Which is Better for Durable Goods Producers, Exclusive or Open Supply Chain?[*]

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Abstract

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Running head: Exclusive or Open Supply Chain

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1 Introduction

We commonly observe an exclusive supply chain in many markets for durable goods, including industrial machinery/equipment and electronic and electric equipment (Heide, Dutta, and Bergen, 1998),[1] although the recent progress of information communication technology (ICT) helps firms find new trading partners worldwide, which affects the organizational formation of firms in various ways (Granot and Sošić, 2005; World Bank, 2009, Chapter 6; Bloom et al., 2014). The exclusive supply chain in the smartphone processor market is a typical example.[2] Apple, for instance, has selected an exclusive supply chain with Taiwan Semiconductor Manufacturing Company (TSMC) for Apple's processors.[3] The argument of supply chain openness is also related to the discussion on exclusive contracts in the context of competition policy (see the earlier discussions of Posner, 1976 and Bork, 1978). In reality, we have observed anticompetitive exclusive contracts in the market for durable goods such as aluminum (*the United States of America v. Aluminum Co. of America* in the US, 1945), furniture (*Paramount Bed Case* in Japan, 1998), artificial teeth (*the United States of America v. Dentsply International, Inc.*, in the US, 2005), and CPUs (*Intel Case* in the

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[1] See also Mollgaard and Lorentzen (2004), who explore exclusive dealings in the Eastern European car component industry. Moreover, in the aviation industry, Boeing Company and Airbus sometimes award exclusivity to one or two jet engine makers over other makers. See "GE Unit Lands Exclusive Boeing Pact For Developing Commercial Jet Engine" *The Wall Street Journal,* July 8, 1999 (`https://www.wsj.com/articles/SB931391538252682453`), and "Airbus selects Rolls-Royce Trent 7000 as exclusive engine for the A330neo" *Rolls-Royce,* July 14, 2014 (`https://www.rolls-royce.com/media/press-releases/yr-2014/140714-a330neo.aspx`).

[2] For the case of Qualcomm's exclusive supply chain with Samsung, see "Samsung beats TSMC to win new Qualcomm order to make mobile chips" *The Korea Economic Daily,* October 6, 2020 (`https://www.kedglobal.com/newsView/ked202010100034`).

[3] See "Taiwan's TSMC to continue as Apple's exclusive A-series chip supplier: reports" *Taiwan News,* October 13, 2018 (`https://www.taiwannews.com.tw/en/news/3551431`). Moreover, in the gaming industry, AMD is the exclusive supplier of CPUs for video-game consoles such as Microsoft Xbox One, Nintendo Wii U, and Sony PlayStation 4. See "Build Your Dream. A Unique Approach to Engineering." *AMD,* (`https://www.amd.com/en/products/semi-custom-solutions`).

US, 2005).[4] Despite these observations, previous studies on exclusive vertical chains and exclusive contracts investigate only perishable goods markets. In this study, to contribute to supply chain management and competition policy, we consider the problem of an exclusive supply chain in durable goods markets.

We consider a two-period durable goods market, as in Bulow (1986), Denicolò and Garella (1999), and Desai, Koenigsberg, and Purohit (2004), by introducing the entrant supplier in the second period. We explore the situation in which a downstream durable goods monopolist chooses one of two trading modes in the first period: (i) a two-period exclusive supply chain with an existing incumbent supplier, or (ii) an open supply chain, which causes competition between the incumbent and a potential supplier.[5] We investigate whether the incumbent supplier and the downstream firm sign a two-period exclusive contract in the first period. To do so, we combine the model framework of durable goods markets (Bulow, 1986; Denicolò and Garella, 1999; Desai, Koenigsberg, and Purohit, 2004) with the scenario of entry deterrence through exclusive contracts in the Chicago School argument (Posner, 1976; Bork, 1978).

By introducing two-part tariffs as in Desai, Koenigsberg, and Purohit (2004), we show that exclusion is a unique equilibrium outcome in a general demand setting; in other words, the durability of products induces a downstream firm to choose an exclusive supply chain. As in the Chicago School framework, second-period entry generates upstream competition, which allows the downstream firm to procure inputs at a lower wholesale price in the second period. Thus, exclusion seems difficult. However, in durable goods markets, a retail price

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[4] For each case, see the United States of America v. Aluminum Co. of America, 148 F.2d 416 (1945, `https://law.justia.com/cases/federal/appellate-courts/F2/148/416/1503668/`); Blair and Sokol (2015); the United States of America v. Dentsply International, Inc., 399 F.3d (2005, `https://www.leagle.com/decision/2005580399f3d1811565`); Advanced Micro Devices, Inc., a Delaware corporation, and AMD International Sales & Services, Ltd., a Delaware corporation, v. Intel Corporation, a Delaware corporation, and Intel Kabushiki Kaisha, a Japanese corporation, Civil Action No. 05-441-JJF (2005, `https://www.amd.com/system/files/amd-intel-full-complaint.pdf`, respectively.

[5] There are many papers on the problem of channel coordination under the rapid development of information technology (see, for instance, the issue of showrooming in Kuksov and Liao (2018) and the papers in the section 'Related Literature' in their article).

reduction through upstream competition in the second period makes some final consumers refrain from purchasing in the first period, leading to a low retail price and low joint profits for the contracting party in the first period. That is, second-period upstream entry exacerbates the intertemporal pricing problem in the downstream market. Because exclusive contracts can mitigate such a pricing problem, the contracting party can enjoy higher joint profits in the first period. Therefore, the incumbent supplier can profitably make a two-period exclusive offer to the downstream firm in durable goods markets in the first period.

The findings in this study provide important predictions for information societies and the openness of supply chains. Recent developments in ICT seemingly facilitate the openness of supply chains because such progress allows downstream firms to find alternative trading partners more easily. However, our findings imply that such a view does not necessarily remain valid in durable goods markets; downstream durable goods producers may choose to develop an exclusive supply chain even when efficient suppliers appear in the future.[6]

Because the exclusive contract in this study is a tool to deter the entry of efficient entrants in the future, this study is suitable for a situation where a local firm faces the threat of entry of highly efficient multinational firms.[7] Several key retailers accepted exclusive distribution agreements with Vist, a Russian personal computer maker, although those retailers expected entry by multinational computer makers such as Compaq, IBM, and Hewlett-Packard (Dawar and Frost, 1999). In such a case, multinational firms usually spend some time entering the markets after the news of their entry (Bao and Chen, 2018). Such news in the media allows every economic agent to predict future entry and reconsider their trading networks, both of which are necessary for this study's exclusion mechanism. Therefore, the exclusion

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[6] Our focus is also related to the exclusiveness of *keiretsu* in the Japanese automobile industry (e.g., Aoki and Lennerfors, 2013) and channel coordination (e.g., Jeuland and Shugan, 1983; Coughlan, 1985; Gupta and Loulou, 1998; Gupta, 2008).

[7] Note that multinational firms usually have high productivity, and they are more efficient than domestic firms (Helpman, Melitz, and Yeaple, 2004; Kimura and Kiyota, 2006).

mechanism can apply to such situations. In Section 5, we introduce several examples of exclusive supply chains in detail and consider the linkage with the results in this study.

