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PRODUCT DIFFERENTIATION, BUNDLING AND MARKET STRUCTURE

GWANGHOON LEE*

In a systems market where two complementary components must be used in combination to provide valuable services, decisions of bundling components and resulting market competition structures are shown to depend on the difference between two components in their degrees of product differentiation. The larger this difference, the greater become the incentives for bundling, and more systems are provided as bundles in the market.

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I. PRODUCT DIFFERENTIATION AND INCENTIVES FOR BUNDLING

Economists have long explained bundling incentives in many different ways. According to Adams and Yellen(1976), Schmalensee(1982, 1984), McAffe *et al*(1989), bundling may serve as a good means of price discrimination by a monopolist. Bundling is also described as an effective tool of deterring market entry of competitors by Whinston(1990), Choi and Stefanadis(2001), Calton and Waldman(2002) and Choi(2003) among many others. Until Whinston(1990) examined the role of strategic bundling as an entry deterrent device in a game theoretical framework, the Chicago school represented by Bowman (1957), Posner (1976) and Bork (1978) had largely succeeded in discrediting the idea of leveraging monopoly power by bundling. They point to a number of efficiency justifications, or benign explanations for bundling practices. Nalebuff (1999) and Choi (2003) provide good surveys on these different views on bundling incentives.

This paper relates product differentiation to bundling incentives and ensuing

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* Correspondence to: Gwanghoon Lee, KISDI, 1-1 Juam, Gwachun, Gyunggi, 427-710, Rep. of KOREA. Tel) +822-570-4331 Fax) +822-570-4169 E-mail:glee@kisdi.re.kr

market competition structures in systems markets. In fact, Carbajo *et al*(1990) and Chen(1997) already pointed out that product bundling could be adopted as a product differentiation device. But they do not specifically investigate the relationship between the degree of product differentiation and the bundling incentives.

Intuitively, in a duopoly situation, as commodities produced by two firms become more differentiated, each firm can raise its price as it gains more market power and, thus, garner more profits. Therefore, firms may try to differentiate their products as much as possible to maximize their profits. Firms, however, can face limitations in achieving further differentiation with their own products. In such cases, they can achieve their goals by bundling complementary products that are distinctly differentiated. For instance, in telecommunications industries, most service providers try to differentiate their voice telecommunications services by incorporating various types of other complementary services such as voice recognition, conference call, Internet connection, etc. This is motivated by the fact that basic voice telecommunications services among providers become less differentiated as most regulatory bodies guarantee equal access to physical networks. For the same reason, providers of high speed Internet services bundle various types of value added services with their Internet services and mobile handset manufacturers bundle digital camera or MP3 player with their handset products.

In a systems market where two complementary components must be used in combination to provide valuable services, it is expected that bundling incentives become stronger as the difference between two components in their degrees of differentiation becomes larger. In this case, bundling can work as a device to capture more surpluses by enhancing product differentiation. Let's call this 'the differentiation effect'. This effect becomes weak when the difference in the degrees of differentiation becomes small since bundling does not help much in improving product differentiation. On the other hand, intuitively, this bundling strategy is also expected to have an offsetting effect on the profits. A firm will lower its price of the system after bundling because bundling will make the firm internalize the effect of an increase in the price of one of its component products on the demand of the whole bundled system. Denicolo (2000) calls this 'the price effect'. The differentiation effect is more likely to dominate the price effect, as the difference in the degrees of differentiation between two components becomes larger. In this case, bundling becomes an attractive strategy among more firms, which results in changes of the market competition structure.

In such systems market, Denicolo(2000) analyzes bundling incentives of a generalist firm that produces both components when it faces competition against two specialist firms that produce one component each. By extending a mix-match model developed by Matutes and Regibeau (1988), he shows that the generalist firm may have an incentive to choose to engage in bundling when one component becomes less differentiated than the other so that the difference between two components in their degrees of differentiation becomes large. But he considers only an asymmetric situation where only the generalist is capable of bundling in advance of its specialist competitors.

