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Partial passive ownership holdings and licensing☆

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ABSTRACT

In a homogeneous good Cournot duopoly, a firm owns a cost-reducing technology and has a non-controlling share over its rival. We show that partial passive ownership holdings (PPOs) may induce licensing via a fixed fee and increase consumer surplus and social welfare. We thus identify a novel pro-competitive effect of PPOs.

1. Introduction

Partial passive ownership holdings (henceforth PPOs), a situation in which a firm owns non-controlling minority shares of its rivals, have raised antitrust concerns due to their well-documented anti-competitive effects (Azar et al., 2018; Elhauge, 2020). However, recent literature points out that PPOs may also have beneficial effects on market outcomes and welfare (Bayona and Lopez, 2018; Papadopoulos et al., 2019). This has prompted a vivid debate among competition authorities and policy-makers regarding the pro- or anti-competitive effects of PPOs and the need for their regulation (European Commission, 2014; OECD, 2017; Phillips, 2018).

A central issue in this debate concerns the impact of PPOs on patent licensing and technology transfer (as crucial drivers of economic growth) between the involved firms (López and Vives, 2019; Vives, 2020). In general, if a firm owns a cost-reducing technology which is contractible, then it can license it to a rival firm. But, if the technology is non-contractible, then the low-cost firm can induce technology transfer by acquiring a part of the rival firm. These two ways are often seen as *substitutes* (Ghosh and Morita, 2017).

In this paper, we offer an alternative view. By introducing fixed-fee licensing in an otherwise standard homogeneous product Cournot duopoly, we show that these two channels of technology transfer can be *complements*.[1] We show that PPOs can promote licensing via fixed fees and thus, contrary to common perception, can lead to higher consumer surplus and social welfare. We thus highlight a novel pro-competitive effect of PPOs.

Our paper relates to the growing literature on the pro- and anti- competitive effects of PPOs (Gilo et al., 2006; Li et al., 2015; Azar et al., 2018; Schmalz, 2018; Brito et al., 2019). Recent results provide conditions under which PPOs have positive effects on product innovation (Anton et al., 2021; López and Vives, 2019), product quality and consumer surplus (Brito et al., 2020), and transfer of tacit knowledge and product innovation (Ghosh and Morita, 2017; Papadopoulos et al., 2019). We contribute to this literature by providing a novel pro-competitive effect of PPOs within a licensing framework.

Ghosh and Morita (2017) is the closest paper to our work. The authors consider firms choosing to transfer their technology either via PPOs *or* via licensing under royalties and highlight the substitutability between these alternative methods of technology transfer. We, instead, establish cases of complementarity between

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PPOs and technology licensing via fixed fees. We consider fixed fees because, as we discuss below, there are situations in which royalties are hardly applicable or may not be preferable.

There is substantial empirical evidence that fixed fees are common in many real-world markets. For instance, they are used in short-term licensing (Mendi, 2005), when licensing has a high potential of follow-up innovations (Yanagawa and Wada, 2000), in licensing activities in developing countries (Yang and Maskus, 2009), or when firms import foreign technology under volatile sales (Vishwasrao, 2007). They are also common in technology licensing in university start-ups and spin-offs (Aksoy and Beaudry, 2021), and in university–industry partnerships (Drozdoff and Fairbairn, 2015). Fixed fees have also found their way into the digital economy. Patent pledges and the use of non-fungible tokens to trade digital creative work can be seen as equivalent to fixed fees (Handke et al., 2016; Crow, 2021).

In contrast to royalties which are output-based licensing schemes, fixed fees are lump sum upfront transfers. So, in practice, firms may prefer the latter over the former in situations where the licensees' output is difficult to observe.[2]

2. The model

We consider a homogeneous good Cournot duopoly. Firms face an inverse linear demand, $p(q_1, q_2) = \alpha - q_1 - q_2$, where q_i is firm i's quantity and p is the price of the good. Firm 2 has a production technology with marginal cost $c > 0$. Firm 1 owns a *superior* technology, and produces with marginal cost $c - e$, where $e \in (0, c)$ is the marginal cost reduction induced by the technology. Firm 1 also has partial passive ownership holdings (PPOs) over firm 2, owning a share $k \in (0, \frac{1}{2}]$ of firm 2's *net* profits.