The exclusion mechanism in our study also provides an important implication for competition policy. The Chicago School argument, which introduces the impossibility of exclusive contracts for anticompetitive reasons, does not necessarily apply to durable goods markets. Our study's exclusion mechanism arises from the nature of a durable goods monopolist, initially argued by Coase (1972).[8] Moreover, the exclusion outcomes in our study are derived under a general demand setting. The Supplementary Appendix shows that exclusion outcomes are attainable under the general demand setting even when efficiency improvements reduce the incumbent supplier's marginal cost in the second period and even when the efficient supplier exists in the first period. The appendix also shows that exclusion outcomes are achievable under a linear demand system in various extended settings. Hence, we can apply the findings to diverse real-world exclusive supply chains in durable goods markets.

The remainder of this paper is organized as follows. Section 2 provides the literature review. Section 3 constructs the model. Section 4 analyzes the existence of exclusion outcomes under two-part tariffs. Section 5 extends the model and discusses the relevance of this study to real-world examples. Section 6 offers concluding remarks. Appendix A provides the proofs of the results.

2 Literature Review

This study is related to the literature on entry deterrence in durable goods markets.[9] By comparing selling with renting, Bucovetsky and Chilton (1986) show that a durable goods

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[8] For a model analysis of the Coase conjecture, see Stokey (1981), Bulow (1982), Gul, Sonnenschein, and Wilson (1986), and Hart and Tirole (1988).

[9] Several studies analyze firms' strategies to deter future entry in the perishable goods market because of cost uncertainty (Milgrom and Roberts, 1982), quality uncertainty (Schmalensee, 1982), and switching costs (Klemperer, 1987).

monopolist may choose selling to deter future entry. Bulow (1986) also shows that a durable goods monopolist has an incentive to increase durability to prevent future entry from the viewpoint of planned obsolescence. These studies focus on how vertically integrated durable goods monopolists influence the demand for future entrants. By contrast, this study discusses entry deterrence by an upstream firm that trades with a downstream durable goods monopolist by focusing on exclusive contracts.

The market environment in our model is also related to those in which consumers have multi-period opportunities to purchase final products. In those models, Besanko and Winston (1990) and Dudine, Hendel, and Lizzeri (2006) discuss storable goods markets, and Coase (1972), Bulow (1982, 1986), Denicolò and Garella (1999), Bruce, Desai, and Staelin (2006), Agrawal et al. (2012), and Gilbert, Randhawa, and Sun (2014) investigate durable goods markets. Our paper contributes to the research stream on those product markets with vertical supply chains (storable goods markets (Desai, Koenigsberg, and Purohit, 2010; Lin, Parlaktürk, Swaminathan, 2018; Kabul and Parlaktürk, 2019), leasing versus selling (Purohit, 1995; Desai and Purohit, 1999; Bhaskaran and Gilbert, 2009, 2015), and secondary markets (Shulman and Coughlan, 2007; Oraiopoulos, Ferguson, and Toktay, 2012)).

In particular, the model formulation of our paper has links to the models of durable goods markets concerning vertical channel coordination (Desai, Koenigsberg, and Purohit, 2004; Arya and Mittendorf, 2006; Su and Zhang, 2008; Bhaskaran and Gilbert, 2009, 2015; Yang, 2012; Gümüş, Ray, and Yin, 2013; Ramanan and Bhargava, 2014). Desai, Koenigsberg, and Purohit (2004) employ two-period durable goods monopoly models with a separate retail channel to discuss the effect of commitment on the vertical trading term. They show that the commitment to the vertical contract overcomes the Coase problem, leading to a higher profit for the monopoly manufacturer. Arya and Mittendorf (2006) consider a multi-period durable goods monopoly market. The monopolist determines if it separates its input sector to overcome the Coase problem. The trading term between the input and retail sectors is a

linear wholesale price. They show the possibility that vertical separation by the monopolist occurs in equilibrium.[10] In line with the discussions by Desai, Koenigsberg, and Purohit (2004) and Arya and Mittendorf (2006), Su and Zhang (2008) investigate a newsvendor problem with demand uncertainty to discuss channel coordination. Bhaskaran and Gilbert (2009, 2015) follow Bulow (1982) to investigate the durability choice by a monopoly manufacturer under four scenarios ((i) centralized or decentralized channel and (ii) selling or leasing). Gümüş, Ray, and Yin (2013) discuss return policy under demand uncertainty in decentralized durable goods markets. The authors of those papers do not address the openness of the supply chain in durable goods markets, which is the primary topic of our article.

Our paper contributes to the literature on how to mitigate future price reduction in dynamic models.[11] Recently, for instance, Deb and Said (2015) discuss the monopolist's optimal mechanisms in a two-period model and show that it manipulates the timing of contracting to mitigate the negative effect of price reduction in period 2. Dilmé and Li (2019) consider a finite period model with high- and low-valuation consumers and show that managing the monopolist's limited product stock can induce high-valuation consumers to buy at regular prices. The key factors of mitigating future price reduction in those papers differ from ours (exclusive dealing).

This study is also related to the literature on anticompetitive exclusive contracts that deter the socially efficient entry of a potential entrant.[12] The literature on anticompetitive exclusive contracts starts from the Chicago School argument in the 1970s (Posner, 1976;

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[10] Yang (2012) extends Arya and Mittendorf (2006) to downstream oligopoly. Ramanan and Bhargava (2014) also employ the framework of Arya and Mittendorf (2006) to discuss consumers' uncertainty on their valuations of the product.

[11] Hörner and Samuelson (2011) and Chen (2012) investigate optimal pricing strategies under multi-period sales opportunities. They do not emphasize a seller's specific (non-price) manipulation to mitigate future price reduction.

[12] Several studies focus on the fact that active firms may compete for exclusivity and explore the welfare effect (Mathewson and Winter, 1987; O'Brien and Shaffer, 1997; Bernheim and Whinston, 1998). Recently, Calzolari and Denicolò (2013, 2015) introduced asymmetric information in this literature.

Bork, 1978). Using a simple setting, they point out that rational economic agents never sign exclusive contracts for anticompetitive reasons if we consider all members' participation constraints in the contracting party.[13] In rebuttal to the Chicago School, post-Chicago economists find that rational economic agents agree with exclusive contracts for anticompetitive reasons in certain market environments.[14] Some papers extend a single-buyer model in the Chicago School argument to a multiple-buyer model. For instance, the entrant needs a certain number of buyers to cover its fixed costs (Rasmusen, Ramseyer, and Wiley, 1991; Segal and Whinston, 2000b), and buyers compete in downstream markets (Simpson and Wickelgren, 2007; Abito and Wright, 2008).[15] In these studies, negative externalities exist; signing exclusive contracts reduces the possibility of entry under scale economies, and upstream entry reduces industry profits in the presence of downstream competition.[16] Furthermore, in the framework of a single downstream firm, several studies point out that the intensity of upstream competition plays a crucial role in the Chicago School argument.[17] They show that the exclusion result is attainable in the cases where the incumbent sets liquidated damages for the case of entry (Aghion and Bolton, 1987), where the entrant is

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[13] For the analysis of the impact of this argument on antitrust policies, see Motta (2004), Whinston (2006), and Fumagalli, Motta, and Calcagno (2018).

[14] Post Chicago School economists also explore the market environment in which exclusive contracts encourage the relationship-specific investment in vertical relationships (e.g., Marvel, 1982; Masten and Snyder, 1993; Segal and Whinston, 2000a; de Meza and Servaggi, 2007).

[15] In the literature on exclusion with downstream competition, Fumagalli and Motta (2006) show that the existence of participation fees to remain active in the downstream market plays a crucial role in exclusion if buyers are undifferentiated Bertrand competitors. See also Wright (2009), who reconsiders the result of Fumagalli and Motta (2006) in the case of two-part tariffs.

