

# *Application of Game Theory Strategies in Supply Chain Decisions*

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**Abstract** — in the progress of time, purchasing and supply chain management evolved into an inherent part of every company and represented an important possibility to increase the company's performance and competitive advantage. It is embedded in the corporate processes and transforms from raw materials to final products. Parallel to the development of the supply chain management, numerous theories evolved which facilitate managerial procedures and support company performances like the social capital theory, transaction cost economics or the resource-based view. The aim of this paper is to introduce the game theory, connect it to the supply chain management and analyze the added value the combination generates. Game theory has become an essential tool in the analysis of supply chains with multiple agents, often with conflicting objectives. Next to the origin of the history this literature review will illustrate main variable, assumptions and statements. With the outlined knowledge basis the game theory will be used to analyze its influence in the four major decision point of supply chain management: make or buy decision, sourcing strategies, supplier selection, contracting and vendor selection. Evolving from these finding a matrix is developed that outlines key competences of the game theory in regard to the five decision points

**Keywords**—*game theory, supply chain management, make or buy decision, sourcing strategies, supplier selection, contracting, vendor selection*

## I. INTRODUCTION

The appropriate positioning and management of purchasing and supply chain has an increased recognition in organizations compared to previous times where the purchasing process was only seen as an administrative support function and not a strategic advantage itself (Cousins et al., 2008, p. 11). A supply chain can be defined as the process that embraces the transformation of raw materials into final products that are delivered and sold to end customers. It consists out of four basic sections that consist of a variety of own facilities: supply, manufacturing, distribution and consumers. With this scaling a supply chain becomes more complex the more facilities it involves and that need to be managed (Beamon, 1999, p. 275). Over time, companies discovered the value of integrating supply chains and purchasing evolved into a supply chain management process which can lead to extensive competitive advantages through effectiveness (Carr & Smeltzer, 1997, p. 199; Cousins et al., 2008, p. 12). The increased popularity of supply chain management can be traced backed to trends in quality-based competition, global sourcing or the increasing environmental uncertainty (Mentzer et al., 2001, p. 2). The term supply chain management itself is not clearly defined in literature and can be categorized in the three different categories "management philosophy, implementation of a

management philosophy, and a set of management processes" (Mentzer et al., 2001, p. 5). Another increasingly important subject in the existing literature addresses numerous theoretical frameworks for different economical areas and their appropriate utilization. Theories are an important fraction of the economy and serve as a foundation for organizational sciences (Ferris et al., 2012, p. 94). Moreover, theories are not supposed to be true or approve specific assumption but need to be interesting since the truth of a theory as the truth of a theory has little influence on its impact (Davis, 1971, p. 309). Through the merger of theoretical frameworks and supply chain activities four decision points were determined as the core tasks that embody the most value. These four arrangements start by evaluating the internal resources inconsideration of the make or buy decision. Hereafter the sourcing strategies are being observed. Sourcing strategy can influence a company's performance and need to be carefully evaluated to benefit the final outcome. The appropriate supplier selection is incorporated in the third decision point and requires a value adding approach in order to defy competition. The final decision point is addressing negotiation and contracting interactions between different companies. These four decision points outline a major value adding area of responsibility in every company and need to be handled with care. This paper will discuss how suitable the use of the game theoretical framework by Morgenstern and von Morgenstern is in regard to the supply chain. It emerged in the 1940s and was originally intended as a mathematical approach but is now an established part of several other research fields (Von Neumann & Morgenstern, 2007, p. ix). Therefore the following question was designed and leads through the paper:

*In how far represents the game theory an added value to purchasing and supply chain management?*

To answer this question, the remainder of this review is divided into four different main sections. First, the origin and history of the game theory will be explained and introduced. Afterwards the assumptions made by researchers and designers will be evaluated. The next section presents the main variables of the game theory together with the underlying core model and hypothesis. The propositions are followed by a categorisation of the game theory according to a theory evaluation process developed by Vos and Schiele (2014). After the main statements are implied an insight into existing empirical findings will be given by means of analysing different case studies and their outcome. Due to the orientation towards supply chain management of this literature review, empirical findings related to the purchasing sector will follow. Constructing on the

aforementioned literature review the following section will implicate the added value of this paper and relates the game theory to the four decision points of supply chain. An overview in form of a matrix will also be constructed. The final section discusses all aforementioned information and gives a concluding summary and will implement some recommendations.