This paper approaches the same mix-match model with different viewpoints. In this paper, a system is also composed of two components, which are produced by two generalist firms. That is, unlike the asymmetric situation of Denicolo (2000), we start with a symmetric situation where two firms are what Denicolo calls generalist, i.e. producers of both components. These firms can choose to bundle their components. In fact, this setup of the model is similar to Matutes and Regibeau (1988) except the fact that the degree of product differentiation can vary and two components are not symmetric in their locations. What we want to see from the model is how the market competition structure is eventually determined, or, how many bundled products are expected to emerge in the market, depending on the difference between two components in their degrees of differentiation. That is, market competition structure is endogenized and determined by the degree of product differentiation in the model. In fact, the market structure that Denicolo(2000) or Matutes and Regibeau (1988) deals with is just one of possible outcomes from the interactions among firms in the model explained below.

Ⅱ. MODEL

A system is composed of two components X and Y. There are two horizontally differentiated firms I and II and each firm produces both components. The mass of consumers is normalized to one and they are located uniformly over the unit square with angular points, $(0,0), (0,1), (1,0)$ and $(1,1)$. Firm I produces component $X=\alpha$ and $Y=0$ while firm II produces component $X=1-\alpha$ and $Y=1$, where $0 \leq \alpha \leq \frac{1}{2}$. Therefore, consumers have four systems to choose from, namely $(\alpha,0), (\alpha,1)$, $(1-\alpha,0)$ and $(1-\alpha,1)$. This setting implies that Y is fully differentiated and that its degree of differentiation is fixed while the degree of differentiation of X varies. When $\alpha=0$, X is also fully differentiated and both goods have the same degree of differentiation. In this case, the model becomes that of Matutes and Regibeau(1988). When $\alpha=\frac{1}{2}$, X is not differentiated and thus the difference between X and Y in their degrees of differentiation reaches its maximum. Note that the parameter α measures the difference between X and Y in their degrees of product differentiation. For simplicity, we do not consider the situation where the degree of product differentiation in Y also varies. Varying the degree for Y would further generalize the model but it would not give any practical benefits because the main result of the paper is derived from the difference between X and Y in their degrees of differentiation.

For simplicity, each consumer is assumed to consume at most one system.

Consumers have reservation values for the system that are high enough to cover all the market. The marginal production cost is normalized to zero. Consumers will choose to consume the system that minimizes the sum of the price of the system and the transportation cost to the system. The transportation cost from a consumer (x, y) to a system (k, l) is simply measured by the quadratic function $(x-k)^2+(y-l)^2$.

Ⅲ. EQUILIBRIUM

Each firm will decide whether to bundle its components, and then engage in price competition. We consider only a 'pure bundling' situation. In other words, we do not allow a 'mixed bundling' situation where firms price and sell their bundled systems separately from their individual components.[1] The equilibrium concept will be the sub-game perfect equilibrium. We will solve the equilibrium by the backward induction. In the first place, the results of price competition will be figured out for the possible outcomes of market competition structures. Then firms' decisions regarding whether to bundle their components and ensuing market competition structures will be analyzed.

3.1. Price competition

3.1.1. Unbundling

In the market for X, prices for two products $X=a$ and $X=1-a$ and corresponding profits are denoted by p_a^X, p_{1-a}^X, π_a^X and π_{1-a}^X, respectively. These are simply calculated as

$$p_a^X=p_{1-a}^X=1-2a, \pi_a^X=\pi_{1-a}^X=\frac{1}{2}(1-2a). \tag{1}$$

Similarly, in the market for Y, prices and profits are given as follows:

$$p_0^Y=p_1^Y=1, \ \ \pi_0^Y=\pi_1^Y=\frac{1}{2}. \tag{2}$$

Note that prices and profits are lower in the less differentiated component X market. The system price and profit for firm i, in this case, are denoted by P_i^{UU} and Π_i^{UU}, respectively. Then, we have:

$$P_I^{UU}=P_{II}^{UU}\equiv P^{UU}=2(1-a), \ \ \Pi_I^{UU}=\Pi_{II}^{UU}\equiv\Pi^{UU}=1-a. \tag{3}$$

[1] Matutes and Regibeau (1992) extend Matutes and Regibeau (1988) to investigate the implications of the introduction of mixed bundling in their mix-match model.