[16] For the extended model of exclusion with scale economies, see Miklós-Thal and Shaffer (2016), Stefanadis (2016), Choi and Stefanadis (2018), and Chen and Shaffer (2014, 2019). By contrast, for extended models of exclusion with downstream competition, see Wright (2008), Argenton (2010), Kitamura (2010), and DeGraba (2013), who show the anticompetitiveness of the realized exclusive contracts. Gratz and Reisinger (2013) show procompetitive effects if downstream firms compete imperfectly and contract breaches are possible.

[17] For another mechanism of anticompetitive exclusive dealing, see Fumagalli, Motta, and Rønde (2012), who focus on the incumbent's relationship-specific investments. See also Kitamura, Matsushima, and Sato (2018), who focus on a complementary input supplier with market power.

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capacity constrained (Yong, 1996), where upstream firms compete à la Cournot (Farrell, 2005), and where upstream firms can merge (Fumagalli, Motta, and Persson, 2009).[18] To the best of our knowledge, existing papers in this literature consider only perishable goods markets. Thus, we construct the model here to clarify that the exclusion mechanism in this study depends on the nature of durable goods markets; exclusion occurs because of the negative externality that future entry reduces current industry profits.

3   Model

We consider a two-period model with a common discount factor $\delta \in (0, 1)$ for all players. There is a final good that is perfectly durable; that is, the final good produced and used in period 1 can be used in period 2, without depreciation.

Consumers   There is a unit mass of consumers, each of whom buys at most one unit of the final good. Let $v \in [0, \bar{v}]$ be a type of consumer's willingness to pay, which is stationary for all periods and whose distribution depends on $F(v)$, where $F'(v) > 0$ for all $v \in [0, \bar{v}]$, $F(0) = 0$, and $F(\bar{v}) = 1$.[19] If a type v consumer purchases the final good at p_t in period $t(= 1, 2)$, the consumer's gross lifetime discounted surplus evaluated in period 1 becomes

$$u = \delta^{t-1}(v - p_t).$$

Denicolò and Garella (1999) use a similar formulation to discuss a durable goods market.[20]

In period 2, a consumer type v, who does not purchase the final good in period 1,

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[18] See also Kitamura, Matsushima, and Sato (2017), who show that anticompetitive exclusive dealing can occur if the downstream buyer bargains with suppliers sequentially.

[19] In the Supplementary Appendix, we introduce the analysis under linear demand in which $F(v) = v$ to check various situations such as linear wholesale pricing and vertical product differentiation.

[20] Alternatively, we can consider the setting in which v represents a value of per period use; the surplus of consumer type v is $(1 + \delta)v - p_1$ for the purchase in period 1, while it is $\delta(v - p_2)$ for the purchase in period 2. In the Supplementary Appendix, we explore such a setting under linear demand and derive exclusion results.

purchases the final good if and only if the consumer surplus is nonnegative, i.e., $v - p_2 \geq 0$.
By rationally predicting p_2, the consumer purchases the final good in period 1 if and only if
$v - p_1 \geq \delta(v - p_2)$. The indifferent consumer type v_1 is defined by $v_1 - p_1 = \delta(v_1 - p_2)$. Let
q_1 be the mass of consumers purchasing in period 1. By definition, we have $q_1 = 1 - F(v_1)$.
Then, by using these two equations, we have the static inverse demand in period 1:

$$P_1(q_1, p_2) \equiv (1 - \delta)F^{-1}(1 - q_1) + \delta p_2.$$

$P_1(q_1, p_2)$ has the following properties:

$$\frac{\partial P_1(q_1, p_2)}{\partial q_1} = -\frac{1 - \delta}{F'(1 - q_1)} < 0, \quad \frac{\partial P_1(q_1, p_2)}{\partial p_2} = \delta > 0.$$

Firms   The upstream market consists of an incumbent supplier U_I and an entrant supplier
U_E. U_I and U_E produce an identical input but differ in terms of cost efficiency. The constant
marginal costs of U_I and U_E are $c_I(< \bar{v})$ and $c_E \in [0, c_I)$, respectively. To guarantee that
some consumers prefer to purchase the final good in period 1 ($q_1 > 0$), we assume that the
difference in suppliers' marginal costs is not too large.[21] Each supplier offers a two-part tariff,
which consists of a linear wholesale price w and an upfront fixed fee ψ, to the downstream
market if it is active.

The downstream market is composed of a downstream monopolist D. This modeling
strategy clarifies the role of durable goods; namely, the prevention of efficient entry occurs
even in the absence of scale economies and downstream competition, both of which require
more than one downstream firm. D transforms one unit of the input into one unit of the final
good, which is durable. To simplify the analysis, we assume that the cost of transformation
is zero. Thus, if D faces a wholesale price w_t in period t, its per-unit production cost in
period t becomes w_t. We assume that all firms cannot commit to future prices and that
there is no possibility of renting products. There is no resale market for simplicity.

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[21] In Section 4.4, we extend the model to the case in which the difference in the efficiency is too large and
no consumer purchases the final good in period 1 when U_E's entry is anticipated.

Timing The timing of the game is as follows (see Figure 1). In period 1, only U_I exists in the upstream market.[22] This may be because of a patent right, superior technology, efficient marketing, or an industry protection policy. Period 1 consists of three stages. In period 1.1, U_I offers a two-period exclusive contract to D, with fixed compensation $x \geq 0$.[23] Following the standard literature on naked exclusion, we assume that the exclusive offer does not contain the term of wholesale prices.[24] After observing the exclusive contract, D decides whether to accept the exclusive contract. D immediately receives x if it accepts the contract. In period 1.2, U_I offers a two-part tariff contract to D. In period 1.3, D orders the input and sells the final good to consumers.

At the beginning of period 2, U_E appears in the upstream market if D rejects the exclusive contract in period 1.1. Period 2 consists of three stages. In period 2.1, U_E decides whether to enter the market if U_E appears.[25] We assume that the fixed entry cost is sufficiently small such that U_E can earn positive profits; namely, U_E always enters the upstream market if D rejects the exclusive contract in period 1.1. In period 2.2, active suppliers offer two-part tariff contracts to D. For the case of U_E's entry, U_I and U_E become homogeneous Bertrand competitors. We assume that if they charge the same input price, the efficient supplier, U_E, supplies its input to D. In period 2.3, D orders the input and sells the final good to consumers.

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[22] This assumption simplifies the analysis. In the Supplementary Appendix, we consider the case in which both U_I and U_E exist in the upstream market at the beginning of period 1. We obtain exclusion outcomes even in such a setting. Section 5.1 introduces a brief summary of the results in the extensions.

[23] In Section 4.3, we show that for the existence of exclusion outcomes, it does not matter whether U_I or D makes exclusive offers.

[24] If U_I is able to credibly commit to the trading terms after achieving the two-period exclusive contract, U_I can eliminate the time-inconsistency problem by committing to a prohibitively high second-period wholesale price, facilitating signing the exclusive contract. Moreover, in the naked exclusion literature, it is known that if the incumbent can commit to wholesale prices, then the possibility of anticompetitive exclusive dealing is enhanced. See Yong (1999) and Appendix B of Fumagalli and Motta (2006).

[25] The result does not change if we consider the possibility that U_I makes exclusive offers in period 2 if its exclusive offer in period 1 is rejected. In such a case, the Chicago School argument can be applied; U_I cannot make exclusive offers to profitably compensate D in period 2.