## II. GAME THEORY

### A. The Game Theory as Mathemized Economic Theory

The game theory was developed in the 1940s by John von Neumann and Oskar Morgenstern and was originally only thought of as a mathematical approach. After the exposure, the game theory was further developed by other researchers like Luce and Raiffa (1957) who related the game theory further into the social science and empirical research fields of study (Von Neumann & Morgenstern, 2007, p. ix). "Game theory is therefore a rigorous branch of mathematical logic that underlies real conflicts among (not always rational) humans" (Poundstone, 1992, p. 6). It is furthermore, according to McCain (2010, p. 5), the examination of strategic choices between interacting individuals and therefore also called the interactive decision theory. The theory's routes can be traced back into ancient times where Socrates used a comparable approach (the corresponding way of thinking) to describe battle situations (Ross, 2012, 1.). The name 'game theory' emerged after the careful analysis of several games in the usual sense (Poundstone, 1992, p. 6) varying from relatively easy unto rather complex and entangled setups. A differentiation was made between games of perfect and imperfect information. Perfect information games are like chess where it can always be expected which moves and possible outcomes there are and how they influence the own strategic choices. Games of imperfect information like poker, that allow for example 'bluffing' on the contrary are limited in forecasting moves and outcomes (McCain, 2010, p. 10). The first application of game theory was as a tool for war strategies.

The most established example of the game theory is the 'Prisoner's Dilemma'. It is an approach that can be described as a transposition between cooperation and betrayal between two interacting parties. It was formalized by the scientists Merrill Flood and Melvin Dresher but was named Prisoner's Dilemma by Albert W. Tucker who stated that it shows an exemplary conflict situation (Poundstone, 1992, p. 8). Table 1 was composed for this review in order to show not only the numerical payoff value as usual in the normal form but also the outcome relation of both agents.

**Table 1: Payoff overview for the Prisoner's Dilemma**

		Player 1	
Player 2		Cooperation	Betrayal
	Cooperation	5-5 (Win-Win)	15-0 (Lose-Win)
	Betrayal	0-15 (Win-Lose)	10-10 (Lose-Lose)

It describes a situation where two agents (two criminals in the original approach) are separated from each other and

are asked to either cooperate with the other one which would generate the best possible outcome for both. Other options are a one-sided betrayal which would be a win-lose situation and in the case that both betray each other they get the worst outcome (lose-lose) (McCain, 2010, p. 15). The Prisoner's dilemma already shows that the most rational decision does not necessarily lead to the best possible outcome. Figure 1 shows a situation where a rational behavior would be to betray the other agent. This situation is given since a betrayal would either save person 1 to lose against person 2 if he betrayed (e.g. 10 years for both instead for 15 years for 1) or might even yield a winning situation if person 2 did not betray (0 years instead of 10). In every situation betrayal seems to be the better and the rational option since every agent tries to maximize the own payoff. Nevertheless, acting rational would generate the biggest disadvantage for both agents (Mailath, 1998, p. 1347). The optimal payoff for both of them would be to cooperate and therefore act irrational (McCain, 2010, p. 15). The Prisoner's Dilemma only shows a rather simple approach of the game theory since only two variables and two strategies are given. In most of the economic decisions that need to be evaluated there is a significantly higher number of strategy alternatives involved agents in the interaction (McCain, 2010, p. 16; Scarf, 1967, p. 50). It can be stated that the game theory passed through a renewal from a pure mathematical approach to an economic theory. It is used as device to analyze human interaction and is applicable in different game settings. The following section discusses the underlying assumptions of the game theory.

### B. Game setting - rationality and information assumptions

Due to the fact of having different manifestations of the game theory, there are different assumptions belonging to the particular forms. Despite these differences some general assumptions can be found in the settings of the game theory concerning the mind-set of included agents, their rationality, self-interest, objective specifications or amount of information. The interaction of agents is assumed to take place in a social structure that allows agents to be entirely autonomous (Burns & Roszkowska, 2005, p. 9). In general, the game theory is built on the agent's being rational and acting strategically or intelligent (Agah et al., 2004, p. 1; Myerson, 2013, p. 2), which means that each agent involved is trying to maximize their possible payoffs (Myerson, 2013, p. 3). During the process of the game and the decisions towards the maximum payoff, every party involved is supposed to know the preference patterns of the other agents in order to facilitate actions in an optimal and efficient way (Luce & Raiffa, 1957, p. 5). Even though a rationality is being assumed, this mindset and the behavior is dependent on the agent's amount of knowledge about the possible statistic options he/she can take (Von Neumann & Morgenstern, 2007, p. 9) or affected by the amount of knowledge about the opposing agent (Rosenthal, 1981, p. 93).