3.1.2. Bundling

Both firms participate in bundling

When both firms engage in bundling, only two systems $(a, 0)$ and $(1-a, 1)$ are available to consumers. The system price and profit for firm i, in this case, are denoted by P_i^{BB} and Π_i^{BB}, respectively. Simple calculation gives the following:

$$P_I^{BB}=P_{II}^{BB}\equiv P^{BB}=1,\ \Pi_I^{BB}=\Pi_{II}^{BB}\equiv\Pi^{BB}=\frac{1}{2}. \tag{4}$$

Note that $P^{UU}>P^{BB}$ and $\Pi^{UU}>\Pi^{BB}$ except for the extreme case where products of component X are perfect undifferentiated, namely, $a=\frac{1}{2}$. In this case, the difference between X and Y in their degrees of product differentiation reaches its maximum and, thus, the 'price effect' disappears while the 'differentiation effect' is maximized.

Only one firm participates in bundling

In this case, the model becomes that of Denicolo (2000). As the basic analysis here coincides with Denicolo (2000), only results are presented. Prices and profits for the bundling firm and the unbundling firm are denoted by (P^{BU}, Π^{BU}) and (P^{UB}, Π^{UB}), respectively. When $a=\frac{1}{8}$, these are given as follows:

$$P^{BU}=\frac{(-6+6a+4\sqrt{a^2-22a+11})}{5},\ P^{UB}=\frac{2(1-a+\sqrt{a^2-22a+11})}{5} \tag{6}$$

$$\Pi^{BU}=\frac{(2-2a)(a^2+158a-79)+(a^2-82a+41)\sqrt{a^2-22a+11})}{125(1-2a)} \tag{7}$$

$$\Pi^{UB}=\frac{(2-2a)(2a^2-34a+17)+(2a^2-14a+7)\sqrt{a^2-22a+11})}{125(1-2a)} \tag{8}$$

On the other hand, they are given as follows when $a\geq\frac{1}{8}$:

$$P^{BU}=\frac{5}{4},\ P^{UB}=\frac{6}{4} \tag{9}$$

$$\Pi^{BU}=\frac{25}{32},\ \Pi^{UB}=\frac{18}{32} \tag{10}$$

3.1.3. Firm's profit and the degree of differentiation

From (3), (4), (7) and (8), we can order the magnitudes of firm's profits in various market competition situations. That is, we have the following.

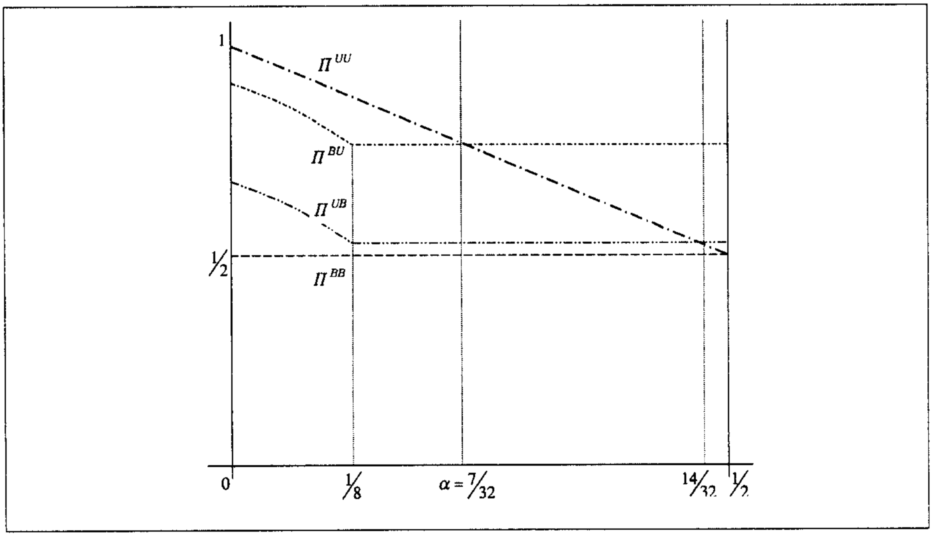
$$\Pi^{UU} > \Pi^{BU} > \Pi^{UB} > \Pi^{BB} \text{ if } 0 \le \alpha < \frac{7}{32} \quad (11)$$

$$\Pi^{BU} \ge \Pi^{UU} > \Pi^{UB} > \Pi^{BB} \text{ if } \frac{7}{32} \le \alpha < \frac{14}{32} \quad (12)$$

$$\Pi^{BU} > \Pi^{UB} \ge \Pi^{UU} \ge \Pi^{BB} \text{ if } \frac{14}{32} \le \alpha < \frac{1}{2} \quad (13)$$

Using (11) - (13), the figure 1 summarizes the results of price competition in the model. As we can see from the figure, each firm's profit depends on the difference between two components in their degrees of differentiation and the market competition structure.

