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EXCLUSIONARY CONTRACTS, ENTRY, AND COMMUNICATION

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Exclusionary Contracts, Entry, and Communication

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Abstract

I examine the incentives of firms to communicate entry into an industry where the incumbent writes exclusionary, long-term contracts with consumers. The entrant's information provision affects the optimal contract proposal by the incumbent and leads to communication incentives that are highly non-linear in the size of the innovation. Entry with small and medium-to-large innovations is announced whereas small-to-medium and large innovations are not communicated. It is demonstrated that this equilibrium communication behavior maximizes ex ante total welfare by reducing the anti-competitive impact of excessively exclusive contracts. By contrast, consumers always prefer more communication and the incumbent's equilibrium contract maximizes ex ante consumer surplus.

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1 Introduction

The economic efficiency of long-term contract is the subject of a long-standing debate in antitrust economics. It is widely recognized that long term contracts reduce transaction cost and may provide incentives for relation-specific investment for buyers and sellers. At the same time a growing body of literature stresses the anti-competitive potential of such contractual provisions. In particular, it has been argued that incumbent firms have an incentive to lock customers into exclusionary long-term contracts and thereby reduce the profitability of an entrant or prevent efficient entry altogether. In this line of argument the existence of an entrant and the timing of entry are assumed to be common knowledge among consumers and incumbent. However, if the incumbent is likely to establish contractual barriers when threatened with entry, the entrant's incentives to communicate its entry may be reduced and this might in turn erode the anti-competitive impact of long-term contracts.

In September 2002, Telecom New Zealand, the incumbent telecommunication company, was almost over-night confronted with a serious rival in the broadband internet access market in Auckland. Woosh Wireless Inc had taken only a few months to establish a fully functioning wireless broadband network by secretly acquiring radio frequencies and transmission capacity. The new network could completely by-pass the terrestrial network of the incumbent monopolist and Woosh's intitial offering included a bandwidth twice as fast as Telecom's for the same monthly charge. Its first advertising campaign was launched the same day the product was available.[1]

In the same industry, Vodafone announced in 2006 the launch of its new 3G wireless broadband network three months in advance. Shortly afterwards Telecom NZ started an advertising campaign (including land mail to all households in the country) offering a 20% lower price for new consumers who sign up for at least 12 months and a 25% lower price for customers who switch from a competitor and don't switch back again within the next twelve months.[2]

In this article I formally examine the conditions under which communication of entry might be privately and/or socially desirable when an entrant is confronted with an incumbent who offers long-term contracts to consumers. For this purpose I analyze a simple two-period model with consumers who face random shocks to their transaction costs of subscribing to a service or non-durable good. In the first period consumers can sign a long-term contract with an incumbent firm who offers a basic quality over the two periods. A potential entrant is expected with a strictly positive probability to introduce a service of higher quality in the second period. The long-term contract generically specifies payments for period 1 and for period 2 conditional upon contract fulfillment and termination. These contract conditions can be collapsed into two strategic contract

[1] See "New name on line for broadband", *New Zealand Herald*, September 11, 2002.

[2] See "Vodafone launches 3G broadband", *New Zealand Herald*, September 12, 2006.

instruments, total contract payment and contractual switching costs for consumers who swap suppliers in the second period. Before the long-term contract is offered and signed, the entrant can communicate the launch of his service to consumers and incumbent.

The entrant's information provision affects the optimal contract choice of the incumbent. First consider the effect on contractual switching costs. If there is new entry, contractual switching costs reduce the expected utility of consumers by decreasing the probability of and the benefit from changing supplier. For the incumbent, on the other hand, damage payments constitute a source of revenue but he has to take into account the negative effect on consumers through a lower willingness-to-pay for the long-term contract. As a result, the incumbent proposes contractual switching costs that maximize the expected joint benefit of consumers and incumbent in the case of entry. From this two comparative static results follow. First, the contractual switching cost increases in the size of the innovation. This is because consumers' benefit from switching and the probability of switching increase in the size of the innovation. And second, contractual switching costs increase in the incumbent's expectation and decrease in the consumers' expectation of entry. The second contract instrument is the total contract payment which directly determines the number of contracts sold in period 1. If the incumbent's expectation of entry increases, he becomes more aggressive in terms of long-term contract sales for two reasons. The more contract he sells today, the more profit he will make from switching consumers tomorrow. And second, the opportunity cost of a sale shrinks because the incumbent perceives it less likely to remain monopolist in the future. If consumers' expectations of entry increase, their willingness-to-pay decreases, which lowers the total contract payment and the number of long-term contracts sold.

The entrant's incentives to communicate depend on the effect of expectations on the two contractual instruments. Proposition 1 establishes that the incentive to communicate depends on the size of the innovation in a highly non-linear way. Entry with small and medium-to-large innovations is always communicated whereas small-to-medium and large innovations are not announced. This result derives from the interaction of four effects, two demand pull effects and two strategic contracting effects. For small innovations, the products of entrant and incumbent are close substitutes and price competition for new consumers after entry is intense. This makes consumers stand to lose more from buying a long-term contract and makes communication profitable for the entrant (*demand pull effect of competition*). For larger innovations, consumer switching becomes more attractive and thus generates more revenue from switching consumers for the incumbent after entry. This in turn commands stronger price reductions from the incumbent in period 1 in order to attract long-term customers. This *first strategic contracting effect* reduces the profitability of communication and the entrant does not announce small-to-medium innovations. At the same time, large innovations also increase the informational rent consumers can extract from the entrant. In particular, the difference in rents that unattached consumers can extract versus what consumers with a long-term contract can extract increases in the innovation size (*demand pull effect of* *large innovations*). This makes the long-term contract less attractive and communication profitable for medium-to-large innovations. Finally, for large innovations, a *second strategic contracting effect*, which works through the contractual switching costs, kicks in. The larger the innovation, the higher the contractual switching cost that the incumbent proposes and, thus, the higher the marginal gain of selling long-term contracts. This makes the incumbent more aggressive in terms of contract sales and prevents large innovations from being communicated by the entrant.

The welfare analysis then shows that while communication is not always profitable for the entrant due to the threat of strategic contracting from the incumbent, the described equilibrium communication behavior maximizes total welfare (see Proposition 2). The reason for this result is that the incumbent imposes a socially excessive contractual switching cost on consumers and the entrant. Therefore, communication is only efficient if it reduces the number of long-term contracts. However, this is exactly equivalent to the private incentives of the entrant. In other words, communication incentives endogenously limit the anti-competitive damage of exclusionary, long-term contracts.

Finally, Proposition 3 demonstrates that the total welfare results stand in stark contrast to the effect of communication and contracting on consumer surplus. Ex ante consumers would be best off if the entrant always communicated and the incumbent's equilibrium contractual switching cost maximizes consumer surplus. Both results are due to the fact that from an ex ante perspective all future benefits are anticipated in the total price of the long-term contract in period 1. Hence, all what matters for consumers is the expected number of contracts sold. And, since the number of contracts is maximized at the most profitable contractual switching cost for the incumbent, consumers might be best off with a strictly positive penalty payment for switching suppliers. Ex ante consumers prefer communication because informed quantities have a higher variance than uninformed quantities and the informational rents of consumers are increasing and convex in the quantity.

The present paper is closely related to the literature on contracts as barrier to entry. In their seminal paper Aghion & Bolton (1987) show that an incumbent-buyer pair might have an incentive to write long-term contract with damage payments in case the buyer switches to the entrant. To make the buyer switch, the entrant has to charge a price which is lower than the incumbent's minus the damage payment. This enables the incumbent to extract rents from the entrant and reduce the profitability of entry. Aghion & Bolton (1987) demonstrate that if the incumbent faces uncertainty about the level of efficiency of the entrant, he bases the damage payment on the average efficiency level of entering firms and thereby excludes entry from more efficient (but below average efficient) firms. Spier & Whinston (1995) point out that this socially inefficient entry deterrence does not occur if incumbent and buyer can re-negotiate their contract after learning the entrant's cost level because they prefer to extract rents from a more efficient entrant rather than blocking its entry. However, they also show that inefficient entry deterrence is possible - even with re-negotiation - if the incumbent has to make relation-specific investment. In this case the incumbent-buyer pair ignores the externality it imposes on the entrant by setting damage payments too high and over-investing in relation-specific assets.[3] The present paper departs from these contributions by allowing for communication from the entrant. From a modeling perspective the major difference is that I introduce differentiated consumers which enables buyers to gain informational rents from both the entrant and the incumbent. This has two major implications for the analysis. If consumers can earn benefits from the entrant, they are no longer indifferent with respect to the level of damage payments (which are a complete pass-through from entrant to incumbent in the Aghion & Bolton (1987) framework). At the same time, if consumers prefer lower damage payments after entry, the incumbent's scope for rent extraction via long-term contracts is reduced.

The paper is also related to work on oligopolistic competition with long-term contracts in the absence of entry deterrence. Caminal & Matutes (1990) analyze and compare the effect of price commitments and discount coupons on the competitiveness of an industry. Fudenberg & Tirole (2000) consider the effect of long-term contracts in a duopoly model with price discrimination and customer poaching. Finally, this paper is related to Gerlach (2004) where I analyze the incentives of a firm to announce entry in markets where consumers have exogenous switching costs from one supplier to another. It is shown that entry is announced if the entrant's innovation is sufficiently large and that consumers are ex ante better off without announcements. The present paper has a different set-up but it suggests that if switching costs are purely contractual these two main results are exactly reversed.

The rest of the paper is organized as follows. The next section presents the model set-up. Section 3 analyzes equilibrium communication and optimal contracting. Section 4 performs a welfare analysis and compares with the equilibrium outcome and the last section concludes.

2 The Model

Consider a two-period model for a non-durable good or service with an incumbent firm (I) and a potential entrant (E). The incumbent offers a service of quality v, $v > 0$ in both periods. The potential entrant launches a new product of quality $v + \Delta$, $\Delta > 0$, in period 2 with probability ρ, $0 < \rho < 1$. With probability $1 - \rho$ the new technology

[3] Inefficient entry deterrence can also arise when the entrant has a minimum efficient scale or when he needs a minimum number of buyers like in Rasmusen *et al.* (1991) and Segal & Whinston (2000)). By accepting an offer buyers exert a negative externality on other buyers and this can be exploited by an incumbent to deter entry. Fumagalli & Motta (2006) extend their framework to allow for downstream competition for buyers. Bernheim & Whinston (1998) show more generally that externalities amongst buyers might lead to exclusive dealing in an industry.

is unavailable and the potential entrant does not enter the market.[4] Both firms are assumed to have the same production technology with constant marginal cost of $c > 0$.

A unit mass of *ex ante* identical consumers enter the market in period 1 and live for two periods. Consumers get a per-period gross utility equal to the quality of the service they are contracting. To contract a service from either firm consumers have to incur a transaction cost τ. This transaction cost is drawn independently over consumers and time from a uniform distribution over $[0, \overline{\tau}]$.[5] The upper limit $\overline{\tau}$ is supposed to be sufficiently high to avoid any boundary solution.[6] While the distribution parameters are common knowledge, the transaction cost of an individual consumer is private information.

The timing and contracting assumptions are as follows. First, E learns whether he is able to enter the market in period 2 or not. Then, before the start of period 1, an entrant with an innovation chooses whether to announce his entry in period 2 or not.[7] Both the incumbent and the consumers observe this choice and update their beliefs to $\widetilde{\rho}_i$ and $\widetilde{\rho}_c$ respectively. Although I assume that the belief updating of the incumbent and the consumers is identical this distinction proves useful for the exposition of the main effects of the model. At the start of period 1, the incumbent proposes consumers a long-term contract (p_1, p_2, s) to supply his service in both periods.[8] This contract stipulates a payment p_1 (p_2) for the supply in period 1(2) and a payment s in case the consumer terminates the contract and switches supplier. Consumers receive their transaction cost shock and decide whether to sign the contract or not.[9] Upon contracting, consumers receive the service and the payment is made.

In the second period, two cases can arise. If firm E does not enter, the incumbent offers short-term contracts at a price p_i to consumers who did not purchase a long-term contract in period 1 and continues to supply its contracted customer base. If firm E enters, the two firms compete head-to-head for two different clienteles, consumers with long-term contract and new consumers. The incumbent can perfectly price discriminate between the two groups and charge (p_2, s) to his customer base[10] and p_I to new

[4] The entrant does not enter with the low quality product if the incumbent's technology is protected by patents of if there is a fixed cost of entry. Allowing for entry with the incumbent's technology would not qualitatively alter any of the effects or results of the model.

[5] The uniform distribution delivers a simple linear demand structure. Using a more general distribution would make the welfare analysis intractable.

[6] The corresponding parameter restriction is given in the proof of Lemma 1.

[7] A non-innovative entrant has no stake in the industry and therefore no incentive to claim future entry. More formally, one could assume that a non-innovative entrant always sends the message μ_0, whereas an innovative entrant can send a message out of $\{\mu_0, \mu_1\}$.