The main assumptions in the game theory are stated as the rationality and information assumption which build the underlying basis for the game setting. The subsequent chapter focuses on the core model, the main variables and hypotheses of the game theory.

### C. The Core Model of the Game Theory and links to its Main Variables and Hypotheses

Since the scope of this theory framework is not big enough to highlight all different approaches of the game theory, the focus will be on the main differences of using the game theory and the statements of an extract of authors. Applicable for all kinds of game theory is that the outcome of an interaction between agents is dependent on what they jointly do and reach (Bicchieri, 2004, p. 289). An important difference on how to use the game theory is the distinction between the normal and the extensive form (Cachon & Netessine, 2004, p. 201). The normal form represents the strategic choices and payoffs for every participant in a matrix. It is always expressed in numbers and additionally the choices of each participant are made simultaneously. In the extensive form, the strategic choices are visualised with a decision tree where every node represents a strategic decision. In the extensive form the participant's decisions are made one after the other (which does not necessarily mean that they know what the other one has decided) which allows their strategies to change and might cause a learning process (Cachon & Netessine, 2004, p. 201; McCain, 2010, p. 17).

FIGURE 1. Extensive vs. normal form game representation.

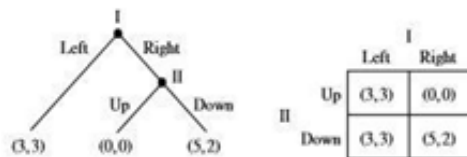


Figure 1: Extensive vs. normal form according to Cachon & Netessine (2004), p.201

The next distinction that can be made is the difference between cooperative and non-cooperative game setups. A cooperative game represents a setting in which involved agents can form commitments or coordinate their strategies in order to win jointly or take part in the game as long as it seems to be worth playing together (Cockburn, 2006, 1.; McCain, 2010, p. 404). Non-cooperative games are dealing with situations where there is no chance for the interacting partners to form a union or an agreement. Therefore no joint strategy is being used and every agent assumes the other is going to take the best possible response (Friedman, 1971, p. 1; McCain, 2010, p. 55; Scodel et al., 1959, p. 115). Another differentiation is the distinction between zero-sum games and non-zero sum games. While a zero-sum game portrays a situation where the agent's payoff adds up to zero (McCain, 2010, p. 97; Von Neumann & Morgenstern, 2007, p. 46) a non-zero-sum game allows multiple winners or losers and a result of payoffs that does not equal zero (Cockburn, 2006, 1.). The Nash equilibrium is a useful and commonly used perspective in the game theory and is marked as the situation where "each player's strategy is optimal against those of the others" (Nash, 1951, p. 287). In other words it describes an outcome of a game where every agent chooses the best possible option in regard to the opponent's selection (or the assumption of how that agent will act) a Pareto-efficient choice (Bicchieri, 2004, p. 290; Nash, 1951, p. 287). It can be used in cooperative and non-cooperative games. The game theory is not only applicable

in situations with two agents but can be used with n-agents where every agent has a finite number of strategies. This approach is called 'n-Person game' and usually addresses a large number of agents (McCain, 2010, p. 229; Nash, 1950, p. 48). The variables influencing the possible outcomes in the different games need to be well specified in order to clearly identify them and the adhering values they influence (Luce & Raiffa, 1957, p. 4). Since the theory is used to analyze the procedure and outcome of an interaction there are various variables that can affect the occurrences and need to be considered in regard to human behavior. Camerer (2003) states not only economic variables but identifies agent's characteristics and their perspective towards the objective as important impact (Camerer, 2003, pp. 60, 64-73). An important variable that should be considered as well is the nature of the agent's connection to each other as well as the nature of the game. This importance arises since a game and the whole course of events can be influenced by the agents being strangers or partners (cooperative or non-cooperative in a metaphorical sense) (Andreoni & Miller, 1993, p. 574). Schultz (2004, p. 144) furthermore considers magnitude, probabilities and reward utility as variables in the game theory approach. The main part of game theory can be seen as the interdependency of agents meaning that during an interaction both agents influence each other's decisions (Lasaulce & Tembine, 2011, p. 3). Hence, the central hypothesis asks "to model interactions between players, to define different types of possible outcome for the interactive situation under study (solution concepts), to predict the solution(s) of a game under given information and behavior assumptions, to characterize all possible outcomes of the game, and to design good strategies to reach some of these outcome" (Lasaulce & Tembine, 2011, p. 4).

