Value creation and value appropriation in innovative coopetition projects

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IN INNOVATIVE COOPETITION PROJECTS

Accepted by Associate Editor Simon Porcher.

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Abstract

This article provides a formal model of the value creation-appropriation dilemma in the coopetition for innovation, i.e., alliances among competing firms. The model determines the levels of cooperation that maximize the profit of each firm in an innovative coopetition agreement regardless of the number of firms and their respective budget endowments dedicated to the coopetitive project. We answer the following questions. Within an innovative coopetition agreement, will the partners cooperate more or less when their budget endowments change? What is the impact on profit? When is it profitable to accept a new partner into the agreement? What happens to the remaining firms when a partner withdraws from the agreement? We show that when the coopetitive budget of the focal firm increases, the focal firm allocates a larger part of this budget to value creation activities and increases its profit. In contrast, when a partnering firm increases its coopetitive budget, the focal firm reduces its budget for value creation activities to maintain a sufficient budget for value appropriation activities. We also show that the addition of a competitor with a large coopetitive budget to the innovative coopetition agreement decreases the cooperation of the focal firm but increases the profit of the initial partnering firms. In contrast, the exit of a partnering firm with a large coopetitive budget from the agreement intensifies the cooperation among the remaining firms but reduces their profit.

Highlights

- This paper provides a formal model of the value creation-appropriation dilemma in coopetition for innovation allowing the determination of the levels of cooperation that maximize the profit of each firm regardless of the number of firms and their respective budget dedicated to the coopetitive project.
- We show that when the coopetitive budget of the focal firm increases, the focal firm allocates a larger part of this budget to value creation activities and increases its profit. In contrast, when a partnering firm increases its coopetitive budget, the focal

firm reduces its cooperation to maintain a sufficient budget for value appropriation activities.

- We also highlight that the addition of a competitor with a large coopetitive budget to the agreement decreases the cooperation of the focal firm but increases the profit of the initial partnering firms.

Keywords

coopetition; value creation; value appropriation; innovative coopetition projects; game theory

Acknowledgements

The authors would like to thank the Associate Editor Simon Porcher and the anonymous reviewers for their insightful suggestions and comments, which greatly contributed to improving this manuscript. The authors also thank the following researchers for their helpful insights and observations: Jamal Azzam, Héloïse Berkowitz, Anne-Sophie Fernandez, Frédéric Le Roy, Nicola Mirc and Petros Sekeris. This research benefitted from the financial support of the Labex Entreprendre.

1. INTRODUCTION

Increasingly more firms rely on alliances between competitors to accelerate their development and foster innovation. Because these alliances present several particularities, a specific stream of literature has emerged around the concept of "coopetition" (Bengtsson and Kock, 2000; Brandenburger and Nalebuff, 1996; Gnyawali and Park, 2011; Fernandez et al., 2018). Coopetition can be defined as a paradoxical situation in which firms compete in some activities, markets or products but simultaneously cooperate regarding other activities. Coopetition is supposed to generate superior performance for the partnering firms as it combines the benefits of cooperation and competition (Ritala, 2012). However, coopetition also generates strong tensions between the participating firms (Fernandez et al., 2014; Tidström, 2014), which are mainly driven by the conflict between generating shared benefits and capturing private benefits (Ritala and Tidström, 2014; Ritala and Hurmelinna-Laukkanen, 2018). Nevertheless, several scholars have argued that instead of attempting to

reduce these tensions, firms must accept and manage them because their outcomes can be highly beneficial if these tensions are managed properly (Bengtsson et al., 2016; Le Roy and Czakon, 2016; Le Roy et al., 2018).

The ability to manage coopetition implies that firms can find the correct balance between value creation and value appropriation strategies (Gnyawali and Ryan Charleton, 2018; Park et al., 2014). Although the claim that cooperative and competitive behaviors should be balanced is often made, few studies have analyzed in detail the nature and specifics of this balance. The existing contributions analyzing this balance remain mainly qualitative (Gnyawali and Park, 2011; Ritala and Tidström, 2014), or when quantitative assessments are made, they are done at the firm level and not at the coopetitive agreement level (Park et al., 2014). Moreover, despite several calls for further analysis of the value creation-appropriation tension (Bengtsson and Kock, 2014; Chou and Zolkiewski, 2018; Ritala and Hurmelinna-Laukkanen, 2018; Ritala and Tidström, 2014), little academic attention has been devoted to the details of the budget allocation between cooperation and competition.

Our aim is therefore to provide a theoretical framework that allows a discussion and analysis of the determinants of the balance between value creation and value appropriation within innovative coopetition projects. To do this, we develop a formal model based on a game-theoretical approach. We focus on allocative decisions of partners in a coopetitive agreement by modeling each partnering firm's choice as a decision about how to allocate a given amount of their budget between a common creative activity and a private appropriation activity. That is, we focus on budget allocations that are conditional on being a member of the coopetitive agreement, and we do not consider a firm's decision to enter or leave a coopetitive agreement. We frame the budget allocation strategies as a standard one-stage non-cooperative game. Each firm chooses an allocation that is a best response to the budget allocation chosen by the other partners.

Our research differs from previous contributions regarding the value creation/appropriation dilemma in coopetition along several dimensions. First, contrary to previous articles that provide a qualitative assessment of the balance between cooperative and competitive behaviors, our game-theoretical approach allows us to capture the strategic uncertainty that surrounds managers' decisions in an innovative coopetition agreement. By doing this, we identify the equilibrium allocation of the budget for each participant involved in the agreement between value creation activities and value appropriation activities. Second, while previous game-theory models were decomposing such agreements in two phases as a two-stage game (compete-then-cooperate or cooperate-then-compete), we adopt a single-stage approach to take into account the specificities stemming from the simultaneity of competition and cooperation in coopetition. By doing so, we provide a stronger analysis of the dilemma between value creation and appropriation by putting the tension between these two objectives in the core of the analysis. Third, contrary to previous research that assumed that value creation and value appropriation behaviors were independent, we adopt a perspective in which the partnering firms have a limited budget such that allocation decisions made for value creation are made at the expense of value appropriation. Fourth, consistent with a recent stream of research inviting researchers to investigate coopetitive agreements involving more than two partners, our modeling allows us to analyze the value creation/appropriation dilemma in settings involving more than two partners with different sizes or budgets. Finally, in contrast to previous articles identifying a specific balance in a given situation, our approach allows us to realize some comparative statics and answer various questions, such as the following: Will the focal firm cooperate more or less when its budget dedicated to coopetitive activities increases? What is the impact of such a change on its profit? What is the impact of an increase in the coopetitive budget of a partner firm on the focal firm's cooperativeness and profit? To what extent is it profitable for firms belonging to

an established coopetition agreement to accept a new partner into the agreement? What are the consequences for a firm that remains in the agreement if a partner withdraws from it?

We show that there is a unique Nash equilibrium budget allocation for each firm, which depends on the number of firms and their dedicated budgets. In addition, we show that the Nash budget allocations and profits evolve according to some key factors. When the focal firm's dedicated budget (to the coopetitive project) increases, it allocates a larger fraction of it to value creation activities and increases its profit. By contrast, when a partnering firm increases its budget, the focal firm reduces its investment in value creation activities to increase its appropriation capacity. As the partner increases its budget dedicated to coopetition, the focal firm sees its Nash profit increase. Finally, we show that the entry of a new competitor into an existing coopetitive agreement reduces the focal firm's investment in the coopetitive project and increases the profit for the initial partners only if the incomer's coopetitive budget is sufficiently large. Symmetrically, the exit of a standing partner is profitable for the remaining firms only if the exiting partner has a relatively small coopetitive budget.

Our research contributes to the growing literature on coopetition and innovation by offering a formal model that allows us to study the incentives for competing firms to cooperate with one another to create common appropriable value. More precisely, we provide a theoretical analysis of the value creation/appropriation dilemma in a simultaneous cooperation-competition game between heterogeneous firms. To our knowledge, this paper is the first to develop a formal analysis of this value creation/value appropriation dilemma that offers clear theoretical predictions for firms' coopetitive strategies in a one-stage game. Our very generic model allows us not only to characterize the equilibrium for any fixed number of firms but also to study how it evolves when the structure of the agreement changes.