[8] It is demonstrated in the proof of Lemma 1 that the incumbent always prefers long-term contracts over short-term contracts. See footnote 14 for a brief discussion.

[9] As the analysis below shows, this type of contract is over-determined by one dimension. However, it is instructive to start out with this general form and reduce the number of contract dimension subsequently.

[10] As the analysis shows there is no scope for renegotiation in this model. See footnote 15 for a

consumers. By contrast, the entrant has no prior information to identify and segment consumers directly. However, if at least one of the two groups can prove their type then the entrant might be able to practice price discrimination on a voluntary basis.[11] Here, this endogenous segmentation works if the entrant's price p_e for consumers with a contract is lower than the price p_E that the entrant charges if a consumer cannot prove that he has a long-term contract with the incumbent. After firms make their offers and consumers receive their transaction cost shock, consumers with a contract decide whether to stay with the incumbent or to switch while consumers without contract decide whether to buy, and if so, from whom. Finally, consumers use the service they have contracted and all profits are realized.

Firms and consumers are risk neutral and discount future profits and utility with a common discount factor δ, $0 \leq \delta \leq 1$. In the following analysis I look for perfect Bayesian equilibria of this game.

3 Equilibrium Analysis

■ I start by solving the two subgames of period 2 for a given mass m of consumers with long-term contracts. Then I turn to the first period purchase decision and the incumbent's optimal contract proposal. Finally, I analyze the entrant's incentive to communicate.

□ **The second period.** Suppose m consumers have signed the long-term contract (p_1, p_2, s) with the incumbent in the first period. First consider the case without entry in the second period. Consumers with a contract receive a utility of $v - p_2$ while the incumbent gets monopoly profits of $\Pi_i^c(p_2) = p_2 - c$ per unit mass of consumer.
Consumers without contract from the first period have a transaction cost of signing with the incumbent which is uniformly distributed over $[0, \overline{\tau}]$. Suppose the incumbent charges a price of p_i. A consumer with transaction τ buys if $v - \tau - p_i \geq 0$, i.e. all consumers $\tau \leq v - p_i$ purchase and the incumbent's demand is $(1-m)(v-p_i)/\overline{\tau}$. Maximizing his profits $(1-m)(p_i - c)(v - p_i)/\overline{\tau}$ yields an optimal price of $p_i' = (v+c)/2$ at which all consumers with $\tau \leq \tau' = (v-c)/2$ purchase. The incumbent's monopoly profits per unit mass of consumer without contract are $\pi_i^m = (v-c)^2/(4\overline{\tau})$. A consumer without contract at the beginning of period 2 has an ex ante expected utility of

$$U_0 = \int_0^{\tau'} (v - \tau - p_i') \frac{1}{\overline{\tau}} d\tau.$$

discussion.

[11]Fudenberg & Tirole (1998) refer to this information structure as the *semi-anonymous* case which is between the *anonymous* case where all types' claims are cheap talk and the full information *identified customer* case. See also Chen (1997) who analyzes price discrimination with exogenous switching costs for consumers.

Suppose entry occurs and the incumbent and the entrant compete for consumers with long-term contract and new consumers. More precisely, the incumbent offers a price p_I to new consumers whereas the entrant charges p_e to consumers with a long-term contract and p_E to new consumers. To achieve price discrimination with semi-anonymous consumers it has to hold that $p_e \leq p_E$. To simplify the exposition, I shall ignore this constraint and show that it is satisfied in equilibrium (see proof of Lemma 1). First, consider competition for the mass m of consumers with a long-term contract with the incumbent. A consumer with a transaction cost draw of τ switches to the entrant if

$$v + \Delta - s - p_e - \tau \geq v - p_2,$$

which implies that all consumers with $\tau \leq p_2 - s + \Delta - p_e$ prefer to switch. Then introduce $\sigma \equiv s - p_2$ as the contractual cost of switching. The entrant maximizes $(p_e - c)\, m\, (\Delta - \sigma - p_e)/\overline{\tau}$ with respect to his price which yields $p_e'' = (\Delta - \sigma + c)/2$ at which all consumers with $\tau \leq \tau'' = (\Delta - \sigma - c)/2$ switch suppliers. The higher the contractual switching costs σ, the lower the price of the entrant and the less consumers switch. The entrant's profits per unit mass of consumer with contract is simply $\pi_e^c(\sigma) = (\Delta - \sigma - c)^2/(4\overline{\tau})$ which decrease and are concave in σ up to the point $\overline{\sigma} \equiv \Delta - c$ where the penalty payment becomes prohibitive for switching. The incumbent's profit from consumers with a contract is composed of penalty payments from switchers and contract payments from non-switchers. Per unit mass of consumers, profits are

$$\begin{aligned} & s\,\frac{1}{\overline{\tau}}\tau'' + (p_2 - c)\,\frac{1}{\overline{\tau}}(\overline{\tau} - \tau'') \\ &= p_2 - c + (\sigma + c)\,\frac{(\Delta - \sigma - c)}{2\overline{\tau}} \equiv p_2 - c + \pi_i(\sigma). \end{aligned}$$

Re-arranging yields that profits per consumer can be expressed as the net profit from contract fulfillment $(p_2 - c)$ plus the expected net revenues from switching. The net revenues are the contract termination fee (s) minus the opportunity cost of switching, i.e. the profits from contract fulfillment, multiplied by the ex ante probability that a consumer switches which is $(\Delta - \sigma - c)/(2\overline{\tau})$. Increasing the contractual switching cost implies a higher net revenue per switching customer but reduces the probability that the consumer switches. The incumbent's profits are therefore concave in σ with a maximum at $\sigma = \Delta/2 - c$. The better the technology of the entrant, the higher the probability of a consumer to switch and the more profitable it is to increase contractual switching costs. The higher the entrant's marginal cost the lower the switching probability and the less profitable it is for the incumbent to increase σ.
The expected utility of a consumer with a long-term contract in case of entry is the

expected sum of the utility if he switches and the utility if he fulfills the contract,

$$\int_0^{\tau''} (v + \Delta - s - \tau - p_e'') \frac{1}{\overline{\tau}} d\tau + \int_{\tau''}^{\overline{\tau}} (v - p_2) \frac{1}{\overline{\tau}} d\tau$$
$$= v - p_2 + \frac{(\Delta - \sigma - c)^2}{8\overline{\tau}} \equiv v - p_2 + \nu(\sigma).$$

The expected utility can be decomposed into the certain benefit from fulfilling the contract $(v - p_2)$ plus an expected gain from switching to the new supplier. This gain is the probability of switching times the average additional surplus from switching, i.e. $(\Delta - \sigma - c)/4$. Both factors decrease in the contractual switching cost σ (up to the prohibitive level $\overline{\sigma}$) which makes these additional gains decreasing and convex. Note that the average additional surplus from switching decreases in σ although the entrant's price decreases in these switching costs. Following a unit increase in switching cost, the entrant optimally reduces his price by less than one unit because he takes into account the effect of his price reduction on infra-marginal consumers. Consequently, consumers bear part of the switching cost increase and the incumbent extracts rent from both the entrant and consumers.[12]

Finally consider the mass of $1 - m$ consumers without a long-term contract and suppose the incumbent and the entrant simultaneously set their prices (p_I, p_E). A consumer with transaction cost τ buys from the entrant if

$$v + \Delta - p_E - \tau \geq v - p_I - \tau$$

or simply $p_E \leq p_I + \Delta$. For these prices all consumers $\tau \in [0, v + \Delta - p_E]$ prefer buying the new technology to not buying at all. The incumbent's best response to any p_E is to set a price slightly smaller than $p_E - \Delta$ as long as (i) $p_E - \Delta \geq c$, and (ii) $p_E - \Delta$ is less than his monopoly price. If the first inequality fails to hold he sets his price equal to marginal cost; if the second fails to hold he sets his monopoly price. Similarly, the entrant's best response to p_I is to undercut $p_I + \Delta$ as long as the undercutting price is between marginal cost and the entrant's monopoly price $p_E^m = (v + \Delta + c)/2$. It follows straight from the usual Bertrand logic that in a Nash equilibrium the incumbent charges a price equal to marginal cost. The entrant's equilibrium price depends on whether his undercutting price $c + \Delta$ is larger or smaller than his monopoly price, i.e. there are two different pricing regimes for consumers without contracts. For $\Delta \leq v - c$, the undercutting price is below the monopoly price and therefore the entrant's best response to $p_I = c$ is $p_E''' = c + \Delta$ and all consumers with $\tau \leq \tau''' = v - c$ buy the new technology. This results in equilibrium profits (per unit mass of consumers) of $\pi_e^{\emptyset} = \Delta(v - c)/\overline{\tau}$. For

[12] This effect is not present in the models of Aghion & Bolton (1987) and Spier & Whinston (1995). In their model, buyers are homogenous and the entrant does not have infra-marginal consumers. Consequently, the entrant has to repay the full switching cost to the consumer which results in the fact that buyers are completely indifferent about the level of switching costs in these models.

$\Delta > v - c$, the entrant wins the market at his monopoly price, i.e. $p_E''' = p_E^m$, and serves all consumers with $\tau \leq \tau''' = (v + \Delta - c)/2$. The entrant earns his monopoly profits $\pi_e^{\o} = (v+\Delta-c)^2/(4\overline{\tau})$. The expected utility for consumers without a long-term contract in case of entry is

$$U_1 = \int_0^{\tau'''} (v + \Delta - \tau''' - p_E''')\frac{1}{\overline{\tau}}d\tau.$$

□ **The first period.** Suppose that after a possible communication by the entrant, consumers have an updated belief of $\widetilde{\rho}_c \in [0, 1]$ that entry occurs in the second period. The incumbent offers consumers a long-term contract (p_1, p_2, s). Consumers observe their transaction cost draw τ and decide whether to accept the incumbent's offer. Accepting the contract yields an expected utility of

$$\begin{aligned} & v - \tau - p_1 + \delta\,\widetilde{\rho}_c\,(v - p_2 + \nu(\sigma)) + \delta\,(1 - \widetilde{\rho}_c)\,(v - p_2) \\ & = v(1 + \delta) - \tau - p_1 - \delta p_2 + \delta\widetilde{\rho}_c\,\nu(\sigma), \end{aligned}$$

which is the value of the old technology for two periods minus a total payment $P \equiv p_1 + \delta p_2$ plus an option value to switch to the new technology in case of entry. Note that consumers only care about two dimensions of the proposed contract, the total discounted payment, P, and the contractual switching cost, σ. If the consumer does not contract with the incumbent his expected utility is

$$\delta\,\widetilde{\rho}_c\,U_1 + \delta\,(1 - \widetilde{\rho}_c)\,U_0.$$

The lower a consumer's transaction cost, the higher is his willingness to accept the contract in period 1. Thus, there exists a $\widetilde{\tau}(P, \sigma)$ such that all consumers $\tau \in [0, \widetilde{\tau}(P, \sigma)]$ sign the contract with the incumbent while consumers in $[\widetilde{\tau}(P, \sigma), \overline{\tau}]$ wait for the second period. The incumbent's demand at a given contract offer (P, σ) is $Q = \widetilde{\tau}(P, \sigma)/\overline{\tau}$ or, inverted, the willingness-to-pay (in terms of total payment P) of the marginal consumer when selling to Q consumers is

$$P(Q, \sigma) = v(1 + \delta) - \overline{\tau}Q + \delta\,\widetilde{\rho}_c\,(\nu(\sigma) - U_1) - \delta\,(1 - \widetilde{\rho}_c)\,U_0.$$

Let us turn to the incumbent's optimal contract offer. Assume the incumbent has an updated belief of $\widetilde{\rho}_i$ that entry occurs in period 2. Similar to the consumer's purchase problem, the incumbent's contract design problem can be reduced to two dimensions. The reason for this is that an increase of the second period price p_2 raises the expected, discounted (second period) profits of the incumbent by the same amount as it decreases the willingness-to-pay for the long-term contract in the first period. Therefore, all that matters is the total payment of consumers and the contractual switching cost.[13] Writing

[13] The fact that one of the three contract instruments is indeterminate also holds in Caminal & Matutes (1990) and Fudenberg & Tirole (2000). The indeterminacy would be broken if, for example, the discount factors of consumers and firms would differ.

the expected profits of the incumbent as a function of Q and σ yields

$$E\Pi_i(Q,\sigma) = [P(Q,\sigma) - c(1+\delta)]\,Q + \delta\,\widetilde{\rho}_i\,Q\,\pi_i(\sigma) + \delta\,(1-\widetilde{\rho}_i)(1-Q)\,\pi_i^m.$$

The incumbent's expected profits consist of three parts. The first term is the total net profits from selling the long-term contract to Q consumers and serving them in both periods. With some probability entry occurs and the incumbents receive revenues from switching consumers in period 2. Finally, in the case of no entry, the incumbent makes monopoly profits from the consumers who didn't buy in the first period. Maximizing the expected profit with respect to Q and σ yield the following first-order conditions

$$\frac{dE\Pi_i}{dQ} = P(Q,\sigma) - c(1+\delta) + \frac{\partial P(.)}{\partial Q}Q + \delta\,\widetilde{\rho}_i\,\pi_i(\sigma) - \delta(1-\widetilde{\rho}_i)\,\pi_i^m = 0 \tag{1}$$

$$\frac{dE\Pi_i}{d\sigma} = \delta\,\widetilde{\rho}_c\,\frac{\partial \nu(\sigma)}{\partial \sigma}\,Q + \delta\,\widetilde{\rho}_i\,\frac{\partial \pi_i(\sigma)}{\partial \sigma}\,Q = 0 \tag{2}$$

The next lemma summarizes the main insights from the optimal design of the long-term contract for the following analysis.[14]

Lemma 1 *At the optimal contract proposal (Q^*,σ^*) of the incumbent it holds that:*

(i) The optimal contractual switching cost maximizes the expected joint surplus of incumbent and consumers from switching in the case of new entry. It is independent of the number of contracts sold.