As it becomes more explicit in the preceding section, the game theory consists out of numerous interconnected components that need to be carefully considered and analyzed. The characterization and close observation of the game theory itself is the core content of the next section and analyses the theoretical position of the game theory.

### D. Analysis and Forecast of Interactions as Main Statements of the Game Theory

The main purpose of using the game theory is to define possible outcomes of a game and design adhering strategies towards these objectives (Lasaulce & Tembine, 2011, p. 4). Dealing with the strategy design does not only call for careful consideration of influencing market details but also the need to operate with complications (Roth, 2002, p. 1342). Even though the game theory was originally intended as a mathematical approach, the economic adaption merely requires a primal mathematical knowledge and is rather demanding concerning the agent's reasoning (Gintis, 2000, p. xxii). The initial idea of the game theory is to treat and analyse aspects of strategic human choices as if they were games even though they do not seem to have any game characteristics. It is therefore seen as a theory of interaction decisions (Bicchieri, 2004, p. 289; Myerson, 2013, p. 1; Parsons & Wooldridge, 2002, p. 243; Poundstone, 1992, p. 7). Nonetheless is the game theory itself primarily about strategy and the correlation between different strategic

decisions (Poundstone, 1992, p. 6). It is therefore of great importance to observe a player's optimal response in regard to the chosen strategies of the opposition (McCain, 2010, p. 5). The progression of the game depends on the information each agent has about the other one and in how far the strategic decisions and reactions can be comprehensible (Rosenthal, 1981, p. 93). Moreover, the game theory studies the rational decisions of humans with a key factor of the most profitable response an agent can choose while considering the decisions made by opponents. The most profitable response can be seen as the strategic decision that gives the agents the maximum payoff in regard to the strategy (that will be) chosen by the other player (McCain, 2010, p. 12). The game setting is usually conducted repeatedly in order to gather information about equilibria and inspect a potential learning curve during the individual rounds (Camerer, 2003, p. 8). Kreps (1990) additionally states that the game theory by itself cannot increase the understanding of an economic phenomenon but is rather an analysis tool that provides clear standards, insight to logical consistency and reveals supporting opinions or conclusions (Kreps, 1990, p. 9). Concluding, the game theory is an influential application in regard to outcome analyses and the consideration of most profitable responses in learning affected situations. Hereafter the game theory is observed concerning the empirical findings in general and in context with supply management.

#### *E. Rationality Assumption as point of Criticism*

Visible through the prior literature review it becomes clear how broad the game theory's scope and diffusion has become since the 1950's. Regardless of the progress and success from a pure mathematical to a widely used economic theory, the game is object to several critical statements that can be found in published works. A broad opinion is the doubt of the rationality assumption which might be too difficult to accomplish (Burns & Roszkowska, 2005, p. 9; Camerer, 1991, p. 137). Another concern regarding the agent's mind-set is the assumption of absolute interdependence from each other. Researcher doubt that agents are completely independent from each other or judge the situation by themselves in all situations as demanded in the classical game theory (Burns & Roszkowska, 2005, p. 9). Due to these narrow regulations researchers need to take into account that agents might be interdependent in social, institutional or cultural-moral terms (Burns & Roszkowska, 2005, p. 9). Not only the mind-set but also the assumed amount of knowledge is exposed to some criticism. Burns, Roszkowska and Rosenthal mention in their publications the rather unrealistic assumption of agents' being in possession of complete, valid and shared knowledge about the other agent's objectives, selection and the game (Burns & Roszkowska, 2005, p. 10; Rosenthal, 1981, p. 93). They furthermore state that the assumption of a consistent utility preference is hardly realistic (Burns & Roszkowska, 2005, p. 10). Even the designers of the game theory John von Neumann and Oscar Morgenstern admit in their introduction to game theory that the hypothesis of complete information and knowledge about strategic decisions is not generally realizable in real life due to several outside factors. Additionally they state that, even