[Figure 1] Changes in profits with respect to the change in α



Π^{BU} and Π^{UB} have kinked points at $\alpha = \frac{1}{8}$. The order of magnitudes of profits is changed at $\alpha = \frac{7}{32}$ and $\alpha = \frac{14}{32}$.

3.2. Bundling decision

Given the results of price competition, each firm will decide whether to bundle their component products. Therefore the game is reduced to a two by two game where the payoff matrix is given by the table 1.

[Table 1] Payoff matrix for the game

		Firm II	
		Unbundling	Bundling
Firm I	Unbundling	(Π^{UU}, Π^{UU})	(Π^{UB}, Π^{BU})
	Bundling	(Π^{BU}, Π^{UB})	(Π^{BB}, Π^{BB})

Depending on the size of α, that is, the difference between X and Y in their degrees of product differentiation, the values of Π^{UU}, Π^{BU}, and Π^{UB} change as can be seen in figure 1 and thus several different outcomes are possible.

3.2.1. Small difference $(0 \leq \alpha < \frac{7}{32})$

From (11) and figure 1, we can notice that both Π^{BU} and Π^{UB} are smaller than Π^{UU} and greater than Π^{BB} for $(0 \leq \alpha < \frac{7}{32})$. Therefore, the sub-game perfect equilibrium in this case is that both firms choose the unbundling strategy and have Π^{UU} as a consequence of price competition. This equilibrium is unique and thus regarded as the natural choice of the market. This result continues to hold even if we consider a dynamic game where each firm decides its strategy by turns instead of by simultaneous decision. Results can be summarized as follows.

Proposition 1. *With small difference between X and Y in their degrees of product differentiation $(0 \leq \alpha < \frac{7}{32})$, firms choose not to bundle regardless of the order of move.*

3.2.2. Large difference $(\frac{7}{32} \leq \alpha < \frac{1}{2})$

From (12), (13) and figure 1, we can verify that sub-game perfect equilibria for both cases of $(\frac{7}{32} \leq \alpha < \frac{14}{32})$ and $(\frac{14}{32} \leq \alpha < \frac{1}{2})$ coincide. Firstly, there are two pure strategy equilibria where one firm chooses bundling and earns the profit of Π^{BU} while the other firm chooses unbundling and earns the profit of Π^{UB}. There also exists a mixed-strategy equilibrium. Let the probability $q(\alpha)$

be assigned to the choice of bundling in this mixed-strategy equilibrium. Then, $q(\alpha)$ is calculated as follows:

$$q(\alpha)=\frac{32\alpha-7}{32\alpha-5},\ \ q'(\alpha)>0,\ \ \frac{7}{32}\leq\alpha\leq\frac{1}{2} \tag{14}$$

Note that the probability of choosing bundling is an increasing function of α (the difference between X and Y in their degrees of product differentiation). Among these equilibria it is not straightforward which one is likely to be the natural outcome of the market. However, pure strategy equilbria are not very interesting because there is no knowing which firm chooses bundling. Without additional assumptions about the game, it would be rational to expect that firms choose to randomize their choices of strategies in this symmetric situation. The choice of mixed strategy equilibrium makes the market competition structure random. This random structure of the market is given as follows.

$$Q^{UU}=(1-q(\alpha))^2,\ \ Q^{BB}=q(\alpha)^2,\ \ Q^{UB}=2q(\alpha)(1-q(\alpha)), \tag{15}$$

where Q^{UU} is the probability that both firms choose unbundling, Q^{UB} is the probability that one firm chooses a different strategy from the other firm, and Q^{BB} is the probability that both firms engage in bundling.

From (14) and (15), we can check that the likelihood of all groups choosing bundling increases while the likelihood of all groups choosing unbundling decreases, as α increases. The figure 2 shows how these probabilities respond to a change in α.

