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On the commoditization of complementary markets

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Abstract

A widely held view in strategy suggests that a firm with monopoly power in one market should seek to "commoditize" its complementary market. We examine the conditions under which this principle holds in a model where the complementary market features two vertically differentiated firms, and higher product quality entails higher per-unit production costs. We show that whether the monopolist chooses to commoditize the complementary market depends on the degree of heterogeneity in consumers' marginal valuation of quality, and on whether commoditization reduces production costs that are related or unrelated to quality.

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1. Introduction

In a widely cited industry letter on the economics of open source software and technology strategy, Spolsky (2002) observed that "smart companies try to commoditize their products' complements." That is, layers of the tech stack attempt to become monopolies while commoditizing adjacent layers. In their influential book, *Information Rules*, Shapiro and Varian (1999, p. 296) also emphasize: "Commoditize complementary products to make your systems more attractive to consumers." They explain that firms often seek to drive down the cost of complementary goods to enhance demand for their own core products, a strategy repeatedly observed in technology markets. Numerous industry analyses also document these strategies in high tech (e.g., Gwern 2018; Peterson 2024).

This paper explores some boundary conditions for this adage. We model a system in which consumers must purchase one product each from two complementary markets (e.g., hardware and software). There is a monopolist in one market and two vertically differentiated firms in the complementary market. Product qualities and prices are endogenous. We show that the monopolist benefits from lowering costs in its complementary product market if (i) the cost is independent of product quality, or (ii) the cost increases in product quality and the degree of heterogeneity in consumer valuation of quality is sufficiently large. If, on the other hand, the cost increases in product quality and the degree of heterogeneity in consumer valuation is small, then the monopolist loses from lowering costs in the complementary product market.

These results contribute to the academic literature on complementary goods by identifying a boundary condition on a widely cited strategy. They may also help explain why firms in some markets do not commoditize complementary product markets, even when they have the power to do so. For example, high-end platform providers like Apple do not aggressively commoditize the markets for their complements (e.g., app developers, accessory makers), while some firms targeting mass-market consumers or advertisers (such as Google) often provide more cost-lowering free tools to their complementary services (e.g., browsers, mobile OS) to commoditize those layers.

Relationship to Literature. Our paper mainly belongs to the literature on the pricing and coordination of complementary markets. Beginning with Cournot (1838), the literature highlights the inefficiency of double marginalization caused by independent pricing by monopolists in complementary markets. Subsequent research has explored various mechanisms to mitigate this inefficiency. For example, Spulber (2017) allows bargaining between a number of suppliers and complementary good producers, and shows that commitment to supply schedules by suppliers can internalize the externality between complements. Packalén (2009) shows that monopolist incumbents in complementary markets can sometimes achieve more coordinated outcomes by subsidizing entry of new firms into each other's markets.

Farrell and Katz (2000) examine a firm's incentive to enter complementary market B to squeeze profits in market B, so that it can then extract more profit in market A. They allow firms in market B to have different qualities, but assume Bertrand price competition and homogeneous consumer valuation of qualities. Casadesus-Masanell et al. (2010) also allow firms in the complementary market to have different qualities, but in their model, production costs are independent of quality and the monopolist does not influence these costs.

In contrast to these papers, our paper considers a setting where consumers are heterogeneous in their valuations of quality, producing higher quality requires higher per-unit costs, and the mo-

nopolist in one market can influence the cost structure of quality production in the complementary product market.

Our paper also relates to the literature on vertical relationships, which address double marginalization through contractual arrangements such as vertical integration, two-part tariffs, quantity forcing, and resale-price maintenance (e.g., Spengler 1950; Tirole 1988; Mathewson and Winter 1984; Hart et al 1990). These mechanisms align incentives by altering pricing contracts. By contrast, in our model, each firm sets its own price directly to consumers, and the monopolist's strategic lever is its ability to affect the complementor's cost of quality production.

Finally, our analysis connects to the literature on platform markets, where cross-group externalities drive cross-subsidization, exclusivity, and access rules (e.g., Rochet & Tirole 2003; Armstrong 2006; Carrillo & Tan 2021). In our setup, the monopolist's ability to shift the complementor's marginal cost of quality provides a channel for influencing outcomes in complementary markets, distinct from the traditional focus on platform access and pricing.

2. The Model

We consider a market for a system of two components, A and B. Every consumer requires one unit of A and one unit of B to derive utility, i.e., one cannot use A without a B, and vice versa. Market A consists of a single firm (Firm A) that is the monopolist producer of product A. Market B consists of two vertically differentiated competing firms, firms B_L and B_H, each producing a variant of product B.