We use the superscripts "a" and "r" to indicate the acceptance and the rejection of the exclusive contract by D in period 1.1. Then, $\pi_{i|t}^{\omega}$ $(i \in \{I, E\})$ is U_i's profit in period t when D's decision in period 1.1 is $\omega \in \{a, r\}$. Likewise, $\pi_{D|t}^{\omega}$ is D's profit in period t.

We assume that U_I and D maximize the present discounted value of their profits $\pi_{I|1}^{\omega} + \delta\pi_{I|2}^{\omega}$ and $\pi_{D|1}^{\omega} + \delta\pi_{D|2}^{\omega}$ respectively, while U_E maximizes the second-period profits $\pi_{E|2}^{r}$ for the case of entry.

[Figure 1 about here.]

4   Analysis

We characterize the properties of subgame perfect Nash equilibria by solving the game using backward induction. Starting from the game in period 2, we explore the equilibrium outcomes in the subgame after D's decision in period 1.1. We then explore the contractual decision in period 1.1 to examine the existence of exclusion outcomes.

4.1   Period 2

Let v_2 denote the indifferent consumer in period 2, which satisfies $v_2 - p_2 = 0$. By defining q_2 as the mass of consumers purchasing in period 2, the sum of the production level in both periods becomes $q_1 + q_2 = 1 - F(v_2)$. From these two equations, we obtain the residual inverse demand function in period 2 given q_1:

$$P_2(q_2|q_1) \equiv F^{-1}(1 - q_1 - q_2).$$

For notational convenience, we define $q_2^*(q_1, z)$, $P_2^*(q_1, z)$, and $\Pi_2^*(q_1, z)$ as follows:

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\begin{aligned}
q_2^*(q_1, z) &\equiv \underset{q_2 \geq 0}{\operatorname{argmax}} \ (P_2(q_2|q_1) - z)q_2, &(1)\\
P_2^*(q_1, z) &\equiv P_2(q_2^*(q_1, z)|q_1),\\
\Pi_2^*(q_1, z) &\equiv (P_2^*(q_1, z) - z)q_2^*(q_1, z), \quad \text{where } 0 \leq z < P_2(0|q_1).
\end{aligned}
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In period 2.3, given the two-part tariff contract (w_2, ψ_2), D chooses $q_2^*(q_1, w_2)$ to maximize its second-period profit, which leads to the equilibrium price $P_2^*(q_1, w_2)$. D earns $\Pi_2^*(q_1, w_2) - \psi_2$. The following lemma summarizes the properties of $q_2^*(q_1, w_2)$, $P_2^*(q_1, w_2)$, and $\Pi_2^*(q_1, w_2)$.

Lemma 1. $q_2^*(q_1, w_2)$, $P_2^*(q_1, w_2)$, and $\Pi_2^*(q_1, w_2)$ have the following properties:

$$\frac{\partial q_2^*(q_1, w_2)}{\partial w_2} < 0, \quad \frac{\partial P_2^*(q_1, w_2)}{\partial w_2} > 0, \quad \frac{\partial \Pi_2^*(q_1, w_2)}{\partial q_1} < 0.$$

Proof. See Appendix A.1. □

In period 2.2, the supplier(s) considers (consider) the profit maximization problem(s), given q_1. First, we discuss the case in which D accepts the exclusive contract in period 1.1. Second, we explore the case in which D rejects the exclusive contract in period 1.1. Finally, we compare both cases.

Exclusive supply chain When D accepts the exclusive contract (chooses the exclusive supply chain), only U_I exists in the upstream market in period 2. In period 2.2, U_I offers the trading term, $(w_{2|I}^a, \psi_{2|I}^a) = (c_I, \Pi_2^*(q_1, w_2))$. D accepts this trading term, and the resulting profits of U_I and D are given by

$$\pi_{I|2}^a = \Pi_2^*(q_1, c_I), \quad \pi_{D|2}^a = 0.$$

The realized price in period 2 is $p_2^a = P_2^*(q_1, c_I)$.

Open supply chain When D rejects the exclusive contract (chooses the open supply chain), U_E enters the upstream market in period 2.1 anticipating positive profits. In period 2.2, the upstream competition between U_I and U_E induces U_I to offer the best trading term, $(w_{2|I}^r, \psi_{2|I}^r) = (c_I, 0)$, which allows D to earn $\Pi_2^*(q_1, c_I)$. Anticipating this trading term by U_I, U_E needs to leave $\Pi_2^*(q_1, c_I)$ for D and therefore sets $(w_{2|E}^r, \psi_{2|E}^r) = (c_E, \Pi_2^*(q_1, c_E) - \Pi_2^*(q_1, c_I))$. D accepts this trading term, and the resulting profits of D, U_I, and U_E are

$$\pi_{D|2}^r = \Pi_2^*(q_1, c_I), \quad \pi_{I|2}^r = 0, \quad \pi_{E|2}^r = \Pi_2^*(q_1, c_E) - \Pi_2^*(q_1, c_I).$$

The realized price in period 2 is $p_2^r = P_2^*(q_1, c_E)$.

Comparison Finally, we compare the above outcomes in period 2 given q_1. For the pair of U_I and D, their joint profit under the exclusive supply chain is the same as that under the open supply chain. The difference between these two cases appears in the realized prices in period 2. Using the results in Lemma 1, we have the following property:

Lemma 2. *Given q_1, the realized price under the exclusive supply chain is higher than that under the open supply chain: $P_2^*(q_1, c_I) > P_2^*(q_1, c_E)$ always holds.*

The lower realized price in period 2 under the open supply chain follows from the efficiency of U_E.

4.2 Period 1

Anticipating the outcome in period 2, D determines q_1 given the trading term (w_1, ψ_1) in period 1.3.

We use $P_1(q_1|c_I) \equiv P_1(q_1, P_2^*(q_1, c_I))$ and $P_1(q_1|c_E) \equiv P_1(q_1, P_2^*(q_1, c_E))$ to express the static inverse demand functions under the exclusive supply chain and the open supply chain in period 1, respectively. Using the properties of $\partial P_1(q_1, p_2)/\partial p_2 > 0$ and Lemma 2, the two inverse demands in period 1 have the following property:

Lemma 3. *The static inverse demand in period 1 under the exclusive supply chain is always strictly larger than that under the open supply chain; i.e., $P_1(q_1|c_I) > P_1(q_1|c_E)$ holds for any q_1.*

The result in Lemma 3 implies that the exclusive supply chain allows D to face larger consumer demand than the open supply chain, which can be explained by the intertemporal external effect of entry in period 2. Under the open supply chain, the entry of U_E occurs in period 2, allowing consumers to purchase the final good at a low price in period 2. Such a

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low price in period 2 induces some consumers to refrain from purchasing in period 1. Hence, the consumer demand in period 1 under the open supply chain becomes smaller than that under the exclusive supply chain. In other words, the contracting party suffers from the small consumer demand in period 1 under the open supply chain.

In the rest of this subsection, we derive the equilibrium outcomes in the cases of the exclusive supply chain and the open supply chain, separately.

