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Modelling the Performance Consequences of Coopetition in Business Relationships – a Quantitative Approach

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Abstract

The objective of the paper is to develop an analytical tool that is capable of modelling decision-making in coopetitive business relationships. Managers in the same industry differ in respect of their willingness to adopt coopetition. To better understand coopetitive decision-making, we need a model whereby such decisions can be experimented with and analysed. An important prerequisite of such a model would be its capacity to measure the performance consequences of coopetitive interactions at both firm and relationship levels. We show that existing operationalisation has limited capacity to do that. Based on existing game theoretical constructs, we propose a new operationalisation of a coopetitive decision-making episode in horizontal business relationships using a two-step sequential game. We suggest developing what we term a "coopetitive composite solution matrix" by summing up the payoff functions of the two steps of the game. The suggested operationalisation has the capacity to measure all the potential performance consequences of a complex piece of coopetitive decision-making in an episode. In this way, the decision problem's cognitive representation becomes straightforward and analysis of the impact of the behavioural attributes of managers on the actual decision-making process is unambiguous.

Keywords

coopetition, business relationship, performance consequences, decision-making, game

1 Introduction

The term coopetition was used first by a practitioner. Shortly after this, Brandenburger and Nalebuff (1995) published a work providing the first academic discussion on horizontal coopetitive relationships. They used a game theoretical approach by conceptualising coopetition as a positive-sum game. Since that, coopetition has been investigated in different types of relationships, not only horizontal but also vertical (Lacoste, 2012); and at different analytical levels: at dyadic, triadic (Thomason et al., 2013) and even more complex network (Wilhelm, 2011) levels. The extension of analytical levels was driven by the desire to obtain deeper insight into the dynamic character of coopetition (Ritala and Tidström, 2014). However, diversity has created obstacles for future research, highlighting the need for more systemic analysis (Fjeldstad et al., 2012; Pitelis, 2009). The high degree of heterogeneity in coopetition research, and specifically the lack of understanding performance consequences of coopetitive interactions, hinders further theoretical development (Dorn et al., 2016). We therefore think that going back to the origin of the concept, and applying dyadic, relationship-level analysis has relevance.

Brandenburger and Nalebuff (1995; 1996) interpreted coopetition as a business strategy involving horizontal industry agents, where competition and cooperation are simultaneously present, leading to a positive-sum game. Later, Bengtsson and Kock (2000) defined the term slightly differently, putting an emphasis on its relational aspects. They defined coopetition as a specific type of B2B relationship, where competition and cooperation are simultaneously present. These two approaches still dominate the literature. Some papers approach it from a strategic perspective (Jena and Sarmah, 2016; Teller et al., 2016), while others have a relational approach (Vedel et al., 2016; Klimas, 2016). However, while these two approaches might appear to have different areas of theoretical focus, coopetition encompasses both. It can be interpreted only in a specific relational context and be analysed through the specific

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strategic actions (or moves) of the actors involved (Ritala and Tidström, 2014). Both of the two inherent aspects of coopetition are expressed by its interpretation as a special, paradoxical relational strategy (Bengtsson and Kock, 2014; Gnyawali et al., 2016). We also apply this interpretation.

The objective of the paper is to develop a model using game theoretical concepts that models coopetitive decision-making at an episode level in horizontal relationships. Coopetition literature is rich in game-theoretic models (e.g. Nagarajan and Sosic, 2008; Devece et al., 2019) assuming rational decision makers, perfect information (e.g. Lin and Huang, 2013), and where the decision-making process is operationalised using backward induction (McCain, 2014). Backward induction calculates the best solution, and then it reasons backwards from the end of the game. Full information allows one to determine the appropriate sequence of decisions that has led to optimal solution. However, individual decision makers are not fully informed, and they might not have the ability or opportunity to perform the necessary adaptation steps assumed by backward induction. We lack an analytical tool that would make it possible to model, test and analyse real coopetitive decision-making processes.

As Wang and Krakover (2008) have highlighted, firms in the same industry differ in respect of their willingness to adopt coopetition. This might be because of different behavioural patterns of individual managers, their different perceptions, or behavioural bounds. Although such behavioural antecedents significantly affect decisions (Levinthal, 2011; Gavetti, 2012), the understanding of these mechanisms is still limited. An important prerequisite of a tool useful in analysing this is its capacity to measure the performance consequences of coopetitive decisions, making their cognitive aspect clear. We aim to present such an analytical model. We go back to the origin of the phenomenon and apply game theoretical concepts. We propose a general model using which both action and relation level performance consequences of a two-step coopetitive decision-making process can be analysed. Such a model is useful for future research investigating real coopetitive decision-making and related behavioural patterns of individual managers.

The Section 2 provides a literature review on how extant research has operationalised coopetitive decisions and measured performance implications. Both business and game theoretical approaches are discussed. It also highlights limitations. Section 3 proposes a new operationalisation using existing solutions of game theory but combining them in a unique way. This models the coopetitive decision-making in horizontal business relationships using a two-step sequential game. The game is sequential in the sense that the two transactions of coopetition are assumed to follow each other in a sequential way. Using this operationalisation, we can develop a new theoretical construct – the coopetitive composed solution matrix– that is useful in the systemic analysis of complex performance consequences. Section 4 illustrates the model with a numerical example, but also provides its generalised mathematical description. We close the paper by elaborating the practical relevance of the proposed model and potential future research avenues.

