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Impact of incentive schemes and personality-tradeoffs on two-agent coopetition: A theoretical examination

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Abstract

The main purpose of the present paper is to analyze the feasibility of managing coopetition among two given agents in a firm, under a Markovian structure, where the transition probabilities are defined by the incentive schemes for cooperation and competition and the personality-tradeoffs between the two agents. Furthermore, the asymptotic behavior of the model is considered and analyzed through a numerical estimation of the different possibilities. The behavior of the steady state probabilities as a function of the incentive scheme is shown for different possibilities of personality-tradeoffs between the agents. The existence of a Dominant Coopetitive Range, wherein the steady state probability of the coopetition state is higher than the similar probabilities of the cooperation and competition state, is shown to exist for some types of personality-tradeoffs. The State Dominance Mapping is found, and it is shown that the locus of the types of personality-tradeoffs in which coopetition is prevalent is quite narrow. Lastly, the probabilities of remaining in a specific state of cooperation, competition, and no coopetition are found, for the Coopetition Locus. Our results indicate that the possibilities for managing coopetition through incentive schemes are quite narrow and that an active management of interpersonal relationships in the firm is required. The paper also aims to introduce a general framework for the analysis of coopetition at the micro level, by explicitly considering coopetition and not merely a treatment of alternating behavior between pure cooperation and pure competition.

Keywords: Cooperation; coopetition; competition; Markov; management.

1. Introduction and Theoretical Framework

Initially introduced in 1992 by Raymond Noorda, the term *coopetition* was coined as a new paradigm of research by the seminal work of Brandenburger and Nalebuff in 1996. Ever since, coopetition has received much attention, both in the academia and in the business arena. The etymology of the term coopetition refers to competition and cooperation appearing simultaneously between the same parties. Pure cooperation, on the one hand, is generally characterized by the efforts placed by a group of individuals working together to achieve a common goal (Deutsch, 1949, 1962).

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Pure competition, on the other hand, generally refers to the efforts of one person attempting to outperform another in a zero-sum situation (Kelley & Thibaut, 1969).

It is in this context that coopetition has been generally defined as a situation in which there is simultaneous cooperation and competition between firms: cooperation with one another and coordination of activities in order to achieve mutual goals and competition with each other in order to achieve individual goals. In other words, coopetition means that parties can compete due to conflicting interests, but they can also cooperate due to common interests (Bengtsson & Kock, 2000). The underlying assumption is that extraordinary achievements come not only from competitive efforts of an isolated individual, but also from the efforts of a cooperative group (Johnson & Johnson, 1999). Based on this postulation, Luo (2004) advanced a conceptual and typological framework of coopetition in which both cooperation and competition coexist.

Coopetition has become an important item on many businesses' agenda, not only because a business relationship usually contains elements of both cooperation and competition (Håkansson, 2010; Young & Wilkinson, 1997), but also because the traditional business environment has experienced changes that led to the need to consider the dynamic roles simultaneously played by the various organizations in their contradictory interactions with each other (Bengtsson & Kock, 2014). These changes include, but are not limited to the classic issue of our time: do more with less and within a limited time frame – ultimately, the need is to become more efficient (Bruce & Ricketts, 2008). In practice, this has been translated into more than two decades of research on coopetition, whether it has been or not characterized as coopetition.

As such, coopetition has been studied from many perspectives: (a) following the game theory view (Brandenburger & Nalebuff, 1996; Cairo, 2006; Clarke-Hill, Li, & Davies, 2003; Gnyawali, He, & Madhavan, 2008); (b) following the resource-based view (Chen, 1996; Emden, Calantone, & Droge, 2006; Lado, Boyd, & Hanlon, 1997; Quintana-García & Benavides-Velasco, 2004), and (c) following a network approach (Gnyawali & Madhavan, 2001; Powell, Koput, & Smith-Doerr, 1996); and within different organizational settings, such as low carbon manufacturing (Luo, Chen, & Wang, 2016) and supply chain (Gurnani, Erkoc, & Luo, 2007; Nasr, Kilgour, & Noori, 2015).

Furthermore, new concepts have been advanced, such as coopetitive advantage and coopetition strategy (Dagnino & Padula, 2002), coopetitive business models (Ritala, Golnam, & Wegmann, 2014), and coopetitive practices (Dahl, Kock, & Lundgren-Henriksson, 2016).

As editors of *Coopetition Strategy*, Dagnino and Rocco (2009) presented research by different authors in reference to coopetition between organizations and within organizations. The large number of topics enclosed in the research studies presented was not exclusively related to firms, but also covered organizations such as governments, universities, and opera houses, among others. The themes covered included knowledge creation, innovativeness, trust, creation of high technology industries, globalization, biotechnology, multiparty alliances, automotive industry, insurance fraud problems, fairness, and reciprocity. Moreover, the papers covered cases from different countries, such as Israel, Taiwan, Australia, Italy, and Japan.

In a more recent study conducted by Czakon, Mucha-Kus, and Rogalski in 2014, the authors provided a comprehensive analysis of academic research on coopetition, spanning the years 1997-2010. In their literature review, they covered topics such as definitions, methodologies, linkage of the topic with related fields, types of coopetition and geographical distribution of coopetition research, top-cited papers, facets of coopetition, aspects related to the intensity of cooperation and competition relationships, theoretical approaches, patterns in coopetitive relationships and coopetition strategies, typology of coopetitive strategies, roles in network coopetition, empirical research foci, and topics for further research. Other relevant references on coopetition are the studies by Stein (2010) and Bouncken, Gast, Kraus, and Bogers (2015).

It is to be noted, however, that despite the various research efforts existing in the literature, there is a lack of unified definitions (Bengtsson, Johansson, Näsholm, & Raza-Ullah, 2013).

In time, research on coopetition has focused mainly on the advantages, opportunities, and outcomes that it entails: the pooling of competencies, the increased incentive to take risks and be proactive in product development, and the prospect of healthy competition (Juttner & Wehrli, 1995), knowledge sharing (Cabrera & Cabrera, 2002; Dahl & Kock, 2013, Quigley, Tesluk, Locke, & Bartol, 2007), knowledge creation (Zhang, Shu, Jiang, & Malter, 2010), knowledge transfer (Solitander, 2011), knowledge acquisition (Li, Liu, & Liu, 2011), and team or group performance (Baruch & Lin, 2012; Enberg, 2012), among others. As Zineldin (2004) stated, partners in a coopetitive relationship can create new value by reducing many uncertainties and risks, while gaining "access to vast information about common needs, aspiration and plans, which provides a substantial competitive advantage by strengthening strategic cooperation" (p. 785). Additionally, Tauer and Harackiewicz (2004) examined the effects of competition and cooperation on intrinsic motivation and performance and found that cooperation and competition both have positive aspects and that integrating both can facilitate high levels of both intrinsic motivation and performance.

Nevertheless, although coopetition is a source of value, it also creates tensions within the firm (Bengtsson & Kock, 2003; Fernandez, Le Roy, & Gnyawali, 2014; Gnyawali & Park, 2011; Lacoste, 2014; Raza-Ullah, Bengtsson, & Kock, 2014). Tension is often "multidimensional and multi-level, and dealing with tension requires an implicit recognition and management of the inherent contradictions" (Bez, Fernandez, Le Roy, & Dameron, 2015, p. 4., based on Raza-Ullah, Bengtsson, & Kock, 2014). In consequence, in order to optimize the benefits of coopetition, the challenge for managers is to simultaneously manage cooperation and competition (Luo, 2004). As Clarke-Hill et al. (2013) stated, firms should focus on maintaining a balance between cooperation and competition.

It is also to be noted that in all of the above studies, no explicit reference has been found with regards to coopetition and interpersonal relationships within a firm. There are important research efforts on cooperation and competition at the individual level but, as far as our knowledge goes, there is no relevant research concerning the specific concept of coopetition at the individual level. The studies at the individual level have been developed mainly in the fields of social psychology, social biology, political science, and other social sciences, and lack in the field of management. For more information, the reader is referred to the studies by Axelrod (1984, 1997), Wilson and Wilson (2007), Nowak (2006), Nowak and Highfield (2012), Deutsch (1949a,b), and Johnson and Johnson (1989).

It is not too bold to say that most of the research on the topic of coopetition has been developed at the inter firm level and to a lesser extent at the intra firm level; no significant attention has been given to aspects of coopetition among individuals within a firm. Knowledge about this important topic is, thus, still very superficial, fragmented, and lacking a solid academic basis. The present research endeavor directs its attention to address this gap. The aim is to introduce a general framework for the analysis of the coopetition at the micro level, by explicitly considering coopetition and not merely a treatment of alternating behavior between pure cooperation and pure competition.

