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Integration between the Behavioral Game Theory and the Field of Global Operations

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INTRODUCTION

Modern behavioral economics (MBE) points out there is a preference order among choices and studies the decisions people make to maximize the utility of their outcome (Kao & Velupillai, 2015). Hence, MBE is concerned with the behavior of the decision maker, which can be people, governments or, in the field of operations, firms.

We assume that, in the field of global operations, firms will do what is necessary to try to maximize their outcomes too. Thus, MBE seems to fit the theoretical need, hence it can help predict firms' behavior in a global context. MBE provides elements that can help understand the perceived outcome of a firm's decision, so those elements shall bring light to operations research topics. Such decisions include outsourcing, offshoring, and sustainable decisions.

Four areas stand out in the search for an explanation of the decision makers' behavior. Game theory is one of them. Among the areas of MBE, we highlight four subfields: (1) behavioral microeconomics: a theoretical tendency that understands that the preferences of the decision maker suffer variations for different reasons, such as: status quo bias, loss aversion and ambiguity; (2) behavioral macroeconomics: theoretical approach that makes use of the same reasons of behavioral microeconomics to interpret phenomena at the macro level, such as the rigidity of wages; (3) behavioral finance: theoretical approach that studies market anomalies, assuming market inefficiency; and (4) behavioral game theory: it studies the results of the strategic interactions of decision makers (Kao & Velupillai, 2015). Figure 1 illustrates the fields of MBE study and helps identify where behavioral game theory stands in behavioral economics discussion:

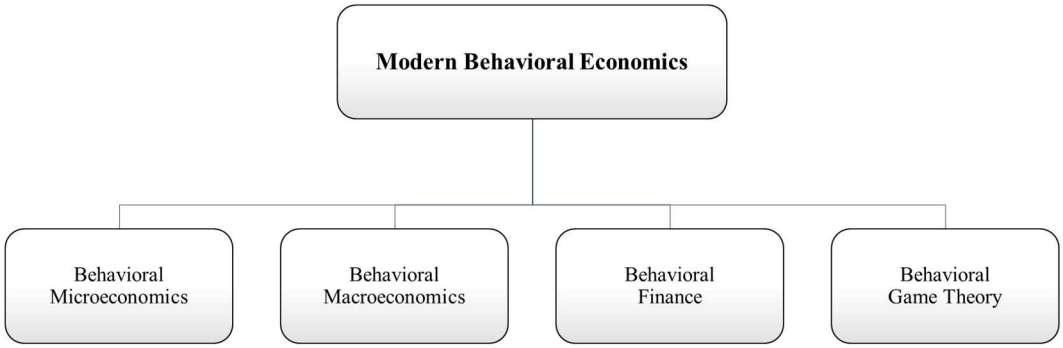

Figure 1: MBE and its subfields. Source: made by the author.

Operations usually analyzes decision-making by taking into account only one decision maker. However, that is not how the real world works. Regarding strategy, the result of a firm's operational decisions depends at least partly on the operational decision of other firms (Fiestras-Janeiro *et al*., 2011). This is the object of study of modern behavioral economics, more specifically of its subfield that is studied by game theorists. Interactions among decision makers mutually affect their results (Kao & Velupillai, 2015).

Game theory has the potential to help scientific community and practitioners to get a better understanding of firms' strategic and operational decisions. The the field of operations has studied the field of cooperation in game theory. This approach aims at identifying possible outcomes for the players' set of actions, studying what results each player can

achieve and how robust and stable such results are (Nagarajan & Sošić, 2008). The theoretical background of cooperative games in the supply chain is scarce, although this approach has become popular (Nagarajan & Sošić, 2008; Fiestras-Janeiro *et al*., 2011).

The integration between game theory and the field of operations appears in cost-allocation models of centralized inventories between cooperating firms (Meca, García-Jurado & Borm, 2003). Such integration is used to propose models to explain the exchange of information and knowledge, as in the case of Nasr, Kilgour and Noori (2015), who studied cooperation the sharing of innovations inside the supply chain. Another study by Bernstein, Kök and Mecca (2015) proposed a cooperation model of knowledge exchange to gain cost reduction. Other studies have proposed models for profit maximization, as in the study by Lu, Qi and Liu (2014), who sought to understand how low-scale recycling firms can cooperate in production and price decisions, and the Hamidi, Liao and Szidarovszky (2016) study proposed the use of nonlinear transfer-payment contracts to maximize profits in lease contracts.