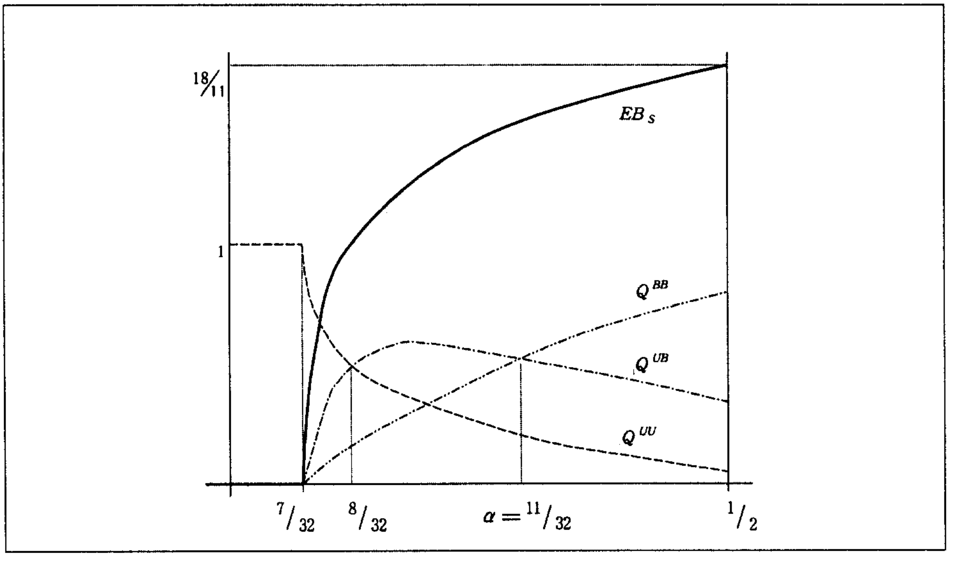
From figure 2, we can see that the likelihood of both firms choosing bundling is the highest when $\frac{7}{32}\leq\alpha<\frac{8}{32}$ while the likelihood of both firms choosing unbundling is the highest when $\frac{11}{32}<\alpha-\frac{1}{2}$. On the other hand, when $\frac{8}{32}<\alpha-\frac{11}{32}$, each firm choosing a different strategy is the most likely. The following proposition summarizes results.

Proposition 2. *With large difference between X and Y in their degrees of product differentiation ($\frac{7}{32}\leq\alpha<\frac{1}{2}$), a market competition structure becomes random when firms move simultaneously with a mixed strategy. As the difference becomes larger, the more likely firms are engaging in bundling.*

In fact, from (15) we can figure out how the expected number of bundled products that emerge in the market changes with the change in α. In figure 2, a thick line labeled as *EBs* represents this.

Although there is no knowing which firm bundles their components in pure strategy equilibria with simultaneous move, it becomes clear that the first mover will bundle its components if we consider a sequential move. This sequential move can be justified if we further assume that bundling requires a serious idea or innovation and this idea or innovation occurs in random manner to firms that are in need of bundling. Therefore, we have the following result.

[Figure 2] Random structure of the market



When $\alpha<\frac{7}{32}$, both firms choose unbundling so that we have $Q^{UU}=1$. The term EB_s represents the expected number of bundled systems.