2. THEORETICAL BACKGROUND

2.1. Combining cooperative and competitive behaviors in coopetition strategies

As a growing number of firms cooperate with competitors (Fernandez et al., 2018), the concept of coopetition has been developed to analyze and understand the specificities of these strategies (Brandenburger and Nalebuff, 1996). Accordingly, coopetition can be defined as "*a paradoxical relationship between two or more actors simultaneously involved in cooperative and competitive interactions, regardless of whether their relationship is horizontal or vertical*" (Bengtsson and Kock, 2014, p. 182). Because it combines the benefits of cooperative and competitive behaviors (Lado et al., 1997; Bengtsson and Kock, 2000), coopetition is expected to yield superior performance compared to other relational modes. Although several contributions indeed find a positive impact of coopetition on innovation performance (Bouncken and Kraus, 2013), market performance (Robert et al., 2018) or stock-market performance (Wu et al., 2015), some recent reviews have underlined that coopetition has a mixed impact in terms of performance, either from an innovation (Gast et al., 2018) or from a market performance standpoint (Ritala, 2018).

A possible explanation of these mixed results comes from the presence of multiple coopetitive tensions felt at different levels (Fernandez et al., 2014; Tidström, 2014). Because the partnering firms are competitors, they have to address contradictory and paradoxical incentives that force them to sufficiently cooperate to create value while competing to capture enough value (Fernandez and Chiambaretto, 2016). To avoid self-destructive behaviors, several contributions have noted that coopetitors need to manage these tensions if they want to make it a successful strategy (Le Roy and Czakon, 2016; Le Roy et al., 2018). In this vein, Park et al. (2014) show that the firms that can find the right balance between their collaborative and competitive efforts tend to exhibit higher innovation performance.

2.2. Specificities of value creation and value appropriation in coopetition

In their seminal contribution, in addition to introducing the term “coopetition”, Brandenburger and Nalebuff (1996) underline the tensions related to the cooperative dimension of value creation and the competitive dimension of value appropriation. By using the metaphor of a cake, they explain that the cooperative side of coopetition increases the size of the cake, whereas the competitive side increases the size of the slice. That is, tensions between cooperation and competition are driven by the conflict between generating shared benefits and capturing private benefits (Ritala and Tidström, 2014; Ritala and Hurmelinna-Laukkanen, 2018). It is interesting to note that even if the cooperative side of coopetition generates common benefits for the partnering firms, the allocation of the efforts between value creation and value appropriation activities is not made in concert with the coopetitors (Ritala and Hurmelinna-Laukkanen, 2018). Consequently, each firm has to find the optimal budget allocation to maximize its profit (at the expense of the other partnering firms). By building on Lavie (2007), we define value creation as the value generated by the relationships with partners as they collectively pursue shared objectives. In contrast, value appropriation determines the relative share of the relational rents that the focal firm can appropriate.

Even if partners must also decide how they will share and appropriate the relational rent generated by the cooperation in alliances between non-competitors (Adegbesan and Higgins, 2011) under coopetition, the value appropriation patterns are very different. The main specificity comes from the simultaneity of cooperative and competitive behaviors (Gnyawali and Ryan Charleton, 2018). Simultaneity can be understood in two ways. First, simultaneity can be understood as the fact that two firms cooperate in some markets, while they remain at the same time competitors in other markets. For instance, Le Roy and Fernandez (2015) emphasize how Astrium (Airbus Group) and Thales fully cooperated on a satellite program (Yahsat) while remaining in competition for other satellite markets. In this situation, each parent firm has to make a decision on the amount of budget (and engineer time) to allocate to

the common project on the one hand and to the competing activity on the other hand. In parallel, simultaneity can be understood as the situation in which two firms cooperate on a joint product while developing, at the same time, unique knowledge, features or competencies that will be used to improve the joint product so that they will have a larger market share than their coopetitor. For example, Gnyawali and Park (2011) explain how Sony and Samsung allocated teams to develop in cooperation a new LCD technology for televisions while having in parallel other teams that worked on specific features that would allow Sony to develop a better final LCD product than Samsung. In this case, a single decision is made at the beginning of the product development stage to determine how to optimally allocate the budget (or the team members) between the cooperative and competitive activities.

Regardless of the simultaneity approach adopted, several contributions that have focused on the value creation/appropriation dilemma have concluded that cooperative and competitive behaviors must be balanced (Park et al., 2014; Ritala and Tidström, 2014; Bengtsson et al., 2016; Le Roy et al., 2018; Gnyawali and Ryan Charleton, 2018; Ritala and Hurmelinna-Laukkanen, 2018). Most of these papers are theoretical or qualitative contributions such that they define balance as "evenness between competition and cooperation" (Gnyawali and Ryan Charleton, 2018, p. 2522). This concept of balance is quite blurry and yields general recommendations that state that partners must share resources and knowledge for the success of the common project while keeping sufficient resources for themselves to remain able to differentiate their offer from their competitors' offer in other projects. In that vein, Gnyawali and Ryan Charleton (2018, p. 2526) conclude that "a firm with more intent for firm value creation may prevent the joint pie from reaching its full potential, while pursuit of joint value creation may similarly hinder firm benefits."

To the best of our knowledge, the only quantitative contribution addressing this question of balance in coopetitive agreements is a study conducted by Park et al. (2014). The authors of this study first argue that "balance helps to maintain and control the relationship and at the same time increases the chances of realizing gains provided by both competition and collaboration" (p. 213). Accordingly, they expect firms that have a balanced behavior to present higher performance levels. Using the SDC Platinum database, they show that firms that adopt a balanced coopetition strategy (with simultaneously a high degree of competition and a high degree of cooperation) tend to have a superior innovation performance. However, their measure of "balance" raises methodological questions as it is a mere multiplication of the competition and cooperation variables that are respectively measured as the degree of market commonality between the two firms (for the competition variable) and the number of repeated ties between the two firms (for the cooperation variable). Furthermore, Park et al. (2014)'s investigation is made at the firm level and not at the dyadic (or agreement) level so that they do not actually investigate the value creation and value appropriation behaviors within a given coopetition agreement.

Despite several calls for further analysis of the value creation-appropriation tension in coopetition (Bengtsson and Kock, 2014; Chou and Zolkiewski, 2018; Ritala and Tidström, 2014; Ritala and Hurmelinna-Laukkanen, 2018), to the best of our knowledge, no study has investigated the details of the budget split between cooperation and competition within coopetition projects. In this research, we investigate how firms actually decide to allocate their budget to cooperative or competitive activities in coopetition projects. By doing so, contrary to previous contributions that provide either a qualitative or firm-level assessment of the "balance" firms need to reach, we aim at determining precisely the balance associated with each coopetitive agreement and observe how this balance evolves when key parameters change (number of partners involved, budget dedicated to the coopetitive project, etc.).

However, determining the optimal budget allocation between value creation and value appropriation activities is challenging and requires a specific modeling approach.[1]

2.3. Modeling the trade-off between value creation and value appropriation in coopetition

As explained by Ritala and Hurmelinna-Laukkanen (2009, 2018), some of the theoretical underpinnings of coopetition are rooted in the economics literature regarding conflict and appropriation, particularly contest games with endogenous prizes (see Garfinkel and Skaperdas (2007) for a survey). This stream of literature, which is sometimes referred to as "Guns versus Butter," was initiated by Haavelmo (1954) and was mainly developed by the contributions of Hirshleifer (1989, 1991). The basic idea is that heterogeneously endowed agents must cooperate to produce goods jointly (e.g., butter) in a world of anarchy (without property rights); therefore, they must also privately build appropriation capacity (e.g., guns) to secure a share of the commonly produced goods. One of the striking results of this literature is the "paradox of power" (Hirshleifer, 1991), which equalizes the payoffs of asymmetric players. At equilibrium, resource heterogeneity leads poorly endowed agents to invest a larger share of their resources in producing guns rather than butter, while the well-endowed agents prefer the opposite allocation. The paradoxical result arises because the marginal return from appropriation is larger for poorly endowed players, whereas the marginal return from joint production is larger for the well-endowed. Nevertheless, modeling the trade-off between value creation and value appropriation in coopetition requires considering several specificities of coopetition strategies.