Despite the studies above mentioned, there is a different approach to game theory: a behavioral approach formalized by Camerer (1997). This behavioral approach points out that a player is not always sufficiently rational while making decisions. Thus Camerer (1997), using evidence from previous studies in game theory, identifies violations of game theory principles regarding the independence of payoff utility, game loss-gain asymmetry, common prior, irrelevance of strategy labels and timing, iterated dominance, and backward induction. Based on those violations, he proposes the study of the behavior of players in practice, which should improve game theory models towards a better prediction power.

The behavioral game theory approach can help explain the behavior of decision makers in operations management. It is important to point out that operations management has been using a single firm's decisions approach, **however**, nowadays decisions are made by considering other decision makers' choices and involve multiple firms, which try to optimize their individual objectives (Fiestras-Janeiro *et al*., 2011). Thus, the question that this paper aims at answering is how can the behavioral game theory approach contribute to a better understanding of global operations research? To answer this question, we reviewed behavioral game theory, identified topics related to the area of operations and relate such theory to the research topics of the global operations research agenda.

In the following sections, we will present the method, a descriptive result, a content result, the discussion of results and our conclusion; at the end of this paper, we present our bibliographical references.

2. METHOD

This paper uses the systematic review methodology proposed by Tranfield, Denyer & Smart (2003) to conduct this review. First, we defined our subject and the keywords that represent our research subject. Our research on Web of Science used the following keywords and syntax: "behavioral game-theory" OR "behavioral game theory" OR "behavioural game-theory" OR "behavioural game theory".

We used both known spellings of "behavioral" in American English and European English. Our results returned 101 documents; then, we filtered them by the categories "editorial, article, and review." We used this filter to avoid papers that were not submitted to a blind review or a solid analysis before being published. After that, we ended up with 81 articles. Firstly, we read all abstracts to select which ones would be subjected to further analysis. At this stage, we did not eliminate any document. However, we could not access

four papers and could not read three other papers due to the fact that they were not written in English. Nevertheless, we add these documents in our descriptive analysis.

3. DESCRIPTIVE RESULTS

This section presents the descriptive analysis of the study sample. First, we identified the journals that have been publishing papers about behavioral game theory. In our research, we identified three countries which journals were interested in behavioral game theory: Netherlands, United Kingdom and the United States. We identified the Journal of Economic Behavior & Organization as the one with the most publications about the topic (7). Thus, we list the top five considering a tie among three journals on the fifth position in Table 1.

Table 1
Rank of journals that publish papers on behavioral game theory.

Rank	Journal	Country	Frequency
1	Journal of Economic Behavior & Organization	Netherlands	7
2	Econometrica	United Kingdom	4
3	Games and Economic Behavior	United States	4
4	Management Science	United States	4
5	Behavioral and Brain Sciences	United Kingdom	3
6	Journal of Economic Theory	United States	3
7	Marketing Science	United States	3

The full list of journals makes it possible to draw a figure of the journals' location on the world map, which makes it easier to identify who is interested in this topic around the world. Figure 2 illustrates the location of journals; the size of the circles represents the number of documents in each country.

Figure 2. Distribution of journals that publish papers on behavioral economics. Source: made by the author.

3.1. Authors and Country Affiliation

The authors who have more papers published are Colin Camerer, Teck-Hua Ho and Elena Katok, respectively seven, four and three articles. Similar to what was done regarding the journals' locations, we identified the authors' affiliations and their respective countries. Thus we could map the location of the universities and institutions interested in the topic of behavioral game theory, and we found out that it is more widespread than the publishing journals' location. Table 2 identifies the country of the authors' affiliation at the moment when the paper was published.

Table 2
Rank of Country Affiliation of authors who publish papers on behavioral game theory.

Rank	Country Affiliation	Frequency	% of Docs
1	United States	72	48,98%
2	England	17	11,56%
3	Switzerland	8	5,44%
4	France	7	4,76%
5	Italy	6	4,08%
-	Others (16)	37	25,17 %

The full list of authors and their affiliation makes it possible to draw a figure of their location on the world map, as stated before. Figure 3 illustrates the location of universities and institutions; the size of the circles refers to the sum of papers published in each country.