Within an organization, at the interpersonal relationships level, what are the links between incentives and coopetition? How can incentives be used to manage coopetition? How to define a typology of coopetition in accordance with an incentive structure, for management purposes? How do the interpersonal relationships influence the level of coopetition? What is the appropriate level of coopetition in accordance with the industry? What should be an appropriate level of cooperation, competition, and coopetition in an organization? How could measurement instruments be defined for management purposes? All these are important questions begging for answers in the strategic management field.

The present research focusses specifically on the relationship between the incentives and the level of cooperation, competition, and coopetition, in the interpersonal relationships within an organization. The interaction between two agents is modelled under a game theory setting. The dynamic interaction between the two agents is modelled as a Markovian process, wherein the steady state probability vector defines the level of cooperation, competition, and coopetition between the two agents. These steady state probabilities depend directly on the whole structure of incentives, on the agents, and on the characteristics of their interpersonal relationship. Under these circumstances, the research results will permit to analyze how these probabilities change due to incentive manipulation. The steady state probabilities will represent the basis for the measurement of cooperation, competition, and coopetition.

The remainder of the paper is organized as follows: the next section describes the setting underpinning the interaction between two agents, along with the assumptions and the incentive scheme structure. Further technical details are provided with regard to the game strategies, the incentive scheme, and the probabilities used, all of which are employed in modelling the interaction between the agents. The Dominant Coopetitive Range and the State Dominance Mapping are then defined. The analysis is further enhanced with a consideration of the importance of the coopetition locus in the overall mapping. The subsequent section discusses the main findings with regard to the interpersonal relationship and the general dynamic performance. The last section concludes the paper.

2. The Setting

Consider two agents (hereafter called players, considering the game theory setting) in a firm, I1 and I2, who are in constant job interaction, under the direct supervision of a general manager (GM). Both I1 and I2 are constantly cooperating, pooling efforts for the benefit of the firm; nonetheless, at the same time, they are also constantly competing to impress the GM. For the GM, cooperation between I_1 and I_2 is important to achieve the goals of the firm efficiently and competition is also important to obtain the best out of I_1 and I_2. For both I_1 and I_2, cooperation is important to improve their own performance and to achieve better performance of the firm, among others. However, for each of them it is also highly important to compete one with the other for promotion purposes, obtaining rising payments and more resources for management, inter alia. Thus, both I_1 and I_2 are continuously and simultaneously cooperating and competing, that is, both are under coopetition. The amount of effort they assign for cooperation and competition is influenced by both the incentive structure that the GM establishes for their actions and by their interpersonal relationship.

Let us consider the following assumptions and incentive structure:

- The business of the firm evolves through a series of moves made by the two players. Each move is a decision pair, defined by the decision of each player to either cooperate (CO) or compete (CM), which each player takes without any coordination between them. Thus, there are two pure moves and two mixed moves; hence, a total of four moves are possible: (CO, CO), (CO, CM), (CM, CO), and (CM, CM), where the first decision of the pair corresponds to I_1 and the second to I_2.
- *Pure Move* (CO, CO): Whenever they both cooperate, the firm obtains a return of A_1, which is shared equally between both players[1].
- *Mixed Move* (CO, CM) or (CM, CO): If one player cooperates and the other one competes, the firm obtains a return of A_2, and the player who cooperates receives a share of mA_2, while the player who competes receives $(1-m)A_2$, where $0 \le m \le 1$.
- *Pure Move* (CM, CM): Whenever they both compete, the firm obtains a return of A_3, which is shared equally between both players[1].

Figure 1 shows the payoff matrix for I_1 and I_2, where A_1, A_2, and A_3 represent the "cake" in accordance with defined shares. It is assumed that A_1, A_2, and A_3 are fixed and dependent on the type of industry the firm belongs to, and that *m* is assigned by the GM.

[1] A symmetric treatment of both the players will be assumed throughout the paper. The more general situation of different treatments is reserved for future research.

(I_1, I_2)	**CO**	**CM**
CO	A_1 $(0.5A_1, 0.5A_1)$	A_2 $(mA_2, (1-m)A_2)$
CM	A_2 $((1-m)A_2, mA_2)$	A_3 $(0.5A_3, 0.5A_3)$

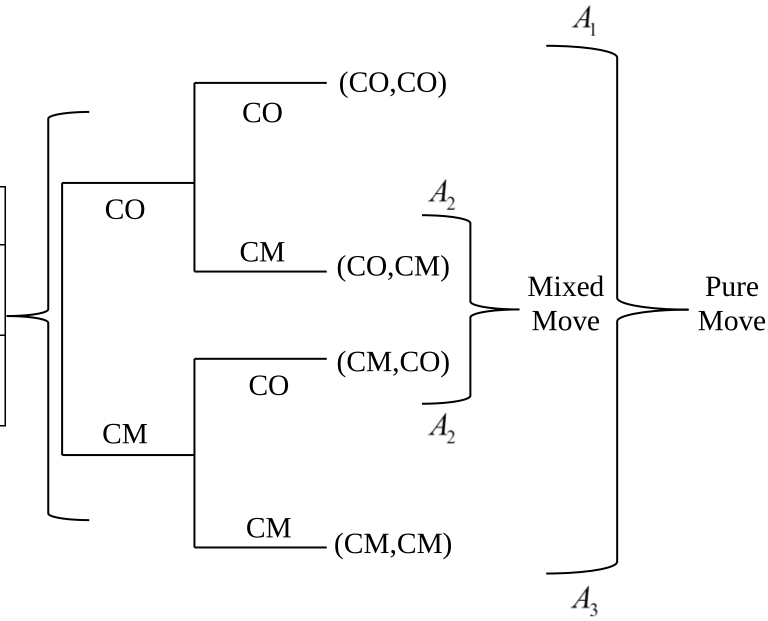

Figure 1: Payoff matrix

Game strategies

The absolute magnitude of the payoffs is irrelevant. What matters is the magnitude of the relative payoffs; hence, the following could be defined to scale the payoffs:

- Total payoff for *pure move* (CO, CO): $m_1 = A_1 / A_2$
- Total payoff for *mixed move* (CO, CM) or (CM, CO): $m_2 = A_2 / A_2 = 1$
- Total payoff for *pure move* (CM, CM): $m_3 = A_3 / A_2$

Figure 2 shows the payoff matrices for each player. Based on these payoff matrices, the combinations of incentive structures can be defined as shown in Table 1.

Payoff for I_1

I_1 \ I_2	CO	CM
CO	$0.5m_1$	m
CM	$1-m$	$0.5m_3$

Payoff for I_2

I_1 \ I_2	CO	CM
CO	$0.5m_1$	$1-m$
CM	m	$0.5m_3$

Figure 2: Payoff matrices for each player

Table 1: Combinations of incentive structures

Combinations subject to $m_1 \geq m_3$		Combinations subject to $m_3 \geq m_1$	
Combo	Incentive structure	Combo	Incentive structure
1	$0.5m_1 \geq m \geq 1-m \geq 0.5m_3$	13	$0.5m_3 \geq m \geq 1-m \geq 0.5m_1$
2	$0.5m_1 \geq m \geq 0.5m_3 \geq 1-m$	14	$0.5m_3 \geq m \geq 0.5m_1 \geq 1-m$
3	$0.5m_1 \geq 0.5m_3 \geq m \geq 1-m$	15	$0.5m_3 \geq 0.5m_1 \geq m \geq 1-m$
4	$0.5m_1 \geq 0.5m_3 \geq 1-m \geq m$	16	$0.5m_3 \geq 0.5m_1 \geq 1-m \geq m$
5	$0.5m_1 \geq 1-m \geq m \geq 0.5m_3$	17	$0.5m_3 \geq 1-m \geq m \geq 0.5m_1$
6	$0.5m_1 \geq 1-m \geq 0.5m_3 \geq m$	18	$0.5m_3 \geq 1-m \geq 0.5m_1 \geq m$
7	$m \geq 0.5m_1 \geq 1-m \geq 0.5m_3$	19	$m \geq 0.5m_3 \geq 1-m \geq 0.5m_1$
8	$m \geq 0.5m_1 \geq 0.5m_3 \geq 1-m$	20	$m \geq 0.5m_3 \geq 0.5m_1 \geq 1-m$
9	$m \geq 1-m \geq 0.5m_1 \geq 0.5m_3$	21	$m \geq 1-m \geq 0.5m_3 \geq 0.5m_1$
10	$1-m \geq m \geq 0.5m_1 \geq 0.5m_3$	22	$1-m \geq m \geq 0.5m_3 \geq 0.5m_1$
11	$1-m \geq 0.5m_1 \geq m \geq 0.5m_3$	23	$1-m \geq 0.5m_3 \geq m \geq 0.5m_1$
12	$1-m \geq 0.5m_1 \geq 0.5m_3 \geq m$	24	$1-m \geq 0.5m_3 \geq 0.5m_1 \geq m$

Under a classical Prisoner's Dilemma setting, the 12th combination is the interesting case. As it is well known, the solution to the static version of the Prisoner's Dilemma is the non-cooperative state [*pure move* (CM, CM)], which is the worst state for both the players and the firm. However, this static framework not only that it does not reflect the situation of continuous interaction between the two players under the influence of the GM, but it is not the most relevant for an incentive scheme designed to develop coopetition either, which is the topic of our interest. To foster coopetition, the 11th case becomes important and it is this one that will be considered further.