2 Performance consequences of coopetitive decisions – operationalisation and measurement

This section provides a literature review in three steps. First, we discuss performance consequences of coopetition. Then, we critically discuss how extant literature operationalises and measures them. Finally, we present game theoretical concepts for modelling coopetitive decision-making that can be used for developing a new operationalisation capable to overcome limitations of existing ones.

2.1 Potential performance outcomes of coopetition

As indicated earlier, we conceptualise coopetition as a special relational strategy. We capture its strategic aspect by different actions of decision-makers in a horizontal relationship. Recent research highlights that competitive and cooperative actions in relationships are usually dynamic and might even overlap (Gnyawali and Park, 2011; Ritala and Tidström, 2014). Although this conceptualisation is close to real life situations, it makes the analysis of coopetitive performance implications hard to operationalise and measure. Thus, this paper limits focus on its traditional interpretation that captures coopetition as a set of two sequential strategic actions, one cooperative and another coopetitive, or vice versa (Brandenburger and Nalebuff, 1996). Based on Holmlund (2004), we treat a pair of such interlinked actions as a coopetitive episode.

To analyse the performance consequences of coopetition effectively, we first must understand its two constituents, competition and cooperation, and their distinguishing characteristics (MacDonald and Ryall, 2004; Ritala and Hurmelinna-Laukkanen, 2009). Coopetition relies on divergent interests; therefore, it is inherently paradoxical. Bengtsson and Kock states that the two strategic – a competitive and a cooperative – actions making up coopetition, are based on "diametrically opposite assumptions"

(2000). In the competitive action, each firm's goal is to earn above-normal profit, even at the expense of its competitors (Padula and Dagnino, 2007) with single, firm-specific actions. Whereas in the cooperative action, the main interest is to achieve common and not individual goals by means of cooperative actions. Objectives related to value creation and value appropriation are usually in conflict, since individual and mutual objectives typically do not converge (Padula and Dagnino, 2007; Tidström, 2009; Ritala and Hurmelinna-Laukkanen, 2009; Ling, 2010).

Many benefits may accrue from coopetitive endeavours, including higher overall firm performance, and increased firm competitiveness (Das and Teng, 2000; Rusko, 2011). These might stem from various types of positive outcome arising from the different strategic actions taken by the two agents of a coopetitive relationship. Most of these outcomes are action-level performance consequences; however, Lacoste (2012) has highlighted that coopetition has relational consequences as well.

Based on an extensive literature review Bengtsson and Raza-Ullah (2016) distinguished the following core action-level positive outcomes for firms: increased operational performance, better innovation and a more competent knowledge base. These outcomes might positively influence the improvement of several concrete key performance indicators, such as decreased costs (Chin et al., 2008), or increased product and service quality (Luo, 2007), but also increased market share (Gnyawali and Park, 2011).

Knowledge development is another widely discussed aim of coopetition (Walley, 2007). Firms pro-actively pool their knowledge, research resources and activities to get access to, and internalise external resources (Bengtsson and Kock, 2000; Wang et al. 2014), or create a common, enriched knowledge base (Ritala and Hurmelinna-Laukkanen, 2009). These can be drivers of the increased innovation performance of the firms (Ritala, 2012; Klimas and Czakon, 2018; Vanyushyn et al., 2018). In addition to these widely discussed action-level benefits, the relation-level positive outcomes have recently gained more and more academic attention. Increased level of trust and commitment are typical relation-level positive outcomes that have been reported (Bengtsson and Raza-Ullah, 2016). Any coopetitive horizontal business relationship has a vital relation-level performance dimension, the relative competitive position of the firms involved (Ritala et al, 2014; Mudambi et al., 2017), since the ultimate motivation of competitors is this: "The successful new-game strategists measure every strategic move by its impact on this relative competitive position" (Buaron, 1981; quoted by Mione, 2018).

As previously mentioned, the conceptualisation of Brandenburger and Nalebuff (1995; 1996) interprets coopetition as a strategy involving horizontal industry actors, where both competition and cooperation is present. Here, coopetition incorporates both cooperative and competitive strategic action types. Hence, firms have both a relational and a firm- level strategy. Relational strategy refers to the collaborative action that aims at achieving the "relational rent" (Dyer et al., 2008; Lavie, 2006). Conversely, the competitive action is driven by firm-level strategies (Dyer et al., 2008; Adegbesan and Higgins, 2011).

Coopetition is, by definition, the concurrent existence of competition and cooperation in a given relationship. However, the benefits of cooperative actions in relationships are not easy to align with individual strategic objectives and moves (Dyer et al., 2008; Tidström, 2009; Ritala and Tidström, 2014), and arguably, one needs to be able to measure and analyse the performance consequences at action, episode, firm and relationship levels.