Figure 3. Distribution of authors' affiliation. Source: made by the author.

The interest in behavioral game theory is widespread, which allows us to conclude that the interest on the topic is not limited to the publishers' countries; we must consider what people are studying around the globe to be able to identify general trends or local trends.

3.2. Approach and Method

After the analysis of each document, we could identify the approach adopted by the authors to reach their research objectives. We confirmed that experimental methodology (48,65%) is the dominant method in this field. We could also identify that this field of study adopts empirical approach (62,16%). However, there is a surprising number of theoretical papers in the field, which leads me to believe that this area is still in development. The following Table identifies our classification:

Table 3
Classification of documents according to their approach.

Rank	Approach	Frequency	% of 74
1	Empirical (Experiment)	36	48,65%
2	Theoretical Empirical (Experiment)	22	29,73%
3	Empirical (Data from Previous Experiments)	7	9,46%
4	Theoretical (Simulation)	5	6,76%
5	Empirical (Secondary Data)	2	2,70%
6	Theoretical (Simulation/Case Study)	1	1,35%
7	Empirical (Survey)	1	1,35%
-	Out of Analysis	7	-

4. CONTENT RESULTS

This paper presents the full list of papers and their contributions and findings in the appendix. In this section, we will present the papers that can influence research and management in operations field. We will show the results in three topics that can be related directly or indirectly to operations management: (1) auctions, reverse auctions and procurement activities, (2) cognitive hierarchy, level-K approaches in strategic thinking and (3) learning and cooperation.

4.1. Auctions, reverse auctions and procurement activities

There is a behavioral approach in procurement activities. We found some articles that applied behavioral principles and tested them in procurement activities, especially in auctions and reverse auctions. The articles about this subject are highlighted in Table 4. Thus, through the application of the behavioral game theory approach, we discovered that, in procurement activities that use buyer-determinant mechanisms with a high number of suppliers, there is a higher buyer surplus; otherwise, with a small number of suppliers, the mechanism that gives more buyer surplus is a price-based mechanism (Engelbrecht-Wiggans, Haruvy & Katok, 2007). These findings give an insight into managerial community and about how to set up the procurement activities of each product considering the number of possible suppliers; however, as we can see in the study of Fugger, Katok and Wambach (2016), the buyer-determined reverse auction allows suppliers to collude, because suppliers do not enter a price competition, since they know that, in the end, the buyer will choose the winner considering a characteristic other than price, instead of what happens in a price-based auction.

We also highlight the study of Haruvy and Katok (2013), which identified that the transparency of a bidder's quality affects the negatively the buyer surplus, probably because they know who has more chances to win.

Table 4
Selected papers about auctions

Author	Contribution and Findings
Engelbrecht-Wiggans, Haruvy and Katok (2007)	In reverse auctions procurement activities, buyers-determinant mechanisms maximize buyer welfare when there is a high number of competitors; on the other hand, with a small number of suppliers, the price-based mechanisms dominate.
Haruvy and Katok (2013)	The authors studied buyer surplus in different procurement auction settings. Sealed bid request for proposals generates more surplus than an open-bid dynamic auction. Another contribution is that the open-bid format is affected by quality transparency, so the higher is the transparency about bidder quality, the lower is the buyer surplus.
Fugger, Katok and Wambach (2016)	Manager practice in procurement using dynamic buyer-determined reverse auctions allows suppliers to collude and take advantage, setting high prices.

4.2. Cognitive Sciences, Learning and Backward Induction

The behavioral game theory is grounded on cognitive sciences. The famous Nash Equilibrium is a powerful theory to predict behavior in the long run. However, the traditional approach of game theory fails to explain behavior in some stages of a game. The behavioral approach uses cognitive sciences to explain and predict human behavior in some games. I highlight papers in Table 5 that used the assumptions of a cognitive approach to create models and explain human behavior in game situations.