The present paper considers a situation where, in accordance with the GM's preference, the game results are ordered as follows:

(CO, CM) = (CM, CO) > (CO, CO) > (CM, CM)

Additionally, this setting is more relevant to generate coopetition. Under this game, under a static setting, if the first player cooperates, then the best result for the second player is competition; and if the first player competes, then the best strategy for the second player is to cooperate; a similar analysis holds if we consider the analysis of the game from the point of view of the second player. Thus, this structure of outcomes incentivizes a coopetitive behavior. To properly talk about coopetition, we need to consider a dynamic setting, with both the players under continuous interaction, behaving without coordination, and taking into account their personality-tradeoff – this is the focus of what follows.

Under the static setting, coopetition is mildly represented by (CO, CM) and (CM, CO); nevertheless, these sets of static strategies do not fully capture a coopetition setting, due to the fact that each strategy only considers one player as cooperating and the other one as competing, but none represents both players behaving as cooperating and competing simultaneously. To represent coopetition, a dynamic framework is required, a framework that shows both players constantly alternating their strategies between cooperation and competition.

3. Modelling Coopetition and the Incentive Scheme

3.1 Coopetition interaction between the players

This research models coopetition as a Markovian process. At any stage, based on a known incentive structure and on their interpersonal relationship, each player, without coordination, selects one strategy, either CO or CM, generating a result in terms of sharing a premium – the premium also depends on the result obtained (namely, A_1, A_2, and A_3). At the next stage, the players would move probabilistically to another state, this is, to another result, which again will depend on the strategies they take at that stage. The constantly changing states will depend on the probabilities involved in the changing behavior of the players. These probabilities will depend on the incentive structure and also on the personality-tradeoff between the two players.

The following four states are defined:

E_1: (CO, CO)
E_2: (CO, CM)

E_3 : (CM, CO)
E_4 : (CM, CM)

and the payoffs for the defined four states are as follows:

E_1 : $(0.5m_1, 0.5m_1)$
E_2 : $(m, 1-m)$
E_3 : $(1-m, m)$
E_4 : $(0.5m_3, 0.5m_3)$

Figure 3 graphically shows the Markov process. In the figure, r_{ij} is the probability of a transition from E_i to E_j. E_1 represents a cooperation state, while E_4 represents a competition state. Coopetition is represented by the transitions from E_2 to E_3, E_3 to E_2 and also by the transitions to E_2 and E_3 from and to itself. Thus, under this framework, coopetition is not a state but a transition between different states involving combinations of cooperation and competition.

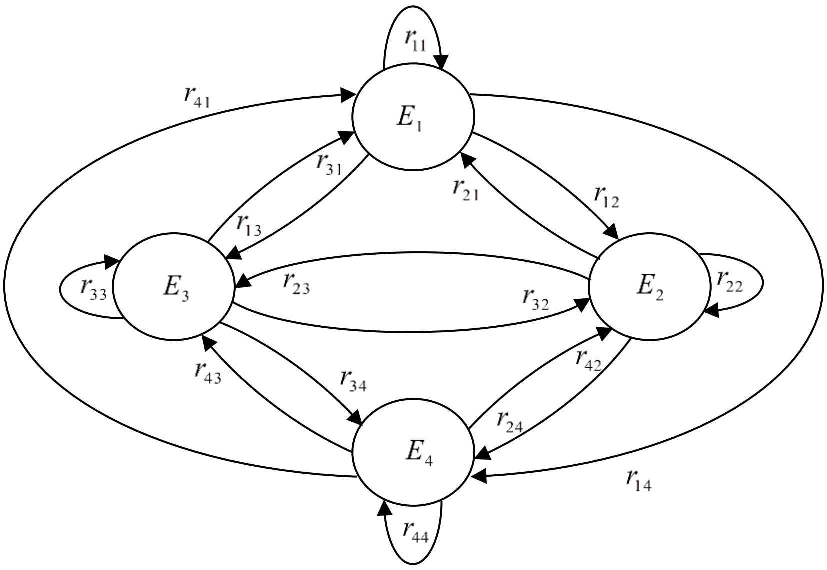

Figure 3: The Markov process for the general model

Given the symmetry between the players, the states E_2, E_3, and the transitions between them can be collapsed into a single state. Thus, the states will be redefined as follows:

S_1 : Cooperation state, defined by E_1

S_2 : Coopetition state, defined by E_2, E_3, and their internal transitions

S_3 : Competition state, defined by E_4

This redefined Markov process is shown in Figure 4, where p_{ij} is the probability of a transition from S_i to S_j.

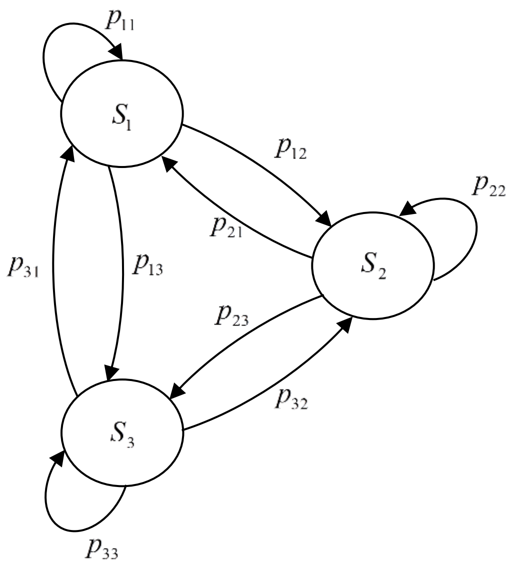

Figure 4: The three-state Markov process

The probabilities shown in Figure 4 depend on the incentive structure and on the personality-tradeoff between the players. As mentioned, the incentive structure considered satisfies the 11th combination, which is $1-m \geq 0.5m_1 \geq m \geq 0.5m_3$.

The relative sizes of these premiums influence the probabilities of transitions among the states. On the other hand, the personality-tradeoff between the players also influences these transition probabilities, that is, the propensity of the players to retaliate a non-cooperative behavior, the propensity to forgive a non-cooperative behavior, and so on, will also influence the transition probabilities.

The transition probabilities in Figure 4 are expressed in terms of the premiums involved in the incentive strategy and are based on parameters that reflect the personality-tradeoffs between the players. Based on the transition probabilities, the steady-state probabilities can be determined. These steady-state probabilities describe the level of cooperation, competition, and coopetition. Furthermore, as the steady-state probabilities are functions of the incentive scheme and of the personality-tradeoffs between the players, this will allow to study how changes in the incentive scheme and the personality-tradeoffs impact the level of cooperation, competition, and coopetition.

3.2 The incentive scheme

Without any incentive scheme, that is, with $m_1 = m_3 = m,$ the firm will remain passively in state S_1: (CO, CO), under a listless situation. To improve competitiveness, GM defines an incentive scheme to favor competition between I_1 and I_2, with the aim to emphasize state S_2, the coopetition state. For this, GM defines a differential premium scheme with a compensation of $w = 1 - m$ for the player who competes and an incentive of m, positive and lower than 0.5, for the player who cooperates. This scheme will provide incentives to move from state S_1, and it will make the desirable state S_2 possible; nevertheless, the conflict state S_3 will also be possible. To attenuate the possibility of occurrence of S_3, GM gives a compensation of $A_3 = 0,$ and $m_3 = 0.$ Furthermore, for simplicity purposes, we consider equal premiums for the cooperation and coopetition states. Thus:

$$A_1 = A_2 = 1 \text{ and } A_3 = 0,$$

$$1 \geq w = 1 - m > 0.5 > m > 0.$$

3.3 Transition probabilities

Given the incentive scheme, let us consider the following transition probabilities:

- *Cooperation state* (S_1)

Being in S_1, each player is cooperating and receiving and incentive of 0.5. The incentive for a player to change from cooperation to competition, hence, from CO to CM, is the margin he could obtain, that is, $(1-m)-0.5.$ The incentive to remain cooperating is the current compensation: 0.5. Let us calibrate p_{12} as:

$$p_{12} = \left[(1-m)-0.5\right][0.5] + [0.5]\left[(1-m)-0.5\right],$$
$$p_{12} = 0.5 - m.$$

On the other hand, the transition from S_1, to S_3 could occur if both changed from CO to CM. The incentive for this move depends on the margin of compensation the players could obtain. Let us calibrate p_{13} as:

$$p_{13} = \left[(1-m)-0.5\right]\left[(1-m)-0.5\right],$$
$$p_{13} = \left[0.5-m\right]^2.$$

Therefore:

$$p_{11} = 1 - p_{12} - p_{13},$$
$$p_{11} = 1-(0.5-m)-(0.5-m)^2,$$
$$p_{11} = (0.5+m)-(0.5-m)^2.$$

- *Coopetition state* (S_2)

Being in S_1, the transition probabilities were defined by GM by means of fixing *m*. In S_2, the coopetition state, the probabilities will be defined by the personal characteristics of the players and by the characteristics of their interpersonal relationship. For instance, see Cowgill (2015) and Schmitt (1984).

