrant retailer. Hence, ceteris paribus, the entrant manufacturer distorts production less with information sharing. Since reaction functions are downward sloping, however, the increase of the entrant’s production triggers a reduction of the incumbent’s production. The net effect on aggregate production depends on the degree of demand persistency, which measures the precision of the information that the entrant obtains on $\theta_2$ when it learns $\theta_1$. In the working paper version of the paper (Karakoç et al., 2018) we show that (for small uncertainty) when demand is sufficiently persistent information sharing has a stronger impact on the entrant’s production than on the incumbent’s production, thus increasing aggregate production. By contrast, when the information obtained by the entrant manufacturer does not result in a sufficiently large increase in the entrant retailer’s production, information sharing reduces aggregate production.

\(^{26}\)Of course, transparency may be welfare beneficial in other contexts. For example, improving price and quality transparency unambiguously benefit consumers — e.g., Varian (1980), Schultz (2009) and Gu and Wenzel (2011). But while these models focus on firms’ ability to inform consumers about product characteristics, in our environment communication is about past demand or performance. Moreover, as in our model, information sharing (about past prices or quantities) is detrimental to consumers in repeated games when it allows firms to enforce collusive agreements — see, e.g., Green and Porter (1984) and subsequent models.
7 Conclusions

It is commonly believed that forcing incumbents to be more transparent with entrants intensifies competition and increases consumer surplus, efficiency and total welfare. This presumption may be incorrect, however, in vertically related markets like the franchise industry. Specifically, our analysis highlights the link between dynamic vertical contracting and disclosure of past production to entrants (e.g., through sale reports), and shows that this form of transparency does not necessarily increase competition and consumer surplus, although there are other channels through which information sharing may affect welfare.

Therefore, when incumbents contract over time with privately informed retailers or downstream units, mandatory disclosure rules that forces them to adopt transparency standards that reveal information about past performances to potential entrants may actually lower total welfare. Interestingly, in our environment, when downstream firms are willing to disclose information to entrants, upstream firms do not want to do so (and vice-versa).

Finally, even if we developed our arguments in a manufacturer-retailer framework, the scope of our analysis is broader. Our insights apply to any environment involving entry by a competing organization with horizontal externalities, where principals deal with exclusive and privately informed agents, like procurement contracting, executive compensations, patent licensing, and insurance or credit relationships.
A Appendix

Proof of Proposition 1. Both constraints (5) and $U_1(\theta) \geq 0$ bind at the optimum. Maximizing (6) with respect to $q_1(\overline{\theta})$ and $q_1(\theta)$ yields

$$q_1^N(\overline{\theta}) = \frac{\overline{\theta}}{2} > q_1^N(\theta) = \frac{\theta - \Delta \theta}{2}.$$ 

Under parametric restrictions, maximizing (6) with respect to $q_2(\overline{\theta}, \theta_1)$, $q_2(\theta, \overline{\theta})$ and $q_2(\theta, \theta)$ yields

$$\begin{align*}
\overline{\theta} - 2q_2(\overline{\theta}, \theta_1) - q_2^N(\overline{\theta}) &= 0, \quad \forall \theta_1 \in \Theta, \\
\theta - 2q_2(\theta, \overline{\theta}) - q_2^N(\theta) &= 0, \\
\theta - 2q_2(\theta, \theta) - q_2^N(\theta) - \frac{1}{\nu} (\Delta \theta - \Delta q^N) &= 0.
\end{align*}$$

Using $E$’s reaction function (3), we obtain $q_2^N(\overline{\theta}, \theta_1) = q_E^N(\overline{\theta})$ and

$$\begin{align*}
q_2^N(\theta) &= q_C(\theta) + \frac{1}{3} \Delta \theta, \\
q_2^N(\theta, \overline{\theta}) &= q_C(\theta) - \frac{1}{6} \Delta \theta, \\
q_2^N(\theta, \theta) &= q_C(\theta) - \frac{(3 + \nu)}{6 \nu} \Delta \theta.
\end{align*}$$

It is then immediate to verify that

$$q_2^N(\theta, \overline{\theta}) < q_C(\theta) < q_E^N(\theta),$$

$$q_2^N(\theta, \theta) - q_2^N(\theta, \overline{\theta}) = -\frac{1}{2\nu} \Delta \theta < 0,$$

and that $q_E^N(\theta) = q_E^N(\overline{\theta})$, so that $\Delta q^N = 0$.