The inherent tension between individual and common goals shapes managerial decision making. Extant literature argues that both cognitive and behavioural attributes of managers play a crucial role in this (Czakon et al., 2020); however, due to the superficial conceptualisation and operationalisation of coopetitive decisions, managerial decision-making might all too easily lead to ex post rationalisation (Marcel et al., 2011), making further actions biased and academic discussion questionable. The following subsection discusses ideal and existing operationalisations.

2.2 Operationalizing a coopetitive episode and measuring its performance consequences – business literature

As mentioned, business literature has conceptualised a coopetitive episode and operationalised it through two separate, and subsequent strategic actions (Brandenburger and Nalebuff, 1995; 1996). From an analytical perspective, this means that researchers using this conceptualisation should analyse a coopetitive horizontal relationship that evolves over time through two separate, subsequent strategic actions. To avoid any cognitive bias in the decision-making process, performance implication of both actions should be clearly measured (see Fig. 1). Although this conceptualisation is clear, we have not found any empirical paper in the business literature that has specifically operationalised coopetitive decisions in this way.

A quasi episode-level operationalisation of a coopetitive horizontal business relationship is illustrated in Fig. 2. Such a relationship is competitive by definition. Given this basic

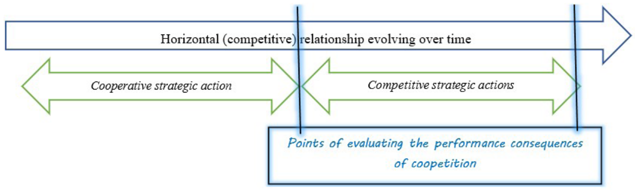

Fig. 1 Operationalisation of a coopetitive episode in horizontal relationship: two separate and subsequent strategic actions between competitors – measurement of performance consequences at the end of both actions. Source: own elaboration

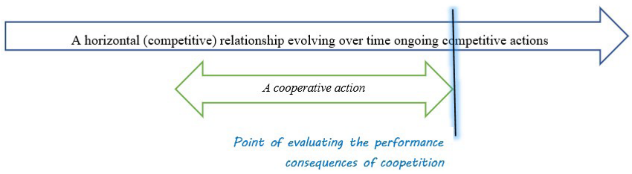

Fig. 2 A quasi-episode level operationalisation in a horizontal relationships – measuring performance consequences only after the cooperative action. Source: own elaboration

competitive status of the relationship, operationalisation and analysis in the business literature is limited to one specific cooperative strategic action. Competition is supposed to be the fundamental strategy pervading all key actions of the counterparts; therefore only cooperation, the paradoxical strategic action is discussed. Performance implications are measured at the end of the cooperative action.

This way of operationalisation is applied by Rodrigues et al. (2011) or Gnyawali and Park (2011), for example. Performance measures used in these papers are complex and report the competitive state of the partners involved. However, it is hard to capture concretely the focal cooperative action's contribution to this state, since no comparison with the performance consequences of the alternative, non-cooperative action is provided.

Such an inadequate operationalisation limits the potential of measuring coopetitive performance in a systemic way (Rai, 2016), both value creation and capture are problematic. The total value created is conceived as the sum of individual firm-level values generated by a cooperative action (Ritala and Hurmelinna-Laukkanen, 2009; Bouncken et al., 2020). While the total value generated is a dyadic (relational) concept, value capture is a firm-level construct indicating a firm's return that stems from a competitive action (Lavie, 2006; Bouncken et al., 2020). It reflects the proportion of the total value created that firms can individually appropriate (Ritala and Hurmelinna-Laukkanen, 2009). The most important concern in relation to measuring value creation is that some measures capture value appropriation. Several papers have operationalised value generation through financial indices, like higher share prices (Gulati and Wang, 2003). However, these are firm-specific measures capturing some aspects of the value captured, not value creation, which is a relation-level, aggregated construct.

Additionally, firm-specific measures cannot automatically indicate value appropriation either, since suitable measures should indicate the individual share of the overall value created by the partners (Ritala and Hurmelinna-Laukkanen, 2009). Firm-specific financial measures, such as a higher share price, indicate scarcely comparable values, although value capture is – by definition – a relative one.

Overall, we may state that the operationalisation found in the business literature thus far is capable of measuring and analysing the concrete performance consequences of a coopetitive episode only to a limited extent. The lack of an operationalisation capable of measuring performance consequences at an action-level is especially problematic from the perspective of seeking to understand relation-level performance outcomes, specifically the relative positions of the firms.

The objective of this study is to propose an operationalisation and an analytical model that makes it possible to measure and analyse both the action- and the relation-level performance consequences of coopetition. The proposed model uses game theoretical concepts. Thus, in the following section we provide an overview of how coopetition has been operationalised for the purposes of our own research.

2.3 Operationalising coopetition using game theoretical concepts

Since its first academic discussion, coopetition is closely linked to game theory. We found two game theoretical approaches that operationalised coopetition analysis. On the one hand, several papers with game theoretical background conceptualise coopetition as two separate games, strategic actions (e.g. De Ngo and Okura, 2008). The competitive strategic action is captured in a zero-sum game, while the cooperative action is correspondingly captured in a positive-sum game. However, these games have specific, well-designed structures, and payoff functions.[1] Real life strategic actions are much more diverse – and might have highly different sets of potential payoff values. We argue that the payoff values of these traditional games cannot capture all relevant payoff structures of real coopetitive scenarios. Consequently, they have only limited potential for enabling the analysis of managerial decision-making.