The transition from S_2 to S_1 requires that the player who is cooperating maintains that behavior and the player who is competing changes to cooperation. Thus, it requires forgiveness and regret. Let us characterize these traits by a probability α of transition from S_2 to S_1, thus,

$p_{21} = \alpha,$ where α is the level of *Reconciliation*.

The transition from S_2 to S_3 will happen when the cooperating player retaliates the competing behavior of the other player, while the latter maintains his behavior. This move is characterized by retaliation and aggressiveness. Let us characterize these traits by a probability β of transition from S_2 to S_3, thus,

$p_{23} = \beta,$ where β is the level of *Conflict*.

Thus, the transition from S_2 to itself would be:

$p_{22} = 1-\alpha-\beta,$ where the level of *Reconciliation* plus the level of *Conflict* cannot exceed unity, *i.e.*, $\alpha+\beta \le 1$.

- *Competition state* (S_3)

The transition from S_3 to S_2 means that one of the players changes from competition to cooperation, hence, from CM to CO, while the other one remains competing, that is, he maintains CM. In S_3, there is no compensation; the incentive to change from CM to CO depends on what could be obtained by this change, which is m, if the next state is S_2, and 0.5 if the next state is S_1. Let us consider that decisions are taken conservatively, assuming an incentive of m. The incentive to maintain CM would be based on the expectation that the other player changes to CO, which would generate a compensation of $1-m$. The incentive for maintaining CM will be considered the margin between $1-m$ and the minimum it could be obtained by changing from CM to CO, *i.e.*, $(1-m)-m=1-2m$.

Let us consider:

$p_{32}=m(1-2m)+(1-2m)m=2m(1-2m)$.

The transition from S_3 to S_1 means that both the players change simultaneously from competition to cooperation; hence, from CM to CO. Thus,

$p_{31}=m.m=m^2$.

Therefore:

$p_{33}=1-p_{31}-p_{32}$,

$p_{33}=1-2m+3m^2$.

Hence, $0\leq 1-2m+3m^2\leq 1$.

3.4 The transition probability matrix

Based on the above discussion, let us define the transition probability matrix as follows:

$$T=\left[p_{ij}\right]_{3x3}=\begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix}$$
$$=\begin{bmatrix} (0.5+m)-(0.5-m)^2 & 0.5-m & (0.5-m)^2 \\ \alpha & 1-\alpha-\beta & \beta \\ m^2 & 2m(1-2m) & 1-2m+3m^2 \end{bmatrix}$$

with the following restrictions:

$0\leq m\leq 0.5\leq w=1-m\leq 1$,
$0\leq \alpha+\beta\leq 1$ with α and β positives,
$0\leq 1-2m+3m^2\leq 1$,
$0\leq 2m(1-2m)\leq 1$.

3.5 The steady state probabilities

The steady state probabilities for the Markovian process are defined by the left eigenvector of the transition probability matrix associated with the largest eigenvalue, which is unitary. Thus:

Let p_i be the steady state probability for the state S_i. The following steady state probabilities have been derived from the transition state probabilities:

$$p_1=\phi(\alpha,\beta,m),$$
$$p_2=\phi(\alpha,\beta,m)\left[\frac{(0.5-m)(1.5-m)(2-3m)-m(0.5-m)^2}{(2-3m)\alpha+\beta m}\right],$$
$$p_3=\phi(\alpha,\beta,m)\left[\frac{(0.5-m)^2}{m(2-3m)}+\frac{\beta}{m(2-3m)}\frac{(0.5-m)(1.5-m)(2-3m)-m(0.5-m)^2}{(2-3m)\alpha+\beta m}\right],$$

where:

$$\phi(\alpha,\beta,m)=\left[1+\frac{(0.5-m)(1.5-m)(2-3m)-m(0.5-m)^2}{(2-3m)\alpha+\beta m}+\frac{(0.5-m)^2}{m(2-3m)}+\right.$$
$$\left.\frac{(0.5-m)(1.5-m)(2-3m)-m(0.5-m)^2}{(2-3m)\alpha+\beta m}\frac{\beta}{m(2-3m)}\right]^{-1}$$

4. Model Analytics

To analyze the behavior of the steady state probabilities, a numerical computation was employed; results can be appreciated graphically in Figures 5 and 6. From these figures, the following can be observed.

<Insert Figure 5 and Figure 6>

- Low values of m correspond to incentive schemes that favor competition, while high values correspond to incentive schemes that favor cooperation. Thus, low values of m correspond to the low probabilities for the cooperation state S_1 and the high probabilities for the competition state S_3. For either case of low or high values of *m*, the probability of the coopetition state S_2 is dominated by S_1 or S_3. The coopetition state S_2 is favored by intermediate levels of *m.*

- As expected, with m, p_1 is increasing and p_3 is decreasing. The behavior of the probability p_2 shows a concave pattern. This is so because a higher *m* represents an incentive scheme that favors cooperation and penalizes competition; thus, the probability of being in the cooperation state S_1 is favored with *m*, while the probability of being in the competition state S_3 is penalized with *m*.
- In the case of the coopetition state S_2, its probability increases with m, for low values of m, until it reaches a maximum value and then it decreases with m. For very low values of m, the competitive behavior is favored against the cooperative behavior; as m increases, cooperation starts appearing, and henceforth, coopetition, too. As m continues its increasing behavior, p_2 reaches a maximum and thereafter shows a decreasing behavior. The decreasing behavior is explained for the higher values of m, which start transforming the situation into a cooperative game, decreasing the possibilities of the competitive behavior and with it, the possibility of coopetition.
- The steady state probability of being in the cooperation state S_1 is highly insensitive to the variations in the level of conflict β, while the steady state probability of being in the competition state S_3 is highly insensitive to the level of reconciliation α. Thus, there is some kind of independence of the cooperation state from the level of conflict of the players, and some kind of independence of the competition state from the level of reconciliation of the players. Thus, the steady state probability of cooperation depends mainly on the incentive scheme and on the level of reconciliation of the players; while the steady state probability of competition depends mainly on the incentive scheme and on the level of conflict of the players.
- The steady state probability for the coopetition state S_2 depends on the incentive scheme and on the levels of reconciliation and conflict of the players.
- As either the level of reconciliation or the level of conflict increases, the sensitivities of the steady states probabilities decrease. That is, as the level of reconciliation increases, the probabilities become less sensitive to the level of conflict; and vice versa, as the level of conflict increases, the probabilities become less sensitive to the level of reconciliation.
- For a fixed level of reconciliation, the cooperation state is favored by low levels of conflict and penalized by high levels of conflict, though sensitivity is not high. The

reverse is true for the competition state: for fixed levels of reconciliation, the competition state is favored by high levels of conflict and penalized by low levels of conflict, and sensitivity could be high.

- For a fixed level of conflict, the cooperation state is favored by high levels of reconciliation and penalized by low levels of reconciliation, and sensitivity could be high. The reverse is true for the competition state: for fixed levels of conflict, the competition state is favored by low levels of reconciliation and penalized by high levels of reconciliation, though sensitivity is not high.
- For a fixed level of reconciliation, the coopetition state is favored by low levels of conflict and penalized by high levels of conflict. For a fixed level of conflict, the coopetition state is favored by low levels of reconciliation and penalized by high levels of reconciliation. In both the cases, sensitivity could be high.