We now show $R$’s rent is positive in every period in order to satisfy the limited liability constraint. The second-period rent is obviously strictly positive since

$$\text{Sign} U_2^N(\overline{\theta}, \theta_1) = \text{Sign} [\Delta \theta - \Delta q^N] = \text{Sign} \Delta \theta.$$ 

Moreover, $R$’s first-period rent is

$$U_1^N(\overline{\theta}) = \Delta \theta q_1^N(\theta) + \delta p \Delta \theta \left[ q_2^N(\theta, \theta) - q_2^N(\theta, \overline{\theta}) \right] = \frac{1}{2} \Delta \theta \left( \theta - \Delta \theta (1 + \delta) \right),$$

which is strictly positive if $\delta$ is not too large. ■

Proof of Proposition 2. Both constraints (10) and $U_1(\theta) \geq 0$ are binding at the optimum. Maximizing (11) with respect to $q_1(\cdot)$, it is straightforward to show that first-period production is the same as without information sharing. Maximizing (11) with respect to
\( q_2(\overline{\theta}, \theta_1), q_2(\theta, \overline{\theta}) \) and \( q_2(\overline{\theta}, \overline{\theta}) \) yields

\[
\overline{\theta} - 2q_2(\overline{\theta}, \theta_1) - q^S_E(\overline{\theta}, \theta_1) = 0, \quad \forall \theta_1 \in \Theta, \quad (A4)
\]

\[
\overline{\theta} - 2q_2(\theta, \overline{\theta}) - q^S_E(\theta, \overline{\theta}) = 0, \quad (A5)
\]

\[
\overline{\theta} - 2q_2(\theta, \overline{\theta}) - q^S_E(\theta, \overline{\theta}) - \frac{\Delta \theta - \Delta q^S(\overline{\theta})}{\nu} = 0. \quad (A6)
\]

Using \( E \)'s reaction function (2), we obtain

\[
q^S_2(\theta, \overline{\theta}) = q^C(\overline{\theta}) - \frac{4}{3(3\nu - 1)} \Delta \theta, \quad (A7)
\]

\[
q^S_E(\theta, \overline{\theta}) = q^C(\overline{\theta}) + \frac{2}{3(3\nu - 1)} \Delta \theta. \quad (A8)
\]

Moreover,

\[
q^S_2(\overline{\theta}, \theta_1) = q^S_E(\overline{\theta}, \theta_1) = q^C(\overline{\theta}), \quad \forall \theta_1 \in \Theta,
\]

\[
q^S_2(\theta, \overline{\theta}) = q^S_E(\theta, \overline{\theta}) = q^C(\overline{\theta}).
\]

Therefore,

\[
q^S_2(\theta, \overline{\theta}) - q^S_2(\overline{\theta}, \theta_1) = -\frac{4}{3(3\nu - 1)} \Delta \theta < 0,
\]

\[
q^S_E(\theta, \overline{\theta}) - q^S_E(\overline{\theta}, \theta_1) = \frac{2}{3(3\nu - 1)} \Delta \theta > 0,
\]

and \( E \) produces more than \( R \) when demand is low in both periods.

Notice that \( q^S_2(\theta, \overline{\theta}) < q^N_2(\theta, \overline{\theta}) \) for \( \nu \geq \frac{1}{3} \). Hence, we need to impose \( \Delta \theta \leq \overline{\Delta \theta} \triangleq \frac{(3\nu - 1)\Delta \theta}{4} \) to guarantee that the incumbent does not shut down production when demand is repeatedly low.