1 Games with such well-designed payoff functions are for example the Stag hunt or the Prisoners' dilemma.

Another stream of research within game theory suggests capturing the two paradoxical actions making up a coopetition within a single game (Carfi, 2015; Okura and Carfi, 2014). In these papers competitive behaviour is captured by following the Nash Equilibrium of the game, while cooperation by the best Pareto Optimum of the same game. The term "best Pareto Optimum" is used hereinafter to mean the Pareto Optimum for which the total utility of the two firms is greatest. If the Nash Equilibrium coincides with the best Pareto Optimum, then the competitive equilibrium and the co-operation reach the same state, i.e. coopetition. It should be added that this is very rare in any two-player game.

We illustrate such a single game with a numerical example but without any prior economic meaning, *Game 1* (Fig. 3)!

Game 1 is a one-move (or one-step) game with two firms (economic agents) and with two strategies. The payoff functions of Firm A and Firm B are as follows[2]:

The Nash Equilibrium of this game is 5,3 with strategy (2,1). Let us now consider the Pareto Optimums of *Game 1*. The game has three Pareto Optimums:

- utilities 2,4, i.e. strategy (1,1) with common utility 6 units;
- utilities 7,2, i.e. strategy (1,2) with common utility 9;
- utilities 5,3 strategy (2,1) with common utility 8.

The best Pareto Optimum is 7,2 with strategy (1,2). This indicates that a coopetition state does not exist in this game because the Nash equilibrium does not fall into one with the best Pareto Optimum.

In the following, we present two concepts in two-person game theory very briefly that compare the Nash Equilibrium within a game with the Pareto Optimums. One compares all the benefits of the two states, while the other breaks down Nash Equilibrium into a state of competition and a state of cooperation. Both concepts thus use the concepts of competition and cooperation at the same time, looking for the question of how the two activities, i.e. competition and cooperation, can be captured simultaneously in a traditional game.

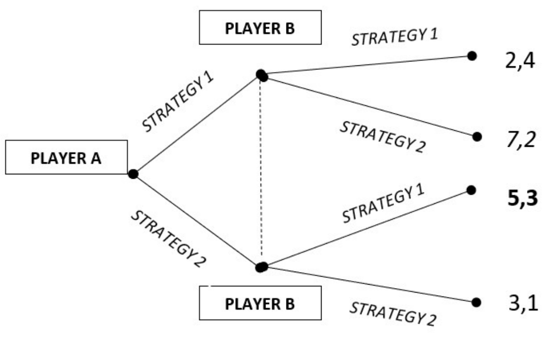

Fig. 3 Game 1 – the Nash Equilibrium differs from Pareto Optimum
Source: own elaboration

2 These payoff values represent transferable utilities in this, and all other games discussed in this paper.

To capture coopetition involving two paradoxical actions in a single-move game, Anshelevich et al. (2008) have introduced the concepts of Price of Anarchy (PoA) and Price of Stability (PoS). In the Computational Game theory, PoA is defined and calculated as the sum of the payoffs of the worst Nash Equilibrium divided by the best Pareto Optimum; while PoS is calculated as the sum of the payoffs of the best Nash Equilibrium divided by the best Pareto Optimum.

In a one-move game, a coopetitive equilibrium is achieved if the PoS indicator is one, that is, the Nash Equilibrium is equal to the best Pareto Optimum. In *Game 1*, both PoA and PoS are equal to 8/9 = 0.888, these indicators are unambiguous. The PoA and PoS values are equal only if the sum of Nash Equilibrium payoffs is the same as that of Pareto Optimum, while the PoS value is equal to one. In this last case, the Nash Equilibrium is Pareto optimal (PoNE).

Kalai and Kalai (2009) have introduced the CoCo-Value to capture parallel competition (Co) and cooperation (Co) in the same one-move game. CoCo-Value is a division of the Nash Equilibrium into two parts: Cooperation Value, i.e. average of the payoff in the Nash Equilibrium, and a Competition Value i.e. a zero sum game, where payoff function of a player is equal to Nash Equilibrium minus average. To illustrate the calculation of CoCo-Value we use the number of *Game 1.* The Nash Equilibrium of the game is strategy (2,1). The game's cooperation value is the average of the sum of the payoff values, i.e. (5 + 3) / 2 = 4. Both firms will surely get this utility value, i.e. 4,4. If this value is subtracted from the equilibrium value of both firms, we get a zero-sum game, where Firm *A* wins 1 utility while Firm *B* loses the same, i.e. 1,-1.