Exclusive supply chain We derive the equilibrium outcome starting from D's profit maximization problem in period 1.3. When the exclusive supply chain is chosen in period 1.1, D anticipates that it earns zero profit in period 2; namely, $\pi_{D|2}^a = 0$. Then, given the two-part tariff contract (w_1, ψ_1), which is offered by U_I in period 1.2, D chooses the production level $q_1^a(w_1)$ to maximize its overall profits in period 1.3:

$$q_1^a(w_1) \equiv \underset{q_1 \geq 0}{\operatorname{argmax}} \ (P_1(q_1|c_I) - w_1)q_1 - \psi_1. \tag{2}$$

The first-order condition of the maximization problem in (2) is

$$P_1(q_1^a(w_1)|c_I) - w_1 + \frac{\partial P_1(q_1^a(w_1)|c_I)}{\partial q_1}q_1^a(w_1) = 0. \tag{3}$$

We now consider U_I's profit maximization problem in period 1.2. By anticipating $\pi_{I|2}^a = \Pi_2^*(q_1^a(w_1), c_I)$, U_I's overall profits become

$$(w_1^a, \psi_1^a) \equiv \underset{w_1, \psi_1}{\operatorname{argmax}} \ (w_1 - c_I)q_1^a(w_1) + \psi_1 + \delta\Pi_2^*(q_1^a(w_1), c_I).$$

U_I determines the highest ψ_1 such that D prefers accepting (w_1, ψ_1) to declining it; that is, $\psi_1 = (P_1(q_1^a(w_1)|c_I) - w_1)q_1^a(w_1)$. Under this two-part tariff contract, D's overall profits are zero; $\pi_{D|1}^a + \delta\pi_{D|2}^a = 0$. Then, U_I's profit maximization problem is rewritten as

$$w_1^a \equiv \underset{w_1}{\operatorname{argmax}} \ (P_1(q_1^a(w_1)|c_I) - c_I)q_1^a(w_1) + \delta\Pi_2^*(q_1^a(w_1), c_I). \tag{4}$$

The first-order condition of the maximization problem in (4) is

$$\left\{ (P_1(q_1^a(w_1^a)|c_I) - c_I) + \frac{\partial P_1(q_1^a(w_1^a)|c_I)}{\partial q_1}q_1^a(w_1^a) + \delta\frac{\partial\Pi_2^*(q_1^a(w_1^a), c_I)}{\partial q_1} \right\} q_1^{a\prime}(w_1^a) = 0. \tag{5}$$

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Using the first-order conditions in (3) and (5), we obtain the following:

$$w_1^a = c_I - \delta \frac{\partial \Pi_2^*(q_1^a(w_1^a), c_I)}{\partial q_1}.$$

From Lemma 1, we have $\partial \Pi_2^*(q_1^a(w_1^a), c_I)/\partial q_1 < 0$, which implies that $w_1^a > c_I$ holds. The following proposition summarizes the discussion.

Proposition 1. *When an exclusive supply chain is chosen for both periods, the equilibrium wholesale price in period 1 is strictly higher than the marginal cost of U_I; that is, $w_1^a > c_I$.*

Proof. The above discussion is based on $q_1^{a\prime}(w_1^a) < 0$. The proof of $q_1^{a\prime}(w_1^a) < 0$ is provided in Appendix A.2. $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ □

This proposition is a generalization of Desai, Koenigsberg, and Purohit (2004) in that the demand system in our paper is a general form. Under the exclusive supply chain, D chooses the first-period production level without considering the profit in period 2 because it anticipates that it earns nothing in period 2. To control D's behavior in period 1, U_I sets $w_1^a > c_I$ to fulfill the overall joint profit maximization of U_I and D.

Note that the realized production level in period 1, $q_1^a(w_1^a)$, is the same as q_1^*, which is the solution of the following maximization problem:

$$q_1^* \equiv \underset{q_1 \geq 0}{\operatorname{argmax}} \; (P_1(q_1|c_I) - c_I)q_1 + \delta \Pi_2^*(q_1, c_I).$$

This means that U_I indirectly controls q_1 through its wholesale price, w_1, to maximize the overall joint profits of U_I and D. As a result, the overall joint profits of U_I and D become

$$\pi_{I|1}^a + \delta \pi_{I|2}^a + \pi_{D|1}^a + \delta \pi_{D|2}^a = (P_1(q_1^*|c_I) - c_I)q_1^* + \delta \Pi_2^*(q_1^*, c_I). \tag{6}$$

Open supply chain When the open supply chain is chosen in period 1.1, D anticipates it earns $\pi_{D|2}^r = \Pi_2^*(q_1, c_I)$ in period 2. Then, given the two-part tariff contract (w_1, ψ_1), which

is offered by U_I in period 1.2, D chooses the production level $q_1^r(w_1)$ to maximize its overall profits in period 1.3:

$$q_1^r(w_1) \equiv \operatorname*{argmax}_{q_1 \geq 0} \ (P_1(q_1|c_E) - w_1)q_1 - \psi_1 + \delta\Pi_2^*(q_1, c_I). \tag{7}$$

The first-order condition of the maximization problem in (7) is

$$P_1(q_1^r(w_1)|c_E) - w_1 + \frac{\partial P_1(q_1^r(w_1)|c_E)}{\partial q_1}q_1^r(w_1) + \delta\frac{\partial \Pi_2^*(q_1^r(w_1), c_I)}{\partial q_1} = 0. \tag{8}$$

By anticipating this reaction, U_I's profit maximization problem in period 1.2 becomes

$$(w_1^r, \psi_1^r) \equiv \operatorname*{argmax}_{w_1, \psi_1} \ (w_1 - c_I)q_1^r(w_1) + \psi_1.$$

Note that under the open supply chain, D can earn $\delta\Pi_2^*(0, c_I)$ in period 2 through the competition between U_I and U_E if it rejects the two-part tariff contract (w_1, ψ_1). U_I determines the highest ψ_1 such that D prefers accepting (w_1, ψ_1) to declining it; the optimal level of upfront fixed payment satisfies $\psi_1 = (P_1(q_1^r(w_1)|c_I) - w_1)q_1^r(w_1) + \delta\Pi_2^*(q_1, c_I) - \delta\Pi_2^*(0, c_I)$. Under this two-part tariff contract, U_I cannot extract all the overall joint profits of U_I and D; unlike the exclusive supply chain, D earns positive overall profits, $\pi_{D|1}^r + \delta\pi_{D|2}^r = \delta\Pi_2^*(0, c_I)$. Then, U_I's profit maximization problem is rewritten as

$$w_1^r \equiv \operatorname*{argmax}_{w_1} \ (P_1(q_1^r(w_1)|c_E) - c_I)q_1^r(w_1) + \delta\Pi_2^*(q_1^r(w_1), c_I) - \delta\Pi_2^*(0, c_I). \tag{9}$$

The first-order condition of the maximization problem in (9) is

$$\left\{ (P_1(q_1^r(w_1^r)|c_E) - c_I) + \frac{\partial P_1(q_1^r(w_1^r)|c_E)}{\partial q_1}q_1^r(w_1^r) + \delta\frac{\partial \Pi_2^*(q_1^r(w_1^r), c_I)}{\partial q_1} \right\} q_1^{r\prime}(w_1^r) = 0. \tag{10}$$

Using the first-order conditions in (8) and (10), we obtain the following:

$$w_1^r = c_I.$$

The following proposition summarizes the discussion.

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Proposition 2. *When U_E enters the upstream market in period 2, the equilibrium linear wholesale price in period 1 equals the marginal cost of U_I; that is, $w_1^r = c_I$.*

Proof. The above discussion is based on $q_1^{r\prime}(w_1^r) < 0$. The precise proof of $q_1^{r\prime}(w_1^r) < 0$ is provided in Appendix A.3. $\square$

Under the open supply chain, from (8) and (10), we find that D's maximization problem aligns with U_I's if and only if U_I sets $w_1^r = c_I$ as in the standard two-part tariff pricing.

