International Journal of Industrial Organization 28 (2010) 176–190

Contents lists available at ScienceDirect

International Journal of Industrial Organization

journal homepage: www.elsevier.com/locate/ijio

Cooperation in product development and process R&D between competitors☆

Marc Bourreau [a], Pınar Doğan [b,*]

[a] Telecom ParisTech and CREST-LEI, Paris, France
[b] Harvard Kennedy School of Government, Harvard University, United States

ARTICLE INFO

Article history:
Received 7 April 2008
Received in revised form 20 May 2009
Accepted 27 July 2009
Available online 4 August 2009

JEL classification:
L1
O3

Keywords:
Cooperation
Product development
Process R&D

ABSTRACT

In this paper, we first provide a simple framework for cooperation in product development between competitors. We put forward the trade-off between the benefits obtained through development cost-sharing and the cost of intensified competition due to reduced product differentiation, which implies that no-cooperation can be an equilibrium outcome. We allow for firms to cooperate partially, i.e., to develop some product components jointly, but not necessarily all components. This enables us to study the factors that may have an effect on the degree of cooperation in product development, both in the presence and in the absence of process R&D. We also analyze the interaction between cooperation decisions on product development and process R&D. By considering a direct link between the two, we show that the degree of cooperation in product development may adversely affect the intensity of cooperation in process R&D.

1. Introduction

Many products are made of distinct product components that, on their own, have no value to end consumers. In the automotive industry, for instance, a number of product components (e.g., engine, break system, suspension system, etc.) are used to produce a single vehicle. Usually, one distinct product component can be used to produce a variety of products, provided that the relevant interfaces in different varieties are fairly standardized. This is why different firms (that may or may not be competitors) often agree to develop some product components through cooperative R&D. For example, in September 2005, the BMW Group, DaimlerChrysler AG, and General Motors Corporation signed an agreement to form an alliance for the joint development of a two-mode hybrid drive system for engines that would allow the vehicles to switch to a different driving mode depending on the driving conditions (i.e., in city driving or highway driving). The two-mode hybrid system is now used in different vehicles of all three participants.[1] While firms cooperate on the development of a particular product component, each one of them pursues its independent R&D for other product components that are necessary for the creation of a functional end-product.

This real-world example illustrates the first important point we would like to emphasize in this paper; firms often cooperate only partially —if at all, and besides the well acknowledged reasons like high transaction costs, this can also be due to the impact of cooperation on product competition. The co-opetitors' (the firms that cooperate in R&D but compete in product markets) explicit decision on *how much to cooperate* may also involve an implicit decision on *how much to compete*. This is because even if firms may prefer a higher degree of differentiation (softer product competition) at the outset, they may have limited ability to differentiate their products when they engage in joint product development for too many product components.[2] This, in turn, may imply that joint product development, along with its benefits, may involve a cost in terms of intensified product competition, which may be significant in markets where product differentiation matters to consumers. With very few exceptions, notably Vilasuso and Frascatore (2000), Lambertini et al. (2002, 2003), and Ghosh and Morita (2006, 2008), the existing literature does not consider any economic cost of

☆ We appreciate the comments of the participants at the 2007 EARIE Conference (Valencia, Spain) and the 2007 Journées de Microéconomie Appliqué e (Fribourg, Switzerland). We are grateful to two anonymous referees for very useful remarks and suggestions. We also thank Katie Naeve for her editorial assistance.

* Corresponding author. 79 JFK Street, Cambridge, MA, 02138, United States. Tel.: +1 617 496 6757; fax: +1 617 496 5747.
E-mail addresses: marc.bourreau@telecom-paristech.fr (M. Bourreau), pinar_dogan@hks.harvard.edu (P. Doğan).

[1] For example, in the 2008 model year GM introduced the Chevrolet Tahoe, the GMC Yukon, and the Cadillac Escalade SUVs, while DaimlerChrysler launched a Dodge Durango SUV with the two-mode hybrid system.