3 The new conceptualisation and operationalisation proposed

We know that existing coopetitive business relationships are dynamic in nature, and it is hard to capture the complex interrelationships between different competitive and cooperative strategic actions. Bengtsson and Kock (2000) argue that both cooperative and competitive strategic actions need to be visible in a coopetition analysis. Thus, the basic analytical unit in this paper is a dyadic relationship with one competitive and one cooperative strategic action. We model a horizontal coopetitive relationship with a two-step sequential game. The game is sequential because the two steps of the coopetition are assumed to follow each other in a sequential way. Given the payoff functions of both actions (steps), we can explicitly measure relation-level performance consequences too. Two consecutive games, one modelling the competitive situation and the other modelling the cooperation, may be independent of each other, or they may even be related. If two decision situations are interdependent, then with the usual pie analogy we can ask how the cooperation increases or decreases the benefits available in a competitive situation. In what follows, we consider the case where competition and cooperation do not interact, so they are independent of each other. Then, based on the result and result of the two games, the final strategies can be chosen in both decision situations.

As mentioned, traditional conceptualisation of coopetition incorporates two one-step games, a zero-sum and a positive-sum game. However, this has limited potential for analysing performance consequences of coopetition. Mainly because these games have specific, well-designed structures, and payoff functions.

We now propose a new operationalisation of coopetition, one that is rooted in game theory. It uses existing game theoretical concepts but combines them in a unique way. It also makes it possible to introduce a concept that seem to be useful in the systematic analysis of both action and relation-level performance consequences of coopetition matrix. The suggested operationalisation works as follows:

1. We represent a coopetitive business relationship with a two-step sequential game. Both steps (strategic actions) are played by the same economic actors in a given horizontal business relationship. Each step represents a specific strategic action, either competitive or cooperative. The game is sequential in the sense that the two transactions of coopetition are assumed to follow each other in a sequential way.
2. Payoff values of both steps of the game represent transferable utilities. The payoff functions of the two steps are not dependent on each other. The firms are in a horizontal relationship. Thus, at a relation-level they follow individual rationality, pursuing maximal utility, and aim to improve their competitive position. In a manner similar to the understanding of coopetition provided in a one-step game, we capture competitive behaviour by following the Nash Equilibrium and cooperative behaviour by pursuing the best Pareto Optimum of the same game. A specific game represents a competitive game, in case firms are assumed to pursue the Nash Equilibrium. A game is a cooperative one if the same firms seek the Pareto Optimum of the game (Gibbons, 1997).[3] This operationalisation is logical, because the Nash Equilibrium represents a non-cooperative behaviour that results in a lower total payoff function then the best Pareto Optimum. It also means that the total payoff function (the sum of the payoff values of the two firms) of the Nash Equilibrium is always guaranteed to the firms.
3. The two separate steps (strategic actions) of the sequential game with known payoff values make it possible to calculate the so-called coopetitive composed solution matrix of the sequential game, by simple summing up the respective payoff values of the two separate steps of the sequential game. Such a matrix provides the capacity of analysing not only the direct performance consequences of the two separate strategic actions, but their combined, relation-level performance outcome as well. This is the overall competitive position of the actors in the relationship. A higher than the partners' value in this matrix represents a better competitive position for the payer.

In the following section, we provide a numerical example using the operationalisation outlined above. Values of the payoff functions are specified randomly.

4 Developing insights into the proposed model

Initially, this section will provide a numerical example of the proposed model. This will be followed by a generalised mathematical realisation of the proposed coopetition model.

4.1 A numerical example of the proposed model

As discussed above, we operationalise and model coopetition as a sequential game and assume that it is divided into two steps: competition and cooperation. We have the same two firms in each step, with 2-2 strategies for each of them. The sequence of the two strategic actions is not important; we could start with competition but also with cooperation. However, in the example, we start with a competitive action (that might represent a customer-close

3 We could choose other equilibria as well, see for example the Berge equilibrium (Berge, 1957). However, we think Nash Equilibrium and Pareto Optimum are widely known and accepted. Moreover, they are suggested in one-move games for representing competition and cooperation respectively.

marketing campaign) and continue with a cooperative action (that might represent a customer-far joint resource utilisation action). For simplicity, we use the payoff values of *Game 1* as a starting point. Thus, Fig. 3 represents the first, the competitive step of our coopetitive sequential game. The Nash Equilibrium is given by the strategy (2,1), which means a pair of utilities 5,3 for the two firms.

Fig. 4 represents the cooperation step of the coopetitive sequential game in our example. Thus, the utility values are summed up and the highest is chosen, which value 12 is now. This means that the best Pareto Optimum is the strategy (2,2) in the second step of the game.

After the application of the Pareto Optimum, we do not deal with the distribution of the benefits obtained, because that would imply a move towards another, rather broad research direction, namely contract theory. A good survey of the available literature is given by Bolton and Dewatripont (2004), while Kállay (2012) provides a good overview of the corporate application. The application of contract theory to supply chains is dealt with in supply chain coordination. For a thorough overview of this research area, Cachon (2003) provides a good introduction.

Let us also mention that the Nash Equilibrium of the cooperation step in the sequential game would be the strategy pair (1,2), which means a pair of utilities 6,5 for the two firms.

The sum of the payoff values of the two steps, i.e. competition and cooperation (Figs. 3 and 4), defines the coopetitive composed solution matrix of the sequential game (Table 1).