Note that the realized production level in period 1, $q_1^r(w_1^r)$, is the same as q_1^{**}, which is the solution of the following maximization problem:

$$q_1^{**} \equiv \operatorname*{argmax}_{q_1 \geq 0} \; (P_1(q_1|c_E) - c_I)q_1 + \delta\Pi_2^*(q_1, c_I).$$

Thus, the overall joint profits of U_I and D become

$$\pi_{I|1}^r + \delta\pi_{I|2}^r + \pi_{D|1}^r + \delta\pi_{D|2}^r = (P_1(q_1^{**}|c_E) - c_I)q_1^{**} + \delta\Pi_2^*(q_1^{**}, c_I). \tag{11}$$

4.3 Exclusive contracts

For an exclusion equilibrium to exist, the equilibrium transfer x^* must simultaneously satisfy the following two conditions.

First, the exclusive contract must satisfy individual rationality for D:

$$\pi_{D|1}^a + x^* + \delta\pi_{D|2}^a \geq \pi_{D|1}^r + \delta\pi_{D|2}^r \quad \text{or} \quad x^* \geq \pi_{D|1}^r + \delta\pi_{D|2}^r - (\pi_{D|1}^a + \delta\pi_{D|2}^a). \tag{12}$$

Second, the exclusive contract must satisfy individual rationality for U_I:

$$\pi_{I|1}^a + \delta\pi_{I|2}^a - x^* \geq \pi_{I|1}^r + \delta\pi_{I|2}^r \quad \text{or} \quad x^* \leq \pi_{I|1}^a + \delta\pi_{I|2}^a - (\pi_{I|1}^r + \delta\pi_{I|2}^r). \tag{13}$$

From the above conditions, it is evident that an exclusion equilibrium exists if and only if inequalities (12) and (13) simultaneously hold. This is equivalent to the following condition:

$$\pi_{I|1}^a + \delta\pi_{I|2}^a + \pi_{D|1}^a + \delta\pi_{D|2}^a \geq \pi_{I|1}^r + \delta\pi_{I|2}^r + \pi_{D|1}^r + \delta\pi_{D|2}^r. \tag{14}$$

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Condition (14) implies that anticompetitive exclusive contracts are attained if exclusive contracts increase the overall joint profits of U_I and D. The condition also implies that whether U_I or D makes an exclusive offer does not affect the existence of exclusion outcomes.

Comparison We finally examine the contractual decision in period 1.1. We compare equations (6) and (11): the overall joint profits in the two trading modes. For q_1, the overall joint profits in period 1 under the exclusive supply chain are

$$\Pi^a(q_1) \equiv (P_1(q_1|c_I) - c_I)q_1 + \delta\Pi_2^*(q_1, c_I), \tag{15}$$

while those under the open supply chain are

$$\Pi^r(q_1) \equiv (P_1(q_1|c_E) - c_I)q_1 + \delta\Pi_2^*(q_1, c_I). \tag{16}$$

The only difference between $\Pi^a(q_1)$ and $\Pi^r(q_1)$ is in the static inverse demand in period 1, $P_1(q_1|\cdot)$. From Lemma 3, we have $P_1(q_1|c_I) > P_1(q_1|c_E)$ for any q_1, which implies that $\Pi^a(q_1) > \Pi^r(q_1)$ holds for all q_1. Recall that, under the two modes, U_I indirectly controls q_1 through its wholesale price, w_1. Therefore, under the exclusive supply chain, by setting $w_1 = w_1^a$, U_I achieves the overall joint profits, $\Pi^a(q_1^*)$, which are strictly higher than those under the open supply chain, $\Pi^r(q_1^{**})$; that is, condition (14) always holds.

Theorem 1. *In durable goods markets, U_I and D choose an exclusive supply chain for any c_I, c_E, and δ if D produces the positive production level in period 1 when consumers predict U_E's entry in period 2.*

Theorem 1 implies that if at least some consumers purchase final goods in period 1 under the open supply chain, the two-period exclusive supply chain, which deters the entry of an efficient entrant in period 2, is always established in durable goods markets. This result can be explained by the intertemporal negative externality in durable goods markets. In durable goods markets, future entry intertemporally affects the current market outcome. Efficient

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entry in period 2 discourages final consumers from purchasing final goods in period 1 because they predict that entry leads to a future price reduction. Such a property prevents the contracting party from choosing the optimal pair of prices (p_1, p_2) to maximize overall joint profits under the open supply chain. In other words, using the two-part tariff contract, U_I can indirectly control the pair of prices to achieve overall joint profit maximization under the exclusive supply chain, whereas it cannot control the prices in period 2 because of the entry of U_E under the open supply chain. Therefore, although consumers benefit from future entry, such entry is harmful to the contracting party; namely, in durable goods markets, rational economic agents choose the exclusive supply chain, which deters efficient future entry.

In addition, from the viewpoint of competition policy, the findings here provide a new insight for anticompetitive exclusive contracts. If we modify our model to the case of perishable goods markets, the modified model coincides with the framework of the Chicago School argument; exclusive contracts cannot deter the entry of an efficient entrant. Theorem 1 implies that the Chicago School argument cannot be applied to durable goods markets; the nature of durable goods markets allows the inefficient incumbent supplier to deter efficient future entry thorough anticompetitive exclusive contracts.[26]

4.4 Highly efficient entrant

Thus far, we have explored the case in which at least some consumers purchase final goods in period 1. However, if U_E is sufficiently efficient, the inverse demand in period 1, $P_1(q_1|c_E)$, becomes so small that no consumer purchases final goods in period 1 under the open supply chain; that is, $q_1^r = 0$. In this case, the overall joint profits in period 1 under the open supply chain are $\Pi^r(0) = \delta\Pi_2^*(0, c_I)$. From (15) and (16), we have

$$\Pi^a(q_1^*) > \Pi^a(0) = \Pi^r(0),$$

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[26] In the Supplementary Appendix, we compare the social surpluses under the exclusive supply chain and the open supply chain, by introducing linear demand. We show that the exclusive supply chain to deter the efficient entrant is always undesirable from the viewpoint of social surplus.

which implies that the exclusive supply chain leads to higher overall joint profits of U_I and D than the open supply chain even when U_E is highly efficient.

Theorem 2. *In durable goods markets, U_I and D choose an exclusive supply chain for any c_I, c_E, and δ even if D does not produce the positive production level in period 1 when consumers expect U_E's entry in period 2.*

The results in Theorems 1 and 2 imply that in durable goods markets, the exclusive supply chain is always established regardless of the difference in cost efficiency. Note that the results in this study depend on the assumption that upstream suppliers can adopt two-part tariffs. In the Supplementary Appendix, we extend the model of linear demand to the case of linear wholesale pricing. We show that in contrast to the case of two-part tariffs, linear wholesale pricing does not lead to exclusion outcomes for a high discount factor. The major difference between the two types of wholesale pricing is the existence of a double marginalization problem, which is often observed for the case of linear wholesale pricing. When the exclusive supply chain is chosen, the double marginalization problem occurs for both periods, which reduces the overall joint profits of U_I and D under the exclusive supply chain. By contrast, when the open supply chain is chosen, efficient entry in period 2 can mitigate such a problem; D can earn considerably high profits in period 2. If the discount factor is high, this effect becomes dominant and thus, the open supply chain is chosen in the equilibrium.