Firms engage in a two-stage game. In stage 1, firm 1 decides whether to license its superior technology to firm 2 via a fixed fee $F \geq 0$. In stage 2, firms compete in quantities. The firms' net profits are:

$$\pi_1(q_1, q_2, F) = [p(q_1, q_2) - c + e]q_1 + F + k[(p(q_1, q_2) - c_2)q_2 - F]$$
$$\pi_2(q_1, q_2, F) = (1 - k)[(p(q_1, q_2) - c_2)q_2 - F] \quad (1)$$

where $c_2 = c$ and $F = 0$ under no licensing, while $c_2 = c - e$ and $F > 0$ under licensing. We solve the game by backward induction.

To guarantee that firm 2 is active in the market under no licensing, we assume that $\varepsilon = \frac{e}{\tilde{\alpha}} < 1$, where $\tilde{\alpha} = \alpha - c$ is a proxy for market size, and $\varepsilon \in (0, 1)$ measures how effective is the technology in reducing marginal cost (relative to market size).[3]

It can be verified that, in a setting like ours, a per-unit royalty licensing scheme is superior to a fixed fee licensing scheme. Also, it is the best among licensing schemes that combine fixed fees with per-unit royalties, e.g., licensing via two-part tariffs. This is consistent with the existing literature, e.g., Wang (1998). However, as mentioned above, in practice firms may prefer to use fixed fees rather than royalties due to various reasons. Due to such practical constraints, this paper considers licensing based only on fixed fees.[4]

3. Equilibrium analysis

In stage 2, there are two subgames. The *No Technology Licensing* subgame (superscript N) in which firms' marginal costs are asymmetric, $c - e$ and c, and the *Technology Licensing* subgame (superscript L) in which firms have the same marginal cost, $c - e$.

3.1. No technology licensing

Setting $c_2 = c$ and $F = 0$ in (1), each firm i chooses q_i to maximize its profits, taking the rival's output as given. The reaction functions are downward slopping:

$$R_1^N(q_2) = \tfrac{1}{2}[\tilde{\alpha}(1 + \varepsilon) - (1 + k)q_2]$$
$$R_2^N(q_1) = \tfrac{1}{2}(\tilde{\alpha} - q_1) \quad (2)$$

Notice that the higher firm 1's level of PPOs, the less aggressive it becomes in the market ($\frac{\partial R_1^N}{\partial k} < 0$), shifting production towards its partially owned rival. Solving the system of (2) and using (1), we get the equilibrium outcome under no licensing:

$$q_1^N = \frac{(1 - k + 2\varepsilon)\tilde{\alpha}}{(3 - k)}$$
$$q_2^N = \frac{(1 - \varepsilon)\tilde{\alpha}}{(3 - k)}$$
$$\pi_1^N = \frac{[1 + (4 - k)(1 - k + \varepsilon)]\tilde{\alpha}^2}{(3 - k)^2}$$
$$\pi_2^N = \frac{(1 - k)(1 - \varepsilon)^2\tilde{\alpha}^2}{(3 - k)^2} \quad (3)$$

Since $\varepsilon < 1$, $q_2^N > 0$. Clearly, the higher ε, the higher (lower) are firm 1's (firm 2's) profits. Further, due to production shifting, firm 2's (firm 1's) output increases (decreases) with k. As PPOs ease competition (Brito et al., 2019), aggregate output, $Q^N = q_1^N + q_2^N$, decreases with k.

Interestingly, firm 1's profits as well as industry profits, $\Pi^N = \pi_1^N + \pi_2^N$, increase with k but only if the technology is not too effective.[5] But, firm 2's profits always decrease with k. As a result, consumer surplus $CS^N = \frac{1}{2}(Q^N)^2$ and social welfare $SW^N = CS^N + \Pi^N$ decrease with k as well.