4.1 Existence of a Dominant Coopetitive Range (DCR)

Any possible combination of the level of reconciliation (α), the level of conflict (β), and the incentive scheme (m) determines a specific setting for the firm. Each setting defines completely the Markovian process that describes the probabilistic behavior of the firm, which in turn determines the steady state probabilities p_1, p_2, and p_3, which show the long term probability of being in the cooperation state (S_1), the coopetition state (S_2) and the competition state (S_3). Thus, to any particular triple (α,β,m) corresponds a triple (p_1, p_2, p_3).

Our interest in this article refers to settings where GM wants to generate coopetition. Specifically, settings capable to produce $p_2 > p_1$ and p_3. Under this framework, we are particularly interested to see if for a given pair (α,β) there could be possibilities to implement an incentive scheme where the probability of the coopetition state (p_2) is higher than that of any other state $(p_1$ or $p_3)$. This is equivalent to seeing if for a pair (α,β) there is an interval for m for which the probability of coopetition is greater than the probability of any other state; we name this interval DCR.

Consider the case $(\alpha,\beta)=(0.20,0.20)$. For this case, Table 2 and Figure 7 present the steady state probabilities for different values of m. Let us describe Figure 7 in some detail.

Table 2: Dominant Coopetitive Range (DCR)

(Case $\alpha = 0.20$ $\beta = 0.20$)							
m	p_1	p_2	p_3	m	p_1	p_2	p_3
0.01	0.0186	0.0676	0.9137	0.26	0.3227	0.3795	0.2979
0.02	0.0351	0.1229	0.8420	0.27	0.3383	0.3735	0.2882
0.03	0.0499	0.1688	0.7814	0.28	0.3546	0.3667	0.2787
0.04	0.0634	0.2072	0.7294	0.29	0.3717	0.3591	0.2692
0.05	0.0760	0.2395	0.6844	0.30	0.3896	0.3506	0.2597
0.06	0.0880	0.2670	0.6450	0.31	0.4083	0.3414	0.2503
0.07	0.0993	0.2905	0.6102	0.32	0.4280	0.3313	0.2407
0.08	0.1103	0.3105	0.5792	0.33	0.4486	0.3203	0.2311
0.09	0.1210	0.3275	0.5514	0.34	0.4702	0.3085	0.2213
0.10	0.1316	0.3421	0.5263	0.35	0.4930	0.2958	0.2113
0.11	0.1420	0.3545	0.5035	0.36	0.5168	0.2822	0.2010
0.12	0.1524	0.3649	0.4827	0.37	0.5419	0.2677	0.1904
0.13	0.1629	0.3736	0.4635	0.38	0.5682	0.2523	0.1794
0.14	0.1734	0.3808	0.4459	0.39	0.5959	0.2360	0.1681
0.15	0.1840	0.3865	0.4294	0.40	0.6250	0.2188	0.1563
0.16	0.1949	0.3910	0.4141	0.41	0.6555	0.2006	0.1439
0.17	0.2060	0.3942	0.3998	0.42	0.6875	0.1815	0.1310
0.18	0.2173	0.3964	0.3863	0.43	0.7211	0.1615	0.1174
0.19	0.2290	0.3975	0.3736	0.44	0.7562	0.1407	0.1031
0.20	0.2410	0.3976	0.3614	0.45	0.7930	0.1189	0.0881
0.21	0.2534	0.3968	0.3499	0.46	0.8313	0.0964	0.0723
0.22	0.2662	0.3950	0.3388	0.47	0.8712	0.0732	0.0556
0.23	0.2795	0.3924	0.3281	0.48	0.9127	0.0493	0.0380
0.24	0.2933	0.3889	0.3178	0.49	0.9557	0.0248	0.0195
0.25	0.3077	0.3846	0.3077				

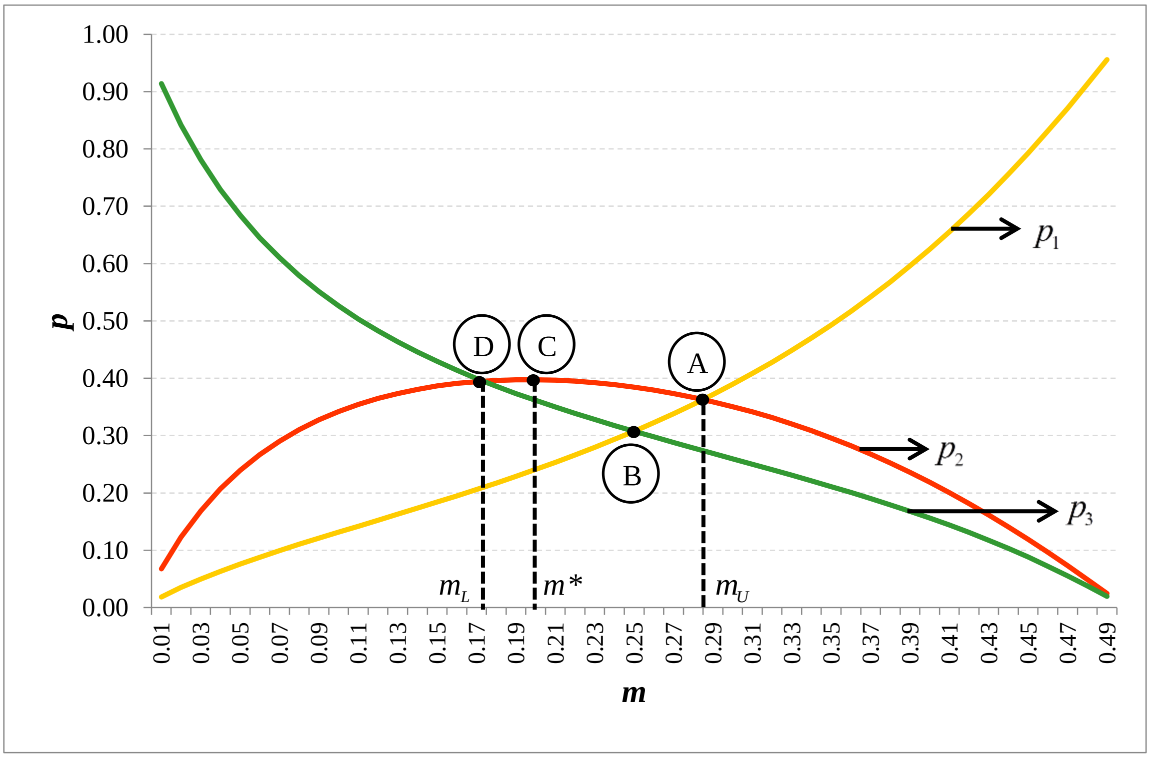

Figure 7: Dominant Coopetitive Range (DCR): Case $\alpha = 0.20$ $\beta = 0.20$

Let us start our description by considering the highest possible value for m, that is, $m = 0.5.$ The case is not actually shown in the figure. It corresponds to a no incentive situation for competition. Actually, there will be only one state, the state of cooperation, and the transition probability from that state to itself will be $p_{11} = 1.$ The steady state probabilities would be $p_1 = 1,$ $p_2 = p_3 = 0,$ – this will be a setting characterized by conformism, passiveness, listlessness. From that extreme setting, consider a small reduction in m, a small incentive to compete. The value of m will still be quite high, close to 0.5; thus, we will be at the far right-hand side of the figure. At that level of incentive, the probability for cooperation will be close to 1, and the probabilities of competition and coopetition will be close to zero. Consider a further reduction in $m,$ further incentives to compete. We start moving from right to left in the figure, p_1 is still high, but $p_3,$ the probability of competition, starts increasing; the probability of the coopetition state also increases due to the reduction in $m,$ Furthermore, due to the large difference between p_1 and $p_3,$ in favor of $p_1,$ the probability of coopetition is higher than the probability of competition. A further reduction in m continues the movement to the left, reducing $p_1,$ and increasing p_2 and $p_3;$ the difference between p_2 and p_3 continues to increase due to a reduction in the difference p_1 - p_3 > 0.

A further reduction in $m,$ will eventually lead to $m = m_U,$ where $p_2 = p_1 > p_3.$ An additional reduction in m will lead to reach point B, where $p_2 > p_1 = p_3,$ Also, notice that from point A to point B we have $p_2 > p_1 > p_3.$ From then on, reductions in m reduce p_1 and increase $p_3,$ but now $p_3 > p_1,$ and $p_2 - p_3$ starts decreasing. Eventually, point C is reached, where $m = m^*$ is such that p_2 reaches its maximum value and we have $p_2 > p_3 > p_1.$ A further reduction in m continues to decrease p_1 and increase $p_3,$ and p_2 starts decreasing, still $p_2 > p_3 > p_1,$ until point D is reached. At point D, $m = m_L,$ and $p_2 = p_3 > p_1.$ A further reduction in m accentuates the difference between an increasing p_3 and a decreasing $p_1,$ with p_2 reducing its magnitude, with $p_3 > p_2 > p_1.$ Continuing the reduction in m leads to maintaining the same pattern characterized by increasing $p_3,$ and decreasing p_2 and p_1, with $p_3 > p_2 > p_1.$ As m approaches the value of 0, we are approaching a setting characterized by full competition and low probabilities of cooperation and coopetition; p_3 approaches 1 and p_2 and p_3 approach 0.