(ii) The optimal contractual switching cost decreases in the consumers' belief $\widetilde{\rho}_c$ and increases in the incumbent's belief $\widetilde{\rho}_i$. It increases in the size of the entrant's innovation Δ and decreases in the marginal cost c.

(iii) The optimal quantity increases (decreases) in σ if $\sigma < (>)\ \sigma^*$. It increases in the consumers' belief $\widetilde{\rho}_c$ and decreases in the incumbent's belief $\widetilde{\rho}_i$.

The contractual switching cost enters the incumbent's maximization problem in two ways. It has a direct impact on the incumbent's expected second period profits from switching consumers in the case of new entry. At the same time, σ affects consumers' expected benefits from switching and the willingness-to-pay for the long-term contract of the marginal consumer. The incumbent takes full account of this second effect and therefore maximizes the expected joint surplus of consumers and incumbent from customer switching in the case of entry.[15] Further note that both effects apply to all

[14] The proof for this lemma also includes a short demonstration that long-term contracts always dominate short-term contracts for the incumbent. This is due to the transaction cost savings for consumers and the possibility of extracting rents with long-term contracts. Also note that offering a menu of short-term and long-term contracts would not alter the results because consumers have the same expected future transaction cost and all consumers would choose the long-term contract.

[15] A direct implication of this result is that renegotiation of the contract terms in the case of new entry is never optimal. The ex ante chosen contract maximizes the interim joint surplus of consumers and incumbent in the case of entry and any change in contract terms would make either consumers or the incumbent worse off.

consumers who purchase in the first period and therefore the quantity Q cancels out in the first-order condition and the second part of Lemma 1(i) follows.

To see point (ii) solve equation (2) for the optimal contractual switching cost which yields

$$\sigma^* = \frac{(2\widetilde{\rho}_i - \widetilde{\rho}_c)\Delta}{4\widetilde{\rho}_i - \widetilde{\rho}_c} - c. \tag{2'}$$

Consumers' willingness-to-pay decreases in the contractual switching cost. The incumbent's future expected profits from switching consumers are maximized at $\sigma = \Delta/2 - c$. Thus, the stronger consumers believe that there is entry (the higher $\widetilde{\rho}_c$), the more important is the first effect and the lower is the optimal σ. Similarly, the more the incumbent expects entry, i.e. the higher $\widetilde{\rho}_i$, the stronger the incentive to increase σ towards $\sigma = \Delta/2 - c$. The optimal switching cost equates the marginal loss in consumers' willingness-to-pay from an increase in σ and the expected marginal gain in second period switching profits. The larger the innovation advantage of the entrant (and the smaller the marginal cost), the lower is the marginal loss for consumers (through a higher switching probability and a higher average switching utility) and the higher is the expected marginal gain of the incumbent (via a higher switching probability). Therefore, the optimal switching cost increases in Δ and decreases in c.

Point (iii) in Lemma 1 first states that the optimal quantity Q first increases in σ, up to σ^*, and then decreases. This inverted U-shape is due to the fact that the incentive to sell long-term contracts depends on how much profit an individual contract generates. Since the profit-maximizing contract is at σ^*, lower or higher switching costs induce smaller first period quantities. Finally, in order to assess the effect of $\widetilde{\rho}_i$ on the incentive to sell more contracts in period 1 consider

$$\frac{\partial^2 E\Pi_i}{\partial Q \partial \widetilde{\rho}_i} = \delta\pi_i(\sigma^*) + \delta\pi_i^m. \tag{3}$$

An increase in entry expectations makes the incumbent more aggressive for two reasons. First, he anticipates that the more contracts he sells in period 1, the more switching revenues he can collect after entry. And second, the opportunity cost of selling a long-term contract to the marginal consumer shrinks because it becomes less likely that the incumbent remains monopolist and sells in the second period. The effect of $\widetilde{\rho}_c$ on the first period quantity is given by

$$\frac{\partial^2 E\Pi_i}{\partial Q \partial \widetilde{\rho}_c} = \frac{\partial P(.)}{\partial \widetilde{\rho}_c} = -\delta(U_1 - \nu(\sigma^*) - U_0). \tag{4}$$

The consumers' expectations affect their willingness-to-pay for the long-term contract and thereby the incumbent's incentive to increase Q. The difference $U_1 - \nu(\sigma)$ is the expected second period loss upon entry if the consumer contracts in period 1. The third term is the gain from not being locked in if no entry occurs.

□ **Communication decision.** Before the incumbent offers the terms of his long-term contract, an innovative entrant can communicate the launch of the new service to consumers and the incumbent.[16] As demonstrated in Lemma 1 changes in expectations have an impact on the optimal contract proposed by the incumbent, i.e. on the optimal contractual switching costs and on the number of long-term contracts sold. For a given contract (Q, σ), the entrant's discounted profits after entry are given by

$$\Pi_e(Q, \sigma) = \delta \left(Q \, \pi_e^c(\sigma) + (1 - Q) \, \pi_e^{\varnothing} \right).$$

It is straightforward to verify that profits are decreasing in σ for $\sigma < \overline{\sigma}$ and decreasing in Q. Furthermore, the "rate of substitution" of a higher penalty payment for a lower quantity is decreasing and goes to zero as σ approaches $\overline{\sigma}$ where switching costs become completely prohibitive (see iso-profit line $\overline{\Pi}_E$ in Figure 1).

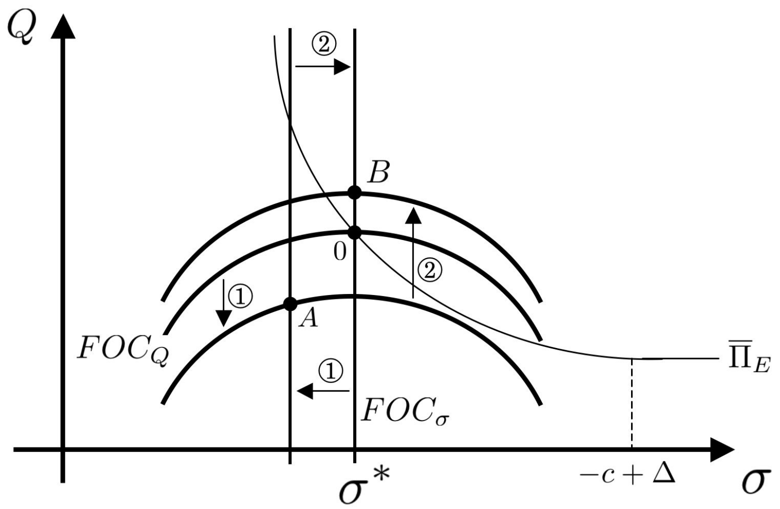

Figure 1: *Effect of expectations on optimal contract and entrant's profits*

What is now the effect of an increase in the consumers' belief $\widetilde{\rho}_c$ and the incumbent's belief $\widetilde{\rho}_i$ on the entrant's profits? Consider the $Q - \sigma$ diagram in Figure 1 which depicts the effect of changes in expectations on the incumbent's optimal contract. Suppose for an initial set of beliefs, the optimal contract is at the intersection of the two first-order conditions of the incumbent (denoted by FOC_Q and FOC_σ). By Lemma 1 an increase in $\widetilde{\rho}_c$ shifts FOC_σ to the left and the optimal quantity curve downwards, i.e. the optimum moves from point 0 to point A. An increase of consumer expectations leads to a lower σ and a lower number of contracts sold. This is good news for the entrant

[16]In practice, an announcement might be an advertising campaign that reaches a certain fraction of consumers as a function of the advertising spending. Modeling the announcement decision as an advertising expenditure would not alter the strategic forces at work in this paper.

who unambiguously reaches a higher iso-profit curve. An increase in $\widetilde{\rho}_i$ has the opposite effect, it shifts FOC_σ to the right and increases the optimal quantity. The optimal contract moves from point A to, say, point B. In particular, the effect of $\widetilde{\rho}_c$ on σ exactly outweighs the effect of the incumbent's expectations, i.e. the optimal switching cost remains unchanged after an equal increase in $\widetilde{\rho}_c$ and $\widetilde{\rho}_i$. The reason for this is that in (2) the optimal switching cost equates the marginal loss in consumers' willingness-to-pay from an increase in σ and the expected marginal gain in second period switching profits. Thus, at the optimal contractual switching cost, marginally increasing $\widetilde{\rho}_c$ must have the exact opposite effect of increasing $\widetilde{\rho}_i$.

It follows that the overall impact of communication on the entrant's profits is solely determined by the effect of the change of expectations on the number of contracts sold in period 1. To compare the size of the effects of $\widetilde{\rho}_i$, and $\widetilde{\rho}_c$ respectively, on the optimal quantity, it is convenient to compare their impact on the first order condition (1). From (3) and (4) follows that communication is profitable for the entrant if and only if

$$U_1 \geq \pi_i(\sigma^*) + \nu(\sigma^*) + \pi_i^m + U_0, \tag{5}$$

i.e. if the utility of an unlocked consumer from entry is larger than the joint second period surplus of incumbent and locked consumers and total welfare in the case of no entry. The following proposition compares these effects and characterizes the perfect Bayesian equilibrium of the game.

Proposition 1 *Consider the communication decision of the entrant before period 1. There exist Δ_1, Δ_2 and Δ_3 with $0 < \Delta_1 < v - c < \Delta_2 < \Delta_3$ such that for all parameter values a unique perfect Bayesian equilibrium exists:*

(i) If $0 < \Delta \leq \Delta_1$ or $\Delta_2 < \Delta \leq \Delta_3$, then there exists a separating equilibrium in which the entrant announces entry.

(ii) If $\Delta_1 < \Delta \leq \Delta_2$ or $\Delta > \Delta_3$, then there exists a pooling equilibrium in which the entrant does not announce entry.

The proposition states that for all parameter values a unique perfect Bayesian equilibrium exist. The type of equilibrium depends on the size of the innovation in a highly non-linear way. Small and medium-to-large innovations are announced by the entrant whereas small-to-medium and large innovations are not announced.

The intuition for this result comes from the effect of innovation size on expected consumer demand and strategic contracting. Figure 2 plots condition (5) as a function of Δ. The thick line depicts the left-hand side and the dashed line the right-hand side. The size of the innovation enters (5) at two points. The left-hand side is increasing and convex for drastic innovations because the higher Δ, the more consumers buy from the entrant and the bigger the utility of the average consumer. For non-drastic innovations, $\Delta \leq v - c$, the entrant appropriates the full innovation rent and U_1 is independent of Δ.

The impact of Δ on the right-hand side comes from a direct and an indirect effect. For a given σ, it holds that the larger the innovation, the higher the switching probability for a consumer and the higher the average surplus from switching. Hence, the joint surplus of incumbent and consumers increases. At the same time, if Δ increases, the optimal σ^* increases by virtue of point (ii) in Lemma 1.