3.2. Technology licensing

Under licensing, firms' marginal costs are equal. Setting $c_2 = c - e$ in (1), each firm i chooses q_i to maximize its profits. Both reaction functions are downward slopping:

$$R_1^L(q_2) = \tfrac{1}{2}[\tilde{\alpha}(1 + \varepsilon) - (1 + k)q_2]$$
$$R_2^L(q_1) = \tfrac{1}{2}[\tilde{\alpha}(1 + \varepsilon) - q_1] \quad (4)$$

Technology licensing shifts firm 2's reaction function outwards, $R_2^L(q_1) > R_2^N(q_1)$, while it has no effect on firm 1's reaction function, $R_1^N(q_2) = R_1^L(q_2)$. So, in equilibrium, there is a shift of production towards firm 2. Solving the system of (4), we get the equilibrium outputs under licensing:

$$q_1^L = \frac{(1 - k)(1 + \varepsilon)\tilde{\alpha}}{(3 - k)}$$
$$q_2^L = \frac{(1 + \varepsilon)\tilde{\alpha}}{(3 - k)} \quad (5)$$

Notably, no matter firm 1's level of PPOs k, firm 2's output is higher, $q_2^L > q_1^L$. Due to production shifting, firm 2's (firm 1's)

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[2] Also, a licensor may prefer fixed-fee licensing for accountability reasons due to profits misrepresentation, or due to weak patent protection against imitators. For a comprehensive comparison of various licensing schemes, see Sen and Tauman (2018).

[3] We, thus, assume that firm 1's superior technology is *non-drastic* (Arrow, 1962).

[4] We would like to thank an anonymous referee for pointing this out to us.

[5] In particular, $\frac{\partial \pi_1^N}{\partial k} > 0$ if and only if $\varepsilon < \frac{2}{5-k} \leq \frac{4}{9}$, and $\frac{\partial \Pi^N}{\partial k} > 0$ if and only if $\varepsilon < \frac{1-k}{2(2-k)} \leq \frac{1}{4}$.

output increases (decreases) with k. Moreover, aggregate output, $Q^L = q_1^L + q_2^L$, decreases with k, because PPOs ease competition.

Substituting (5) into (1), we get the firms' profits as a function of the license fee $F \geq 0$.[6] Since $\frac{\partial \pi_1^L(F)}{\partial F} = 1 - k > 0$, firm 1 sets the highest fee in stage 1 such that firm 2 agrees to become a licensee. Hence, the equilibrium fee F^L is such that $\pi_2^L(F^L) = \pi_2^N$, which leads to $F^L = \frac{4\varepsilon\tilde{\alpha}^2}{(3-k)^2}$. As expected, F^L increases with ε. But, it also increases with k, because firm 2's profits decrease faster with k under no licensing than under licensing. The firms' equilibrium profits under licensing are:

$$\pi_1^L = \frac{[1 + \varepsilon(6 - 4k + \varepsilon)]\tilde{\alpha}^2}{(3-k)^2}$$

$$\pi_2^L = \frac{(1-k)(1-\varepsilon)^2\tilde{\alpha}^2}{(3-k)^2} \qquad (6)$$

Once more, the higher ε, the higher (lower) are firm 1's (firm 2's) profits. Contrary to no licensing, firm 1's profits as well as industry profits, $\Pi^L = \pi_1^L + \pi_2^L$, always increase in k. As firm 2's profits are equal across licensing regimes, $\pi_2^L = \pi_2^N$, they always decrease in k. As under no licensing, consumer surplus CS^L and social welfare SW^L decrease with k.

3.3. Licensing incentives

By comparing the equilibrium market outcomes across the non-licensing and the licensing regimes, we get the following result.

Lemma 1. *It holds that:* $q_1^L < q_1^N$, $q_2^L > q_2^N$, $Q^L > Q^N$, *and* $p^L < p^N$.

Licensing allows firm 2 to produce a higher output because: (i) it lowers its marginal cost, and (ii) firm 1 further shifts production towards its partially owned rival. Licensing intensifies competition and leads to higher aggregate output and lower market prices.

In stage 1, licensing occurs only if it is profitable for firm 1, i.e., $\pi_1^L \geq \pi_1^N$. Proposition 1 identifies the conditions under which licensing occurs.