Each firm has two strategic alternatives in each of the two steps of the sequential game. Thus, this matrix includes four possible alternatives/strategies. These are enclosed in brackets. For example, strategy pairs ([1,1], [1,2]) in Table 1 show that if Firm *A* would choose the first strategy in both the competition and cooperation steps of the sequential game, while Firm *B* the first strategy during

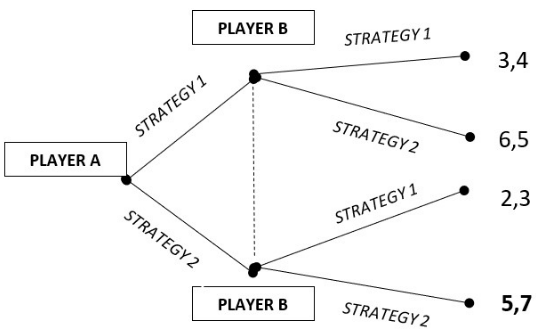

Fig. 4 The cooperation step of our coopetitive two-step sequential game
Source: own elaboration

Table 1 The coopetitive composed solution matrix of the two-step sequential game

		Firm *B*			
		[1,1]	[1,2]	[2,1]	[2,2]
Firm *A*	[1,1]	5,8	8,9	10,6	13,7
	[1,2]	4,7	7,11	10,5	<u>12,9</u>
	[2,1]	8,7	11,8	5,5	9,6
	[2,2]	7,6	**10,10**	5,4	8,8

Source: own elaboration

the competition step and the second strategy in the cooperation step. Because of these hypothetical subsequent decisions, Firm *A* would have achieved 8 utility units, while Firm *B* 9 utilities on relationship level. With these two strategies the total, summed-up utilities would be 17.

In the two-step sequential game (Figs. 3 and 4) firms choose strategy (2,1) in the competitive step, then strategy (2,2) in the second, cooperative step. The total realised utility values describing the combined, relation-level performance effect are utilities 10,10 in the matrix. This represents the **Coopetitive State** of the sequential game, the combined result of the two previous decisions in the sequential game. It is 20 utilities for the two firms in total. It is easy to determine the best <u>Pareto Optimum</u> of the two-step sequential game: 12,9 with total utility of 21; underlined in Table 1. Finally, we determine the *Nash Equilibrium* of the composite matrix, indicated in italics. This is given by strategies ([2,1] [1,2]) with a total utility of 19.

We summarise the three distinguished states of the sequential game in Table 2.

The coopetitive composed solution matrix summarises all potential performance outcomes of the two-step sequential game. Thus, we can compare the relation-level performance consequences of the two actual decisions in the matrix with other potential relation-level performance consequences of different hypothetical combination of decisions. Brandenburger and Nalebuff (1996) highlights that coopetition is rational only when cooperation between competitors leads to their better performance than they could have achieved without such collaborative endeavour.

Table 2 Summary of the three distinguished states of the hypothetical two-step sequential game

	Sum of utilities of Firms *A* and *B*	Firm *A*	Firm *B*
Nash Equilibrium	19	11	8
Coopetitive State	20	10	10
Best Pareto Optimum	21	12	9

Source: own elaboration

This means that the goal of the coopetition should be to give firms a higher utility compared to the Nash Equilibrium of the matrix. In our case, this failed for Firm *A* because he/she lost one unit of utility (11 − 10 = 1), while Firm *B* won two units (8 + 2 = 10). In such a situation, the firms need to find an agreement for fairly distributing the surplus utility. This is not necessary if both firms close the two-step sequential game with a surplus on individual-level. If firms reach the best Pareto Optimum in the Coopetitive State, a similar problem occurs. We do not address these distribution issues in our paper. However, the question arises, which one dominates actual decisions in such situations, the action, or the relation-level outcomes?

A mathematical description of the number example presented can be found in the appendix for readers interested in mathematical details. Reading requires no more than a basic knowledge of game theory.

4.2 The generalised mathematical model of the proposed coopetition model

In the previous subsection, we illustrated the proposed operationalisation with a numerical example. Now, we present the two-step sequential game in a generalised form using mathematical game theoretical tools. We examine the competitive situation first.

Consider a two-person strategic game represented by a tuple $\left(N,\left(S_i\right)_{i\in N},\left(f_i\right)_{i\in N}\right)$, where:

- Set $N = \{1,2\}$ is the set of players in the game.
- S_i represents the strategy set available to player *i*. That is, $S_i=\left\{s_{i_1},s_{i_2}\right\}$ where there are two strategies available to each player *i*.
- $f_i : S_1 \times S_2 \to \mathbb{R}$ is the payoff function for player *i*, mapping the joint strategy profile (s_1, s_2) to a real number representing the utility or payoff for player *i*, where s_i is the strategy chosen by player *i*.