The quality of product A is q_A, and that of product B_L and B_H are q_{BL} and q_{BH} respectively,[1] with $q_{BH} > q_{BL}$. There is a unit mass of consumers who are heterogeneous in their marginal valuation of quality, θ. We assume that θ is distributed uniformly in the range $[x, x+h]$, with $x > 0$. The higher is x, the less is the heterogeneity in consumers' marginal valuation of quality (Gabszewicz and Thisse 1979, Tirole 1988, pg. 296-297); a higher x also represents a market in which all consumers value quality more highly.

We assume that the market is fully covered, i.e., all consumers buy either the combination $\{\text{A,B}_L\}$ or the combination $\{\text{A,B}_H\}$. This commonly-used assumption is more applicable to mature ecosystems, such as late-stage consoles or smartphones, in which virtually all consumers buy from the ecosystem. It also helps us isolate two core mechanisms in our model - surplus generation and surplus allocation among firms and existing users - without confounding these effects with market expansion.

Given product prices p_A, p_{BL} and p_{BH}, the utility of a consumer of type θ from buying the set $\{\text{A,B}_i\}$, $i = L, H$ is

$$U(A, B_i) = \theta\left(q_A + k q_{Bi}\right) - p_A - p_{Bi},$$

where parameter $k \in (0, 1]$ captures the importance that consumers place on complementary product B relative to that of product A.

On the cost side, we assume that production of quality is costly. Specifically, in market B, the unit variable cost of producing a product of quality q_i is $c + \alpha q_{Bi}^2$. Since our focus in this paper is on firm A influencing the costs of vertically differentiated firms in market B, we normalize firms A's product quality, q_A, to be 1, and its unit variable cost to 1.

[1] As is well known, firms choose different qualities in a vertical differentiation framework.

The time line is as follows. In the first stage, firm A decides whether to lower the cost of production in market B by lowering c and/or α. This assumption reflects commonly-observed technology market scenarios where a monopolist in market A shapes the cost structure in the complementary market B by providing and controlling tools such as SDKs, APIs, and free software libraries essential for complementary product development and production in market B. In the second stage, firms B_L and B_H choose their product qualities; in the third stage, all firms choose their prices; and in the last stage, consumer choose the product combination that gives them the higher utility.

We focus on subgame-perfect equilibrium of this game, and solve it by backward induction.

Pricing Decisions. In the last stage, the consumer of type θ chooses product combination $\{\mathrm{A},\mathrm{B}_H\}$ over the combination $\{\mathrm{A},\mathrm{B}_L\}$ if

$$\theta\left(1+kq_{BH}\right)-p_A-p_{BH}\geq\theta\left(1+kq_{BL}\right)-p_A-p_{BL},$$

leading to the indifferent consumer defined by

$$\overline{\theta}=\frac{p_{BH}-p_{BL}}{k(q_{BH}-q_{BL})}.$$

The demands for the two firms in market B become

$$\begin{aligned}
d_{BH} &= \frac{\left(x+h-\overline{\theta}\right)}{h}=\frac{k\left(x+h\right)\left(q_{BH}-q_{BL}\right)-\left(p_{BH}-p_{BL}\right)}{kh(q_{BH}-q_{BL})},\\
d_{BL} &= \frac{\left(\overline{\theta}-x\right)}{h}=\frac{-kx(q_{BH}-q_{BL})+\left(p_{BH}-p_{BL}\right)}{kh(q_{BH}-q_{BL})}.
\end{aligned}$$

Given that the market is covered, firm A sells to all these consumers.

Firms' profit functions are

$$\begin{aligned}
\pi_{BH} &= \left(p_{BH}-c-\alpha q_{BH}^2\right)d_{BH},\\
\pi_{BL} &= \left(p_{BL}-c-\alpha q_{BL}^2\right)d_{BL},\\
\pi_A &= \left(p_A-1\right)\left(d_{BH}+d_{BL}\right).
\end{aligned}\tag{1}$$

The lowest valuation consumer buys product combination $\{\mathrm{A},\ \mathrm{B}_L\}$, and its utility has to be non-negative, i.e.,

$$U_x=x\left(1+kq_{BL}\right)-p_A-p_{BL}\geq 0.\tag{2}$$

Using (1) and (2), the Nash equilibrium prices, as functions of product qualities chosen in an earlier stage, become:

$$\begin{aligned}
\widehat{p}_{BH} &= c+\frac{k\left(2h+x\right)\left(q_{BH}-q_{BL}\right)+\alpha\left(2q_{BH}^2+q_{BL}^2\right)}{3},\\
\widehat{p}_{BL} &= c+\frac{k\left(h-x\right)\left(q_{BH}-q_{BL}\right)+\alpha\left(q_{BH}^2+2q_{BL}^2\right)}{3},\\
\widehat{p}_A &= -c+\frac{x(3+kq_{BH}+2kq_{BL})-\alpha\left(q_{BH}^2+2q_{BL}^2\right)-hk(q_{BH}-q_{BL})}{3}.
\end{aligned}\tag{3}$$