Proposition 1. *(i) For* $\varepsilon \leq \frac{2}{3}$*, firm 1 always licenses its technology to firm 2.*

(ii) For $\frac{2}{3} < \varepsilon < \frac{9}{10}$*, firm 1 licenses its technology to firm 2 if and only if* $k \geq k_{cr}(\varepsilon) > 0$*, where* $k_{cr}(\varepsilon) = \frac{1}{2}\left[1 + \varepsilon - \sqrt{(9-\varepsilon)(1-\varepsilon)}\right] < \frac{1}{2}$*, with* $\frac{dk_{cr}}{d\varepsilon} > 0$*.*

(iii) For $\varepsilon \geq \frac{9}{10}$*, firm 1 never licenses its technology to firm 2.*

Fig. 1 illustrates Proposition 1. According to Proposition 1, firm 1 always licenses its superior technology to its partially owned firm 2 as long as the technology is not too effective, i.e., $\varepsilon \leq \frac{2}{3}$. Thus, the well-known incentives for licensing under a fixed fee (Wang, 1998) hold under PPOs too. However, PPOs may promote licensing even for more effective technologies.

In particular, for values of $\varepsilon \in (\frac{2}{3}, \frac{9}{10})$, firm 1 licenses its superior technology to firm 2 as long as it owns a large enough share k of firm 2. The critical level of k above which licensing occurs, $k_{cr}(\varepsilon)$, increases as the technology becomes more effective. Intuitively, licensing of an effective technology leads to fiercer market competition that tends to reduce industry profits.

On the other hand, it is well-known that PPOs induce less competitive market outcomes, with a higher level of PPOs leading to higher industry profits (Azar et al., 2018). The bulk of these higher industry profits are then captured by a licensor that owns a large share of its rival.

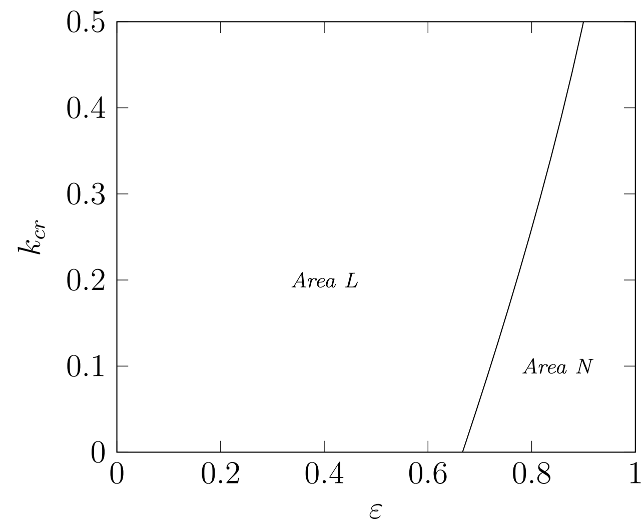

Fig. 1. Critical partial horizontal ownership $k_{cr}(\varepsilon)$.

Besides, under no licensing, an effective technology creates a strong cost advantage, leading to high profits for firm 1 and low profits for firm 2. The latter, in turn, permits firm 1 to set a high fixed fee, which, as we saw above, increases with the level of PPOs. As a consequence, when firm 1 owns a large share of its rival, its profits under licensing exceed those under no licensing. Nevertheless, for $\varepsilon \geq \frac{9}{10}$, licensing under a fixed fee does not occur if firm 1 owns a share in firm 2 less than 1/2.[7]

3.4. Welfare implications

In this section, we evaluate the impact of PPOs on welfare. Proposition 2 identifies the range of the technology effectiveness ε values for which higher levels of PPOs may enhance consumer surplus and social welfare.

Proposition 2. *(i) For* $\varepsilon \leq \frac{2}{3}$ *or* $\varepsilon \geq \frac{9}{10}$*, consumer surplus and social welfare decrease in k for all* $k \in (0, \frac{1}{2}]$*.*
(ii) For $\frac{2}{3} < \varepsilon < \frac{9}{10}$*, consumer surplus and social welfare:*
(a) increase in k if k switches from $(0, k_{cr}(\varepsilon))$ *to* $(k_{cr}(\varepsilon), \frac{1}{2}]$*.*
(b) decrease in k in all other cases.

Proposition 2 essentially says that PPOs have a positive impact on consumer surplus and social welfare whenever they induce technology licensing. Recall by Proposition 1 that for small or large values of ε, technology licensing does not depend on k. So in these cases, a higher k has the usual negative impact on consumer surplus and welfare.