I begin with Camerer (2003), who reinforces the importance of cognitive sciences to explain human behavior in games and to complement the common math approach of traditional game theory. This paper is also based in Wilson, Stevenson and Potts (2006) in order to differentiate the decision-making process of an individual who does not have a counterpart, and the decision-making process of an individual with a counterpart. Their pre-frontal cortex activity diverges. Thus, combined, both sentences lead us to conclude that the managerial challenge passes through a specific cognitive process, in which the solutions to some games must be reached by considering the moves of one's counterpart with limitations and sometimes without the objectivity of a traditional game theory model.

The traditional game theory will assume that players will do backward induction from the end of the game to the beginning. Thus, every player will anticipate the counterpart. On the other hand, previous experiments already evidence that humans have limited cognition and can not struggle through more than few levels of backward induction; in other words, humans can not think so forward and, due to this limitation, the backward induction is limited to few steps ahead of their opponents (Johnson, Camerer, Sen & Rymon, 2002; Ho & Su, 2013). The explanations are that this mental process of thinking about a future that will not necessarily happen stresses and tires our thinking capacity.

A different way to make our decisions more efficient and anticipate our opponents in a game is related to our accumulated knowledge. That knowledge is directly affected by our learning capacity. In our research, we identified learning as an important field in behavioral game theory. We highlight the study by Camerer and Ho (1999), who proposed an experience-weighted attraction learning model. This model combines two different approaches to learning: the belief and reinforcement. Belief is the process through which players learn according to the other player's previous choice and outcomes. Reinforcement is the learning process through which the player learns from the previous outcomes of his own choices.

Ansari, Montoya and Netzer (2012) complement this view of the learning process; they found evidence that players adapt the learning process during a game. The main idea is that a player has a dynamic learning process: the rules learned in the beginning can be changed according to the evolution of the game.

Table 5
Selected papers about cognitive sciences, learning and backward induction

Author	Contribution and Findings
Camerer and Ho (1999)	Proposition of the Experience-weighted attraction (EWA) learning model. The EWA integrates two theoretical approaches to learning: belief and reinforcement. The model weighs previous experiences of the player *by* changing his choice's attraction. Thus, his learning process incorporates the outcome of his previous choice (reinforcement) and other players' past choices (belief).
Johnson, Camerer, Sen, and Rymon (2002)	Backward induction does not occur as supposed because players have social preferences (ex.: fair and unfair) and limited cognition. The authors show with experiments of three rounds of bargaining that the players do not do backward induction naturally. However, they can be trained to do so. They also provide information about the influence of social preferences and limited cognition in bargaining games.
Camerer (2003)	Discussion of the importance of alternative theories and approach to a better understanding of behavior in games. Inclusion of the importance of cognitive sciences to complement the common math approach of game theory.
Wilson, Stevenson and Potts (2006)	Analyzing the pre-frontal cortex activity, the authors identified that the cognitive process of solving strategic games diverge from those simple problem games (without counterpart). The results lead authors to conclude that the cognitive process is different according to the type of game.
Ansari, Montoya and Netzer (2012)	Reinforcement and belief are used as learning mechanisms in learning games. However, the authors support with evidence from past experiments that learning is a dynamic process that players adapt, changing their learning rules while they are playing.
Ho and Su (2013)	The authors propose a dynamic level-k model to explain violations of backward induction by players. Their model assumes that players avoid backward induction in games with a high number of stages; another assumption is that players get closer to backward induction with repetition.

4.3. Studies of interest for the operations field

Another paper that we must mention is the one written by Chen, Liu and Yang (2015), who found out that radical recovery strategies are the most effective to mitigate the negative impact of supply chain derail caused by unanticipated disasters, whether they are human-made or natural. One of their explanations is because, by acting rapidly, firms would not permit the disruption to be spread to others supply chain members. In the same vein, we have found many studies in the field of cooperation and coordination that can be applied to the operations field.

Looking for coordination findings, we can mention Mas and Nax (2016), who studied behavior deviation in coordination games; they found that deviations are related to small deviation cost and to previous experiences. This deviation cost can be translated to the field of operations, for example, as the transaction cost of switching from one supplier to another. In the same field of coordination, Sally (2002, 2003) discusses the coordination of communication, the importance of emission and the interpretation of a message. In global operations, this communication approach seems to be important, and it will be discussed in the following section.