First, models based on sequential games fail to properly capture the resource allocation dilemma inherent to coopetitive agreements. Such models assume a sequential ordering of

[1] In this article, we do not aim at investigating the trade-off between coopetitive and private activities (which would match with the first approach of simultaneity). This approach would require setting hypotheses on the returns of the projects that are in competition. Nevertheless, we provide some discussion regarding this situation in Appendix 1.

cooperation and competition: either an initial cooperative stage is followed by a competition stage (e.g., d'Aspremont and Jacquemin, 1988; Kamien and Zang, 2000, Grünfeld, 2003) or an initial competition stage is followed by a cooperative stage (Brandenburger and Stuart, 2007; Gans and Ryall, 2017; MacDonald and Ryall, 2004; Panico, 2017). Let us refer to these two approaches as "*cooperate-then-compete*" and "*compete-then-cooperate*". By breaking the coopetition dilemma into two stages, the dilemma actually becomes cleared. In the *cooperate-then-compete* literature, duopoly players choose their level of output in stage 2 (conditional on total R&D investments in stage 1), and then solve for their individually optimum level of R&D investment in stage 1. Solving the game by backward induction eliminates the dilemma. In the *compete-then-cooperate* literature, players built their appropriation capacity in stage 1 before bargaining in stage 2 to share a commonly created value. Again, by solving the game backwardly, the tension between appropriation capacity building (stage 1) and value creation (stage 2) is eliminated. Our aim is to focus on the dilemma between value creation and appropriation by putting the tension between these two objectives in the core of the analysis. This tension between value creation and appropriation has been identified as the key issue of coopetitive agreements (Fernandez et al., 2014; Ritala and Tidstrom, 2014; Gnyawali and Ryan Charleton, 2018). To enhance the saliency of the tension between value creation and value appropriation, we need to rely on single-stage non-cooperative game modeling.

Second, contrary to most models, which assume unlimited resources or budget, we assume that firms' budgets (or efforts) are limited. During strategic planning, firms decide how to allocate their limited resources among value creation and value appropriation activities. Therefore, both types of activities are interdependent. As explained by Gnyawali and Ryan Charleton (2018, p. 2526), "past a certain point, the finite nature of resources means that efforts to push joint value creation will occur at the expense of firm value creation

and vice versa." Accordingly, our modeling will require firms to make a trade-off between value creation and value appropriation activities because of their finite budget.

Third, whereas most previous contributions considered partners of similar sizes or similar bargaining powers, we follow Panico's (2017) advice to allow for heterogeneous power positions of partners in an alliance. Recent articles have emphasized an increasing number of coopetitive agreements between firms of different sizes (Hora et al., 2018; Chiambaretto et al., in press). We therefore consider in our model partner firms of different sizes (measured by the heterogeneity of their dedicated budgets for the coopetitive project).

Finally, in contrast to most contributions that investigate coopetition in dyadic agreements (Dorn et al., 2016), we follow the invitation by Ansari et al. (2016) and Rouyre and Fernandez (2019) to study the case of multilateral or multi-partner coopetition in which more than two competitors are involved in the agreement. Such configurations are particularly interesting as they reveal how the competitor's behavior changes according to their budget allocated to the coopetitive project and their own agenda.

3. A FORMAL MODEL OF COOPETITION FOR INNOVATION

3.1. The setting

We define an innovative coopetition agreement (a consortium or a joint venture) as a set of K competing firms ($K \geq 2$) that simultaneously cooperate on a joint project and compete. This agreement can either be a traditional dyadic coopetitive agreement ($K = 2$) or a setting of multipartner coopetition ($K \geq 3$) that involves three or more competing firms. Each of the K competing firms decides how to allocate its dedicated budget to the coopetitive project (the coopetitive budget hereafter) between value creation activities and value appropriation activities. We assume that value creation activities reflect cooperation, while value appropriation activities are related to competition.

Let us note that n_i is the dedicated budget of firm *i* to the coopetitive project. Although in real coopetitive projects, the resources dedicated to the coopetitive project have multiple dimensions, e.g., money, time, skills or technologies, for the purpose of our model, we assume that these dimensions can be converted into money and thus be considered as a budget. This implies that we abstract from the substitutability/complementarity dimension of the resources by considering them as fungible. Considering K firms, the set of coopetitive budgets available to all firms for the project is the set of *K*-uple vector $n = (n_1, n_2, \dots, n_K)$. Let $N = \sum_{i=1}^{i=K} n_i$. We denote $\alpha_i \in [0,1]$, the share of firm i's budget allocated to value creation in the coopetitive project.[2] Firm *i* therefore invests amount $\alpha_i n_i$ of its budget in the joint project for value creation and keeps $(1 - \alpha_i)n_i$ for appropriation activities.

We assume that the total value created by the coopetitive project is equal to the sum of the investments in the cooperative activities.[3] The total value of the project is $V(\alpha_i, \alpha_{-i})$, which is a function of firm *i*'s cooperative decision α_i and the other firms' cooperative decisions α_{-i}:

$$V(\alpha_i, \alpha_{-i}) = \sum_{j=1}^{j=K} \alpha_j n_j. \quad (1)$$

We assume that $V(\alpha_i, \alpha_{-i})$ is increasing in α_i and α_{-i}. This specification implies that the partners' budgets are substitutable.[4]

Regarding the appropriation behavior, we assume that the ability of firm *i* to appropriate value from the joint project positively depends on two types of factors: exogenous factors and endogenous ones. Indeed, following Cohen and Levinthal (1990) or

[2] Strictly, the extreme cases for which a firm does not cooperate at all ($\alpha_i = 0$) or does not compete at all ($\alpha_i = 1$) cannot be considered as coopetition according to our definition which requires simultaneous cooperation and competition. However, for the sake of mathematical completeness we also discuss these two extremes.

[3] To account for empirical evidence that coopetition projects yield higher returns, a multiplicative factor can be added to our definition of the created value without changing the results of the paper.

[4] More generally, our model assumes two types of substitutability: within-firm and across-partners. Within-firm substitutability refers to the allocation of a firm's budget between value creation and value appropriation, while across-partners substitutability refers to the interchangeability of the contributions to value creation.

Ritala and Hurmelinna-Laukkanen (2013), we note that the absorptive capacity and the appropriation capability is the result of firm-specific exogenous factors and of endogenous factors related to the specific agreement. The appropriation function in our model takes into account these two factors which we assume to be independent: (i) a firm-specific and exogenous organizational capacity in appropriating the value created collectively (this organizational capacity represents, for instance, unique knowledge, features, bargaining power, strategic importance or specific competencies that will be used to improve the joint product and obtain a larger market share than partners); and (ii) an agreement-specific endogenous capacity that depends positively on the amount of the firm *i*'s budget that was not invested in value creation to be kept for the value appropriation. Referring to the theoretical literature, the firm-specific capacity is related to the compete-stage of the *compete-then-cooperate* approach, while the agreement-specific capacity is related to the compete-stage of the *cooperate-then-compete* approach.

From a mathematical standpoint, the exogenous appropriation capacity is expressed in relative terms to better capture that the focal firm's appropriation capacity depends upon the appropriation capacity of the other partners. Considering K firms, the set of organizational appropriation characteristics of all firms is the *K*-uple vector $\mu = (\mu_1, \mu_2, \dots, \mu_K)$, which is divided by the sum of its elements such that we define the organizational appropriation capacity as the *K*-uple vector $M = (M_1, M_2, \dots, M_K)$, where $M_i = \frac{\mu_i}{\sum_{j=1}^{j=K} \mu_j}$. The exogenous appropriation capacity of firm i increases with μ_i and decreases with μ_{-i}. In parallel, the endogenous ability to appropriate is positively affected by the budget that the firm does not dedicate to value creation, i.e., $(1-\alpha_i)n_i$, and negatively affected by the amount of the partners' budget kept for appropriation, i.e., $(1-\alpha_{-i})n_{-i}$. We thus define the value appropriation capacity of firm i, A_i, as a function of the vector $\alpha = (\alpha_1, \alpha_2, \dots, \alpha_K) \equiv (\alpha_i, \alpha_{-i})$ for the focal firm i. The set of possible coopetitive agreements is given by $A =$

$\{\alpha, \alpha_i \in [0,1] \; for \; i = 1, \dots, K\}$. Let us note $\alpha^0 = (0, 0, \dots, 0)$ for the null vector and $\alpha^1 = (1, 1, \dots, 1)$ for the full contribution vector. For our purpose, we rely on contest functions (Buchanan et al., 1980) and adopt the following specification:

$$A_i(\alpha_i, \alpha_{-i}) = \begin{cases} M_i \cdot \dfrac{(1-\alpha_i)n_i}{\sum_{j=1}^{j=K}(1-\alpha_j)n_j} \; if \; \alpha \neq \alpha^0 \text{ and } \alpha \neq \alpha^1 \\ {}^1/_K \;\; if \; \alpha = \alpha^0 \\ 0 \; if \; \alpha = \alpha^1 \end{cases} \tag{2}$$

The appropriation function $A_i(\alpha_i, \alpha_{-i})$ decreases in α_i, which indicates the trade-off that firms have to make in terms of budget allocation between value creation and appropriation activities. This appropriation function can be seen as a way to model the competition between the differentiated products. As in any contest game, when the focal firm invests more in its appropriation activities, its likelihood of being chosen by consumers increases such that its "market share" will be larger in the market generated by the coopetitive project.