However, when $\frac{2}{3} < \varepsilon < \frac{9}{10}$, technology licensing does depend on k: any increase from $k < k_{cr}(\varepsilon)$ to $k > k_{cr}(\varepsilon)$ moves the market from the no licensing to the licensing regime (Proposition 1) and thus raises consumer surplus and social welfare. Consumer surplus increases because licensing raises industry output (Lemma 1): $CS^L > CS^N$. Social welfare increases too as licensing is tantamount to an increase in industry profits: $\Pi^L > \Pi^N$, together with $CS^L > CS^N$, imply $SW^L > SW^N$. In all other cases in which there is no regime-switching, a higher k decreases as usual consumer surplus and social welfare (Proposition 2ii.b).

Notably, even a minor increase in the level of PPOs can induce a switch from the no licensing to the licensing regime, and result

[6] In particular: $\pi_1^L(F) = \frac{(1+\varepsilon)^2\tilde{\alpha}^2}{(3-k)^2} + (1-k)F$, and $\pi_2^L(F) = \frac{(1-k)(1+\varepsilon)^2\tilde{\alpha}^2}{(3-k)^2} - (1-k)F$.

[7] In this case, licensing may still occur if firm 1 owns a high enough, *non-controlling*, majority share ($k > 1/2$) over firm 2.

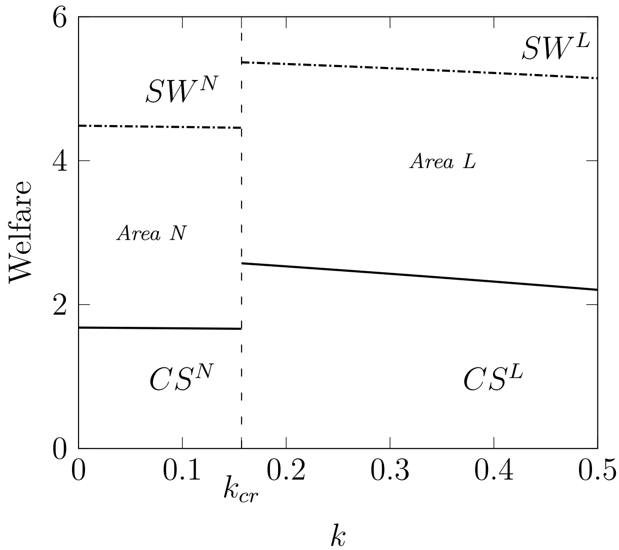

Fig. 2. Consumer Surplus and Social Welfare for $a = 4, c = 2, e = 1.5$, so $\varepsilon = 0.75$ and $k_{cr} = 0.15693$.

in higher consumer surplus, industry profits, and social welfare. Fig. 2 illustrates this case. For example, there is no licensing for $k = 0.1565$, while licensing occurs for $k = 0.1575$. Thus, if firm 1 buys 0.1% more shares of firm 2, consumer surplus increases by 54.7% and social welfare by 20.4%.

Proposition 2 shows that a complementarity relationship may exist between PPOs and licensing in enhancing consumer surplus and social welfare. Interestingly, a similar relationship may exist between indirect taxation and licensing, with similar welfare effects. If we augment our model with ad valorem taxation (VAT or sales tax), we can show that, for any given level of PPOs, an appropriate adjustment (decrease) of the tax rate promotes licensing and enhances welfare.[8] This implies that the favorable implications of lower taxes on firms' licensing incentives and welfare (Sen and Biswas, 2017) continue to hold under PPOs.

4. Conclusions

We considered a homogeneous good Cournot duopoly in which one firm owns a (non-drastic) cost-reducing technology and also has partial passive ownership holdings over the rival firm. We showed that PPOs may provide incentives for technology licensing between the firms in the market and can raise consumer surplus and social welfare. Our paper thus identified a novel pro-competitive effect of PPOs and established a previously unknown complementarity relationship between PPOs and licensing incentives.

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[8] The rationale is that a tax rate reduction augments the "effective" market size and makes the superior technology less effective from firm 1's perspective. According to Proposition 1, firm 1 has then stronger incentives for licensing, for any given level of PPOs. For a detailed discussion of taxation within the current model see Leonardos et al. (2021).