[2] Firms seem to be aware of this trade-off, and often make public statements to underline how their end-products will be "different" despite the cooperative agreement. For example, after mentioning the benefits of the alliance between BMW Group, DaimlerChrysler AG, and General Motors Corporation, a member of the Board of Management for Development and Procurement at BMW AG, Prof. Burkhard Göschel, added that "Because the technologies will be adapted to the individual vehicle models, the participating brands will retain their distinctive characters" (News and Issues, Sept. 9, 2005, available at http://www.gm.com).

0167-7187/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijindorg.2009.07.010

cooperation[3]; it concludes that cooperation is, at least in a weak sense, desirable for firms since they can always replicate the non-cooperative equilibrium. Furthermore, product innovations, by and large, are treated as horizontal improvements in products,[4] i.e., investments in product differentiation. In accord with this view, cooperation in product innovations is usually modeled as firms jointly setting the degree of substitution between the products so as to maximize their joint profits.[5] We find modeling of product development cooperation as firms jointly setting the degree of substitutability between their products or sharing the cost of product differentiation not satisfactory.

We also account for the fact that in a variety of industries, potential competitors cooperate both in product and process innovations. In the majority of the R&D joint ventures that are formed in the automotive industry, for instance, partners cooperate not only on the development of certain product components but also on research to discover more cost-efficient ways to produce those components. For example, BMW, DaimlerChrysler, and General Motors Co. can also cooperate to attain vertical –either cost or quality– improvements on their hybrid system.[6] However, it is very unlikely that they would jointly carry such process R&D on distinct product components they have developed independently (such as the break systems). Instead, each firm conducts in-house process R&D on these product components, thus suggesting a *direct* link between product and process R&D decisions —a link that has been overlooked in the literature and on which this paper aims its focus. With very few exceptions, the literature on R&D cooperation accounts for a single type of R&D activity–product or process.[7] The papers that consider both types of R&D activities, notably Lin and Saggi (2002) and Rosenkranz (2003), consider only the *indirect* link between the two decisions, which is their interaction through the competition stage. Considering the aforementioned direct link that is established by the firms' ability to engage in joint process R&D only on the jointly developed product components also enables us to formally distinguish between joint and in-house investments in process R&D.[8]

We first introduce a simple framework in which firms engage only in product development. We construct a duopoly model with an end-product, composed of distinct components, for which firms can engage in joint development. The degree of cooperation determines the degree of commonality (and hence, the degree of differentiation) in the two end-products. While firms share the cost of developing the common product components, they carry out independent research for the development of the remaining components. Therefore, a higher degree of cooperation (i.e., a higher degree of commonality) leads to savings in development costs, but it intensifies post-innovation competition by reducing the degree of differentiation between the competing end-products. A direct consequence is that no-cooperation can be an equilibrium.

The main trade-off we present in this section is also studied by Lambertini et al. (2002, 2003) with a focus on the impact of RJVs on the sustainability of collusive agreements,[9] and by Ghosh and Morita (2006, 2008) in the context of inter-firm platform sharing. Ghosh and Morita consider both the cost savings and the reduced degree of differentiation that result due to the use of the same platform –of a given size– by two firms.[10] Different than Ghosh and Morita, in our model the degree of differentiation and the degree of cost savings due to joint product development are endogenous to firms' decisions on how much to cooperate on product development.

Next, we use a specific demand setting and bring process R&D into the picture to study the interaction between product development and process R&D. Once firms complete their product development, they invest in process R&D, which reduces the cost of producing product components. We consider three scenarios: i) no-cooperation; ii) full-cooperation; and iii) partial-cooperation. For all three scenarios, we assume that firms decide on how much to cooperate in product development. Scenarios differ with respect to the process R&D stage.