Figure 7 shows some interesting values of m for our purposes:

- For the case presented, characterized by the specific values of (α, β), there is a DCR, where p_2 is greater than p_1 and p_3: the interval $[m_L, m_U]$, this interval contains $m = m^*$, where p_2 achieves its maximum value.
- Within the DCR, there are two intervals: B-A with $p_2 > p_1 > p_3$, and D-B with $p_2 > p_3 > p_1$. If we consider S_3 as an undesirable state, the region of our interest will be B-A. Unfortunately, notice that for this particular case, m^* is within D-B.

The case presented shows that there is a DCR; unfortunately, not only is this not a general case, but it is also somewhat not a common case.

4.2 State Dominance Mapping (SDM)

To any particular triple (α, β, m) corresponds a triple (p_1, p_2, p_3). If we consider only the pairs defined by the characteristics of the interpersonal relationship between the players: (α, β), with m free, then to every pair corresponds a set of triples (p_1, p_2, p_3). From this set, a particular point for our interest will be the one where the incentive scheme maximizes the probability of the coopetition state, that is $m = m^*$ that maximizes p_2 for a given combination of α and β. These points $(\alpha, \beta, m = m^*)$ are shown in Figure 8. Every region exhibits the locus corresponding to some specific ordering of the steady state probabilities: $p_i > p_j > p_k$, where $i, j,$ and k can take the values of 1, 2, and 3. It can be appreciated that every region is possible; there are regions with and without a Dominant Coopetitive Range.

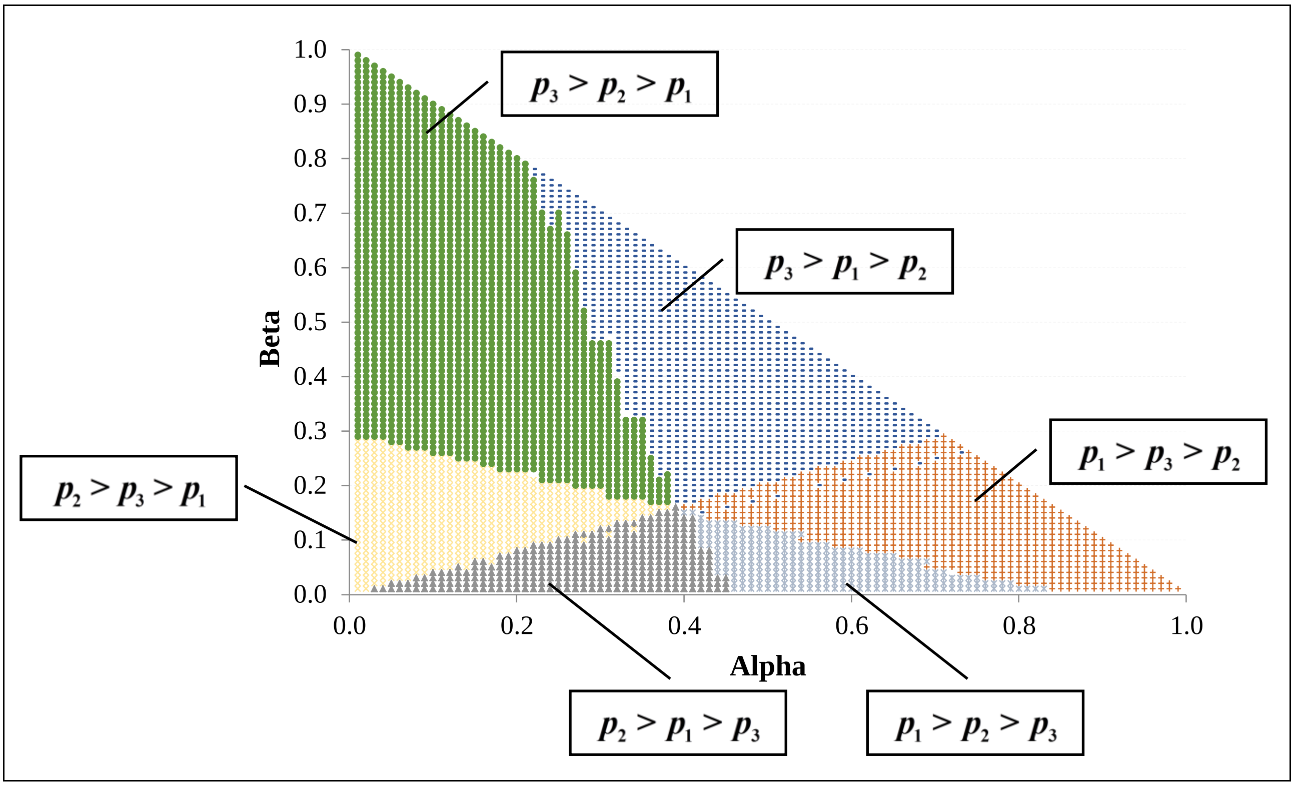

Figure 8: State Dominance Mapping

Which region is more relevant will depend on the particular industry to which the firms belong. The choice of any specific region means the selection of a level of reconciliation (α), and a level of conflict (β) if there was complete flexibility for this choice, and the selection of an incentive scheme that maximizes coopetition $(m = m^*)$. Were α and β fixed, the setting with m = m* would be fixed, that is, (p_1, p_2, p_3) would be determined.

The following cases could be considered:

- Complete flexibility: Free choice of α, β and $m = m^*$.

  GM is free to select players with appropriate characteristics of interpersonal relationships and specify an incentive scheme accordingly. This case could represent the situation of hiring players and implementing an incentive scheme. GM could select a region with DCR.

- No flexibility: α and β are given.

  GM cannot influence the interpersonal relationship between the players; he just chooses an incentive scheme $m = m^*$ for the characteristics of the interpersonal relationship between the players. This case could represent situations of firms with senior players who are difficult to fire. The setting is given; it could correspond or not to a region with DCR.

- Partial flexibility: α and β are manageable.

  GM has some power to manage the interpersonal relationship between the players. There is some flexibility for the GM to move the setting from one region to another by influencing α and β. Depending on the personalities of the players, this could or could not be possible.

4.3 The Coopetition Locus

In what follows, we consider the industries for the case of our interest, where coopetition is the more important state; furthermore, we consider that cooperation is preferable to competition. Thus, the region of interest is:

$p_2 > p_1 > p_3$

The commonality of this locus in the overall mapping, strictly speaking, cannot be appreciated theoretically; data is needed. But we can make some comments based on the mapping in Figure 8. Based on the areas of the regions, we would have the following:

Region	Area (% of total)
$p_1 > p_2 > p_3$	6.5%
$p_1 > p_3 > p_2$	15.3%
$p_2 > p_1 > p_3$	7.4%
$p_2 > p_3 > p_1$	11.3%
$p_3 > p_1 > p_2$	22.1%
$p_3 > p_2 > p_1$	37.4%

Notice that the region of our interest is the second one with the smallest area; it represents only 7.4% of the total area. Furthermore, if we consider the competition state to be an undesirable state, then the total area where S_3 is the most probable state represents almost 60% of the total area; considering the total area where S_3 is either the most probable state or the second most probable state, it would represent 86%. The regions where S_1 and S_2 are the two most probable states represent only 14%.

This situation points to the importance of the management of the interpersonal relationships among the players in a firm, both during the hiring process and in the case in which the players are already hired.

Table 3 presents additional information for each region in Figure 8. As previously indicated, to each pair (α, β) corresponds a set of triples (p_1, p_2, p_3), where these triples are functions of m. Given the interest in coopetition, for each of these triples, the $m = m*$ which maximizes p_2 was found. Thus, to each pair (α, β) corresponds an m*; to each pair of reconciliation-conflict corresponds a scheme which maximizes the probability of coopetition, the probability p_2 of occurrence of S_2, this is shown in Figure 8. Table 3 shows the interval of $m = m*$ for each particular region. Table 3 also shows the range of the steady state probabilities that correspond to each region.