5 Discussion

This section briefly introduces extensions and discusses some real-world exclusive supply chains.

5.1 Extensions

We briefly introduce two extensions. We first introduce the case in which U_I's marginal cost decreases in period 2 because of efficiency improvement. We then introduce the case in which U_E exists at the beginning of period 1.

Future efficiency improvement   In Section 1 of the Supplementary Appendix, we extend the analysis in Section 4 to the case in which the second-period marginal cost of U_I becomes $\hat{c} \in (c_E, c_I)$ because of efficiency improvements. We show that U_I and D always choose the exclusive supply chain even in the extended setting. The result implies that the mechanism of exclusive dealing carries through as long as U_I remains less efficient than U_E even after U_I's efficiency improvements.

When U_E appears in period 1   In Section 2 of the Supplementary Appendix, we extend the analysis in Section 4 to the case in which both U_I and U_E exist at the beginning of period 1. In this setting, we obtain the following results: (i) if only U_I can offer an exclusive contract to D, U_I and D always choose an exclusive supply chain, (ii) if only U_E can offer an exclusive contract to D, U_E and D are always indifferent between an exclusive supply chain and an open supply chain, and (iii) if both U_I and U_E can offer exclusive contracts to D, U_E and D always choose an exclusive supply chain.

The findings in these extended settings confirm the robustness of the exclusion mechanism in this study; the exclusive supply chain can be chosen even when all suppliers are existing firms. In durable goods markets, the inefficient supplier always has an incentive to exclude the efficient supplier. The efficient supplier chooses an exclusive supply chain with the downstream firm to protect the upstream market against the exclusive offer by an inefficient supplier.

5.2 Real-world examples of exclusive supply chains

We briefly discuss the relevance of the exclusive supply chain in this study to real-world examples. We commonly observe exclusive supply chains in markets for durable goods. For example, manufacturers of personal computers and digital cameras often choose exclusive supply chains to procure inputs such as CPUs and sensors.[27] Moreover, camcorder and automotive manufacturers have established exclusive supply chains with retailers and distributors (Shepard, 1993, Nurski and Verboven, 2016).

The following two features play an essential role in the mechanism of exclusion: (i) the price decline of durable goods and (ii) consumers who are aware of the existence of exclusive supply chains.[28] We consider each feature below.

We first consider the price decline of each durable good. In all the above exclusive supply chains, there is a consistent pattern of price declines over time following product introduction. For example, Lou, Pretice, and Yin (2012) investigate a dynamic demand model using data on the US digital camera market. Their estimation results on the supply side show that markups decline over time, suggesting that price declines occur because of intertemporal price discrimination or increased competition between durable-goods producers. See also Copeland and Shapiro (2016) for the personal computer market, Gowrisankaran and Rysman (2012) for the camcorder market, and Copeland (2014) for the automobile market.

We next consider the possibility that consumers know of the existence of exclusive supply chains. First, for input supply, magazines and webpages for personal computer users and

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[27] In the last paragraph of this section, we provide examples of exclusive supply chains for these products.

[28] In Section 4, we consider the situation in which the exclusive contract is used to deter entry by efficient suppliers in the future. Such a situation is suitable for the case of Vist in the Introduction. However, of course, there exists a situation in which the exclusive contract is used to exclude existing suppliers, and the efficient supplier may exclude the inefficient supplier by constructing the exclusive supply chain. The results of extended analyses, introduced in Section 5.1, imply that the exclusive supply chain is attainable even when all firms exist in period 1 and all existing suppliers can use exclusive contracts to exclude their rivals. Moreover, the efficient supplier wins the exclusive-offer competition in the extended model. Thus, our exclusion mechanism can apply to the wide range of real-world examples here.

camera users convey the CPU information of personal computers and the sensor information of digital cameras, allowing consumers to understand the supply chain environment for those durable goods. For example, web news often presents information about the future supply chain of CPUs for Apple's products such as iPhone, iPad, and Mac.[29] Second, auto dealers usually specialize in vehicles produced by a particular automaker in many countries. Furthermore, in Japan, the retail stores engaged in exclusive dealing agreements with the manufacturer and exclusively sold household appliances, including camcorders (Shepard, 1993). These business practices are usually known facts; thus, consumers are aware of the existence of exclusive supply chains.

6 Conclusion

This study has explored a supply chain problem in durable goods markets. We consider the situation in which a downstream durable goods monopolist chooses one of two trading modes: (i) an exclusive supply chain with an existing incumbent supplier, or (ii) an open supply chain, which causes competition between the existing incumbent supplier and a potential supplier in the future. The problem is also related to the discussion of anticompetitive exclusive contracts. Therefore, this study contributes to the literature in terms of both supply chain management and competition policy. Extending the static framework of the Chicago School argument to a two-period durable goods model without price commitment, we show that the downstream durable goods monopolist chooses the exclusive supply chain by signing long-term exclusive contracts; the potential entrant cannot enter the upstream

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[29] See "TSMC to be only supplier of Apple A13 chips in 2019" *Digitimes,* October 11, 2018 (`https://www.digitimes.com/news/a20181011PD215.html` and "TSMC to kick off 3nm chip production in 2H22 for Apple devices" *Digitimes,* August 11, 2021 (`https://www.digitimes.com/news/a20210811PD214.html`). For digital cameras, there exist web pages introducing the input information. See, for example, "List of all Nikon DSLR cameras and their sensor manufacturer/designer" *Nikon Rumors,* December 16, 2015 (`https://nikonrumors.com/2015/12/16/list-of-all-nikon-dslr-cameras-and-their-sensor-manufacturerdesigner.aspx/`).

market even when it is efficient. This study's exclusion mechanism is explained by the time-inconsistency problem (Coase, 1972).

The results here could explain why some vertical relations are too stable, which results in inefficiency. In the literature on business and management, long-standing organization ties cause lower incentives for opportunistic behavior (Williamson, 1975), information search (Uzzi, 1997), and necessary restructuring (Ernst and Bamford, 2005). Such organizations are less likely to search for new partners and capabilities and instead pursue existing business practices, resulting in a decrease in benefits within interorganizational ties or a negative impact on organization performance (Uzzi, 1997; Goerzen, 2007; Poppo, Zhou, and Zenger, 2008).[30] In our model, the downstream firm has an incentive to sign a two-period contract with the incumbent supplier, even by anticipating the appearance of a new efficient supplier in the near future. The resulting outcome leads to inefficiency of the vertical chain. Thus, although the advancement of informatization and globalization seemingly expands the open supply chain, these business environment changes may have a smaller impact on the openness of vertical relations in durable goods markets.

Our result has new policy implications for antitrust agencies; the Chicago School argument, which is based on static perishable goods markets, is not necessarily applicable to durable goods markets. Because of the nature of durable goods, rational economic agents can engage in anticompetitive exclusive contracts to exclude the efficient entrant in the future even under the simplest setting in which exclusion never occurs in static perishable goods markets. When we discuss the anticompetitiveness of exclusive contracts, we need to consider the durability of final goods in the market in which exclusion occurs. Otherwise, we may overestimate the Chicago School argument, which may lead to misleading predictions.

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[30] In addition, as those organizations accumulate relationship-specific experiences, such organizational inertia becomes stronger, and the partners share relationship-specific routines (Kim, Oh, and Swaminathan, 2006). Moreover, the specificity and efficiency of a relationship-specific investment may discourage the downstream firm from switching to a new trading partner (Kitamura, Miyaoka, and Sato, 2016).