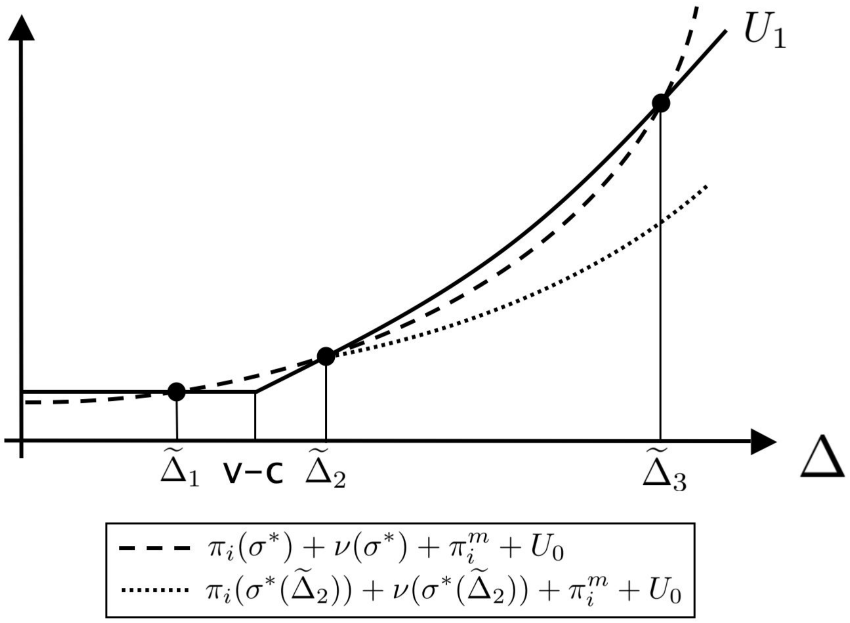

Figure 2: *Incentive constraint for communication.*

First consider (5) for the case of non-drastic innovations. If the innovation step size goes towards zero, the contractual switching cost approaches $-c$ and the probability of switching (and with it all surplus) goes to zero. At the same time, $U_1(\Delta = 0)$ is the same value consumers would get if the old technology were offered at marginal cost price and by a simple efficiency argument this value has to be larger than total welfare without entry and an incumbent monopolist. It follows that small innovations are announced because consumers anticipate low second period prices due to intensive price competition between suppliers of close substitutes.[17] This is the *demand pull effect of competition.* However, as innovation size increases, switching after entry becomes more attractive for consumers and generates more revenues for the incumbent. This in turn makes the incumbent more aggressive and induces him to cut the price of the long-term when his

[17] If, for the sake of the argument, after entry the incumbent would decide not to compete for new consumers with the entrant, this effect would disappear completely and small innovations would not be announced. In this case U_1 would correspond to the utility in the drastic innovation case, $(v + \Delta - c)^2/(8\overline{\tau})$, which is, for $\Delta = 0$, always smaller than total welfare without entry, $3(v - c)^2/(8\overline{\tau})$.

expectations of entry increase. This *strategic contracting effect* reduces the profitability of communication and, for $\Delta_1 < \Delta \leq v - c$, the entrant chooses not to announce.

With drastic innovations, the entrant sets his monopoly price after entry and the demand pull effect of competition disappears completely. At the same time consumers without long-term contract receive a share of the innovation rent after entry and this provides the second leverage for announcements to be profitable. In particular, for a given level of σ, the difference between what the unattached consumers can appropriate from the entrant versus what the incumbent-locked consumers coalition can extract is increasing in Δ. In other words, the bigger the innovation, the more consumers stand to lose by buying the incumbent's long-term contract. This is the *demand pull effect of large innovations* which makes announcements profitable for medium-to-large innovations (i.e. for $\Delta_2 \leq \Delta < \Delta_3$). However, as mentioned above, the innovation step size also increases the optimal contractual switching cost itself. This increases the marginal gain from an individual long-term contract and makes the incumbent even more aggressive in terms of contract sales. The size of this effect is represented in Figure 2 by the difference between the dotted line and the dashed line. The dotted line is the value of the right-hand side of (5) when σ is fixed to its optimal level at Δ_2, $\sigma^*(\Delta_2)$. Without the indirect effect through the size of the contractual switching cost, announcements are always optimal for all $\Delta \geq \Delta_2$. However, large innovations allow the incumbent to extract high rents per contract from the entrant and this makes price cuts (and thereby customer base expansions) more attractive. As a result, large innovations ($\Delta \geq \Delta_3$) are not communicated by the entrant.

4 Welfare Analysis

The above equilibrium analysis contains three potential sources of inefficient behavior: market power, incomplete information and the terms of the contract. For the following welfare analysis I will take the number of firms as given and compare equilibrium and efficient outcomes with respect to communication and contract terms. It turns out that the importance of each inefficiency, and with it any policy implication, depends on whether one measures efficiency in total welfare or consumer surplus.

□ **Total Welfare.** Total welfare is the value of consumption minus production and transaction cost in both periods. First consider the sub-game with entry. Define the second period net surplus of a consumer with a long-term contract as

$$\widetilde{\omega}_1(\sigma) = \int_0^{\tau''(\sigma)} (v + \Delta - c - \tau)\frac{1}{\overline{\tau}}d\tau + \int_{\tau''(\sigma)}^{\overline{\tau}} (v - c)\frac{1}{\overline{\tau}}d\tau$$

and the second period surplus of an unlocked consumer as $\widetilde{\omega}_0 = \int_0^{\tau'''} (v + \Delta - c - \tau)\frac{1}{\overline{\tau}}d\tau$. The interim welfare with entry is the sum of first period net surplus and the net surplus of consumers with and without long-term contract, i.e.

$$\Omega^e(Q,\sigma) = \int_0^{\overline{\tau}Q} [v-c-\tau]\frac{1}{\overline{\tau}}d\tau + \delta\, Q\, \widetilde{\omega}_1(\sigma) + \delta\,(1-Q)\,\widetilde{\omega}_0.$$

Note that interim welfare with entry does not depend on prices but on contractual switching costs which determine the number of long-term contracts. From an interim perspective, it would be efficient that all consumer with a transaction cost less than the quality advantage of the entrant switch rather than fulfilling their long-term contract. To ensure that $\tau'' = \Delta$ the interim efficient contractual switching costs is $\sigma = -c - \Delta$.

Without entry, a consumer with a long-term contract creates a value of $\omega_1 = v - c$ whereas a consumer without contract generates $\omega_0 = \int_0^{\tau'}(v-c-\tau)\frac{1}{\overline{\tau}}d\tau$. Interim welfare without entry is then

$$\Omega^{\o}(Q,\sigma) = \int_0^{\overline{\tau}Q} [v-c-\tau]\frac{1}{\overline{\tau}}d\tau + \delta\, Q\, \omega_1 + \delta\,(1-Q)\,\omega_0.$$

Throughout this analysis I focus on *ex ante* efficiency, i.e. the expected value before it becomes known whether there is entry or not. Since I concentrate on the effects of communication and the size of the switching costs, it is convenient to plug the equilibrium quantity from (1) as a function of σ and $\widetilde{\rho}$ into the interim welfare functions and refer to them simply as $\Omega^e(\sigma,\widetilde{\rho})$ and $\Omega^{\o}(\sigma,\widetilde{\rho})$, respectively. Then, *ex ante* welfare in a situation with communication is given by

$$EW^c(\sigma) = \rho\,\Omega^e(\sigma,\widetilde{\rho}=1) + (1-\rho)\,\Omega^{\o}(\sigma,\widetilde{\rho}=0)$$

where as without communication it is

$$EW^{\o}(\sigma) = \rho\,\Omega^e(\sigma,\widetilde{\rho}=\rho) + (1-\rho)\,\Omega^{\o}(\sigma,\widetilde{\rho}=\rho).$$

From this two main results are derived.

Proposition 2 *From the perspective of a social planner who maximizes ex ante total welfare it holds:*

(i) The socially efficient contractual switching cost with and without communication is lower than the incumbent's equilibrium choice. For sufficiently large innovation steps, a contract with prohibitive switching costs might be welfare superior to the equilibrium outcome.

(ii) The entrant's equilibrium communication behavior is socially efficient.

To understand point (i) consider the first-order condition of the welfare maximization problem with communication with respect to σ,[18]

$$\frac{\partial\widetilde{\omega}_1}{\partial\sigma}\,\delta\, Q(\sigma,1) + \frac{\partial Q(\sigma,1)}{\partial\sigma}\,[v-c-\overline{\tau}Q(\sigma,1) + \delta\,(\widetilde{\omega}_1(\sigma)-\widetilde{\omega}_0)] = 0.$$

[18]The same argumentation applies for ex ante welfare without communication.

The size of the switching costs has two effects on ex ante welfare.[19] The first term in the first order condition is the direct effect of increasing the switching costs on the second period welfare after entry, $\widetilde{\omega}_1$. This effect is negative for $\sigma \geq -c - \Delta$ and applies to all consumers who bought in period 1. The second term is the indirect effect of switching costs on the first period quantity weighed by the net social surplus of selling a long-term contract to the marginal consumer in period 1. By Lemma 1 the effect on quantity is positive (negative) if and only if $\sigma \leq (>) \sigma^*$. Thus, as long as the net welfare contribution of serving the marginal consumer in period 1 (bracketed term) is positive, the efficient contractual switching cost trades off the second period allocative distortion with the gain from selling more long-term contracts to consumers. However the net welfare contribution of the marginal consumer decreases in σ and it is shown that there might exist a $\sigma' \leq \sigma^*$ such that the marginal consumer's contribution is positive for $\sigma \leq \sigma'$. In any case, there always exists a local maximum in $[-c - \Delta, min\{\sigma', \sigma^*\}]$. Nevertheless, as the contractual switching cost increases beyond σ^*, the contribution of the marginal consumer becomes unambiguously negative. At the same time, for $\sigma \geq \sigma^*$, increasing the switching costs reduces the number of long-term contracts sold. Hence, total welfare increases and creates a second local maximizer at the prohibitive switching cost level $\overline{\sigma}$. The last step for the first part of point (i) is to show that the interior maximizer in $[-c - \Delta, min\{\sigma', \sigma^*\}]$ always dominates the prohibitive switching cost level.

By contrast, the second part of point (i) makes the second-best argument that for sufficiently high innovation steps, the prohibitive switching cost contract is welfare superior to the contract chosen in equilibrium. The reason for this is that the incumbent always chooses the contractual switching cost to maximize the number of contracts sold without taking into account the allocative cost, or inversely, the net welfare contribution of the marginal consumer. For a high quality differential between incumbent and entrant, the optimal contractual switching cost is large and therefore the net welfare contribution of the marginally contracted consumer low or even negative. In this case, the economy would be strictly better off (in a second-best sense) with prohibitive penalty payments that force the incumbent to restrict output.

Point (ii) of Proposition 2 considers the welfare effects of communication if the incumbent is free to set the contract conditions. It posits that the equilibrium communication behavior of the entrant maximizes ex ante total welfare. In other words, neither mandatory communication nor a ban on entry communication can improve total welfare. From an ex ante point of view, communication implies that incumbent and consumers learn if there is entry but also, by Bayesian updating, if there is no entry. Communication is socially efficient if and only if $EW^c(\sigma^*) \geq EW^{\emptyset}(\sigma^*)$ or

$$\rho\,[\Omega^e(\sigma^*, 1) \,-\, \Omega^e(\sigma^*, \rho)] \,\geq\, (1-\rho)\,[\Omega^{\emptyset}(\sigma^*, \rho) \,-\, \Omega^{\emptyset}(\sigma^*, 0)].$$

[19]Note that this first-order condition is of third degree in the contractual switching costs σ.

In words, communication is ex ante efficient if expected relative gains from an informed entry outweigh the benefit from a contestable market without information in the case of no entry. This condition simplifies (see appendix) to

$$\rho(1-\rho)\,\frac{\partial Q(\sigma^*,\widetilde{\rho})}{\partial\widetilde{\rho}}\,[\underbrace{\delta(\widetilde{\omega}_1(\sigma^*)-\widetilde{\omega}_0)-\frac{\overline{\tau}}{2}Q(\widetilde{\rho}=1)}_{\text{average consumer with entry}}-\underbrace{(\delta(\omega_1-\omega_0)-\frac{\overline{\tau}}{2}Q(\widetilde{\rho}=0))}_{\text{average consumer without entry}}]\geq 0 \quad (6)$$

where $\widehat{Q}$ is the equilibrium quantity adjustment to a marginal increase in entry expectations. Communication affects the number of long-term contract sold and this change has to be weighed by the average welfare contribution of a contract with and without entry. In the entry case, communication increases expectations from $\widetilde{\rho}=\rho$ to $\widetilde{\rho}=1$ which leads to a (positive or negative) change in equilibrium quantity. Without entry, communication reduces expectations $\widetilde{\rho}=\rho$ to $\widetilde{\rho}=0$ which leads to a quantity adjustment which is the same in absolute terms but always in the opposite direction with respect to the entry case. This implies that in the above condition it is possible to factor out the absolute quantity adjustment effect of communication whereas the bracketed term is the difference of the net welfare contribution of the informed average consumer who buys a long-term contract with and without entry. At the equilibrium contractual switching costs, this bracketed term is always negative. In other words, due to the excessively high contractual switching costs, it is the average consumer in the no entry case who contributes more to welfare than the average consumer with entry. Thus, by virtue of (6), if communicating entry increases the first period quantity, then communication is welfare reducing due to the dominating effect of the loss of contestability in the market without entry. If communicating entry reduces the number of long-term contracts, then communication is socially desirable. As detailed in the previous section, the entrant only benefits from announcing if and only if the first period quantity decreases. Therefore, the entrant's incentives to communicate and the condition for social efficiency of communication are perfectly aligned and part (ii) of Proposition 2 follows. A direct implication of this result is that the entrant's communication behavior can indeed reduce the anti-competitive effects of exclusionary contracts.