We now show that \( R \)'s expected is positive in order to satisfy the limited liability constraint. Notice that

\[
\Delta q^S(\overline{\theta}) = -\frac{1 - \nu}{3\nu - 1} \Delta \theta < 0 < \Delta q^S(\overline{\theta}) = \frac{\Delta \theta}{3}.
\]

Hence, \( R \)'s second-period rent is strictly positive since

\[
\Delta \theta - \Delta q^S(\overline{\theta}) = \frac{2}{3} \Delta \theta > 0,
\]

\[
\Delta \theta - \Delta q^S(\overline{\theta}) = \frac{2\nu}{3\nu - 1} \Delta \theta > 0.
\]
Moreover, $R$’s first-period rent is

$$U_1^S(\overline{\theta}) = \Delta \theta q_1^S(\overline{\theta}) + \delta \nu \left\{ [\Delta \theta - \Delta q^S(\overline{\theta})] q_2^S(\overline{\theta}, \overline{\theta}) - [\Delta \theta - \Delta q^S(\overline{\theta})] q_2^S(\overline{\theta}, \overline{\theta}) \right\} = \frac{(54 \nu - 81 \nu^2 - 9 - 48 \delta \nu^2) \Delta \theta + (9 - 54 \nu + 81 \nu^2 - 4 \delta \nu + 12 \delta \nu^2) \theta}{18 (3 \nu - 1)^2} \Delta \theta.$$ 

which is strictly positive for $\Delta \theta$ not too large (Assumption 1) and $\delta$ sufficiently small. □

**Proof of Proposition 3.** We compare $E$’s equilibrium quantities with and without information sharing. When demand is low in both periods,

$$q_E^S(\overline{\theta}, \overline{\theta}) - q_E^N(\overline{\theta}) = \frac{1 - \nu}{3 \nu - 1} \Delta \theta > 0.$$ 

When demand is low only in the second period,

$$q_E^S(\overline{\theta}, \overline{\theta}) - q_E^N(\overline{\theta}) = -\frac{1}{3} \Delta \theta < 0.$$ 

Moreover,

$$\Delta q^S(\overline{\theta}) = q^C(\overline{\theta}) - q_E^S(\overline{\theta}, \overline{\theta}) = -\frac{1 - \nu}{3 \nu - 1} \Delta \theta < 0.$$ 

For the last part of the proposition,

$$\mathbb{E}_{\theta_1} \left[ q_E^S(\overline{\theta}, \theta_1) - q_E^N(\overline{\theta}) \right] = \Pr \left[ \theta_1 = \overline{\theta} \mid \theta_2 = \theta \right] q_E^S(\overline{\theta}, \overline{\theta}) + \Pr \left[ \theta_1 = \overline{\theta} \mid \theta_2 = \theta \right] q_E^S(\overline{\theta}, \overline{\theta}) - q_E^N(\overline{\theta})$$

$$= \frac{1 - \nu}{3 (3 \nu - 1)} \Delta \theta,$$

which is strictly positive. □

**Proof of Proposition 4.** First, we compare $R$’s ex ante rent with and without information sharing. For any disclosure policy $d \in \{S, N\}$, $R$’s expected rent is

$$\mathcal{V}^d = \sum_{\theta_1 \in \Theta} \Pr [\theta_1 = \overline{\theta}] U_1^d(\theta_1) + \delta \sum_{\theta_2 \in \Theta} \Pr [\theta_2 = \overline{\theta} \mid \theta_1 = \overline{\theta}] U_2^d(\overline{\theta}, \theta_1).$$