The profit of firm i from the coopetitive project depends on the common value created by all partners (V) and its appropriation capacity (A_i) as follows:

$$\begin{aligned} \pi_i(\alpha_i, \alpha_{-i}) &= V \cdot A_i \\ &= \sum_{l=1}^{l=K} \alpha_l n_l \cdot M_i \cdot \frac{(1-\alpha_i)n_i}{\sum_{j=1}^{j=K}(1-\alpha_j)n_j} \\ &= M_i \cdot \sum_{l=1}^{l=K} \alpha_l n_l \cdot \frac{(1-\alpha_i)n_i}{\sum_{j=1}^{j=K}(1-\alpha_j)n_j}, \end{aligned} \tag{3}$$

where M_i is a firm-specific parameter that is strictly positive. Note that for α^0 and α^1, $V = 0$ such that each firm makes zero profit from the coopetitive agreement. If $\alpha_i = 1$, $A_i = 0$ and firm *i* makes zero profit. Therefore, $\alpha_i = 1$ cannot be a profit maximizing solution for firm *i*. On the other hand, firm i can eventually choose $\alpha_i = 0$, i.e., firm i can be better off by contributing zero to value creation and instead by appropriating maximally. In subsection 3.2, we discuss the conditions for which such a solution arises within a coopetitive agreement.

Two comments about our specification of the profit functions are required. First, we assume that firms do not incur specific fixed costs for the coopetitive project. Although fixed costs are relevant, we assume that such costs are associated with the focal firm itself rather than with the coopetitive project (Gnyawali and Park, 2011). Second, we assume that $\mu = (\mu_1, \mu_2, \dots, \mu_K)$ is exogenous, i.e., these parameters are not affected by the budget allocations of the coopetitive firms. From a dynamic perspective, this implies that the firm-specific organizational capacities to appropriate value do not change over the duration of the coopetitive agreement either during the coopetitive stage or during the competitive stage.

3.2. Balancing between value creation and value appropriation activities in innovative coopetition projects

Building on the game-theoretical approach initiated by Brandenburger and Nalebuff (1996),[5] we look for the equilibrium in terms of value creation and value appropriation that maximizes the profit of each partnering firm. We therefore focus on the profit of the focal firm i. Obviously, because the firms interact with one another, the relevant equilibrium concept is the Nash equilibrium, where the assumption is that each firm chooses a strategy that is a best response to its expectations about its partners' strategies. The Nash equilibrium of the model solves the following system of first-order conditions (FOC) where $K \geq 2$:

$$\forall K \geq 2, \forall n_i > 1,$$
$$\frac{\partial \pi_i}{\partial \alpha_i} = \frac{\partial A_i}{\partial \alpha_i} V + A_i \frac{\partial V}{\partial \alpha_i} = 0, \forall i = 1, \dots, K. \quad (4)$$

The first term is firm i's marginal return of increasing its share devoted to the common value creation, and the second term is its marginal return of increasing its endogenous appropriation capacity. As discussed above, the first term is positive, and the second term is

[5] See Okura and Carfi (2018) for a recent survey of coopetition and game theory.

negative. Therefore, at equilibrium, firm *i* equalizes the marginal return of the value creation activity to the marginal return of the appropriation activity.

Once detailed, we have the following FOC:

$$\frac{\partial \pi_i}{\partial \alpha_i} = M_i \left[\frac{(1-\alpha_i) n_i^2 N - n_i \left[\sum_{j=1}^{j=K} (1-\alpha_j) n_j \right] \left(\sum_{j=1}^{j=K} \alpha_j n_j \right)}{\left[\sum_{j=1}^{j=K} (1-\alpha_j) n_j \right]^2} \right] = 0, \forall i = 1, \dots, K. \qquad (5)$$

Solving this system provides the firms' best reply functions that define the optimal share of the budget to invest in value creation (the proof is given in Appendix 2):

$$\alpha_i^* = \begin{cases} \frac{K^2 - (K-1)}{K^2} - \frac{K-1}{K^2} \cdot \frac{N_{-i}}{n_i} & \text{if } n_i > \sum_{j \neq i} n_j \cdot \frac{K-1}{K^2 - (K-1)}, \\ 0 & \text{otherwise.} \end{cases} \qquad (6)$$

At the Nash equilibrium, we can identify the amount of the dedicated budget ($\alpha_i^* n_i$) that is allocated to value creation by each firm and the amount that is retained for appropriating the common value created by the project, i.e., $(1-\alpha_i^*) n_i$. It is interesting to observe that at equilibrium, the fraction allocated by firm *i* to common value creation is decreasing in other firms' total budgets (N_{-i}) and increasing in firm *i*'s total budget for the coopetitive project (n_i). This fact has implications on firm *i*'s reaction to a change in the distribution of budgets across partners. Expression (6) shows that if n_i is sufficiently small, α_i^* could eventually become negative. By assumption, however, α_i^* is constrained to be non-negative. The corner solution $\alpha_i^* = 0$ is chosen by firm *i* if its budget allocated for the coopetitive project is small relative to the aggregate budget of the other members. For instance, in the case of a dyad, from a mathematical standpoint, firm *i* should free-ride on firm *j* if $n_i \leq \frac{1}{3} n_j$. Note that firm *j* has nevertheless an incentive to invest in the coopetitive project as long $\alpha_j M_j > 1$. More generally, any firm *i* for which $n_i < \frac{K-1}{K^2-(K-1)} \cdot \sum_{j \neq i} n_j$ chooses $\alpha_i^* = 0$.

Given the equilibrium values of investment shares α_i^* for each firm *i*, one can also easily compute the equilibrium profit (π_i^*) of each firm:

$$\pi_i^* = M_i . \frac{\sum_{j=1}^{j=K} \alpha_j^* n_j}{K}. \quad (7)$$

Note that the profits reached by the partnering firms differ only because of their different exogenous and specific capacity to appropriate value. Therefore, under such equal capacity, the coopetitive project leads to the remarkable outcome that profits are equalized among all firms. The equilibrium outcome is based on the assumption that the amount of the budget allocated by each firm to the coopetitive project is common knowledge—that is, the information regarding the firms' budget for coopetition is fully transparent.

3.3. Comparative statics

In this section, we investigate the impact of various parameters on the incentives for firm *i* to cooperate. More precisely, we study how the firms' budget allocated to the coopetitive project and the number of firms involved in the agreement affect the individual decision to cooperate. We consider the variations of the parameter values (firm budget and number of firms in the agreement) as exogenous shocks, because our aim is not to analyze the origin of these variations but only their impact on the firms' cooperative choice within the coopetitive agreement. The comparative statics of firm *i*'s equilibrium (α_i^*, π_i^*) allow us to answer the following questions. (1) How is the budget allocation of firm *i* affected by an increase in its dedicated budget (n_i)? That is, does a firm's cooperativeness increase if its budget dedicated to the coopetitive project increases? How does this affect its profit? (2) To what extent is it profitable to involve (eliminate) an additional (standing) partner in the coopetitive agreement? What is the corresponding impact on the cooperation level?

3.3.1. Focal firm's budget and cooperativeness

In most alliances and coopetition agreements, partners tend to have different size budgets that can be allocated to the alliance or coopetition projects. A very rich literature has studied the implications of asymmetric alliances for the degree of cooperation among partners and the

stability of the agreement (Vandaie and Zaheer, 2014; Yang et al., 2014). However, most studies in the coopetition literature consider partners of equal sizes and therefore do not address the effect of the heterogeneity of partners' size on their cooperativeness (see Hora et al. (2018) or Chiambaretto et al. (in press) for recent exceptions). Our framework allows us to address this issue at equilibrium: does a larger coopetitive budget of the focal firm increase its propensity to cooperate in the coopetitive project?

Recall that a larger budget represents an increase in n_i. To assess the impact of an increase in n_i on the cooperativeness of firm i, we examine the sign of $\frac{\partial \alpha_i^*}{\partial n_i}$. We find that

$$\frac{\partial \alpha_i^*}{\partial n_i} = \frac{(K-1)\cdot \sum_{\forall j \neq i} n_j}{(K n_i)^2} > 0. \quad (8)$$

A possible interpretation for the positive sign of the derivative relies on the fact that when the focal firm's budget increases, it can create more value and enlarge the size of the market for the coopetitive project by investing more in cooperation while keeping the same share of its coopetitive budget to appropriate the jointly created value. Firms with larger budgets are thus more willing to create value in coopetition than firms with more modest budgets since they know that they can appropriate this value because of their larger budget to differentiate and distribute the final product.