□ **Consumer Surplus.** Consumer surplus in the case of entry is the sum of utility of all consumers who buy the long-term contract in period 1 and the utility of consumers who buy from the entrant in period 2,

$$\Gamma^e(Q,\sigma)=\int_0^{\overline{\tau}Q}[v(1+\delta)-P(Q,\sigma)-\tau+\delta\nu(\sigma)]\frac{1}{\overline{\tau}}d\tau+\delta(1-Q)U_1.$$

Similarly, in the case without entry, consumer surplus can be written as

$$\Gamma^{\varnothing}(Q,\sigma)=\int_0^{\overline{\tau}Q}[v(1+\delta)-P(Q,\sigma)-\tau]\frac{1}{\overline{\tau}}d\tau+\delta(1-Q)U_0.$$

Plugging the equilibrium quantity as a function of σ and $\widetilde{\rho}$ into the interim consumer surplus yields the *ex ante* consumer surplus with communication,

$$ECS^c(\sigma) = \rho\,\Gamma^e(\sigma, \widetilde{\rho} = 1) + (1-\rho)\,\Gamma^{\emptyset}(\sigma, \widetilde{\rho} = 0),$$

and without communication,

$$ECS^{\emptyset}(\sigma) = \rho\,\Gamma^e(\sigma, \widetilde{\rho} = \rho) + (1-\rho)\,\Gamma^{\emptyset}(\sigma, \widetilde{\rho} = \rho).$$

The next proposition establishes two main results with respect to the level of contractual switching costs and communication.

Proposition 3 *From the perspective of a social planner who maximizes ex ante consumer surplus it holds:*

(i) The incumbent's equilibrium contractual switching costs maximize consumer surplus with and without communication.

(ii) Consumers always prefer full information about future entry.

To understand the first point note that the contractual switching costs σ enter consumer surplus in two ways. They affect the number of contracts sold (and with it the total payment for the long-term contract) and the second period consumer benefit $\nu(\sigma)$ from switching. With full information the latter effect disappears completely because any change in future switching benefits is absorbed by a change in the total price of the contract. However with incomplete information at the interim stage this is not the case. First consider the case of entry and a given belief of $\widetilde{\rho}$. The optimal interim penalty payment is determined by the following condition

$$\frac{\partial \Gamma^e(\sigma, \widetilde{\rho})}{\partial \sigma} = [\overline{\tau} Q + \delta(1-\widetilde{\rho})(\nu(\sigma) - U_1 + U_0)]\,\frac{\partial Q}{\partial \sigma} + \delta(1-\widetilde{\rho})\,Q\,\frac{\partial \nu}{\partial \sigma} = 0.$$

The bracketed term is the surplus contribution of the marginal consumer which can be shown to be positive. The second summand is the unanticipated part of the effect of σ on future consumer benefits from switching. From the fact that $\partial\nu/\partial\sigma$ is negative follows that the contractual switching cost that maximizes interim consumer surplus has to satisfy $\partial Q/\partial\sigma > 0$. This in turn requires a σ lower than the equilibrium switching cost σ^*. In other words, in the entry subgame actual switching benefits are higher than the ones anticipated and included in the price. For this reason, the optimal interim penalty payment should account more for the second period loss of a marginal increase in σ. And thus, the optimal interim contractual switching costs with entry is below the level that maximizes the number of long-term contracts.

Similarly, the optimal interim contractual switching cost in the absence of entry is defined by

$$\frac{\partial \Gamma^{\emptyset}(\sigma, \widetilde{\rho})}{\partial \sigma} = [\overline{\tau} Q - \delta\widetilde{\rho}(\nu(\sigma) - U_1 + U_0)]\,\frac{\partial Q}{\partial \sigma} - \delta\widetilde{\rho}\,Q\,\frac{\partial \nu}{\partial \sigma} = 0.$$

Without entry $\nu(\sigma)$ only enters the interim problem in expected terms through the price of the long-term contract. A higher σ reduces perceived switching benefits and lowers the payment of the long-term contract. This positive price effect implies that consumers are better off with a contractual switching cost that is above the level that only maximizes the number of contracts. To see this in the first-order condition, note that the marginal consumer contribution in the bracketed term is positive, the second term is positive and therefore it has to hold that $\partial Q/\partial\sigma < 0$ or $\sigma > \sigma^*$.
Point (i) of Proposition 3 follows from the addition of these two interim effects. With communication the effect on $\nu(\sigma)$ is always absorbed by the price and consumers simply maximize the number of contracts sold. Without communication consumers prefer a lower σ with entry and a higher σ without entry. The total effect of σ on ex ante consumer surplus is the expectation-weighted sum of the two effects on the interim measures and they exactly cancel each other out. Put differently, at the *interim* level, the price might not capture all future consumer benefits and thereby distort the level of contractual switching cost away from σ^*. However, at the *ex ante* level, anticipation is perfect and consumer choose the contractual switching cost that maximizes quantity.

The second point in Proposition 3 states that ex ante consumer surplus is maximized with full communication about future entry and, consequently, the entrant underprovides information. Information enters consumer surplus through the number of contracts sold weighted by the expected second period contribution to consumer surplus. However, as pointed out above, all expected future consumer benefits are incorporated in the total price of the long-term contract and from an *ex ante* point of view cancel out by anticipation. Thus, there only remains the effect of quantity on consumers' transaction costs. Note that consumers' total first period transaction costs with Q contracts are simply $\overline{\tau}Q^2/2$. At the same time, the incumbent is unable to identify the transaction cost of an individual consumer and therefore has to reduce the first period price by the marginal consumer's transaction cost. This allows consumers not only to recoup their transaction cost expenses but to earn infra-marginal information rents of size $\overline{\tau}Q^2/2$. Hence, consumers prefer the communication pattern that maximizes the expected number of long-term contracts. And it follows from the convexity of these infra-marginal information rents that in expected terms consumers are better off with the higher variance in the full communication quantities $Q^*(\widetilde{\rho} = 0)$ and $Q^*(\widetilde{\rho} = 1)$ compared to the unresponsive, uninformed quantity $Q^*(\widetilde{\rho} = \rho)$ which is set in the absence of communication. In this sense, communication is beneficial to consumers because it increases expected infra-marginal informational rents from their transaction costs.

As shown Proposition 2 and 3 provide very different perspectives on the policy implications of long-term contracts and information provision. A competition policy based on social efficiency should focus on keeping contractual switching cost low whereas a policy based on consumer surplus should try to invigorate communication incentives.

5 Conclusions

This paper contributes to the discussion of the use of exclusionary contracts by investigating the incentives of firms to communicate entry into an industry where an incumbent writes long-term contracts with consumers. It is demonstrated that the anti-competitive effects of long-term contracts can be attenuated by the amount of information the potential entrant chooses to provide to incumbent and consumers. In fact, the possibility of strategic contracting from the incumbent in the form of price cuts and contractual switching costs severely limits the profitability of communicating entry. The analysis shows that entry with small-to-medium innovations is not announced due to potential price cuts whereas large innovations are not communicated due to the installment of high contractual switching costs. However, this lack of communication occurs exactly in those situations in which it is socially efficient not to have full information in the economy because it would lock too many consumers into inefficient long-term contracts. Therefore, equilibrium communication maximizes total welfare and reduces the negative impact of excessively exclusionary long-term contracts.

Interestingly, the policy implications are completely reversed from a consumers' point of view. Ex ante consumer surplus is maximized at the level of contractual switching costs chosen by the incumbent. The reason for this is that the negative effect of penalty payments on future utility is fully anticipated in the price for the long-term contract. Therefore, all that matters to consumers is the number of contracts sold by the incumbent which is maximized at the (for the incumbent) most profitable level of contractual switching costs. Consequently, consumers are ex ante best off with strictly positive penalty payments for switching supplier. It is also shown that ex ante consumers always prefer communication from the entrant. The only effect of communication that is not picked up and cancelled out by the total contract payment is the effect of the number of long-term contracts on infra-marginal, informational rents of consumers. These rents are increasing and convex in the number of long-term contracts. Therefore, ex ante consumers expect to appropriate more rents with the equilibrium quantities that respond to communication rather than with the fixed intermediate number of contracts in the absence of communication.

Thus, based on these results any policy implication should crucially depend on whether the relevant measure is total welfare or consumer surplus. A competition policy based on the total welfare criterion should focus on keeping contractual switching cost low whereas a policy based on consumer surplus should try to invigorate communication incentives of entrants.

Appendix

Proof of Lemma 1

Equation (2) simplifies to

$$\frac{dE\Pi_i}{d\sigma} = \delta\rho_c \frac{\partial\nu}{\partial\sigma} + \delta\rho_i \frac{\partial\pi_i(\sigma)}{\partial\sigma} = -\delta\rho_c \frac{\Delta - c - \sigma}{4\overline{\tau}} + \delta\rho_i \frac{\Delta - 2c - 2\sigma}{2\overline{\tau}} = 0$$

from which (2') and parts (i) and (ii) follow immediately. For part (iii), simplify (1) to

$$\frac{dE\Pi_i}{dQ} = (v-c)(1+\delta) - 2\overline{\tau} + \delta\rho_c[\nu(\sigma) - U_1] - \delta(1-\rho_c)U_0 + \delta\rho_i\pi_i(\sigma) - \delta(1-\rho_i)\pi^m = 0$$

and solve for Q to get

$$Q(\sigma) = \frac{1}{2\overline{\tau}}[(v-c)(1+\delta) + \delta\rho_c[\nu(\sigma) - U_1] - \delta(1-\rho_c)U_0 + \delta\rho_i\pi_i(\sigma) - \delta(1-\rho_i)\pi^m].$$

Taking the derivative with respect to σ yields

$$\frac{dQ(\sigma)}{d\sigma} = \delta\rho_c \frac{\partial\nu(\sigma)}{\partial\sigma} + \delta\rho_i \frac{\partial\pi_i(\sigma)}{\partial\sigma} = 0$$

which is equivalent to the first-order condition for σ, (2). Moreover, $Q(\sigma)$ is concave since

$$\frac{d^2Q(\sigma)}{(d\sigma)^2} = \delta\rho_c \frac{\partial^2\nu(\sigma)}{(\partial\sigma)^2} + \delta\rho_i \frac{\partial^2\pi_i(\sigma)}{(\partial\sigma)^2} = \frac{\delta\rho_c}{4\overline{\tau}} - \frac{\delta\rho_i}{\overline{\tau}} < 0$$

for $\rho_i = \rho_c$ which completes the first part of point (iii). The second part is shown in the text except for the sign of

$$\begin{aligned}
\frac{d^2E\Pi_i}{dQ\,d\rho_c} &= -\frac{\delta}{8\overline{\tau}}(\Delta - c - \sigma^*)^2 - \frac{\delta}{8\overline{\tau}}(v-c)^2 + \frac{\delta}{8\overline{\tau}} \begin{cases} 4(v-c)^2 & \text{if } \Delta < v-c, \\ (v-c+\Delta)^2 & \text{if } \Delta \geq v-c \end{cases} \\
&= \frac{\delta}{8\overline{\tau}} \begin{cases} (\Delta - c - \sigma^*)^2 - 3(v-c)^2 & \text{if } \Delta < v-c, \\ (\sigma^2 + c)^2 - 2\Delta(\sigma^* + v) & \text{if } \Delta \geq v-c \end{cases} \\
&= \frac{\delta}{72\overline{\tau}} \begin{cases} 4\Delta^2 - 27(v-c)^2 & \text{if } \Delta < v-c, \\ -\Delta(5\Delta + 18(v-c)) & \text{if } \Delta \geq v-c \end{cases} < 0.
\end{aligned}$$

To verify the second-order condition check that

$$\frac{\partial^2 E\Pi_i}{(\partial\sigma)^2} = -3\delta\rho/(4\overline{\tau}) < 0, \qquad \frac{\partial^2 E\Pi_i}{(\partial Q)^2} = -2\overline{\tau} < 0 \quad \text{and}$$

$$\frac{\partial^2 E\Pi_i}{(\partial Q)^2}\frac{\partial^2 E\Pi_i}{(\partial\sigma)^2} - \frac{\partial^2 E\Pi_i}{\partial Q \partial\sigma}\frac{\partial^2 E\Pi_i}{\partial\sigma\partial Q} = \frac{\partial^2 E\Pi_i}{(\partial Q)^2}\frac{\partial^2 E\Pi_i}{(\partial\sigma)^2} > 0.$$