Product Quality Decisions. Using the above Nash pricing equations from the pricing stage in firms' profit functions in (1), and solving for the optimal qualities, we get the following Nash equilibrium product qualities in Market B.

$$q^*_{BH} = \frac{k(4x+5h)}{8\alpha},\ q^*_{BL} = \frac{k(4x-h)}{8\alpha}. \tag{4}$$

The resulting degree of product quality differentiation is

$$q^*_{BH} - q^*_{BL} = \frac{3hk}{4\alpha}. \tag{5}$$

Using these qualities in the pricing expressions in (3), we get the equilibrium prices as

$$\begin{aligned} p^*_{BH} &= c + \frac{k^2\left(49h^2+16x^2+40hx\right)}{64\alpha}, \\ p^*_{BL} &= c + \frac{k^2\left(25h^2+16x^2-8hx\right)}{64\alpha}, \\ p^*_{A} &= -c + \frac{16x\left(4\alpha+k^2x\right)-25h^2k^2}{64\alpha}. \end{aligned} \tag{6}$$

And the firms' profits become

$$\pi^*_{BH} = \frac{3h^2k^2}{16\alpha},\ \pi^*_{BL} = \frac{3h^2k^2}{16\alpha},\ \pi^*_{A} = -c + \frac{16x\left(4\alpha+k^2x\right)-25h^2k^2-64\alpha}{64\alpha}. \tag{7}$$

Finally, the following parametric restrictions are necessary for the standard second-order conditions and non-negativity conditions for profits to hold for this model:

a) when $0 < h < \frac{2\alpha}{3k^2}$: for $0 < c \leq \frac{2\alpha h - 3h^2k^2}{8\alpha}$, $x > \frac{h}{4}$;for $c > \frac{2\alpha h - 3h^2k^2}{8\alpha}$, $x > \frac{\sqrt{64\alpha^2+64\alpha ck^2+25h^2k^4}-8\alpha}{4k^2}$.

b) when $h \geq \frac{2\alpha}{3k^2}$: for $c > 0$, $x > \frac{\sqrt{64\alpha^2+64\alpha ck^2+25h^2k^4}-8\alpha}{4k^2}$.

3. Firm A's Incentives for Complementary Market B

3.1 Lowering their cost that does not affect product quality.

Using (4)–(7), we have

$$\begin{aligned} \frac{\partial q^*_{BH}}{\partial c} &= \frac{\partial q^*_{BL}}{\partial c} = 0;\ \frac{\partial p^*_{BH}}{\partial c} > 0;\ \frac{\partial p^*_{BL}}{\partial c} > 0; \\ \frac{\partial p^*_{A}}{\partial c} &< 0;\ \frac{\partial \pi^*_{A}}{\partial c} < 0. \end{aligned}$$

Thus, firm A benefits from lowering c for the complementary market B. This is consistent with the traditional advice that a firm should commoditize its complementary market. In this case, a reduction in the common variable cost in the complementary market leads to the competing firms in Market B lowering their prices without changing their product qualities. This then allows the monopoly firm A to increase its price and extract more of the value generated by the system (A+B).

3.2 Lowering their cost that affects their product quality.

Using (4)-(7), we find that

$$\begin{aligned}
\frac{\partial q^*_{BH}}{\partial \alpha} &< 0;\ \frac{\partial q^*_{BL}}{\partial \alpha} < 0;\ \frac{\partial \left(q^*_{BH} - q^*_{BL}\right)}{\partial \alpha} < 0; \\
\frac{\partial p^*_{BH}}{\partial \alpha} &< 0;\ \frac{\partial p^*_{BL}}{\partial \alpha} < 0;\ \frac{\partial \left(p^*_{BH} - p^*_{BL}\right)}{\partial \alpha} < 0; \\
\frac{\partial \pi^*_A}{\partial \alpha} &= \frac{k^2\left(25h^2 - 16x^2\right)}{64\alpha^2} \gtreqless 0 \text{ for } \frac{x}{h} \lesseqgtr \frac{5}{4}.
\end{aligned}$$

This leads to our main result.

Proposition 1. *A monopoly firm in market A benefits from lowering the marginal cost of quality production in its complementary market B only when the degree of heterogeneity in consumers' marginal valuation of quality is sufficiently small ($x/h > 5/4$).*

The intuition is as follows. When the monopoly firm in market A lowers the marginal cost of quality production in its complementary market B, it makes it optimal for both firms in market B to increase their product qualities. This increases consumer valuation of the whole system, that consists of not only product B but also product A. Thus, this force benefits firm A.