Appendix

Proof of Lemma 1. From (5) and (3), we have that $\frac{q_1^L}{q_1^N} = \frac{(1+\varepsilon)(1-k)}{1+2\varepsilon-k} < 1$, $\frac{q_2^L}{q_2^N} = \frac{1+\varepsilon}{1-\varepsilon} > 1$, and $\frac{Q^L}{Q^N} = \frac{(1+\varepsilon)(2-k)}{1+\varepsilon-k} > 1$ for all $0 < k \leq \frac{1}{2}$ and $0 < \varepsilon < 1$. The latter implies that $p^L < p^N$.

Proof of Proposition 1. From (6) and (3), $\frac{\pi_1^L}{\pi_1^N} = \frac{1+\varepsilon(6+\varepsilon-4k)}{1+(4-k)\varepsilon(1+\varepsilon-k)}$. Then $\frac{\pi_1^L}{\pi_1^N} > 1$ if and only if $k > k_{cr}(\varepsilon) = \frac{1}{2}[1+\varepsilon-\sqrt{(9-\varepsilon)(1-\varepsilon)}]$, with $\frac{\partial k_{cr}}{\partial \varepsilon} > 0$. Yet, $k_{cr}(\varepsilon) \leq 0$ for all $\varepsilon \leq \frac{2}{3}$ and $k_{cr}(\varepsilon) \geq \frac{1}{2}$ for all $\frac{9}{10} \leq \varepsilon < 1$.

Proof of Proposition 2. (i) From Proposition 1 we know that for $\varepsilon \leq \frac{2}{3}$ licensing always occurs. From (6) and (5), consumer surplus is $CS^L = \frac{(1+\varepsilon)^2(2-k)^2\tilde{\alpha}^2}{2(3-k)^2}$ and social welfare is $SW^L = \frac{(1+\varepsilon)^2(2-k)(4-k)\tilde{\alpha}^2}{2(3-k)^2}$. Then $\frac{\partial CS^L}{\partial k} = \frac{-(1+\varepsilon)^2(2-k)\tilde{\alpha}^2}{(3-k)^3} < 0$ and $\frac{\partial SW^L}{\partial k} = \frac{-(1+\varepsilon)^2\tilde{\alpha}^2}{(3-k)^3} < 0$ for all k, ε.

Similarly, for $\varepsilon \geq \frac{9}{10}$ licensing never occurs. From (3), consumer surplus is $CS^N = \frac{(2+\varepsilon-k)^2\tilde{\alpha}^2}{2(3-k)^2}$ and social welfare is $SW^N = \frac{\Omega\tilde{\alpha}}{2(3-k)^2}$, where $\Omega = 8+\varepsilon^2(11-4k)+2\varepsilon(2-k)^2-6k+k^2$. Then $\frac{\partial CS^N}{\partial k} = \frac{-(1-\varepsilon)(2+\varepsilon-k)\tilde{\alpha}^2}{(3-k)^3} < 0$ and $\frac{\partial SW^N}{\partial k} = \frac{-(1-\varepsilon)(1+\varepsilon(5-2k))\tilde{\alpha}^2}{(3-k)^3} < 0$, for all k, ε.

(ii.a) Since both the CS and SW are strictly decreasing for all $k \in (0, \frac{1}{2}]$, it is sufficient to show that the lowest value of them under licensing is higher than the highest value under no licensing. Indeed, $\frac{CS^L|_{k=1/2}}{CS^N|_{k=0}} = \frac{81(1+\varepsilon)^2}{25(2+\varepsilon)^2} > 1$ which holds true for all $\varepsilon \in (\frac{2}{3}, \frac{9}{10})$. Similarly, $\frac{SW^L|_{k=1/2}}{SW^N|_{k=0}} = \frac{189(1+\varepsilon)^2}{25(8+8\varepsilon+11\varepsilon^2)} > 1$ for all $\varepsilon \in (\frac{2}{3}, \frac{9}{10})$.

(ii.b) From (i) we get that CS and SW decrease in k within the two licensing regimes, i.e. $\frac{\partial CS^i}{\partial k} < 0$ and $\frac{\partial SW^i}{\partial k} < 0$ where $i = \{N, L\}$.

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