A pure strategy Nash Equilibrium (s_1^*, s_2^*) is a strategy profile where for each player *i* and each strategy s_i in the strategy set S_i, the following condition holds:

$$f_1\left(s_1^*,s_2^*\right)\ge f_1\left(s_1,s_2^*\right),$$

and

$$f_2\left(s_1^*,s_2^*\right)\ge f_2\left(s_1^*,s_2\right).$$

Consider another two-person strategic game represented by a tuple $\left(N,\left(T_i\right)_{i\in N},\left(g_i\right)_{i\in N}\right)$, where:

- Set $N = \{1,2\}$ is the set of players in the game.
- T_i represents the strategy set available to player *i*. That is, $T_i=\left\{t_{i_1},t_{i_2}\right\}$, where there are two strategies available to each player *i*.
- $g_i : T_1 \times T_2 \to \mathbb{R}$ is the payoff function for player *i*, mapping the joint strategy profile (t_1, t_2) to a real number representing the utility or payoff for player *i*, where t_i is the strategy chosen by player *i*.

A pure strategy Nash Equilibrium (t_1^*, t_2^*) is a strategy profile where for each player *i* and each strategy t_i in the strategy set T_i, the following condition holds:

$$g_1\left(t_1^*,t_2^*\right)\ge g_1\left(t_1,t_2^*\right),$$

and

$$g_2\left(t_1^*,t_2^*\right)\ge g_2\left(t_1^*,t_2\right).$$

Let now the payoff functions of the cooperative step of the sequential game be the best Pareto Optimum strategy (t_1^{**}, t_2^{**}):

$$g_1\left(t_1^{**},t_2^{**}\right)+g_2\left(t_1^{**},t_2^{**}\right)\ge g_1\left(t_1,t_2\right)+g_2\left(t_1,t_2\right).$$

In this case, the following inequality holds for the Nash Equilibrium and Pareto Optimum:

$$g_1\left(t_1^{**},t_2^{**}\right)+g_2\left(t_1^{**},t_2^{**}\right)\ge g_1\left(t_1^*,t_2^*\right)+g_2\left(t_1^*,t_2^*\right).$$

This means that in the Nash Equilibrium, the players do not exceed the full available payoff of the best Pareto Optimum.

The strategy pair of player *i* is defined as (s_i, t_i), $i \in N$. The payoff function of a coopetitive composite game can be defined for both players as follows:

$$F_i\left(\left(s_i,t_i\right)_{i\in N}\right)=f_i\left(s_1,s_2\right)+g_i\left(t_1,t_2\right),\ i\in N.$$

This composite game can be interpreted as a special version of the two-step sequential game. The version, when players decide on both competition and cooperation based on the coopetitive composed solution matrix (Table 1 in our numerical example).

A coopetitive composed solution matrix is a matrix where the "strategy" of both players is the result of two decisions involving the competitive situation in one predetermined game and cooperation in the other predefined game. Therefore, such a strategy can be described by two decisions. This is shown by the strategies $\left(s_i,t_i\right)_{i\in N}$ players *i*. On the consequence matrix thus defined, the Nash Equilibrium can then be interpreted in the usual way, as can the best Pareto Optimum and the Coopetitive State. Each of the three situations describes a mathematical operation and algorithm that we apply to this matrix. The Nash Equilibrium of this coopetitive composite game is the decomposition of the Nash Equilibrium of the two steps of the sequential game, i.e.

$$F_1\left(\left(s_i^*, t_i^*\right)_{i\in N}\right) \geq F_1\left(\left(s_1, t_1\right), \left(s_2^*, t_2^*\right)\right),$$

and

$$F_2\left(\left(s_i^*, t_i^*\right)_{i\in N}\right) \geq F_2\left(\left(s_1^*, t_1^*\right), \left(s_2, t_2\right)\right).$$

This also means that the Nash Equilibrium of the coopetitive composite game (in the matrix) is the state that is achieved by the Nash Equilibriums of both of the steps in the sequential game.

Definition 1. The **Coopetitive State** of the two-step sequential game is defined as the strategy of player i $\left(s_i^*, t_i^{**}\right)_{i\in N}$ a where strategy (s_1^*, s_2^*) is the Nash Equilibrium of the competitive game and strategy $\left(t_1^{**}, t_2^{**}\right)_{i\in N}$ is the best Pareto Optimum of the cooperation game.

It is the result of the two decisions made during the two steps of a sequential game. It Let us denote the Coopetitive State with strategies $\left(s_i^*, t_i^{**}\right)_{i\in N} = \left(s_i^{CS}, t_i^{CS}\right)_{i\in N}$.

We examine the properties of the Coopetitive State. The first proposition states that the total payoff of the Nash Equilibrium of the coopetitive game cannot be greater than the total payoffs available with the Coopetitive State.

Proposition 1. The sum of payoff of total utility of Coopetitive State is not smaller than that of Nash Equilibrium of composite game, i.e.

$$F_1\left(\left(s_i^{CS}, t_i^{CS}\right)_{i\in N}\right) + F_2\left(\left(s_i^{CS}, t_i^{CS}\right)_{i\in N}\right)$$
$$\geq F_1\left(\left(s_i^*, t_i^*\right)_{i\in N}\right) + F_2\left(\left(s_i^*, t_i^*\right)_{i\in N}\right).$$

Of course, the upper limit of the aggregate payoff function of the Coopetitive State is the best Pareto Optimum of the coopetitive composite game:

$$F_1\left(\left(s_i^{**}, t_i^{**}\right)_{i\in N}\right) + F_2\left(\left(s_i^{**}, t_i^{**}\right)_{i\in N}\right)$$
$$\geq F_1\left(\left(s_i^{CS}, t_i^{CS}\right)_{i\in N}\right) + F_2\left(\left(s_i^{CS}, t_i^{CS}\right)_{i\in N}\right)$$

With the latter two inequalities, we have given lower and upper bounds for the solution of the coopetitive two-step sequential game, i.e. the Coopetitive State. Let us briefly discuss when it is more worthwhile for both players to use coopetition. Our second statement can provide an answer to this.