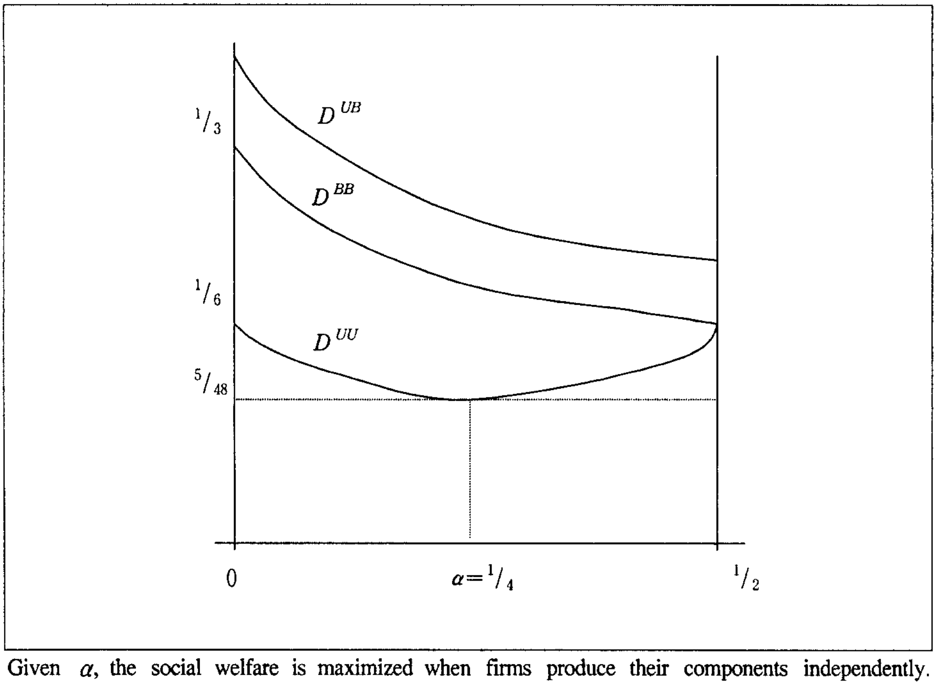
Proposition 3. *With large difference between X and Y in their degrees of product differentiation ($\frac{7}{32}\leq\alpha\leq\frac{1}{2}$), a market competition structure becomes asymmetric when firms move simultaneously with a pure strategy (or move sequentially): the one (or the first mover) is engaging in bundling while the other is producing their component products independently.*

Even in this case, the number of bundled products increases from zero to one as the difference between two component products in their degrees of product differentiation increases. Denicolo(2000) deals with this asymmetric situation where only the generalist firm is capable of initiating bundling.

Ⅳ. WELFARE IMPLICATIONS

Under our simplifying assumptions of sufficient reservation values of consumers and constant marginal costs of producers, a shift in the price of system only transfers surplus from consumers to producers or vice versa. Therefore, the social welfare depends only on the total transportation costs of consumers. Let this total transportation costs be denoted by D^{UU}, D^{UB} and D^{BB}, respectively depending on the market situatations. The total transportation costs when none of firms bundle their products, namely, D^{UU} should be the smallest because consumers have the most choices. That is, given α, the social welfare is maximized when firms do not bundle their products. In fact, this result resembles that of Matutes and Regibeau (1988). They show that compatibility among components increases social welfare. Likewise, in our model, unbundling increases social welfare unless bundling provides consumers with extra benefits. Note that the total transportation costs of consumers are higher when only one firm engages in bundling than when both firms engage in bundling. That is, we have $D^{UB} > D^{BB}$. In fact, the number of choices for systems in these two situations is equally two. Nevertheless, as can be verified from (6), the prices of systems are different when only one firm bundles their components, which causes a part of consumers to choose the system that is not optimal choice in terms of the transportation costs. The figure 3 shows the changes of D^{UU}, D^{UB} and D^{BB} with the change in the difference between X and Y in their degrees of product differentiation

[Figure 3] Total transportation costs of consumers



Given α, the social welfare is maximized when firms produce their components independently. In extreme case where the difference between X and Y in their degrees of product differentiation reaches its maximum (i.e. $\alpha=\frac{1}{2}$), we have $D^{UU}=D^{BB}$.

Therefore, from the proposition 1, we can see that the decentralized equilibrium is socially optimal when the difference between two components in their degrees of product differentiation is small $(0 \leq \alpha < \frac{7}{32})$. However, from the proposition 2 and 3, we can also verify that there is socially excessive bundling in the market when this difference becomes large $(\frac{7}{32} \leq \alpha \leq \frac{1}{2})$.

Ⅳ. CONCLUSION

This paper investigates how the bundling strategies of firms in a systems market that is composed of two components are affected by the difference between these two components in their degrees of product differentiation and what types of market competition structures result from these bundling strategies. The results in this paper, making use of the mix and match models of Matute and Regibeau (1988) and Denicolo(2000), support the following: When the difference between two components in their degrees of product differentiation is relatively small, then bundling incentives are not strong and the market is more likely to be the one where all firms produce their components independently. In contrast, as this difference becomes larger, it is likely that more firms engage in bundling in the market. From the social standpoint, however, there is socially excessive bundling in this case.

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