However, a lowering of marginal cost of quality production in market B also increases the degree of quality differentiation between the two competing firms in market B. Specifically, the higher-quality firm increases its quality more than what the lower-quality firm does. The reason is as follows. On the cost side, since the per-unit cost of quality is convex (αq^2), the marginal cost of increasing quality is $2\alpha q$. When α decreases, the marginal cost of raising quality falls more for the higher-quality firm than for the lower-quality firm because its initial quality level is higher. This incentivizes the higher-quality firm to raise quality more than the lower-quality firm. On the demand-side, given that the higher-quality firm serves consumers with higher valuation of quality than those served by the lower-quality firm, a reduction in α incentivizes the higher-quality firm to raise quality more than the lower-quality firm.

Thus, due to both these cost-side and demand-side incentives, the higher-quality firm raises its quality more than the lower-quality firm does, leading to an increase in the degree of quality differentiation between the two competing firms in market B. This increased degree of quality differentiation in market B softens the price competition in market B, allowing firms in market B to capture a larger portion of the total value generated in the system. Thus this force hurts firm A.

Overall, whether the monopoly firm in market A benefits or not from reducing α in its complementary good market B depends on which of the above two effects dominates – increase in value of the (A+B) system or the softer price competition and more extraction of surplus by firms in the complementary market B. We find that this depends on how heterogeneous consumers are in their valuation of an incremental increase in quality. If this heterogeneity is small ($x/h > 5/4$), then the increase in quality differentiation is small and, also, increase in product qualities are valued more (the valuation floor x is high). Thus the softening of price competition in market B is small, and firm A is able to capture more of the system surplus. Here, firm A finds it optimal to commoditize its complementary market by reducing their cost of producing quality.

Conversely, if heterogeneity in consumer valuation of quality is large ($x/h < 5/4$), then the increase in quality differentiation is large and, also, increase in product qualities are valued less

(the valuation floor x is low). Thus the softening of price competition in market B is large, and firm A is able to capture less of the system surplus. Hence, here firm A does not find it optimal to commoditize its complementary market by reducing their cost of producing quality. As alluded to earlier, these two effects – surplus generation and allocation among firms and existing users - would still persist even when consumers have some outside option.

4. Welfare

Consumer Surplus. If firm A commoditizes its complementary market via reduction of quality-production costs there, consumer surplus is affected through the following channels. First, since product qualities increase in Market B, consumers get to benefit from a higher quality of the system they buy. On the other hand, this action by firm A also softens intensity of price competition in Market B via increased quality differentiation, and this force can hurt consumers. Finally, firm A itself has the option to increase its price to capture some of the additional surplus generated in the system from increased product qualities in Market B.

Formally, consumer surplus is

$$CS = \int_{x}^{\overline{\theta}} \left(\frac{1}{h} \left(\theta \left(1 + k q_{BL} \right) - p_A - p_{BL} \right) \right) d\theta + \int_{\overline{\theta}}^{h+x} \left(\frac{1}{h} \left(\theta \left(1 + k q_{BH} \right) - p_A - p_{BH} \right) \right) d\theta.$$

Using the equilibrium values of product qualities and prices derived earlier, we get

$$CS^* = \frac{h \left(16\alpha + k^2 (h + 8x) \right)}{32\alpha}.$$

This gives

$$\frac{\partial CS^*}{\partial \alpha} = -\frac{h k^2 (h + 8x)}{32\alpha^2} < 0.$$

Thus, in our model, the quality increase effect overwhelms the other two effects mentioned above, and consumers benefit from firm A commoditizing its complementary market through reduction of quality production costs.

Social Surplus. Social surplus can be calculated as the sum of consumer surplus and all firms' profits shown above. It becomes

$$SS^* = \frac{32\alpha(h + 2x) + 16k^2 x(h + x) + h^2 k^2 - 64\alpha(1 + c)}{64\alpha}.$$

This gives

$$\frac{\partial SS^*}{\partial \alpha} = -\frac{k^2 \left(h^2 + 16hx + 16x^2 \right)}{64\alpha^2} < 0.$$

Thus, social surplus increases from firm A commoditizing its complementary market through reduction of quality production costs. This is to be expected as the cost reduction in market B is a pure efficiency improvement. It lowers resource cost one-for-one for any given quality profile and induces both B-firms to raise quality from a level that is already below first best. And price adjustments in A and B merely redistribute the resulting surplus between consumers and firms, leaving total welfare unchanged.

5. Conclusion

This paper identifies some boundary conditions under which a monopolist benefits from commoditizing a complementary market. We show that the strategic value of cost reduction in the complementary market depends critically on whether production costs are tied to product quality, and on the degree of consumer heterogeneity in valuation of quality.

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