Parameter restriction. To ensure that the market is not covered at the optimal contract of the incumbent, it has to hold that $\overline{\tau} \geq max\{\tau', \tau''(\sigma^*), \tau'''\}$. It turns out that for any parameter value the most restrictive constraint is $\overline{\tau} \geq \tau'''$ and I assume throughout the paper

$$\overline{\tau} \geq max\{v - c, (v + \Delta - c)/2\} \tag{A1}$$

Short term contracts. With short term contracts the incumbent makes expected profits of $(1 + \delta(1 - \rho))\, \pi_i^m$ where π_i^m is the monopoly profit he makes in the second period on consumers without contract (see section 3). To compare this with the equilibrium profit with long-term contracts, I show that the minimum of $E\Pi_i(Q^*, \sigma^*)$ always dominates the short-term contract profits. Using the Envelope Theorem derive

$$\begin{aligned}
\frac{dE\Pi_i(Q^*, \sigma^*)}{d\Delta} &= \frac{\partial P}{\partial \Delta} Q^* + (P - c(1+\delta))\frac{\partial Q}{\partial \Delta} + \delta\rho\pi_i(\sigma^*)\frac{\partial Q}{\partial \Delta} + \delta\rho Q^* \frac{\partial \pi_i}{\partial \Delta} - \delta(1-\rho)\pi_i^m \frac{\partial Q}{\partial \Delta} \\
&= \frac{\partial Q}{\partial \Delta}[P - c(1+\delta) - \overline{\tau} Q^* + \rho\delta\pi_i(\sigma^*) - \delta(1-\rho)\pi_i^m] + \rho\delta Q^*[\frac{\partial \pi_i}{\partial \Delta} + \frac{\partial \nu}{\partial \Delta} - \frac{U_1}{\partial \Delta}] \\
&= \rho\delta Q^*[\frac{\partial \pi_i}{\partial \Delta} + \frac{\partial \nu}{\partial \Delta} - \frac{U_1}{\partial \Delta}] = 2\overline{\tau}\frac{\partial Q}{\partial \Delta} Q^* = \delta\rho Q^* \frac{1}{12\overline{\tau}} \begin{cases} 4\Delta & \text{if } \Delta < v - c, \\ \Delta - 3(v-c) & \text{if } \Delta \geq v - c. \end{cases}
\end{aligned}$$

Furthermore, $E\Pi_i(Q^*, \sigma^*)$ is convex in Δ since

$$\frac{d^2 E\Pi_i(Q^*, \sigma^*)}{(d\Delta)^2} = 2\overline{\tau}(\frac{\partial Q}{\partial \Delta})^2 + 2\overline{\tau}\frac{\partial^2 Q}{(\partial \Delta)^2} Q^* > 0.$$

Thus, two minimizers exist, at $\Delta = 0$ and at $\Delta = 3(v - c)$. Check that $Q^*(\Delta = 0) = Q^*(\Delta = 3(v - c))$ and therefore their minimum values are the same and it suffices to verify that

$$E\Pi_i(Q^*, \sigma^*, \Delta = 0) - (1 + \delta(1-\rho))\pi_i^m = \frac{\delta(v-c)^2}{256\overline{\tau}^3}[8\overline{\tau} - (3+\rho)(v-c)][8(2+\delta)\overline{\tau} - (3+\rho)(v-c)] > 0$$

for all $\overline{\tau} \geq v - c$, thus satisfying (A1).

Price discrimination. For price discrimination with semi-anonymous consumers to work, it has to hold that $p_e''(\sigma^*) \leq p_E'''$. For $\Delta \leq v - c$ this is true since $c + \Delta/3 \leq c + \Delta$. It holds for $\Delta > v - c$ since $c + \Delta/3 \leq (v + \Delta + c)/2$ or $-c + \Delta/3 \geq -v$. ■

Proof of Proposition 1

The entrant prefers to announce entry if and only if

$$\begin{aligned}
&\Pi_e(Q^*(\widetilde{\rho} = 1), \sigma^*) - \Pi_e(Q^*(\widetilde{\rho} = 0), \sigma^*) \geq 0 \\
\Leftrightarrow \quad & \delta\,[Q^*(\widetilde{\rho} = 1)\, \pi_e^c(\sigma^*) + (1 - Q^*(\widetilde{\rho} = 1))\pi_e^{\o}] \geq \delta\,[Q^*(\widetilde{\rho} = 0)\, \pi_e^c(\sigma^*) + (1 - Q^*(\widetilde{\rho} = 0))\, \pi_e^{\o}] \\
\Leftrightarrow \quad & [Q^*(\widetilde{\rho} = 1) - Q^*(\widetilde{\rho} = 0)]\, [\pi_e^{\o} - \pi_e^c(\sigma^*)] \leq 0.
\end{aligned}$$

It is straightforward to check that the second term is positive since

$$\begin{aligned}
\pi_e^{\emptyset} - \pi_e^c(\sigma^*) &= -\frac{\Delta^2}{9\overline{\tau}} + \frac{1}{4\overline{\tau}} \begin{cases} 4\Delta(v-c) & \text{if } \Delta < v-c, \\ (\Delta + v - c)^2 & \text{if } \Delta \geq v - c \end{cases} \\
&= \frac{1}{36\overline{\tau}} \begin{cases} 4\Delta[9(v-c) - \Delta] & \text{if } \Delta < v-c, \\ [5\Delta + 3(v-c)]\,[\Delta + 3(v-c)] & \text{if } \Delta \geq v - c \end{cases} > 0.
\end{aligned}$$

Next calculate for two arbitrary beliefs ρ_1, ρ_2, with $0 \leq \rho_1 \leq \rho_2 \leq 1$,

$$Q(\sigma^*, \rho_2) - Q(\sigma^*, \rho_1) = \delta(\rho_2 - \rho_1)\,[\nu(\sigma^*) - U_1 + U_0 + \pi_i(\sigma^*) + \pi_i^m] = (\rho_2 - \rho_1)\,\frac{\partial Q(\sigma^*, \rho)}{\partial \rho}$$

and the condition for announcement equilibria (5) in the text follows. Further simplifying yields that announcement is a perfect Bayesian equilibrium if and only if

$$\begin{aligned}
& \nu(\sigma^*) - U_1 + U_0 + \pi_i(\sigma^*) + \pi_i^m \leq 0 \\
\Leftrightarrow \quad & \frac{\delta}{48\overline{\tau}^2} \begin{cases} [4\Delta^2 - 3(v-c)^2] & \text{if } \Delta < v-c, \\ [\Delta^2 - 6(v-c)\Delta + 6(v-c)^2] & \text{if } \Delta \geq v - c. \end{cases} \geq 0.
\end{aligned}$$

For $\Delta < v - c$ this is equivalent to $\Delta \leq \Delta_1 \equiv \sqrt{3}(v-c)/2$. For $\Delta \geq v - c$, the roots are $\Delta_2 = (3 - \sqrt{3})(v - c)$ and $\Delta_3 = (3 + \sqrt{3})(v - c)$ and the condition holds if $\Delta_2 \leq \Delta \leq \Delta_3$. The conditions for a pooling equilibrium follow straightforward. The entrant prefers not to announce if and only if

$$\begin{aligned}
& \Pi_e(Q^*(\widetilde{\rho} = \rho), \sigma^*) \; - \; \Pi_e(Q^*(\widetilde{\rho} = 1), \sigma^*) \; > \; 0 \\
\Leftrightarrow \quad & [Q^*(\widetilde{\rho} = \rho) - Q^*(\widetilde{\rho} = 1)]\,[\pi_e^{\emptyset} - \pi_e^c(\sigma^*)] \; < \; 0 \\
\Leftrightarrow \quad & \nu(\sigma^*) - U_1 + U_0 + \pi_i(\sigma^*) + \pi_i^m \; > \; 0
\end{aligned}$$

which yields $\Delta_1 < \Delta < \Delta_2$ and $\Delta > \Delta_3$. ■

Proof of Proposition 2

First part of point (i). To save notation and show this point for the case with communication and without communication rewrite the expected welfare as

$$EW(\sigma) = \rho\,\Omega^e(\sigma, \rho_1) + (1 - \rho)\,\Omega^{\emptyset}(\sigma, \rho_0)$$

This expression coincides with the full information case if $(\rho_1, \rho_0) = (1, 0)$ and with the no information case if $(\rho_1, \rho_0) = (\rho, \rho)$. Then derive the first-order condition

$$\frac{dEW}{d\sigma} = \rho \frac{\partial \Omega^e(\rho_1)}{\partial Q} \frac{\partial Q(\rho_1)}{\partial \sigma} + \rho \frac{\partial \Omega^e(\rho_1)}{\partial \sigma} + (1 - \rho) \frac{\partial \Omega^{\emptyset}(\rho_0)}{\partial Q} \frac{\partial Q(\rho_0)}{\partial \sigma} = 0.$$

Using $\partial Q(\sigma,\rho)/\partial\sigma = \rho\,\partial Q(\sigma,1)/\partial\sigma$ and $Q(\sigma,\rho_1) - Q(\sigma,\rho_0) = \rho_1 Q(\sigma,1) + \rho_0 Q(0)$, the sum of the first and third term of this equation can be simplified to

$$\frac{\partial Q(\sigma,1)}{\partial\sigma}T(\sigma) \equiv \frac{\partial Q(\sigma,1)}{\partial\sigma}\left[\rho\rho_1\delta\widetilde{\omega}_1(\sigma) - \overline{\tau}(\rho\rho_1^2 + (1-\rho)\rho_0^2)Q(\sigma,1) + C\right]$$

$$\text{with } C \equiv [\rho_1\rho + \rho_0(1-\rho)](v-c) - \rho\rho_1\delta\widetilde{\omega}_0 + \rho_0(1-\rho)\delta(\omega_1 - \omega_0)$$
$$- [\rho\rho_1(1-\rho_1) + (1-\rho)\rho_0(1-\rho_0)]\overline{\tau}Q(0).$$

Thus, the first-order condition can be rewritten as

$$\frac{dEW}{d\sigma} = \frac{\partial Q(\sigma,1)}{\partial\sigma}T(\sigma) + \rho\delta Q(\rho_1)\frac{\partial\widetilde{\omega}_1(\sigma)}{\partial\sigma} = 0. \tag{7}$$

Before analyzing this equation it is useful to derive three properties (P1-P3) of the function $T(\sigma)$:

P1. $T(\sigma)$ is convex in σ since

$$\frac{\partial^2 T(\sigma)}{(\partial\sigma)^2} = \rho\rho_1\delta\frac{\partial^2\widetilde{\omega}_1}{(\partial\sigma)^2} - \overline{\tau}(\rho\rho_1^2 + (1-\rho)\rho_0^2)\frac{\partial^2 Q(\sigma,1)}{(\partial\sigma)^2}$$
$$= \rho\rho_1\delta(-\frac{1}{4\overline{\tau}}) - (\rho\rho_1^2 + (1-\rho)\rho_0^2)\delta\frac{3}{\overline{\tau}} \quad \geq 0$$

for both $(\rho_1,\rho_0) = (1,0)$ and $(\rho_1,\rho_0) = (\rho,\rho)$.

P2. $T(\sigma)$ has a unique minimizer at σ=$-$c+3Δ since

$$\frac{\partial T(\sigma)}{\partial\sigma} = \rho\rho_1\delta\frac{\partial\widetilde{\omega}_1}{\partial\sigma} - \overline{\tau}[\rho\rho_1^2 + (1-\rho)\rho_0^2]\frac{\partial Q(\sigma,1)}{\partial\sigma}$$
$$= \rho\rho_1\delta(-\frac{c+\sigma+\Delta}{4\overline{\tau}}) - \overline{\tau}[\rho\rho_1^2 + (1-\rho)\rho_0^2](\delta\frac{\Delta - 3(c+\sigma)}{8\overline{\tau}^2}) = 0$$

if and only if σ=$-c+3\Delta$ (for both (ρ_1,ρ_0)=$(1,0)$ and (ρ_1,ρ_0)=(ρ,ρ)).

P3. The value of $T(\sigma)$ at σ=$-c-\Delta$ is positive. Check that

$$\frac{\partial T(\sigma=-c-\Delta)}{\partial\Delta} = \rho\rho_1\delta\frac{\partial(\widetilde{\omega}_1 - \widetilde{\omega}_0)}{\partial\Delta} - \overline{\tau}(\rho\rho_1^2 + (1-\rho)\rho_0^2)\frac{\partial Q(\sigma=-c-\Delta,1)}{\partial\Delta}$$

which reduces to

$$\frac{\partial T(\sigma=-c-\Delta)}{\partial\Delta}|_{\Delta<v-c} = \rho\rho_1\delta\frac{\Delta - v + c}{\overline{\tau}} - \overline{\tau}(\rho\rho_1^2 + (1-\rho)\rho_0^2)\frac{-\delta\Delta}{2\overline{\tau}^2}$$

and

$$\frac{\partial T(\sigma=-c-\Delta)}{\partial\Delta}|_{\Delta\geq v-c} = \rho\rho_1\delta\frac{\Delta - 3v + 3c}{4\overline{\tau}} - \overline{\tau}(\rho\rho_1^2 + (1-\rho)\rho_0^2)\frac{-\delta(5\Delta + v - c)}{8\overline{\tau}^2}$$

From this it is easy to check that $T(\sigma = -c-\Delta)$ is convex in Δ. Moreover, verify that the local minimizer for $\Delta < v-c$ is at $\Delta = 2(v-c)/3$ for both sets of (ρ_1,ρ_0). The minimum value is

$$T(\sigma = -c-\Delta, \Delta = 2(v-c)/3) = \frac{v-c}{48\overline{\tau}}[24(1+\delta)\overline{\tau} - \delta(9+19\rho_1)(v-c)] > 0$$

if $\overline{\tau} > (v-c)(9+19\rho_1)\delta/[24(1+\delta)]$ which holds for any admissible values (δ, ρ_1) under assumption (A1). For $\Delta \geq v-c$ the first derivative is zero at $\Delta = 5(v-c)/7$, thus the local minimum is at $\Delta = v-c$ which is always higher than the local minimum for $\Delta < v-c$ and therefore positive.