Using the first- and second-period information rents just derived, it can be shown that

$$\mathcal{V}^N - \mathcal{V}^S = \frac{\delta}{12 \nu (3 \nu - 1)^2} \left( 1 - \nu \right) (9 \nu^2 + 14 \nu - 3) \Delta \theta - \frac{\delta}{12 \nu (3 \nu - 1)^2} \left( 1 - \nu \right) (9 \nu^2 + 14 \nu - 3) \Delta \theta.$$ 

(A7)

The sign of (A7) depends on the sign of the numerator

$$\zeta(\nu, \Delta \theta) \equiv (1 - \nu) (9 \nu^2 + 14 \nu - 3) \Delta \theta - (1 - \nu) (9 \nu^2 + 14 \nu - 3) \Delta \theta,$$

with

$$\frac{\partial \zeta(\nu, \Delta \theta)}{\partial \Delta \theta} = (1 - \nu) (9 \nu^2 + 14 \nu - 3) > 0.$$
Setting the numerator equal to 0 and solving for Δθ yields

\[ Δθ_R (\nu) \triangleq \frac{2\nu (3\nu - 1) \theta}{14\nu + 9\nu^2 - 3}, \]

which is positive and increasing in \( \nu \) in the relevant region of parameters by Assumption 1. Therefore, \( R \) wants to share information if and only if demand uncertainty is sufficiently small — i.e., \( Δθ \leq Δθ_R (\nu) \).

Second, we compare \( M \)'s expected profit with and without information sharing. For any disclosure policy \( d \in \{ S, N \} \), \( M \)'s expected profit is

\[ \Pi^d = \sum_{\theta_1 \in \Theta} \Pr [\theta_1] \left[ q_1^d (\theta_1)^2 + \delta \sum_{\theta_2 \in \Theta} \Pr [\theta_2 | \theta_1] q_2^d (\theta_2, \theta_1)^2 \right]. \]

Hence,

\[ \Pi^N - \Pi^S = \delta \frac{(1 - \nu) \left( 9 - 63\nu^2 - 38\nu \right) \Deltaθ + 16\nu (3\nu - 1) (1 - \nu) \theta}{72\nu (3\nu - 1)^2} \Deltaθ. \]  

(A8)

The sign of (A8) depends on the sign of the numerator

\[ \varepsilon (\nu, Δθ) \triangleq (1 - \nu) \left( 9 - 63\nu^2 - 38\nu \right) \Deltaθ + 16\nu (3\nu - 1) (1 - \nu) \theta, \]

where it can be shown that

\[ \frac{\partial \varepsilon (\nu, Δθ)}{\partial Δθ} = (1 - \nu) \left( 9 - 63\nu^2 - 38\nu \right) < 0. \]

Setting \( \varepsilon (\nu, Δθ) = 0 \) and solving for \( Δθ \) yields

\[ Δθ_M (\nu) \triangleq \frac{16\nu (3\nu - 1) \theta}{38\nu + 63\nu^2 - 9}, \]

which is positive and increasing in \( \nu \) in the relevant region of parameters by Assumption 1. Therefore, \( M \) prefers not to share information if and only if demand uncertainty is sufficiently small — i.e., \( Δθ \leq Δθ_M (\nu) \).

Finally, showing that \( Δθ_M (\nu) \geq Δθ_R (\nu) \) is immediate. ■

**Proof of Proposition 5.** For any \( d \in \{ S, N \} \), the _ex ante_ joint profit of \( M \) and the \( R \) is \( \Pi^d + \mathcal{V}^d \). For \( Δθ \) small, using the results of Proposition 4, we have

\[ (\Pi^N + \mathcal{V}^N) - (\Pi^S + \mathcal{V}^S) = \delta \frac{(1 - \nu) \left( 46\nu - 9\nu^2 - 9 \right) \Deltaθ + 4\nu (1 - \nu) (3\nu - 1) \theta}{72\nu (3\nu - 1)^2} \Deltaθ. \]