Proposition 2. The two players apply the coopetition if all payoffs are higher than in Nash Equilibrium of the composite coopetition game:

$$F_1\left(\left(s_i^{CS}, t_i^{CS}\right)_{i\in N}\right) \geq F_1\left(\left(s_i^*, t_i^*\right)_{i\in N}\right)$$

and

$$F_2\left(\left(s_i^{CS}, t_i^{CS}\right)_{i\in N}\right) \geq F_2\left(\left(s_i^*, t_i^*\right)_{i\in N}\right).$$

Otherwise, the player would lose money by following coopetitive behaviour along the two-steps sequential game. He/she would not go into the real coopetition in such cases, since a Nash Equilibrium on the composite coopetition game would result in higher utility.

5 Conclusions, limitations, and future research avenues

This paper has investigated coopetition, a phenomenon that has high practical relevance, but whose theoretical understanding needs further development. Specifically, we have limited knowledge on how managers make decisions in coopetitive relationships. This understanding is limited by existing operationalisation of this decision-making process because it cannot provide exact information on performance implications. Extant literature argues that both cognitive and behavioural attributes of managers might influence coopetitive decisions. Limited understanding of performance implications hinders robust and reliable academic analysis on these issues.

We have proposed a new way to model decision-making in coopetitive relationships. This enables the measurement and analysis of its performance consequences in a systemic way. The model is rooted in game theory, and it combines existing game theoretical constructs, but it also allows introducing new concepts. Coopetition is operationalised by means of a two-step sequential game, with the first step representing a competitive, and the second a cooperative strategic action. The game is sequential in the sense that its two steps follow each other sequentially. The actors of the two games are the same, economic agents of a horizontal business relationship. The direct performance consequences of strategic actions are expressed in transferable utilities. We have captured the competitive behaviour of a decision maker by following the Nash Equilibrium, and their cooperative behaviour by aspiring the best Pareto Optimum.

Using this conceptualisation and operationalisation, we introduced a coopetitive composed solution matrix that is obtained by summing up the payoff values of the strategic pairs chosen by the firms during the two sequential steps of the game. This matrix specifies all potential relation-level performance consequences of different strategies that the firms might choose. As our numerical example shows, actual decisions taken during the two steps of the game might result in contradictory performance outcomes at a relationship level. This highlights the paradoxical nature of coopetition and the importance of information to both action- and relation-level performance implications.

A horizontal business relationship consists of two competing actors. Thus, at a relationship level they strive to achieve a better competitive position over the other, the Nash Equilibrium. All possible relation-level performance positions after the two decisions of the game are indicated in the coopetitive composed solution matrix. As we have seen, the Coopetitive State achieved after the two steps of the game might represent an overall, relation-level position that is not stable, making actual managerial decisions ambiguous.

The proposed operationalisation makes the decision problem's cognitive representation straightforward; both action- and relation-level implications become clear. This means that behavioural attributes can be studied in a more robust and reliable way, especially if one designs behavioural experiments using the proposed operationalisation. Such experiments can incorporate into their analyses the following three elements: (1) the idiosyncratic features of the individual decision-makers, like their cooperative or competitive orientation (Czakon et al., 2020); (2) the perception-based features of the decision-makers as experience by his/her partner, like reputation (e.g. Crick and Crick, 2021) or trust (Virtanen and Kock, 2022); and (3) the level of mutuality in these perception-based attributes (Chin et al., 2008).

Experimental analysis of coopetition is still a rarity in the literature (Kraus et al., 2018). The model developed here might be a useful starting point for future research employing specific experimental designs to test assumptions concerning coopetitive behaviour and decision-making, like the existence of perfect information, or rational decision makers without any behavioural bounds or biases. Thus, it might be useful for a relatively new research stream in behavioural strategy that aims to ground strategic management with "realistic assumptions about human cognition, emotion, and social interactions" (Powell et al., 2011), and in coopetition (Czakon et al., 2020; Bouncken et al., 2020).

The order of the steps within the sequential game (first competitive than cooperative), or the independence of the payoff function of these steps are important features of the operationalisation suggested in this paper. These represent limitations, as well as future research revenues. Furthermore, the model represents coopetitive games with pure strategies. We suggest that further research needs to be conducted in the context of dyadic relationships, where pure strategies do not exist. Mixed strategy models could be applied in such cases.

We limited our analysis to the unit of one business relationship. We are aware of the importance of understanding coopetition in more complex setups, like in a triadic relationship, or in even more complex supply chains, or business networks. The conceptualisation and operationalisation of coopetitive relationships offered here might be useful for models capturing more complex network designs.

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