5. DISCUSSION

Research on operations management has scarcely studied strategic interactions among players. In this paper, we presented papers with findings on procurement activities. The application of the behavioral game theory approach identified that buyer-determinant mechanisms work better with a high pool of suppliers, and price-based mechanisms, with a small number of suppliers (Engelbrecht-Wiggans, Haruvy & Katok, 2007). The findings of this study can be applied to internationalized firms, which access foreign market to buy and sell goods. In a global context, with a high number of suppliers, the price-based mechanism seems to fit the needs to create buyer surplus. Obviously, we need to consider a large pool of suppliers to use this mechanism. On the other hand, with specific assets, following behavioral approach, we need to consider adopting a buyer-determinant auction, and be careful about a possible collude among suppliers (Fugger, Katok & Wambach, 2016) because, with a low pool of suppliers, knowing that the price is not determinant, suppliers may not enter a price competition, and it shall be more efficient economically to set an agreement before joining the auction.

Another important fact presented in this paper is the finding of Haruvy and Katok (2013) about the transparency of the bidder's quality, which affects the buyer surplus negatively. When the suppliers know each other's quality, especially in a buyer determinant auction, there is a risk of knowing who fits better the buyer's need and avoiding price competition too.

Everything commented in this section has been considered from the buyer's perspective. However, we can see things from the suppliers' perspective. If one is a global supplier, he can invest in finding out the quality of his competitors, and joining the right auctions that fit his business strategy.

Another topic reported in this paper's results refers to cognitive sciences and the learning process of the players. We must realize that the experiments mentioned were made with people, and operations management concerns firms without ignoring people, so we must be cautious when comparing human behavior to firms' behavior, even when the firms are the result of an organized action of people. We found results of cognitive sciences that can be used to understand how operations strategy is set and learned. If we consider human cognitive limitation (e.g., Ho & Su, 2013) we observe that humans can not struggle through backward induction so forward. Thus, firms must face the same limitation. This opens a research agenda, which is to identify if this behavior is replicated by firms and if the firm's performance is somehow related to its capacity of thinking forward.

Learning is related to the mental process of the decision maker. In operations, we can see the importance of learning in some decisions, such as in the offshoring and outsourcing decision. Mudambi and Venzin (2010) discuss the process of outsourcing and offshoring as a step-by-step process, where one of them comes first. The learning approach of behavior game theory includes the belief in a reinforcement process and can be applied to explain this decision. We can infer from this theory that players – in this case, firms – will make this decision after an analysis of previous outcomes of competitors (belief) and the previous outcomes of a determined strategy (reinforcement); after that, using the EWA model (Camerer & Ho, 1999), they will have an attraction weight of outsourcing and offshoring strategy that will influence future decisions.

This explanation can be useful to understand mass herd effect of offshoring and outsourcing in the past, not only in this field but in others, like the rush to the bottom, made by firms in countries with low regulamentation of social and environmental issues.

There is a number of behavioral approaches that can be applied to operation management, however, due to the limitation of this paper, we will not discuss it. We will finish this section highlighting that behavioral game theory adds some insight into group-representative decisions, cooperation, coordination, supply chain, bargaining, etc.

CONCLUSION

In this paper, we started pointing out that the field of operations does not fully use the literature on interacted strategic decisions derived from game theory. Based on this problem, we proposed to review the literature of game behavioral theory to give insights to the operations research agenda. The selection of behavioral approach was made because traditional game theory lacks the social utility and the human touch that exist in the real world. Though traditional game theory can help the field of operations, the behavioral approach seems to fit the needs to predict and explain the behavior of players, especially in short run.

This paper's results show some theories of the field of behavioral game theory that can be applied to the field of operations, as well as some studies that have already applied concepts of this theoretical approach in procurement activities. Though we reached our objective, we must highlight the limitations of this study. The keywords used in the review were limited to the theoretical approach names proposed by Camerer (1997). Thus, we failed to analyze studies that applied concepts of behavioral game theory without naming them as Camerer, for example, social utility, reciprocity, fairness and other kinds of topics from the behavioral field. Another limitation is related to the research on the theory, but not regarding this field. This limitation gives researchers a unique opportunity to put together both reviews and propose a research agenda for this field of study.

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