Under the no-cooperation scenario, we assume that firms decide on their process R&D investments non-cooperatively. Under the full-cooperation scenario, we assume that firms cooperate in process R&D on all product components, and share the process R&D costs. These two scenarios are similar to the two scenarios considered by Lin and Saggi (2002); semi-cooperation and full-cooperation, respectively.[11] Similar to Lin and Saggi (2002), we show that under both the no-cooperation and full-cooperation scenarios, the equilibrium process R&D investments decrease with the degree of joint product development. Furthermore, the equilibrium degree of cooperation in product development is higher when the marginal cost of component development and the marginal cost of process R&D are higher.

Under the partial-cooperation scenario, which is the novelty of this paper, firms cooperate in process R&D only partially. In particular, we assume that firms can engage in joint process R&D only on the product components that they have developed jointly.[12] This assumption introduces a direct link between the degree of cooperation in product development and process R&D decisions, in addition to their interaction through the competition stage. In contrast with the no-cooperation and full-cooperation scenarios, we find that with partial-cooperation the degree of cooperation in product development can be lower when the process R&D cost is higher. Our major finding is that with partial-cooperation the intensity of cooperation in process R&D

[3] Vilasuso and Frascatore (2000) consider an exogenous fixed cost of forming a Research Joint Venture, which can be attributed to its management or auditing. In Lambertini et al. (2002, 2003) when firms cooperate in product innovation they develop a single product, whereas they produce differentiated products when they do not cooperate. Therefore, cooperative R&D comes with a cost; it leads to fierce competition post-innovation unless firms collude at the competition stage. Ghosh and Morita (2006, 2008) also consider a similar cost, but when cooperation takes the form of platform sharing.

[4] See Eswaran and Gallini (1996) for a brief discussion on horizontal versus vertical innovations.

[5] See, for example, Lin and Saggi (2002). The authors assume an "initial" level of product substitutability between the products, and product innovation involves investment in differentiation. In such a setting, cooperation in product R&D leads to a higher degree of differentiation than with no cooperation.

[6] A recent example of joint process R&D as such is the cooperation between BMW Group and PSA Peugeot Citroën, which resulted in the development of a 1.4 L petrol engine, which is an improved version of the existing 1.6 L petrol engine the companies had developed jointly. The latter engine has already been launched within the car ranges of both partners. (Source: http://www.psa-peugeot-citroen.com).

[7] Most of the literature, including the seminal papers by Katz (1986) and d'Aspremont and Jacquemin (1988), consider cooperation in process R&D. However, the issue has received some attention in the non-cooperative R&D literature. See, for example, Athey and Schmutzler (1995) and Eswaran and Gallini (1996). There is a large set of other interesting questions that have been addressed so far, ranging from how private and social incentives for cooperation compare in different settings, e.g., in the presence of uncertainty, synergies, endogenous as well as exogenous spillovers, with and without an innovation race (see, among others, see Suzumura, 1992; Choi, 1993; Kamien et al., 1992; and Kamien and Zang, 2000) to how cooperation may affect incentives to maintain post-innovation collusion (see Martin, 1996; Cabral, 2000; and Lambertini et al., 2002).

[8] To our knowledge there are only two papers that consider such a "hybrid" structure (i.e., joint and in-house investments) in process R&D: Goyal et al. (2008) and Atallah (2004).

[9] Differently, they assume that formation of a RJV in product development produces completely identical products for two firms which would otherwise compete with differentiated products.

[10] Besides the cost savings in the development stage, the authors consider another advantage of platform sharing in their earlier paper: lower expected prices of procurement due to a larger number of potential suppliers for the shared components.

[11] Except that firms do not share process R&D costs in Lin and Saggi (2002).

[12] Cooperation in process R&D is implicit when firms engage in joint production of the jointly developed product components, in particular when production is realized in one of the partners' facilities (for example, the 1.4 L petrol engine is produced for both BMW and PSA Peugeot Citroën Groups at the PSA's plant in Douvrin). Since joint manufacturing of product components is also likely to involve economies of scale, which is not the focus of our paper, we assume that each firm produces product components separately.