The sign of this expression depends on the sign of the numerator

\[ \Lambda (\nu, Δθ) \triangleq (1 - \nu) \left( 46\nu - 9\nu^2 - 9 \right) \Deltaθ + 4\nu (1 - \nu) (3\nu - 1) \theta, \]

with

\[ \frac{\partial \Lambda (\nu, Δθ)}{\partial Δθ} = (1 - \nu) \left( 46\nu - 9\nu^2 - 9 \right) > 0, \]

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in the relevant region of parameters. Hence, since
\[ \Lambda (\nu, 0) = (1 - \nu) 4 \nu (3\nu - 1) \theta > 0, \]

and
\[ \Lambda (\nu, \Delta \theta) = \frac{1}{4} (1 - \nu) (3\nu - 1) (-9\nu^2 + 62\nu - 9) \theta > 0, \]
the ex ante joint profit of \( M \) and \( R \) is always lower with information sharing than without. 

**Proof of Proposition 6.** Let \( \Pi_E^d, d \in \{S, N\} \), be the entrant’s ex ante profit. Using the equilibrium quantities from Propositions 1 and 2, we have
\[ \Pi_E^N - \Pi_E^S = \frac{(1 - \nu) (1 - 9\nu) \Delta \theta + 2 (1 - 3\nu) \frac{\theta}{4} \Delta \theta}{18 (3\nu - 1)^2}. \]

The sign of this expression depends on the sign of the numerator
\[ \varepsilon (\nu, \Delta \theta) = (1 - \nu) (1 - 9\nu) \Delta \theta + 2 (1 - 3\nu) \theta, \]
with
\[ \frac{\partial \varepsilon (\nu, \Delta \theta)}{\partial \Delta \theta} = (1 - \nu) (1 - 9\nu) < 0. \]

Since
\[ \varepsilon (\nu, 0) = -2\theta (3\nu - 1) < 0, \]
and
\[ \varepsilon (\nu, \Delta \theta) = \frac{\theta}{4} (3\nu - 1) (9\nu^2 - 10\nu - 7) < 0, \]
the ex ante profit of \( E \) is higher with information sharing than without. 

**Proof of Proposition 7.** \( M \) and \( R \) are willing to trade information if and only if
\[ J_2^N - J_2^S \leq \Pi_E^S - \Pi_E^N, \]
where \( J_2^d \) is the joint profit of \( M \) and \( R \) in the second period. Using the results of Propositions 5 and 6, this condition simplifies to
\[ 0 \leq \frac{(1 - \nu) (45\nu^2 - 50\nu + 9) \Delta \theta^2 + 4\nu (1 - \nu) (3\nu - 1) \frac{\theta \Delta \theta}{72\nu (3\nu - 1)^2}}. \]  
(A9)

Since the denominator is strictly positive, the sign of (A9) depends on the sign of the numerator
\[ \vartheta (\nu, \Delta \theta) = (1 - \nu) (45\nu^2 - 50\nu + 9) \Delta \theta^2 + 4\nu (1 - \nu) (3\nu - 1) \frac{\theta \Delta \theta}{\theta}, \]
with
\[ \frac{\partial \vartheta (\nu, \Delta \theta)}{\partial \Delta \theta} = 2 (1 - \nu) (45\nu^2 - 50\nu + 9) \Delta \theta + 4\nu (1 - \nu) (3\nu - 1) \frac{\theta}{\theta}. \]
Setting this expression equal to 0 and solving for $\Delta \theta$ yields the critical point

$$
\Delta \theta^{\text{Crit.}} = \frac{2 \theta \nu (1 - 3 \nu)}{45 \nu^2 - 50 \nu + 9} > 0 \iff \nu \leq 0.88.
$$