For our region of interest, $p_2 > p_1 > p_3$, in Table 3, it can be appreciated that the interval of $m = m*$ is very narrow, from 0.15 to 0.18, reflecting the difficulty in managing the optimal incentive scheme that optimizes the probability of achieving the coopetition state. Moreover, it is to be noticed the strong bias toward competition required in the incentive scheme, reflected in the low values of $m = m$*: between 0.15 and 0.18. In addition, the steady state probabilities are highly sensitive to the optimal incentive scheme.

Table 3: Range of m where P_2 is the maximum for each region of the SDM

	$p_1 > p_2 > p_3$		$p_1 > p_3 > p_2$		$p_2 > p_1 > p_3$		$p_2 > p_3 > p_1$		$p_3 > p_1 > p_2$		$p_3 > p_2 > p_1$	
	min	**max**	**min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**

Range $\boldsymbol{m}$	0.15	0.18	0.15	0.18	0.15	0.18	0.17	0.23	0.17	0.22	0.18	0.23
Range $\boldsymbol{p_1}$	0.34	0.48	0.34	0.50	0.06	0.39	0.03	0.33	0.20	0.39	0.08	0.33
Range $\boldsymbol{p_2}$	0.26	0.39	0.22	0.33	0.33	0.87	0.34	0.93	0.20	0.33	0.20	0.46
Range $\boldsymbol{p_3}$	0.22	0.33	0.26	0.39	0.06	0.33	0.04	0.45	0.34	0.59	0.34	0.69

The above highlights the difficulty in managing coopetition by considering only the incentives schemes; management of the interpersonal characteristics is necessary to achieve coopetition.

4.4 Remaining in a specific state

It is also interesting to consider the probability of the system of remaining in its current specific state. For this purpose, let us consider a specific case within our region of interest: $p_2 > p_1 > p_3$, where coopetition dominates. Specifically, Table 4 shows the mentioned probabilities for $\alpha = 0.27$, $\beta = 0.1$, and $m = m^* = 0.18$, which implies: $p_1 = 0.29$, $p_2 = 0.43$ and $p_3 = 0.28$. The table registers the probability of remaining in the current state after *n* transitions for:

$P_1(n)$: Referring to state S_1, the cooperation state.

$P_2(n)$: Referring to state S_2, the coopetition state.

$P_3(n)$: Referring to state S_3, the competition state.

$P_4(n)$: Referring to remaining out of S_2, not being in S_2.

Table 4: Probability of remaining in a specific state

$\boldsymbol{n}$	$\boldsymbol{p_1(n)}$	$\boldsymbol{p_2(n)}$	$\boldsymbol{p_3(n)}$	$\boldsymbol{p_4(n)}$	$\boldsymbol{n}$	$\boldsymbol{p_1(n)}$	$\boldsymbol{p_2(n)}$	$\boldsymbol{p_3(n)}$	$\boldsymbol{p_4(n)}$
0	0.4224	0.3700	0.2628	0.2765	16	0.0001	0.0002	0.0020	0.0016
1	0.2440	0.2331	0.1937	0.2001	17	0.0000	0.0001	0.0015	0.0011
2	0.1409	0.1469	0.1428	0.1447	18	0.0000	0.0001	0.0011	0.0008
3	0.0814	0.0925	0.1053	0.1047	19	0.0000	0.0001	0.0008	0.0006
4	0.0470	0.0583	0.0776	0.0758	20	0.0000	0.0000	0.0006	0.0004
5	0.0272	0.0367	0.0572	0.0548	21	0.0000	0.0000	0.0004	0.0003
6	0.0157	0.0231	0.0422	0.0397	22	0.0000	0.0000	0.0003	0.0002
7	0.0091	0.0146	0.0311	0.0287	23	0.0000	0.0000	0.0002	0.0002
8	0.0052	0.0092	0.0229	0.0208	24	0.0000	0.0000	0.0002	0.0001
9	0.0030	0.0058	0.0169	0.0150	25	0.0000	0.0000	0.0001	0.0001
10	0.0017	0.0036	0.0125	0.0109	26	0.0000	0.0000	0.0001	0.0001
11	0.0010	0.0023	0.0092	0.0079	27	0.0000	0.0000	0.0001	0.0000
12	0.0006	0.0014	0.0068	0.0057	28	0.0000	0.0000	0.0001	0.0000
13	0.0003	0.0009	0.0050	0.0041	29	0.0000	0.0000	0.0000	0.0000
14	0.0002	0.0006	0.0037	0.0030	30	0.0000	0.0000	0.0000	0.0000

15	0.0001	0.0004	0.0027	0.0022

Note: Table 4 has been computed based on
$(\alpha = 0.27, \beta = 0.10, m^* = 0.18, p_1 = 0.29, p_2 = 0.43, p_3 = 0.28)$

Figure 9 shows graphically the probability of remaining in a specific state when
$(\alpha = 0.27, \beta = 0.10, m^* = 0.18, p_1 = 0.29, p_2 = 0.43, p_3 = 0.28)$

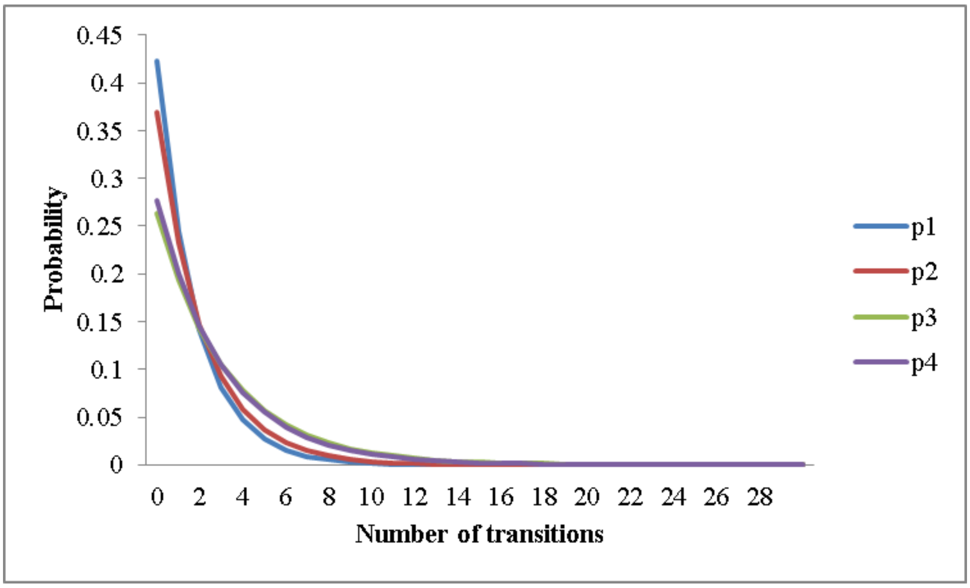

Figure 9: Probability of remaining in a specific state

These probabilities are important in the sense that remaining many transitions in the same state could potentially affect the behavior of the players involved, that is, change α and β. Also, it can influence GM, who could think that the incentive scheme, m, may require an adjustment. From the table, the expected number of transitions that the system will remain in a specific state can be calculated, given that it is in that state. These expected values are as follows: For the cooperation state: 1.37 transitions; for the coopetition state: 1.70 transitions; and for the competition state: 2.80 transitions. The expected number of transitions that the system could remain outside the coopetition state is: 2.61 transitions. Thus, the higher expected number of transitions corresponds to the less desirable state of competition, which is also higher than the expected number of transitions of remaining outside of the coopetition state. This situation complicates the management of coopetition.

5. Interpersonal Relationships and the General Dynamic Performance

As it was shown, managing coopetition by relying solely on incentive schemes is quite difficult to implement. An active management of the interpersonal relationship between the agents is required. Let us make some final comments with respect to the influence of reconciliation and conflict on the general dynamics of the system.

In the model, α and β are the probabilities that represent the levels of reconciliation and conflict, respectively. They describe the personal characteristics of the players, as well as their interpersonal relationship. They are also influenced by the labor climate in the firm, the firm's organizational culture, the management of the players' relationship by the GM, and the leadership characteristics of GM, among others. In the model, these probabilities define the transition probabilities out of the coopetition state, S_2. The level of reconciliation α defines the probability of transition from S_2 to the cooperation state S_1. The level of conflict β defines the probability of transition from S_2 to the competition state S_3.

State S_2 is characterized by cooperation and competition; hence, by coopetition. The probability $\alpha,$ the level of reconciliation, measures the simultaneous occurrence of both: the player who is competing changes his behavior to cooperation, showing some regret in his behavior; and the player who is cooperating insists on his cooperative behavior, in spite of the recent competitive behavior of the other player, showing forgiveness. This joint behavior will produce a transition from S_2 to S_1, hence, from coopetition to cooperation, and this is called reconciliation.