This leads us to the following proposition:

Proposition 1a. *An increase in the coopetitive budget of the focal firm leads to an increase in the fraction of the focal firm's budget invested in value creation.*

3.3.2. Focal firm's budget and profit level

Regarding profit, the comparative statics allow us to establish that a larger coopetitive budget of the focal firm increases the focal firm's profit. Accordingly, we have

$$\frac{\partial \pi_i^*}{\partial n_i} = \frac{M_i}{K} \cdot \left(\sum_{j=1}^{j=K} \frac{\partial \alpha_j^*}{\partial n_i} n_j + \alpha_i^* \right) \quad (9)$$

$$\frac{\partial \pi_i^*}{\partial n_i} = \frac{M_i}{K} \cdot \left(-\frac{(K-1)^2}{K^2} + \frac{(K-1) \cdot \sum_{\forall j \neq i} n_j}{K^2 n_i} + \frac{K^2 - (K-1)}{K^2} - \frac{K-1}{K^2} \cdot \frac{\sum_{\forall j \neq i} n_j}{n_i} \right)$$

$$\frac{\partial \pi_i^*}{\partial n_i} = \frac{M_i}{K^2} > 0$$

When the focal firm's coopetitive budget becomes larger, it increases the percentage of this budget allocated to the value creation activity. Even if the level of cooperation of the partners decreases in the focal firm's budget ($\frac{\partial \alpha_j^*}{\partial n_i} < 0$, see below), this effect is compensated by the joint increase in α_i^* and n_i. This trade-off between investing more budget in cooperation to create more joint value (which consequently also benefits the other firms) and saving the budget for appropriation ends in favor of investing most of the additional budget in cooperation instead of competition. This leads to Proposition 1b.

Proposition 1b. *An increase in the coopetitive budget of the focal firm increases its profit in the coopetitive agreement.*

3.3.3. Partner firm's budget and focal firm's cooperativeness

We now adopt the opposite perspective and consider instead an increase in a partner's coopetitive budget on the level of cooperation of the focal firm. When cooperating with firms that allocate larger budgets to the coopetition project, the focal firm may face different issues, especially with respect to appropriating the value created in the coopetitive agreement (Bae and Gargiulo, 2004; Yang et al., 2014). To assess the impact on cooperativeness of the focal firm when a partner's coopetitive budget increases, we determine the sign of $\frac{\partial \alpha_i^*}{\partial n_j}$.

We find that

$$\frac{\partial \alpha_i^*}{\partial n_j} = -\frac{K-1}{K^2 n_i} < 0. \quad (10)$$

The negative sign means that an increase in the budget of a firm *i*'s partner reduces the focal firm's proportion of the budget dedicated to value creation. Consequently, the focal firm keeps more budget to appropriate to the jointly created value. Firms with smaller coopetitive budgets thus face greater challenges related to value appropriation in alliances with partners that have larger budgets. Keeping more budget to appropriate value allows firms with a lower dedicated budget to maintain their profitability in the coopetitive project. A firm that has less budget vis-à-vis other firms must save it in the cooperative game (value creation) to increase its market share for value appropriation while benefiting from the greater cooperative investments of the other firms (whose budgets are comparatively larger). We thus state the following proposition.

Proposition 2a. *A uniform increase in a partner's coopetitive budget reduces the focal firm's cooperativeness.*

3.3.4. Partner firm's budget and focal firm's profit level

Although an increase in the partner firm's coopetitive budget reduces the focal firm's cooperativeness, we suspect that such adjustment is profitable. We can show that the increase of a partner's dedicated budget positively affects the focal firm's profit. Let us compute the sign of $\frac{\partial \pi_i^*}{\partial n_j}$:

$$\begin{aligned}
\frac{\partial \pi_i^*}{\partial n_j} &= \frac{M_i}{K} \cdot \left(\sum\nolimits_{k=1}^{k=K} \frac{\partial \alpha_k^*}{\partial n_j} n_k + \alpha_j^* \right) \\
\frac{\partial \pi_i^*}{\partial n_j} &= \frac{M_i}{K} \cdot \left(\sum\nolimits_{k \neq j} \frac{\partial \alpha_k^*}{\partial n_j} n_k + \frac{\partial \alpha_j^*}{\partial n_j} n_j + \alpha_j^* \right) \\
\frac{\partial \pi_i^*}{\partial n_j} &= \frac{M_i}{K} \cdot \left(-\frac{(K-1)^2}{K^2} + \frac{(K-1) \cdot \sum_{\forall k \neq j} n_k}{K^2 n_j} + \frac{K^2 - (K-1)}{K^2} \right. \\
&\qquad \left. - \frac{K-1}{K^2} \cdot \frac{\sum_{\forall k \neq j} n_k}{n_j} \right) \\
\frac{\partial \pi_i^*}{\partial n_j} &= \frac{M_i}{K^2} > 0.
\end{aligned} \tag{11}$$

This leads to the following proposition.

Proposition 2b. *An increase in the coopetitive budget of one of the focal firm's partners increases the focal firm's profit in the coopetitive agreement.*

In the case of the partners' budget (at least one) becoming larger, the focal firm invests less in cooperation to preserve its monetary resources to face stronger competitors, whereas the partners whose budgets have increased invest more in value creation. The end of the adjustment process leads to an increase not only in the partner firm's profit (Prop 1b) but also in the focal firm's profit. From a global standpoint, a more (less) coopetitive budget given to the firms if they are considered together, regardless of their distribution among the partners, increases (decreases) the profit of all participating firms.

3.3.5. Number of partners and focal firm's cooperativeness

Although most coopetitive agreements involve only two actors, one can observe an increasing number of coopetitive agreements that involve more than two competing firms. Different contributions have emphasized the existence of "network coopetition" (Padula and Dagnino, 2007) or coopetition in ecosystems (Gueguen, 2009). When more than two firms are involved in the coopetitive project, i.e., in the presence of multipartner coopetition, the question of the optimum set of partners arises. If more firms are involved, it simultaneously increases the budget for the joint project and the strength of competition among the partners (Das and Teng, 2002; Lazzarini, 2007; Heidl et al., 2014; Chiambaretto and Dumez, 2016). The question of the optimum set of partners is therefore a complex issue. Here, we address a somewhat simpler issue about whether adding (removing) an outside (a current) partner to (from) an already existing agreement positively or negatively influences the profit and cooperativeness of its members. We first assess the impact on cooperativeness, i.e., the fraction of the budget allocated to value creation, from a change in the set of partners. We

first consider the addition of a new partner before considering the removal of an existing partner.

The marginal impact of an additional member (the $K+1^{\text{th}}$ firm) on the level of cooperation of partner *i* of the standing coopetitive agreement crucially depends on the newcomer's level of dedicated budget. Let us compute the sign of the difference: $\alpha_i^{*(K+1)} - \alpha_i^{*(K)}$. We obtain

$$\alpha_i^{*(K+1)} - \alpha_i^{*(K)}$$

$$= \frac{(K+1)^2 - K}{(K+1)^2} - \frac{K}{(K+1)^2} \cdot \frac{N + n_{K+1} - n_i}{n_i} - \frac{K^2 - (K-1)}{K^2} + \frac{K-1}{K^2}$$

$$\cdot \frac{N - n_i}{n_i}$$

$$= \frac{N\left(K^2 - (K+1)\right) - K^3 n_{K+1}}{(K+1)^2 n_i K^2}. \quad (12)$$

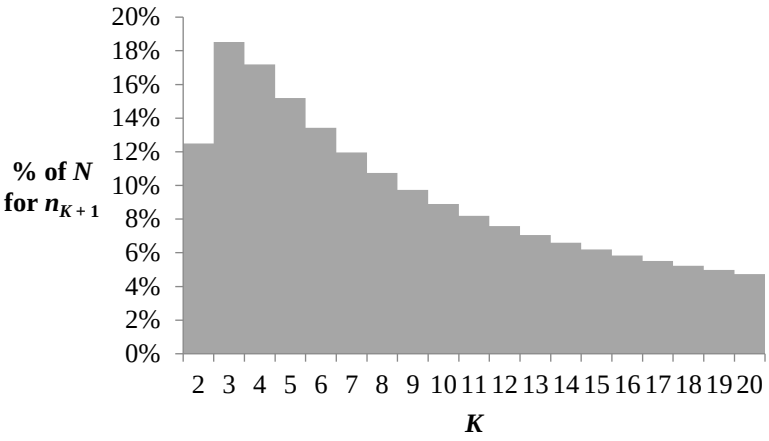
We then obtain

$$\begin{cases} \alpha_i^{*(K+1)} - \alpha_i^{*(K)} > 0, \text{ if } n_{K+1} < N\dfrac{K^2 - (K+1)}{K^3}, \\ \alpha_i^{*(K+1)} - \alpha_i^{*(K)} \leq 0, \text{ if } n_{K+1} \geq N\dfrac{K^2 - (K+1)}{K^3}. \end{cases} \quad (13)$$