P1-P3. From these three properties we can conclude that (i) $\forall \sigma, \sigma < -c-\Delta$, we have that $T(\sigma) > 0$. And (ii) $\forall \sigma, -c-\Delta \leq \sigma \leq \overline{\sigma}$, there are two alternatives. Either $T(\sigma) > 0$ or there exists a σ' such that for $\sigma \leq (>)\, \sigma'$ it holds that $T(\sigma) \geq (<)\, 0$.

Now return to the first-order condition (7) to check for the global maximizer of $EW(\sigma)$. By Lemma 1 $Q(\sigma, \rho)$ is concave in σ with a maximizer at $\sigma^* = -c + \Delta/3$. It is straightforward to check that $\widetilde{\omega}_1(\sigma)$ is also concave with a maximizer at $\sigma = -c-\Delta$. This leaves us with three distinct ranges of σ to be analyzed for local maximizers.

(i) $\boldsymbol{\sigma \leq -c-\Delta}$. From the above follows that both terms in (7) are positive which implies that the local maximizer is at $\sigma = -c-\Delta$. If we include this upper bound into our next range we can dismiss the existence of a global maximizer in this region.

(ii) $\boldsymbol{\sigma \in [-c-\Delta; \sigma^*]}$. Denote the first term in (7) as 'LHS' and the negative of the second as 'RHS'. RHS takes value zero at $\sigma = -c-\Delta$ and is increasing since

$$\frac{dRHS}{d\sigma} = -\rho\delta \underbrace{\frac{\partial Q(\sigma,\rho_1)}{\partial \sigma}}_{+} \underbrace{\frac{\partial \widetilde{\omega}_1(\sigma)}{\partial \sigma}}_{-} - \rho\delta Q(\sigma,\rho_1) \underbrace{\frac{\partial^2 \widetilde{\omega}_1(\sigma)}{(\partial \sigma)^2}}_{-} > 0$$

for $\sigma \in$ [-c-Δ, σ^*]. LHS is zero for $\sigma = \sigma^*$ and $\sigma = \sigma'$ (if it exists in this range). It is decreasing in σ if and only if

$$\frac{dLHS}{d\sigma} = \underbrace{\frac{\partial Q(\sigma,1)}{\partial \sigma}}_{+} \underbrace{\frac{\partial T(\sigma)}{\partial \sigma}}_{-} + \underbrace{\frac{\partial^2 Q(\sigma,1)}{(\partial \sigma)^2}}_{-} \underbrace{T(\sigma)}_{+} < 0$$

which holds true for $\sigma \in [-c-\Delta, min\{\sigma', \sigma^*\}]$. Since RHS and LHS are continuous over the considered range, it follows that there exists a unique solution to (7) in]-c-Δ, σ^*[. To verify that this solution is indeed a maximizer check that

$$\frac{d^2 EW(\sigma)}{(d\sigma)^2} = \frac{\partial Q(\sigma,1)}{\partial \sigma}\frac{\partial T(\sigma)}{\partial \sigma} + \frac{\partial^2 Q(\sigma,1)}{(\partial \sigma)^2} T(\sigma) + \rho\delta \frac{\partial Q(\rho_1)}{\partial \sigma}\frac{\partial \widetilde{\omega}_1(\sigma)}{\partial \sigma} + \rho\delta Q(\rho_1)\frac{\partial^2 \widetilde{\omega}_1(\sigma)}{(\partial \sigma)^2} < 0.$$

(iii) $\boldsymbol{\sigma \in [\sigma^*; \overline{\sigma}]}$. I demonstrate that there is a unique local maximizer either at the lower or the upper bound. I proceed by showing that (a) the slope at $\overline{\sigma}$ is positive if Δ is sufficiently high and (b) the higher σ, the more convex is $EW(\sigma)$.

First calculate the first derivative at the level of prohibitive switching costs for $\Delta < v-c$

$$\frac{dEW(\sigma)}{d\sigma}|_{\sigma=\overline{\sigma}} = \frac{\rho\delta\Delta(v-c)}{64\overline{\tau}^3}[16\delta\rho_1\Delta - 24\overline{\tau}(1+\delta) + 3\delta(3+\rho_1)(v-c)]$$

which is negative if

$$\Delta \leq \frac{24\overline{\tau}(1+\delta) - 3\delta(3+\rho_1)(v-c)}{16\delta\rho_1}.$$

Note that the RHS of this inequality is larger than $v - c$ if and only if $\overline{\tau} \geq \delta(9 + 19\rho_1)(v - c)/24(1+\delta)$ which always hold under assumption (A1). Therefore, the slope is always negative for $\Delta < v - c$. Consider the case $\Delta \geq v - c$ and calculate

$$\frac{dEW(\sigma)}{d\sigma}|_{\sigma=-c+\Delta} = \frac{\rho\delta\Delta}{64\overline{\tau}^3}[7\delta\rho_1(\Delta + v - c)^2 + 3(v - c)(3\delta(1 - \rho)(v - c) - 8(1 + \delta\overline{\tau}))].$$

It follows from inspection that this expression increases and is convex in Δ. We know that it is negative at $\Delta = v - c$. Thus, a positive root must exist, i.e. for sufficiently high Δ, the slope at $\sigma = -c + \Delta$ is positive.
The second step is to ensure that there is no other interior, local maximizer in the considered interval. For this purpose, consider the third derivative

$$\begin{aligned}\frac{\partial^3 EW(\sigma)}{(\partial\sigma)^3} &= \frac{\partial Q(\sigma,1)}{\partial\sigma}\frac{\partial^2 T}{(\partial\sigma)^2} + 2\frac{\partial^2 Q(\sigma,1)}{(\partial\sigma)^2}\frac{\partial T}{\partial\sigma} + 2\rho\delta\frac{\partial Q(\sigma,\rho_1)}{\partial\sigma}\frac{\partial^2\widetilde{\omega}_1}{(\partial\sigma)^2} + \rho\delta\frac{\partial^2 Q(\sigma,\rho_1)}{(\partial\sigma)^2}\frac{\partial\widetilde{\omega}_1}{\partial\sigma} \\ &= \frac{\partial Q(\sigma,1)}{\partial\sigma}\frac{\partial^2 T}{(\partial\sigma)^2} + 2\frac{\partial^2 Q(\sigma,1)}{(\partial\sigma)^2}\frac{\partial T}{\partial\sigma} + 2\rho\delta\rho_1\frac{\partial Q(\sigma,1)}{\partial\sigma}\frac{\partial^2\widetilde{\omega}_1}{(\partial\sigma)^2} + \rho\delta\rho_1\frac{\partial^2 Q(\sigma,1)}{(\partial\sigma)^2}\frac{\partial\widetilde{\omega}_1}{\partial\sigma} \\ &= \frac{3\rho_1\rho\delta^2}{64\overline{\tau}^3}[3\sigma + 3c + 7\Delta] > 0\end{aligned}$$

for all $\sigma > \sigma^*$. We can therefore conclude that for sufficiently high Δ the local maximizer in $[\sigma^*, \overline{\sigma}]$ is its upper bound; otherwise it is the lower bound.

(iv). The last step consists in showing that the local maximizer in $[-c - \Delta,\, \sigma^*]$ is always the global maximizer. Without an explicit solution to (7) it is impossible to compare the two maxima directly. However one can argue to this effect using the non-negativity constraints of the first-period quantity. The optimal quantity in period 1 is concave in σ with a maximum at $\sigma = -c + \Delta/3$. Its parabola takes value zero at

$$\begin{aligned}&\sigma_{1,2}^{Q=0} = -c + \Delta/3 \pm \sqrt{z} \\ &\text{with } z \equiv [3(v - c)[8(1 + \delta)\overline{\tau} - \delta(3 - 2\rho)(v - c)] - 6\rho\delta(v - c)\Delta + \rho\delta\Delta^2]/(\rho\delta)\end{aligned}$$

where $\sigma_1^{Q=0}$ denotes the smaller root. At both roots the ex ante welfare is the same. From our above analysis of the intervals $\sigma \leq -c - \Delta$ and $[-c - \Delta, \sigma^*]$ we know that the smaller root is always weakly dominated for $\sigma \leq \sigma^*$. Suppose the slope at $\overline{\sigma}$ is positive and $\overline{\sigma}$ is the local maximizer in $[\sigma^*,\, \overline{\sigma}]$. If the larger root is higher than $\overline{\sigma}$, then it follows by the increasing convexity of $EW(\sigma)$ that the maximum is smaller than the value at the root which is itself weakly dominated by the interior solution from $[-c-\Delta,\, \sigma^*]$. If the larger root is smaller than $\overline{\sigma}$, then the value at $\overline{\sigma}$ is equal to the value at the two roots. Therefore, the interior solution in $[-c-\Delta,\, \sigma^*]$ always weakly dominates the corner solution in $[\sigma^*,\, \overline{\sigma}]$ and the first part of (i) follows.

Second part of point (i). This can be derived by directly calculating

$$\begin{aligned}&EW(\sigma = -c + \Delta) - EW(\sigma = -c + \Delta/3) = \\ &\qquad \frac{\rho\delta\Delta^2}{1728\overline{\tau}^3}\,[41\delta\rho_1\Delta^2 + 3\delta(39 - 14\rho_1)(v - c)^2 - 312(1 + \delta)(v - c)\overline{\tau} + 150\delta\rho_1(v - c)].\end{aligned}$$

The bracketed term is convex and increasing in Δ. Thus, to show the second part of point (i), it suffices to demonstrate that the bracketed term is positive for the highest admissible value of Δ with respect to the non-negativity constraint for the first period quantity. It is straightforward to check that the upper root $\sigma_2^{Q=0}$ is convex and increasing in Δ with a slope between 0 and 2/3. This implies that $\sigma_2^{Q=0} \geq -c+\Delta$ if

$$\Delta \leq \sqrt{z_2}-(v-c) \quad \text{with } z_2 \equiv (v-c)[8(1+\delta)\overline{\tau}-3\delta(1-\rho)(v-c)]/(\rho\delta).$$

Calculating the difference at this threshold value yields

$$EW(\sigma=-c+\Delta)-EW(\sigma=-c+\Delta/3)\,|_{\Delta=\sqrt{z_2}-(v-c)} = \\ 2(v-c)[8(1+\delta)\overline{\tau}-\delta(3+14\rho)(v-c)+34\sqrt{z_2}].$$

Check that the sum of the first two terms in the bracket is positive for $\overline{\tau}$ sufficiently high. And then the whole expression is positive which proves the second part of (i).