First consider the case in which $\nu \leq 0.88$ so that $\Delta \theta^{\text{Crit.}} > 0$. In this case,

$$
\lim_{\Delta \theta \to 0} \frac{\partial \vartheta (\nu, \Delta \theta)}{\partial \Delta \theta} = 4 \theta \nu (1 - \nu) (3 \nu - 1) > 0,
$$

and

$$
\lim_{\Delta \theta \to \Delta \theta} \frac{\partial \vartheta (\nu, \Delta \theta)}{\partial \Delta \theta} = \frac{3 \theta}{2} (5 \nu - 3) (1 - \nu) (3 \nu - 1)^2 \begin{cases} 
\leq 0 & \text{if } \nu \leq 0.6 \\
> 0 & \text{if } 0.6 < \nu \leq 0.88.
\end{cases}
$$

Let $\nu \leq 0.6$, so that $\lim_{\Delta \theta \to \Delta \theta} \frac{\partial \vartheta (\nu, \Delta \theta)}{\partial \Delta \theta} \leq 0$ and notice that

$$
\frac{\partial^2 \vartheta (\nu, \Delta \theta)}{\partial \Delta \theta^2} = 2 (1 - \nu) (45 \nu^2 - 50 \nu + 9) < 0,
$$

in the relevant region of parameters. It follows that when $\nu \leq 0.6$, the numerator $\vartheta (\nu, \Delta \theta)$ has a local maximum at $\Delta \theta^{\text{Crit.}}$. Moreover, since $\vartheta (\nu, 0) = 0$ and

$$
\vartheta (\nu, \Delta \theta) = \frac{\theta}{16} (1 - \nu) (3 \nu - 1) (45 \nu^2 - 34 \nu + 9) > 0,
$$

it follows that the numerator $\vartheta (\nu, \Delta \theta) > 0$ so that inequality (A9) is satisfied and incumbent players have a joint incentive to sell information to $E$.

Now let $0.6 < \nu \leq 0.88$ so that $\lim_{\Delta \theta \to \Delta \theta} \frac{\partial \vartheta (\nu, \Delta \theta)}{\partial \Delta \theta} > 0$. In this case, it can be shown that

$$
\frac{\partial^2 \vartheta (\nu, \Delta \theta)}{\partial \Delta \theta^2} = 2 (1 - \nu) (45 \nu^2 - 50 \nu + 9) < 0.
$$

It follows that $\vartheta (\nu, \Delta \theta)$ is concave for $0.6 < \nu \leq 0.88$. Moreover, since $\vartheta (\nu, 0) = 0$ and

$$
\vartheta (\nu, \Delta \theta) = \frac{\theta}{16} (1 - \nu) (3 \nu - 1) (45 \nu^2 - 34 \nu + 9) > 0,
$$

in the relevant region of parameters, the numerator $\vartheta (\nu, \Delta \theta) > 0$ and inequality (A9) is satisfied.

Finally, for $\nu > 0.88$ the critical point is outside the interval of interest — i.e., $\Delta \theta^{\text{Crit.}} < 0 < \Delta \theta$. Hence, when $\nu > 0.88$, the numerator $\vartheta (\nu, \Delta \theta)$ is positive so that $M$ and $R$ have an incentive to jointly sell information to $E$.

Summing up, inequality (A9) is always satisfied and $M$ and $R$ have an incentive to jointly sell information to $E$. ■

**Proof of Proposition 8.** For any disclosure policy $d \in \{S, N\}$, expected aggregate pro-
duction in the second period is

\[ Q^d = \sum_{\theta_1 \in \Theta} \Pr[\theta_1] \sum_{\theta_2 \in \Theta} \Pr[\theta_2|\theta_1] Q^d_2(\theta_2, \theta_1). \]

Using the equilibrium outputs from Propositions 1 and 2, we have

\[ Q^S - Q^N = -\frac{1 - \nu}{6(3\nu - 1)} \Delta \theta, \]

which is strictly negative. ■

**Proof of Proposition 9.** Without loss of generality, we focus on the second period, since production in the first period is the same with and without information sharing. For any \( d \in \{S, N\} \), since the inverse demand is linear, expected consumer surplus is

\[ CS^d = \sum_{\theta_1 \in \Theta} \Pr[\theta_1] \sum_{\theta_2 \in \Theta} \Pr[\theta_2|\theta_1] \frac{Q^d_2(\theta_2, \theta_1)^2}{2}. \]