According to condition (13), the sign of the difference depends on the coopetitive budget of the new partner. If the new partner's budget is smaller (resp. larger) than some threshold value that depends on the overall budget of the members of the existing agreement (*N*), the focal firm increases (resp. decreases) its level of cooperation. Thus, by creating more (resp. less) value, the standing members of the agreement compensate for the potential loss (resp. gain) incurred by a larger number of partners involved in the sharing. If the new partner's coopetitive budget is relatively small, the historical members are not threatened by its entrance in the agreement. Therefore, the focal firm can increase its cooperative investment in common value creation. However, if the new partner's coopetitive budget is relatively large, its competitive power threatens the value appropriation capacity of the

standing partners. They react by lowering their cooperative investment to secure sufficient appropriation capacity while counting on the new partner to create more value. Figure 1 represents the boundary percentage of N for n_{K+1} that makes the other K firms increase or decrease their α^* by standardizing N to 1.[6]

FIGURE 1. Budget of the new partner in the percentage of N that determines the increase or decrease of α_i^* for the other firms



Note: $\frac{K^2-(K+1)}{K^3}$ represents the boundary percentage of $N = \sum_{i=1}^{i=K} n_i$ for the budget of the new partner (n_{K+1}), which determines the increase or decrease of the other firms' Nash cooperative investments (α_i^*). K is the number of cooperative firms before the cooperation of a new partner.

Two opposite effects drive the evolution of the boundary, namely, a budget effect (i) and a size effect (ii). Adding a new partner to the agreement (i) increases the potential budget to create common value, which allows firms to be less cooperative (α decreasing) and still create more value overall, but (ii) also increases the number of partners that appropriate this value, which pushes firms to be more cooperative (increasing α) to create more value and maintain at least the same level of profit. In our case, moving from a 2-firm agreement to a 3-firm agreement makes the size effect (ii) greater than the budget effect (i), which is reversed

[6] These results are satisfied for all $K > 1$ since $\lim_{K\to+\infty} \frac{K^2-(K+1)}{K^3} = 0$. Even if K is very large, the boundary remains above 0 ($K^2 - (K + 1) > 0$ for all $K > 1$), which means that there is always at least one case where cooperation can increase with the number of players (as long as the $K + 1^{th}$ firm has a coopetitive budget very close to 0).

when moving from a 3-firm agreement to a 4-(or more)-firm agreement. Roughly, moving from 2 to 3 firms represents an increase of 50% (which is relatively huge), while moving from 3 to 4 firms represents an increase of 25%. This explains why the boundary increases between $K = 2$ and $K = 3$ while decreasing otherwise.

Based on these results, we state Proposition 3a.

Proposition 3a. *Adding a new partner to an existing coopetitive agreement increases the focal firm's cooperativeness if and only if the new partner's budget is sufficiently small (*i.e.*, below the boundary percentage of N displayed in Figure 1).*

We can also interpret this result from the reverse perspective. What occurs if a firm exits the agreement? The corollary of Proposition 3a suggests that the remaining firms increase (resp. decrease) their cooperation levels if the exiting firm's budget is larger (resp. lower) and decrease their cooperation levels if they lose a partner with a small coopetitive budget.

Corollary of Proposition 3a. *Removing a partner from an existing coopetitive agreement increases the focal firm's cooperativeness if and only if the exiting partner's budget is sufficiently large (*i.e.*, above the boundary percentage of N displayed in Figure 1).*

3.3.6. Number of partners and the focal firm's profit level

Regarding profit, it is crucial to understand the impact of adding a new partner to the standing coopetitive agreement on the profit of the focal firm. The Nash profit is determined by budget $\alpha_i^* n_i$ invested in cooperation for value creation:

$$\alpha_i^* n_i = \frac{n_i\left(K^2 - (K-1)\right)}{K^2} - \frac{K-1}{K^2} \cdot (N - n_i) = n_i - N\frac{K-1}{K^2}. \qquad (14)$$

Firm i's profit, as a function of K, is given by

$$\pi_i^*(K) = M_i \cdot \frac{\sum_{j=1}^{j=K} \alpha_j^* n_j}{K} = M_i \cdot \frac{\sum_{j=1}^{j=K} \left(n_j - N\frac{K-1}{K^2}\right)}{K}$$

$$= M_i \cdot \frac{N}{K}\left(1 - \frac{K-1}{K}\right). \quad (15)$$

After adding a new partner to the agreement, the profit of the focal firm i becomes

$$\pi_i^*(K+1) = M_i \cdot \frac{N + n_{K+1}}{K+1}\left(1 - \frac{K}{K+1}\right). \quad (16)$$

To assess the impact of the addition of a partner on the Nash profit of the focal firm, let us determine the sign of $\pi_i^*(K+1) - \pi_i^*(K)$. Observe that

$$\pi_i^*(K+1) - \pi_i^*(K) = M_i \cdot \left(\frac{N + n_{K+1}}{K+1}\left(1 - \frac{K}{K+1}\right) - \frac{N}{K}\left(1 - \frac{K-1}{K}\right)\right)$$

$$= M_i \cdot \frac{K(N + n_{K+1})\frac{1}{K+1} - N(K+1)\frac{1}{K}}{K(K+1)}. \quad (17)$$

We obtain

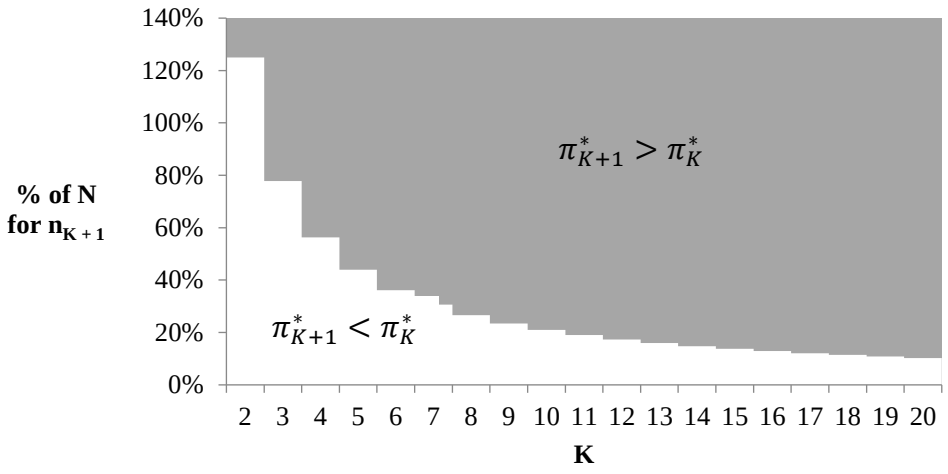
$$\begin{cases} \pi_i^*(K+1) - \pi_i^*(K) > 0, \text{ if } n_{K+1} > N\dfrac{2K+1}{K^2}, \\ \pi_i^*(K+1) - \pi_i^*(K) \leq 0, \text{ if } n_{K+1} \leq N\dfrac{2K+1}{K^2}. \end{cases} \quad (18)$$

For instance, if $K = 2$, then the two standing firms benefit from cooperating with a third partner only if the new partner has a very large coopetitive budget ($n_{K+1} > \frac{5}{4}N$). Figure 2 shows the evolution of this threshold as K increases. When the number of initial partners is small, the additional partner's budget must be very large to increase the Nash profit of the focal firm. The threshold appears to decrease at approximately 10 percent of N when K is approximately equal to 20 firms in the coopetitive game. The threshold is always positive but approaches 0 when K reaches infinity.[7] Thus, when a small number of firms sign the coopetitive agreement, the initial partners usually do not have sufficient incentives to accept

[7] This means that when K is very large, there is always at least one case where cooperation can increase with the number of partners if the $K + 1^{th}$ firm has a coopetitive budget very close to 0.

an additional partner, unless it provides a very large coopetitive budget. Conversely, losing a partner with a large budget decreases the profit of the remaining firms; however, losing a partner with a relatively small budget is always profitable for them.