Despite these contributions, there remain some issues requiring future research. First, we predict that the exclusion results are more likely to be observed if we introduce product durability into the other models of anticompetitive exclusive dealing based on perishable goods in the literature. Second, for the analysis in this study, we restrict our attention to a particular industry structure—a single potential entrant supplier—for clarity, but we can certainly assume multiple entrant suppliers. As in Kitamura (2010), if we assume multiple entrants, the competition between entrants induces the downstream firm to earn higher profits under the open supply chain, which enables us to predict that the exclusive supply chain may not be chosen if multiple entrants are sufficiently efficient. Thus, extensions and applications of our model can help researchers and policy makers address similar real-world issues.

A   Proofs of the results

A.1   Proof of Lemma 1

In this proof, we often use $q_2^* \equiv q_2^*(q_1, w_2)$ for notational simplicity. We first explore the property of $\partial q_2^*(q_1, w_2)/\partial w_2$. For $z = w_2$, the first-order condition of D's profit maximization problem (1) becomes

$$P_2(q_2^*|q_1) - w_2 + \frac{\partial P_2(q_2^*|q_1)}{\partial q_2} q_2^* = 0. \tag{17}$$

The second-order condition of the maximization problem in (1) leads to

$$2\frac{\partial P_2(q_2^*|q_1)}{\partial q_2} + \frac{\partial^2 P_2(q_2^*|q_1)}{\partial q_2^2} q_2^* < 0.$$

Note that $P_2(q_2|q_1)$ has the following property:

$$\frac{\partial P_2(q_2|q_1)}{\partial q_1} = \frac{\partial P_2(q_2|q_1)}{\partial q_2} = -\frac{1}{F'(1 - q_1 - q_2)} < 0. \tag{18}$$

Then, using (17), the implicit function theorem shows that

$$\frac{dq_2^*}{dw_2} = \frac{1}{2\frac{\partial P_2(q_2^*|q_1)}{\partial q_2} + \frac{\partial^2 P_2(q_2^*|q_1)}{\partial q_2^2} q_2^*} < 0. \tag{19}$$

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Hence, we have $\partial q_2^*(q_1, w_2)/\partial w_2 < 0$. We next consider the property of $\partial P_2^*(q_1, w_2)/\partial w_2$.

Using (18) and (19), partial differentiation leads to

$$\frac{\partial P_2^*(q_1, w_2)}{\partial w_2} = \frac{\partial P_2(q_2^*(q_1, w_2)|q_1)}{\partial w_2} = \frac{\partial P(q_2^*|q_1)}{\partial q_2}\frac{\partial q_2^*(q_1, w_2)}{\partial w_2} > 0.$$

Finally, we examine the property of $\Pi_2^*(q_1, w_2)$. Using (18) and (17), we have

$$\frac{\partial \Pi_2^*(q_1, w_2)}{\partial q_1} = \frac{\partial P_2(q_2^*|q_1)}{\partial q_1}q_2^* < 0.$$

<div align="right">Q.E.D.</div>

A.2   Proof of Proposition 1

We only show that $q_1^{a\prime}(w_1) < 0$ holds. The second-order condition of D's profit maximization problem (2) leads to

$$2\frac{\partial P_1(q_1^a(w_1)|c_I)}{\partial q_1} + \frac{\partial^2 P_1(q_1^a(w_1)|c_I)}{\partial q_1^2}q_1^a(w_1) < 0.$$

Using (3), the implicit function theorem shows that

$$\frac{dq_1^a}{dw_1} = \frac{1}{2\frac{\partial P_1(q_1^a(w_1)|c_I)}{\partial q_1} + \frac{\partial^2 P_1(q_1^a(w_1)|c_I)}{\partial q_1^2}q_1^a(w_1)} < 0.$$

<div align="right">Q.E.D.</div>

A.3   Proof of Proposition 2

We only show that $q_1^{r\prime}(w_1) < 0$ holds. The second-order condition of the maximization problem in (7) leads to

$$2\frac{\partial P_1(q_1^r(w_1)|c_E)}{\partial q_1} + \frac{\partial^2 P_1(q_1^r(w_1)|c_E)}{\partial q_1^2}q_1^r(w_1) + \delta\frac{\partial^2 \Pi_2^*(q_1^r(w_1), c_I)}{\partial q_1^2} < 0.$$

Using (8), the implicit function theorem shows that

$$\frac{dq_1^r}{dw_1} = \frac{1}{2\frac{\partial P_1(q_1^r(w_1)|c_I)}{\partial q_1} + \frac{\partial^2 P_1(q_1^r(w_1)|c_I)}{\partial q_1^2}q_1^r(w_1) + \delta\frac{\partial^2 \Pi_2^*(q_1^r(w_1), c_I)}{\partial q_1^2}} < 0.$$

<div align="right">Q.E.D.</div>

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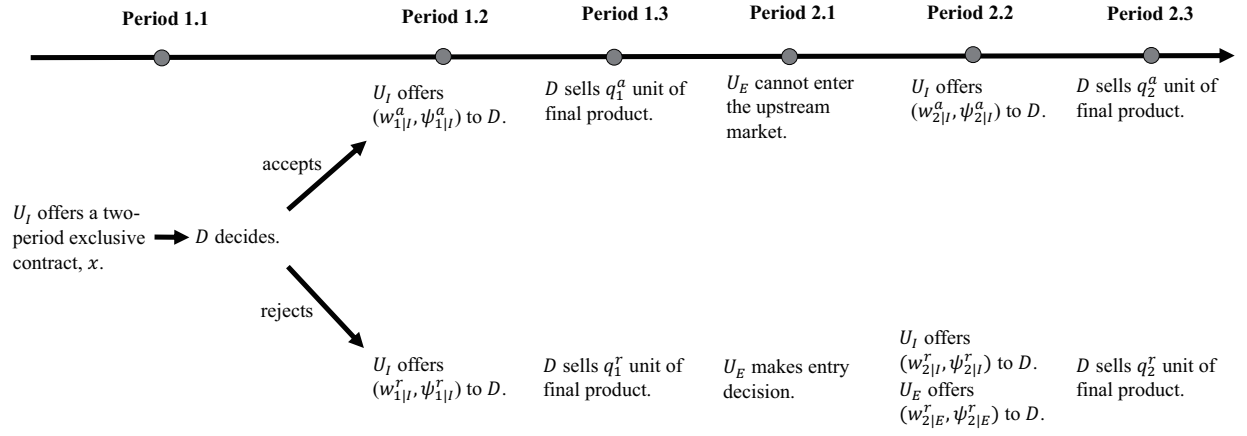
Period 1.1 **Period 1.2** **Period 1.3** **Period 2.1** **Period 2.2** **Period 2.3**

U_I offers $(w_{1|I}^a, \psi_{1|I}^a)$ to D.

D sells q_1^a unit of final product.

U_E cannot enter the upstream market.

U_I offers $(w_{2|I}^a, \psi_{2|I}^a)$ to D.

D sells q_2^a unit of final product.

accepts

U_I offers a two-period exclusive contract, x. $\longrightarrow$ D decides.

rejects

U_I offers $(w_{1|I}^r, \psi_{1|I}^r)$ to D.

D sells q_1^r unit of final product.

U_E makes entry decision.

U_I offers $(w_{2|I}^r, \psi_{2|I}^r)$ to D. U_E offers $(w_{2|E}^r, \psi_{2|E}^r)$ to D.

D sells q_2^r unit of final product.

Figure 1: Time line