The probability $\beta,$ the level of retaliation, measures the likelihood of the simultaneous occurrence of both: the player who is competing remains competing, showing aggressiveness; and the player who is cooperating changes to competing, trying to retaliate the other player's behavior. This will produce a transition from S_2 to $S_3,$ hence, from coopetition to competition, and this is called conflict.

Being in $S_2,$ the coopetition state, the probability of remaining in that state of coopetition is $p_{22} = 1 - \alpha - \beta.$ This transition occurs when either both players change their behavior simultaneously (the TIT FOR TAT strategy) or both players repeat their behavior (domination of one player by the other).

Low values of α and β will favor the remaining in the coopetition state, $S_2;$ but it is to be remembered that state S_2 is actually the composition of states E_2 and E_3 in Figure 3, which represent the transitions from (CO, CM) to (CM, CO) and from (CM, CO) to (CO, CM), and the transitions from (CO, CM) and (CM, CO) to themselves. The first two types of transitions correspond to the TIT FOR TAT behavior and the last two types of transitions correspond to the dominance of one player over the other.

As α and β increase, the probability of remaining in the coopetition state S_2 decreases and the importance of the cooperation state S_1 and the competition state S_3 increases; which of the last two states will be more important will depend on the relative sizes of α and β. A higher α relative to β will favor the cooperation state S_1, and vice versa, a higher β relative to α will favor the competition state S_3.

6. Conclusion

Coopetition – defined as a model that assumes relationships that are filled with tensions related to the coexistence of two contradictory states, cooperation and competition – is considered to be one of the most revolutionary business perspectives in recent years. The existent literature counts with studies that have addressed coopetition at both the inter-firm and intra-firm level; nevertheless, almost no attention has been given to studying coopetition among the individuals within a firm. The present paper attempts to fill this gap by studying the feasibility of managing coopetition among two given agents in a firm, while taking into account the incentive scheme and the personality-tradeoff between the two agents. As such, we advance a general framework for the analysis of coopetition at the micro level and we consider coopetition as a self-standing state instead of a treatment of alternating behavior between pure cooperation and pure competition.

The main insight evolving from the results is that the possibility of managing coopetition among agents through economic incentive schemes is quite limited. The complexity emerges when we consider the requirement of high levels of discriminatory incentives to overcome cooperation (passiveness) and generate competition, but these incentives also generate the possibility of pure competition that might not be desirable. This situation can be seen in the low values for “m” (between 0.15 and 0.18) in the region of interest in the State Dominance Mapping. This narrow range also reflects a possibly quite unstable situation.

This important insight has been overlooked by the limited research devoted to coopetition at the micro level of interpersonal relationships; this may have happened due to the fact that coopetition has not been explicitly modeled before. Former research contemplates the topic of coopetition in models that only consider alternations between pure cooperation and pure competition. When coopetition is explicitly considered, as in this paper, management is realistically modeled targeting to position the agents in an intermediate state, between a less desirable state of pure cooperation and an undesirable state of pure competition, in a context in which the incentive schemes have to be importantly biased toward competition actions among the agents. The situation could be quite unstable for targeting to remain in a saddle state of coopetition and management could be seen as walking on the razor's edge.

Previous research may have also overlooked the mentioned insight because of modeling the situation under static and deterministic frameworks. The stochastic approach taken in this paper allowed to consider the continuous interactions between the agents, emphasizing their reactions not only to incentive schemes, buts also to their interpersonal behavior.

The limited role played by the economic incentives in managing coopetition means that management efforts have to also be directed toward influencing the interpersonal relationships between the agents, which implies influencing the personality-tradeoffs, specifically, the propensities to forgiveness, retaliation, regret, and aggressiveness of the agents; with all the difficulties that these tasks involve, especially considering that at the same time, the management is required to impose an incentive scheme strongly biased toward competition. Coopetition is a saddle and unstable state that is difficult to manage.

From a methodological point of view, we employ a Markovian process to model coopetition, where the transition probabilities are defined by the incentive schemes for cooperation and competition and by the personality-tradeoff between the agents. It would be interesting to extend this research with a study that assesses the robustness of the results found by means of supporting the proposed theoretical framework with real data.

From a managerial point of view, our findings suggest that coopetition management is not an easy task: it cannot be based solely on incentive schemes and an active management of interpersonal relationships in the firm is also required. The results, although theoretically-oriented, may prove to be important for the development of measurement instruments, for setting guidelines for the management of the interaction of agents in the firm, and for setting appropriate incentives for the firm in accordance with the industry, among others.

It is our hope that the current research will discourage researchers from treating coopetition as a treatment of alternating behavior between pure cooperation and pure competition, but rather encourage them to examine further the topic of coopetition, in an attempt to answer to as many remaining research questions as possible.

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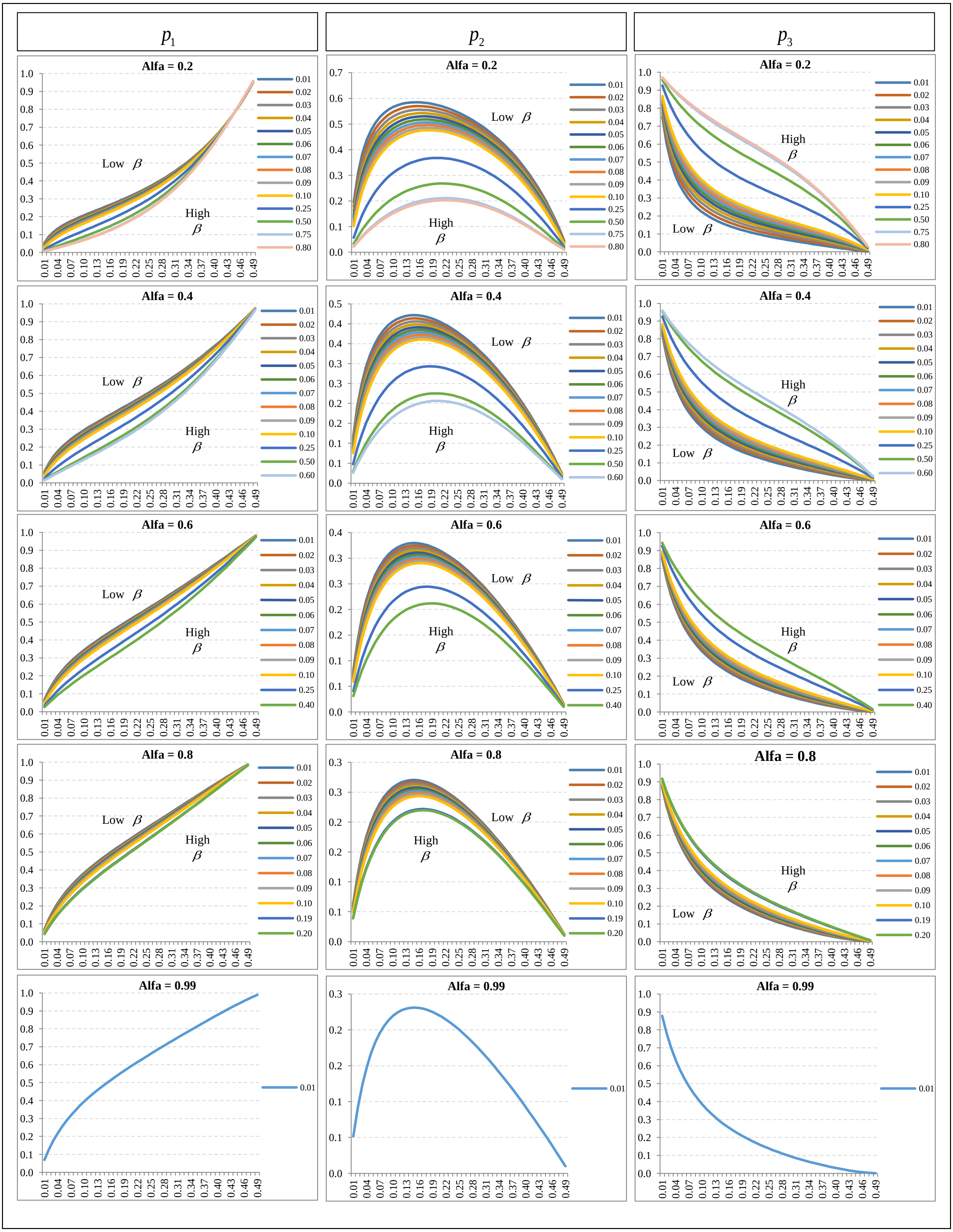

Figure 5: Steady state probabilities under different incentive schemes and fixed level of reconciliation α

Figure 6: Steady state probabilities under different incentive schemes and fixed level of conflict β