FIGURE 2. Budget of the new partner in the percentage of *N* that determines the increase or decrease of π^* for the other firms



Note: $\frac{2K+1}{K^2}$ represents the boundary percentage of $N = \sum_{i=1}^{i=K} n_i$ for the budget of the new partner (n_{K+1}), which determines the increase or decrease of the other firms' Nash profit (π^*). *K* is the number of cooperative firms before the cooperation of a new partner.

These results allow us to formulate the following propositions.

Proposition 3b. *Adding a new partner to a standing coopetitive agreement increases the Nash profit of the focal firm if and only if the new partner's dedicated budget is sufficiently large (*i.e., *above the boundary percentage of N displayed in Figure 2).*

Corollary of Proposition 3b. *Removing a partner from an existing coopetitive agreement increases the focal firm's profit if and only if the exiting partner's*

*budget is sufficiently small (*i.e., *below the boundary percentage of N displayed in Figure 2).*

Before discussing the implications of these results in the following section, Table 1 provides a summary of the results of the comparative statics of the model showing whether there is a positive or negative relationship among the budget size of the focal firm, the budget size of the other partners, the entry or exit of a partner with a small or a large coopetitive budget in the agreement, and the cooperation level and profit of the focal firm.

TABLE 1. Summary of the comparative statics: changes in the cooperation level and profit according to the focal firm's budget size, partner firms' budget size and number of partners

	Focal firm	
	Cooperation	Profit
Increase in focal firm's budget size	+	+
Increase in a partner firm's budget size	–	+
A firm with a large budget joins (exits) the agreement	– (+)	+ (–)
A firm with a small budget joins (exits) the agreement	+ (–)	– (+)

Notes: The positive and negative signs indicate, at the equilibrium, a positive or negative change in the cooperation level and profit of the focal firm or its partners in response to a change in the focal firm's budget size and in its partner firms' budget size and the entry (or exit) of a firm with a large or small budget in the coopetitive agreement.

4. DISCUSSION

4.1. Finding the right balance between value creation and value appropriation in the coopetition for innovation

The existing literature on coopetition has emphasized the necessity to find the right balance between value creation and value appropriation activities to maximize the focal firm's

innovation performance (Park et al., 2014; Ritala and Tidström, 2014; Ritala and Hurmelinna-Laukkanen, 2018). However, these contributions remained mainly qualitative (Gnyawali and Park, 2011; Ritala and Tidström, 2014) or when quantitative assessments were made, the level of analysis was not at the agreement level (Park et al., 2014). Despite several calls to investigate this issue more deeply, there has been a lack of research on how firms can find this optimal balance. Our research answers this call by investigating the value creation/appropriation dilemma in coopetition and provides several key differentiating contributions. First, our game-theoretical approach allows us to identify the equilibrium allocation of the budget for each participant involved in the agreement between value creation activities and value appropriation activities. Second, in opposition with previous contributions using a two-stage game, we adopt a single-stage approach to take into account the specificities stemming from the simultaneity of competition and cooperation in coopetition. Third, we adopt a perspective in which the partnering firms have a limited budget such that allocation decision made for value creation are made at the expense of value appropriation. Fourth, our modeling allows us to analyze the value creation/appropriation dilemma in settings involving more than two partners with different budgets. Finally, our approach allows us to realize some comparative statics and observe how the equilibrium evolves when the characteristics of the agreement change.

Our research yields several key results. First, we have shown the existence of a unique Nash equilibrium of a coopetitive agreement that determines the amount of budget invested by each member firm in value creation activities and the budget kept by each firm for value appropriation activities. We show that the level of cooperation, i.e., the total amount of budget invested cooperatively, depends on the focal firm's coopetitive budget, the partner firms' coopetitive budget and the number of partnering firms. These findings confirm the

importance of the variables identified in Ritala and Hurmelinna-Laukkanen (2018) and Ritala and Tidström (2014), even if we go beyond these studies in clarifying their respective roles.

Second, our approach emphasizes a key outcome regarding the distribution of the value created by the coopetitive agreement among partnering firms. At the Nash equilibrium, the profits of the partnering firms tend to become equalized. Specifically, the profits reached by the partnering firms differ only based on exogenous organizational appropriation factors. Therefore, by neglecting such exogenous differences, we obtain the remarkable outcome that profits are equalized among all firms despite their heterogeneity in the dedicated budgets to the coopetitive project. The appropriation capacity measured by firms' relative budgets explains why their opposite incentives (to cooperate or compete more) do not have the same effect on their profit. The incentive to allocate a larger proportion of a firm's budget to cooperation (which increases value creation) is stronger for firms with large budgets than for firms with more modest budgets. This result is noteworthy because it shows how the very nature of coopetition contributes not only to generating tensions but also to regulating them by avoiding unequal sharing schemes (Ritala and Hurmelinna-Laukkanen, 2018). This situation holds if every partner can observe or anticipate the total budget of the other partners (without having access to each individual budget). We further discuss this assumption in the following sections.

4.2. Understanding the impacts of the firms' budgets and the number of coopeting firms on the focal firm's cooperativeness and profit

Finding the optimal level of cooperation and the resulting profit in a coopetitive setting also requires an understanding of how firms' strategic reactions evolve according to various parameters. Three variables have been investigated: the focal firm's budget dedicated to the coopetitive project, the partner firm's increase in its budget, and the total number of partnering firms.

First, we show that when the budget of the focal firm increases, the amount of the budget invested cooperatively to create value also increases. A richer focal firm has incentives to foster value creation in the coopetitive project by investing a larger amount of its budget in cooperation while keeping the same amount of budget to appropriate the jointly created value. Richer firms are thus more willing to create value in coopetition than firms with lower budgets. Additionally, we show that when the coopetitive budget of the focal firm increases, the additional value created by the focal firm increases its profit. In this case, more cooperation from the focal firm with the larger budget overcompensates for the decrease in the cooperation of the other partners.

Second, by adopting a symmetrical approach, we have investigated the impact of increasing the budget of a partnering firm on the focal firm's strategic reaction. Our model allows us to conclude that when the budget of a partner firm increases, the focal firm reduces its share of budget invested cooperatively while keeping more budget to appropriate the joint value. Indeed, partners with relatively smaller budgets face greater challenges regarding value appropriation in alliances with partners that invest a lot in coopetition activities (Yang et al., 2014). Consequently, keeping a larger amount of the budget to appropriate value is the only way for smaller partners to remain profitable in a coopetitive project. Regarding profits, we show that even if a partner firm increases its budget dedicated to the coopetitive project, the focal firm will also see its profit increase. This result contradicts several contributions on asymmetric alliances that state that partnering with a large firm usually reduces the profit of a smaller partner (Bae and Gargiulo, 2004; Vandaie and Zaheer, 2014). We explain this contradiction by noting that most of these previous contributions have focused on value appropriation mechanisms without accounting for the added value of cooperating with a partner that has a larger coopetitive budget. Even if a smaller firm has a lower market share

(compared to the initial situation), it also benefits from the increased market size and consequently realizes more profit.

Finally, this research has shown that the impact of adding new members on coopetitive agreements has contrasting outcomes for the initial partners. First, when a new member joins a coopetitive agreement, the focal firm invests a larger share of its budget cooperatively to create value only if the new partner is relatively small (from a budgetary standpoint). In the presence of a small new partner, the focal firm invests a larger share of its budget to create more value and to compensate for the loss of total value that can be appropriated because it is now shared with one more firm. However, if the new partner has a large budget dedicated to the coopetitive project, then this budget represents a threat to the focal firm regarding value appropriation, which leads to a downward adjustment of the focal firm's investment in cooperation to keep a sufficient budget to maintain its market share while expecting the new partner to create more value, which occurs at equilibrium. Regarding profit, the situation is even more complicated. The model allows us to conclude that the focal firm's profit increases only if the new partner is sufficiently large (from a budgetary standpoint). The addition of a new partner makes sense only if it creates more value (by adding enough monetary resources to the common pool) than it appropriates (by dividing the value with an additional partner). Thus, only a large partner appears to allow firms to create more value rather than appropriating it. Consequently, if the partnering firms decide to accept a new member in the coopetitive agreement, then this new partner must bring a sufficiently large coopetitive budget, and such a situation leads to a reduction of the budget cooperatively invested by the partnering firms in value creation.