Point (ii). Full communication is welfare superior to no information if and only if

$$\rho[\Omega^e(\sigma^*,1)-\Omega^e(\sigma^*,\rho)] \geq (1-\rho)[\Omega^{\o}(\sigma^*,\rho)-\Omega^{\o}(\sigma^*,0)].$$

The LHS of this inequality can be rewritten as

$$\begin{aligned}
&\rho\,[\,(v-c)Q(\sigma^*,1)-\frac{\overline{\tau}}{2}Q(\sigma^*,1)^2+\delta Q(\sigma^*,1)\widetilde{\omega}_1+\delta(1-Q(\sigma^*,1))\widetilde{\omega}_0-(v-c)Q(\sigma^*,\rho)\\
&+\frac{\overline{\tau}}{2}Q(\sigma^*,\rho)^2]-\delta Q(\sigma^*,\rho)\widetilde{\omega}_1-\delta(1-Q(\sigma^*,\rho))\widetilde{\omega}_0\,]\\
&=\rho[Q(\sigma^*,1)-Q(\sigma^*,\rho)][v-c+\delta\widetilde{\omega}_1-\delta\widetilde{\omega}_0]-\rho\frac{\overline{\tau}}{2}[Q^2(\sigma^*,1)-Q^2(\sigma^*,\rho)]\\
&=\rho[Q(\sigma^*,1)-Q(\sigma^*,\rho)][v-c+\delta\widetilde{\omega}_1-\delta\widetilde{\omega}_0-\frac{\overline{\tau}}{2}(Q(\sigma^*,1)+Q(\sigma^*,\rho))].
\end{aligned}$$

Remember from the proof of Proposition 1 that the equilibrium quantity for two arbitrary beliefs ρ_1, ρ_2 with $0 \leq \rho_1 \leq \rho_2 \leq 1$ can be decomposed into

$$Q(\sigma^*,\rho_2)-Q(\sigma^*,\rho_1)=(\rho_2-\rho_1)\,\delta\,[\nu(\sigma^*)-U_1+U_0+\pi_i(\sigma^*)+\pi_i^m]=(\rho_2-\rho_1)\,\frac{\partial Q(\sigma^*,\rho)}{\partial\rho}$$

Therefore, the LHS can be simplified to

$$\rho(1-\rho)\,\frac{\partial Q(\sigma^*,\rho)}{\partial\rho}\,[v-c+\delta\widetilde{\omega}_1-\delta\widetilde{\omega}_0-\frac{\overline{\tau}}{2}(Q(\sigma^*,1)+Q(\sigma^*,\rho))]$$

Similarly, the RHS can be reduced to

$$\begin{aligned}
&(1-\rho)\,[Q(\sigma^*,\rho)-Q(\sigma^*,0)]\,[v-c+\delta\omega_1-\delta\omega_0-\frac{\overline{\tau}}{2}(Q(\sigma^*,\rho)+Q(\sigma^*,0))]\\
&=(1-\rho)\rho\,\frac{\partial Q(\sigma^*,\rho)}{\partial\rho}\,[v-c+\delta\omega_1-\delta\omega_0-\frac{\overline{\tau}}{2}(Q(\sigma^*,\rho)+Q(\sigma^*,0))].
\end{aligned}$$

Substracting the RHS from the LHS yields the condition in the text. Finally, check that

$$\begin{aligned}
&\delta(\widetilde{\omega}_1(\sigma^*) - \widetilde{\omega}_0 - \omega_1 + \omega_2) - \frac{\overline{\tau}}{2}\frac{\partial Q(\sigma^*,\rho)}{\partial\rho} \\
&= -\frac{\overline{\tau}}{2}\frac{\partial Q(\sigma^*,\rho)}{\partial\rho} + \frac{\delta}{72\overline{\tau}}\begin{cases}[20\Delta^2 - 72(v-c)\Delta - 9(v-c)^2] & \text{if } \Delta < v-c, \\ [-7\Delta - 54(v-c)]\Delta & \text{if } \Delta \geq v-c,\end{cases} \\
&= \frac{\delta}{288\overline{\tau}}\begin{cases}[68\Delta^2 - 288(v-c)\Delta - 27(v-c)^2] & \text{if } \Delta < v-c, \\ [-31\Delta^2 - 198(v-c)\Delta - 18(v-c)^2] & \text{if } \Delta \geq v-c\end{cases}
\end{aligned}$$

which is upon simple inspection negative for all parameter values. ■

Proof of Proposition 3

Point (i). Consumer surplus in the entry case for any given belief ρ is

$$\Gamma^e(\sigma,\rho) = [v(1+\delta) - P(\sigma, Q(\sigma,\rho))]Q(\sigma,\rho) - \frac{\overline{\tau}}{2}Q^2(\sigma,\rho) + \delta\nu(\sigma)Q(\sigma,\rho) + \delta(1-Q(\sigma,\rho))U_1.$$

Taking the first derivative yields

$$\begin{aligned}
\frac{\partial\Gamma^e(\sigma,\rho)}{\partial\sigma} &= [v(1+\delta) - P]\frac{\partial Q}{\partial\sigma} - Q\frac{\partial P}{\partial\sigma} - \overline{\tau}Q\frac{\partial Q}{\partial\sigma} + \delta\frac{\partial\nu}{\partial\sigma}Q + \delta\nu\frac{\partial Q}{\partial\sigma} - \delta U_1\frac{\partial Q}{\partial\sigma} \\
&= [v(1+\delta) - P - \overline{\tau}Q + \delta(\nu(\sigma) - U_1)]\frac{\partial Q}{\partial\sigma} - Q[-\overline{\tau}\frac{\partial Q}{\partial\sigma} + \delta\rho\frac{\partial\nu}{\partial\sigma}] + \delta\frac{\partial\nu}{\partial\sigma}Q \\
&= [\overline{\tau}Q + \delta(1-\rho)(\nu(\sigma) - U_1 + U_0)]\frac{\partial Q}{\partial\sigma} + \delta(1-\rho)Q\frac{\partial\nu}{\partial\sigma}.
\end{aligned}$$

Consumer surplus without entry is

$$\Gamma^{\varnothing}(\sigma,\rho) = [v(1+\delta) - P(\sigma, Q(\sigma,\rho))]Q(\sigma,\rho) - \frac{\overline{\tau}}{2}Q^2(\sigma,\rho) + \delta(1-Q(\sigma,\rho))U_0.$$

The first derivative is given by

$$\begin{aligned}
\frac{\partial\Gamma^{\varnothing}(\sigma,\rho)}{\partial\sigma} &= [v(1+\delta) - P - \overline{\tau}Q - \delta U_0]\frac{\partial Q}{\partial\sigma} - Q\frac{\partial P}{\partial\sigma} \\
&= [-\delta\rho(\nu(\sigma) - U_1) - \delta(1-\rho)U_0]\frac{\partial Q}{\partial\sigma} - Q[-\overline{\tau}\frac{\partial Q}{\partial\sigma} + \delta\rho\frac{\partial\nu}{\partial\sigma}] \\
&= [\overline{\tau}Q - \delta\rho(\nu(\sigma) - U_1 + U_0)]\frac{\partial Q}{\partial\sigma} - Q\delta\rho\frac{\partial\nu}{\partial\sigma}.
\end{aligned}$$

Write ex ante consumers surplus as $ECS(\sigma) = \rho\,\Gamma^e(\sigma,\rho_1) + (1-\rho)\,\Gamma^{\varnothing}(\sigma,\rho_0)$ which coincides with the full information case if $(\rho_1,\rho_0) = (1,0)$ and with no information if $(\rho_1,\rho_0) = (\rho,\rho)$. Then consider the first order condition for a maximum

$$\frac{\partial ECS(\sigma)}{\partial\sigma} = \rho\frac{\partial\Gamma^e(\sigma,\rho_1)}{\partial\sigma} + (1-\rho)\frac{\partial\Gamma^{\varnothing}(\sigma,\rho_0)}{\partial\sigma} = \overline{\tau}\,Q(\rho_1)\,\frac{\partial Q(\rho_1)}{\partial\sigma} = 0.$$

This condition is satisfied if either $\partial Q(\rho_1)/\partial\sigma = 0$, i.e. $\sigma = \sigma^*$ or if $Q(\sigma, \rho_1) = 0$, i.e. $\sigma = \sigma_{1,2}^{Q=0}$ (as defined in the proof of proposition 2). The second-order condition

$$\frac{\partial^2 ECS(\sigma)}{(\partial\sigma)^2} = \overline{\tau}(\frac{\partial Q(\rho_1)}{\partial\sigma})^2 + \overline{\tau}Q(\sigma,\rho_1)\frac{\partial^2 Q(\rho_1)}{(\partial\sigma)^2}$$

reveals that the solutions $\sigma_{1,2}^{Q=0}$ are minima since the second derivative is identical with the first term in the above expression and therefore always positive. The solution σ^*, by contrast, is the unique maximizer since the second derivative at σ coincides with the second term which is always negative.

Point (ii). Full communication is preferred by consumers if and only if

$$\rho\,[\Gamma^e(\sigma^*,1) - \Gamma^e(\sigma^*,\rho)] \geq (1-\rho)\,[\Gamma^{\emptyset}(\sigma^*,\rho) - \Gamma^{\emptyset}(\sigma^*,0)].$$

Drop σ^* to simplify notation and rewrite consumer surplus in the case of entry for a given belief ρ as

$$\begin{aligned}
\Gamma^e(\sigma^*,\rho) &= [v(1+\delta) - P(Q(\rho))]Q(\rho) - \frac{\overline{\tau}}{2}Q^2(\rho) + \delta\nu Q(\rho) + \delta(1-Q(\rho))U_1 \\
&= [\overline{\tau}Q(\rho) - \delta\rho(\nu - U_1) + \delta(1-\rho)U_0]Q(\rho) - \frac{\overline{\tau}}{2}Q^2(\rho) + \delta\nu Q(\rho) + \delta(1-Q(\rho))U_1 \\
&= \delta(1-\rho)[\nu - U_1 + U_0]Q(\rho) + \frac{\overline{\tau}}{2}Q^2(\rho) + \delta U_1.
\end{aligned}$$

Then calculate the LHS of the above inequality as

$$\rho\,[\Gamma^e(\sigma^*,1) - \Gamma^e(\sigma^*,\rho)] = -\delta\rho(1-\rho)[\nu - U_1 + U_0]Q(\rho) + \rho\frac{\overline{\tau}}{2}[Q^2(1) - Q^2(\rho)].$$

Similarly, simplify

$$\begin{aligned}
\Gamma^{\emptyset}(\sigma^*,\rho) &= [v(1+\delta) - P(Q(\rho))]Q(\rho) - \frac{\overline{\tau}}{2}Q^2(\rho) + \delta(1-Q(\rho))U_0 \\
&= [\overline{\tau}Q(\rho) - \delta\rho(\nu - U_1) + \delta(1-\rho)U_0]Q(\rho) - \frac{\overline{\tau}}{2}Q^2(\rho) + \delta(1-Q(\rho))U_0 \\
&= -\delta\rho[\nu - U_1 + U_0]Q(\rho) + \frac{\overline{\tau}}{2}Q^2(\rho) + \delta U_0
\end{aligned}$$

which reduces the RHS to

$$(1-\rho)\,[\Gamma^{\emptyset}(\sigma^*,\rho) - \Gamma^{\emptyset}(\sigma^*,0)] = -\delta\rho(1-\rho)[\nu - U_1 + U_0]Q(\rho) + (1-\rho)\frac{\overline{\tau}}{2}[Q^2(\rho) - Q^2(0)].$$

Then simplifying the inequality using $Q(\sigma^*,\rho_2) - Q(\sigma^*,\rho_1) = (\rho_2 - \rho_1)\,\partial Q(\sigma^*,\rho)/\partial\rho$ we get

$$\begin{aligned}
&\rho\,\frac{\overline{\tau}}{2}\,[Q^2(1) - Q^2(\rho)] \geq (1-\rho)\frac{\overline{\tau}}{2}[Q^2(\rho) - Q^2(0)] \\
&\rho\,[Q^2(1) - Q^2(\rho)] - (1-\rho)\,[Q^2(\rho) - Q^2(0)] \geq 0 \\
&\rho\,(Q(1) - Q(\rho))\,(Q(1) + Q(\rho)) + (1-\rho)\,(Q(\rho) - Q(0))\,(Q(\rho) + Q(0)) \geq 0 \\
&\rho(1-\rho)\,\frac{\partial Q(\sigma^*,\rho)}{\partial\rho}\,[Q(1) - Q(0)] \;=\; \rho(1-\rho)\,(\frac{\partial Q(\sigma^*,\rho)}{\partial\rho})^2 \geq 0
\end{aligned}$$

which always holds. ■

References

AGHION, P. & BOLTON, P. (1987). Contracts as a barrier to entry. *American Economic Review* **77**, 388–401.

BERNHEIM, B. D. & WHINSTON, M. D. (1998). Exclusive dealing. *Journal of Political Economy* **106**, 64–103.

CAMINAL, R. & MATUTES, C. (1990). Endogenous switching costs in a duopoly model. *International Journal of Industrial Organization* **8**, 353–373.

CHEN, Y. (1997). Paying customers to switch. *Journal of Economics and Management Strategy* **6**, 877–897.

FUDENBERG, D. & TIROLE, J. (1998). Upgrades, tradeins, and buybacks. *RAND Journal of Economics* **29**, 235–258.

FUDENBERG, D. & TIROLE, J. (2000). Customer poaching and brand switching. *RAND Journal of Economics* **31**, 634–657.

FUMAGALLI, C. & MOTTA, M. (2006). Exclusive dealing and entry when buyers compete. *American Economic Review forthcoming* .

GERLACH, H. (2004). Announcement, entry and preemption when consumers have switching costs. *RAND Journal of Economics* **35**, 184–202.

RASMUSEN, E. B., RAMSEYER, J. M. & WILEY, J. S. J. (1991). Naked exclusion. *American Economic Review* **81**, 1137–1145.

SEGAL, I. & WHINSTON, M. D. (2000). Naked exclusion: Comment. *American Economic Review* **90**, 296–309.

SPIER, K. & WHINSTON, M. D. (1995). On the efficiency of privately stipulated damages for breach of contract: entry barriers, reliance, and renegotiation. *RAND Journal of Economics* **26**, 180–202.