Using the equilibrium outputs from Propositions 1 and 2, we have

\[ CS^N - CS^S = \frac{(1 - \nu) (45\nu^2 - 50\nu + 9) \Delta \theta^2 + 16\nu (1 - \nu) (3\nu - 1) \theta \Delta \theta}{144\nu (3\nu - 1)^2}. \quad (A10) \]

The sign of this expression depends on the sign of the numerator

\[ \chi(\nu, \Delta \theta) \triangleq (1 - \nu) (45\nu^2 - 50\nu + 9) \Delta \theta^2 + 16\nu (1 - \nu) (3\nu - 1) \theta \Delta \theta, \]

with

\[ \frac{\partial \chi(\nu, \Delta \theta)}{\partial \Delta \theta} = 2 (1 - \nu) (45\nu^2 - 50\nu + 9) \Delta \theta + 16\nu (1 - \nu) (3\nu - 1) \theta. \]

Setting \( \chi(\nu, \Delta \theta) \) equal to 0 and solving for \( \Delta \theta \) yields the critical point

\[ \Delta \theta^{\text{Crit.}} \triangleq \frac{8\theta \nu (1 - 3\nu)}{45\nu^2 - 50\nu + 9} > 0 \quad \Leftrightarrow \quad \nu < 0.88. \]

First, let \( \nu \geq 0.88 \) so that \( \Delta \theta^{\text{Crit.}} < 0 \). Then it is immediate to see that critical point is outside the interval of interest because \( \Delta \theta^{\text{Crit.}} < 0 < \Delta \theta \). In this case, since \( \chi(\nu, 0) = 0 \) and

\[ \chi(\nu, \Delta \theta) = \frac{\theta}{4} (1 - \nu) (3\nu - 1) (14\nu + 45\nu^2 + 9) > 0, \]

in the relevant region of parameters, it follows that \( \chi(\nu, \Delta \theta) > 0 \) for all \( \nu \geq 0.88 \).

Now let \( \nu < 0.88 \) so that \( \Delta \theta^{\text{Crit.}} > 0 \). In this case, \( \chi(\nu, 0) = 0 \) and

\[ \chi(\nu, \Delta \theta) = \frac{\theta}{4} (1 - \nu) (3\nu - 1) (14\nu + 45\nu^2 + 9) > 0, \]
and
\[
\lim_{\Delta \theta \to 0} \frac{\partial \chi (\nu, \Delta \theta)}{\partial \Delta \theta} = 16 \nu (1 - \nu) (3 \nu - 1) > 0,
\]
\[
\lim_{\Delta \theta \to 0} \frac{\partial^2 \chi (\nu, \Delta \theta)}{\partial \Delta \theta^2} = \frac{9}{2} (1 - \nu) (3 \nu - 1) (5 \nu^2 - 2 \nu + 1) > 0,
\]
in the relevant region of parameters.
Moreover,
\[
\frac{\partial^2 \chi (\nu, \Delta \theta)}{\partial \Delta \theta^2} = 16 \nu (1 - \nu) (3 \nu - 1) > 0.
\]
This implies that that \( \chi (\nu, \Delta \theta) \) is convex for all \( \nu < 0.88 \). It follows that the numerator \( \chi (\nu, \Delta \theta) > 0 \) for all \( \nu < 0.88 \). Summing up, (A10) is always positive and consumer surplus is always higher without information sharing.