5. CONCLUSION

Our research aimed at understanding how firms balance value creation and value appropriation behaviors in innovative coopetition projects. More precisely, based on a formal

framework dedicated to coopetition agreements, we investigated the impacts of firms' budget and the number of partners in the coopetitive agreement on the balance between value creation and value appropriation strategies. In this sense, our article contributes to the coopetition literature by offering new insights into the debate concerning the value creation and value appropriation strategies adopted by coopeting firms (Ritala and Hurmelinna-Laukkanen, 2009, 2018; Ritala and Tidström, 2014) and the tensions that they generate (Fernandez et al., 2014; Fernandez and Chiambaretto, 2016; Tidström, 2014). This vast literature has identified the key determinants of these strategies but has not provided an integrative framework to study their respective impacts on firms' value creation and appropriation strategies. Furthermore, our contribution is one of the first studies that investigates situations of "asymmetric coopetition" in which partners have different sizes and "multipartner coopetition" in which there are three or more partners. Therefore, we emphasize the importance of the relative sizes (from a budgetary standpoint) of the partners in explaining value creation and value appropriation strategies.

Inevitably, our study has a number of limitations. As with any theoretical model, our model is based on a series of assumptions that must be discussed. First, our model allows firms to use and allocate their budget for value creation or value appropriation interchangeably. Most of our results depend on this key assumption of investment substitutability across partners. However, resources dedicated by different firms to a coopetitive project are rarely perfect substitutes and frequently involve complementarities (or synergies) between resources. It would therefore be of interest to extend our model to other settings that allow for complementarities (e.g., with a multiplicative value creation function). Second, our results hold only if the coopetitive budgets of partnering firms are observable and common knowledge. Future research could consider asymmetric information among the partnering firms or develop a model in which the appropriation efforts are more difficult to

observe than the value creation efforts. Finally, as with any theoretical paper, further research is needed to empirically assess the validity of our conclusions. This empirical test could be conducted either by relying on existing databases or by running controlled laboratory experiments.

Nevertheless, this research provides new insights regarding the value creation/value appropriation dilemma in coopetition strategies for innovation while identifying promising research avenues for future contributions.

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APPENDIX 1 – Trade-off between a coopetitive project and private activities

Assume that in a preliminary stage, each firm *i* decides how much of its budget ω_i to allocate to the coopetive project (n_i) and how much to allocate to a private productive activity ($\omega_i - n_i$). Let $\Phi_i(\omega_i - n_i)$ be the strictly increasing concave ($\Phi_i'(.) > 0 \; and \; \Phi_i''(.) < 0$) profit function of the private activity and $\Pi_i(\omega_i, n_i, \alpha_i)$ be the total profit that results from the firm's allocation decision.

The total profit $\Pi_i(\omega_i, n_i, \alpha_i)$ is given by

$$\Pi_i(\omega_i, n_i, \alpha_i) = \Phi_i(\omega_i - n_i) + M_i \cdot \sum_{j=1}^{j=K} \alpha_j n_j \cdot \frac{(1-\alpha_i)n_i}{\sum_{j=1}^{j=K}(1-\alpha_j)n_j}.$$

Given the optimal profit of the coopetitive project (Equation 7 in the paper), we have

$$\Pi_i(\omega_i, n_i, \alpha_i) = \Phi_i(\omega_i - n_i) + \pi_i(\alpha_i^*, \alpha_{-i}^*)$$

In looking for n_i^*, the FOC yields

$$\frac{\partial \Pi_i(\omega_i, n_i, \alpha_i)}{\partial n_i} = -\Phi_i'(\omega_i - n_i) + \frac{\partial \pi_i^*}{\partial n_i} = -\Phi_i'(\omega_i - n_i) + \frac{M_i}{K^2} = 0.$$

With Equations 6 and 8, we obtain

$$\Phi_i'(\omega_i - n_i) = \frac{M_i}{K^2}$$

$$n_i^* = \omega_i - \Phi_i'^{-1}\left(\frac{M_i}{K^2}\right).$$

The latter expression shows that the optimum budget dedicated by firm *i* to the coopetitive project is a function of the exogenous parameters: the number of firms (*K*), firm *i*'s exogenous appropriation capacity (M_i) and its total endowment (ω_i). Any change in those parameters directly affects the optimum dedicated budget:

(i) firms with larger endowments contribute more to the coopetitive agreement, noting that an increase in ω_i increases n_i^* by the same amount ($\frac{\partial n_i^*}{\partial \omega_i} = 1$);

(ii) an increase of the exogenous appropriation capacity (M_i) has a positive impact on n_i^*;

(iii) an increase in the number of firms (*K*) has a negative effect on n_i^*.

Property (i) is because the marginal profit of the private activity $\Phi_i'(.)$ depends only on the number of firms and the exogenous appropriation capacity, and not on the available budget. Therefore, any additional budget at the optimum level will be dedicated to the coopetitive project.

APPENDIX 2 – Proof of the Nash equilibrium

Maximizing $\pi_i(\alpha_i, \alpha_{-i})$ according to α_i is equivalent to maximizing $\pi_i(\beta_i, \beta_{-i})$ with $\beta_i = 1 - \alpha_i$

$$\max_{\alpha_i} \pi_i(\alpha_i, \alpha_{-i}) = M_i \cdot \sum_{j=1}^{j=K} \alpha_j n_j \cdot \frac{(1-\alpha_i)n_i}{\sum_{j=1}^{j=K}(1-\alpha_j)n_j}$$

$$\Leftrightarrow \max_{\beta_i} \pi_i(\beta_i, \beta_{-i}) = M_i \cdot \sum_{l=1}^{l=K} (1-\beta_l)n_l \cdot \frac{\beta_i n_i}{\sum_{j=1}^{j=K} \beta_j n_j} \text{ with } \beta_i = 1 - \alpha_i$$

The FOC yields

$$\forall i \in [1, K], \qquad , n_i \cdot \frac{\sum_{j \neq i} \beta_j n_j}{\left(\sum_j \beta_j n_j\right)^2} \cdot \left(\sum\nolimits_j (1-\beta_j)n_j\right) - n_i \cdot \frac{\beta_i n_i}{\sum_j \beta_j n_j} = 0$$

Once simplified, we find

$$\forall i \in [1, K], \qquad \frac{\sum_{j \neq i} \beta_j n_j}{\sum_j \beta_j n_j} \cdot \left(\sum\nolimits_j (1-\beta_j)n_j\right) - n_i \beta_i = 0$$

$$\forall i \in [1, K], \qquad \frac{\sum_{j \neq i} \beta_j n_j}{\sum_j \beta_j n_j} \cdot \left(\sum\nolimits_j (1-\beta_j)n_j\right) = n_i \beta_i$$

Because this result holds for any participating firm, for example, firm k, and because the left-hand side of the equation is independent of i or k, we can conclude that

$$\forall i, k \in [1, K]\ n_i \beta_i = n_k \beta_k$$

By substituting the other $n_j \beta_j$ with $n_i \beta_i$ in the FOC, we find

$$\forall i \in [1, K], \qquad \frac{(K-1)\beta_i n_i}{K \beta_i n_i} \cdot \left(\sum\nolimits_j n_j - K \beta_i n_i\right) - \beta_i n_i = 0$$

$$\forall i \in [1, K], \qquad \frac{(K-1)}{K \beta_i n_i} \cdot \left(\sum\nolimits_j n_j - K \beta_i n_i\right) - 1 = 0$$

$$\forall i \in [1, K], \qquad (K-1) \cdot \left(\sum\nolimits_j n_j - K \beta_i n_i\right) = K \beta_i n_i$$

$$\forall i \in [1, K], \qquad (K-1) \sum\nolimits_j n_j = K^2 \beta_i n_i$$

$$\forall i \in [1, K], \qquad \beta_i^* = \frac{(K-1)\sum_j n_j}{K^2 n_i}$$

From the above, we can conclude that

$$\forall i \in [1, K], \qquad \alpha_i^* = 1 - \beta_i^* = 1 - \frac{(K-1)\sum_j n_j}{K^2 n_i}$$

$$\forall i \in [1, K], \qquad \alpha_i^* = \frac{K^2 n_i}{K^2 n_i} - \frac{(K-1)\sum_{j \neq i} n_j + (K-1)n_i}{K^2 n_i}$$

$$\forall i \in [1, K], \qquad \alpha_i^* = \frac{K^2 - (K-1)}{K^2} - \frac{K-1}{K^2} \cdot \frac{\sum_{j \neq i} n_j}{n_i}$$

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