Total (expected) welfare in the second period — i.e., the sum of \( M \)'s expected profit, \( R \)'s expected rent, \( E \)'s expected rent and the expected consumer surplus is
\[
TW_d = \sum_{\theta_1 \in \Theta} \Pr [\theta_1] \sum_{\theta_2 \in \Theta} \Pr [\theta_2 | \theta_1] \left[ \theta_2 Q_d^d (\theta_2, \theta_1) - \frac{1}{2} Q_{d} (\theta_2, \theta_1)^2 \right].
\]
Using the equilibrium outputs from Propositions 1 and 2, we have
\[
TW^N - TW^S = \frac{(1 - \nu) (50 \nu - 45 \nu^2 - 9) \Delta \theta^2 + 8 \nu (1 - \nu) (3 \nu - 1) \theta \Delta \theta}{144 \nu (3 \nu - 1)^2}.
\]
(A11)
The sign of this depends on the sign of the numerator
\[
\tau (\nu, \Delta \theta) \triangleq (1 - \nu) (50 \nu - 45 \nu^2 - 9) \Delta \theta^2 + 8 \nu (1 - \nu) (3 \nu - 1) \theta \Delta \theta,
\]
with
\[
\frac{\partial \tau (\nu, \Delta \theta)}{\partial \Delta \theta} = 2 (1 - \nu) (50 \nu - 45 \nu^2 - 9) \Delta \theta + 8 \nu (1 - \nu) (3 \nu - 1) \theta.
\]
Setting this equation equal to 0 and solving for \( \Delta \theta \) yields the critical point
\[
\Delta \theta^{\text{Crit}} = \frac{4 \nu (3 \nu - 1)}{45 \nu^2 - 50 \nu + 9 \theta} < 0 \iff \nu < 0.88.
\]
Following the same logic developed above, first let \( \nu < 0.88 \) so that \( \Delta \theta^{\text{Crit}} < 0 \). Hence, for \( \nu < 0.88 \) the critical point is outside the interval of interest — i.e., \( \Delta \theta^{\text{Crit}} < 0 < \Delta \theta \).
Since \( \tau (\nu, 0) = 0 \) and
\[
\tau (\nu, \Delta \theta) = \frac{1}{16} (1 - \nu) (82 \nu - 45 \nu^2 - 9) (3 \nu - 1)^2 \theta^2 > 0,
\]
when \( \nu < 0.88 \) the function \( \tau (\nu, \Delta \theta) \) is positive and never crosses the \( \nu \) axis. Hence, for \( \nu < 0.88 \) total welfare is higher without information sharing.
Similarly, let $\nu \geq 0.88$ so that $\Delta \theta^{\text{crit.}} > 0$. In this case,

$$\lim_{\Delta \theta \to 0} \frac{\partial \tau(\nu, \Delta \theta)}{\partial \Delta \theta} = 8\nu (1 - \nu) (3\nu - 1) > 0,$$

$$\lim_{\Delta \theta \to \Delta \theta^*} \frac{\partial \tau(\nu, \Delta \theta)}{\partial \Delta \theta} = \frac{3}{2} (1 - \nu) (3\nu - 1) (22\nu - 15\nu^2 - 3) \theta > 0.$$

Moreover,

$$\frac{\partial^2 \tau(\nu, \Delta \theta)}{\partial \Delta \theta^2} = 2 (1 - \nu) (50\nu - 45\nu^2 - 9) < 0$$

in the relevant region of parameters. This implies that $\tau(\nu, \Delta \theta)$ is concave for all $\nu \geq 0.88$.

Since $\tau(\nu, 0) = 0$ and

$$\tau(\nu, \Delta \theta) = \frac{1}{16} (1 - \nu) (82\nu - 45\nu^2 - 9) (3\nu - 1)^2 \theta^2 > 0,$$

when $\nu \geq 0.88$ the numerator $\tau(\nu, \Delta \theta) > 0$ so that total welfare is higher without information sharing. Summing up, $\tau(\nu, \Delta \theta)$ is positive for all $\nu \geq \frac{1}{3}$ and total welfare is higher without information sharing.
References