though the zero-sum game exists, the results will usually not be zero since it is dependent of other agents' behavior (Von Neumann & Morgenstern, 2007, p. 47). The supposition that the game theory is encouraging economists to see all kinds of interaction as games (Manski, 2000, p. 2) and that it is eventually not applicable to determine general regularities, but evokes customized solutions, can also be found as criticism (Camerer, 1991, p. 137). Not only states Camerer (1991) the impracticality of game theory for general applications but also outlines the difficulty of using and testing it (Camerer, 1991, p. 137). Next to these partial criticisms, Sharma and Bhattacharya (2013) fault the whole approach and state that the game theory is only based on a simple assumption regarding the human behavior and predictability in terms of rationality and risk-taking. They clarify that human decisions are based on consideration and a bounded rational behavior that come together with 'soft' characteristics like randomness or emotions (Sharma & Bhattacharya, 2013, p. 111). Despite these negative remarks supporting and approving statements can be found in the existing literature. Gintis (2000) emphasizes the usefulness of game theory as it creates a universal language of interaction for the behavioral science. Even the broad extension into the areas of political science, biology or psychology does not complicate the application but provides insight into one another (Gintis, 2000, p. xxiii). This statement can also be found in Lewis and Dumbrell's paper that clarifies that the researches in the different areas do not form separate literature but complement each other (Lewis & Dumbrell, 2013, p. 29).

The following section will compare and differentiate the game theory to two other economic theories in order to show its uniqueness.

#### *F. Unique Applications*

The main differentiation between the game theory and other economic theories frequently used is the focus on the social interaction. Game theory primarily analyses the interaction of two or more agents and takes into account their attempts before the decisions are made. Furthermore are the agents interested in environmental parameters that are influenced by all involved parties (Osborne & Rubinstein, 1994, p. 3). An entirely different perspective on economic decisions embodies the resource based view which is concerned with the resource value and usefulness in order to find optimal product-market activities (Wernerfelt, 1984, p. 171). The resource based view includes all tangible and intangible assets of a firm that can be taken as either strength or weakness and are tied to the firm (Caves, 1980, p. 64; Wernerfelt, 1984, p. 172). Resources can influence the firm's performance and bear advantages over competitors not possessing these resources. Barney (1991) developed a framework that enables researcher and companies to identify and link resource heterogeneity/immobility with the key criteria value, rareness, imperfect imitability and substitutability. The interaction of aforementioned variables is determines a company's sustained competitive advantage attained through resources (Barney, 1991, p. 112). Barney further implies that a company that

strategic management research can be aligned with social welfare, building on the assumptions that resources are heterogeneous, immobile and that the company act efficient as well as effectively in utilizing resources. Through the embodiment of an intimate integration of economic and organisational theory the resource based view enables companies to gain and maintain a competitive advantage (Barney, 1991, p. 116). Moreover, companies are able to benefit from a first mover position built through a resource barrier by owning a resource that inconveniently influence later acquires (Wernerfelt, 1984, p. 173). The concepts of the resource based view show a very concrete application of the theory and are therefore limited in its usage. It can specifically be used to explain or extend varieties in profitability and competitive advantage (Peteraf, 1993, p. 186). Even though there are other theories observing social interaction, game theory seems to be rather unique. The social capital theory is also a theoretical approach that can be used in numerous areas and is one of the most established theories from the sector of sociology (Lesser, 2000, p. 44). The novelty coming along with social capital theory is the centre of attention in the positive effect of sociability and the usage of these effects to emphasise the important source of power of nonfinancial forms (Portes, 1998, p. 2). Pierre Bourdieu (2008, p. 286) defines social capital as “the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition”. Furthermore social capital is influenced by the size of network connection that can be efficiently used and mobilized and the quantity of available economic, symbolic or cultural capital (Bourdieu, 2008, p. 286). The key concept of social capital is being connected to somebody else who simultaneously embodies the source of advantage (Portes, 1998, p. 7). By adapting the social theory concept, companies can release virtual resources, materials and affect the company’s performance through employee inducement (Łopaciuk-Goncaryk, 2011, p. 62). Based on the short aforementioned theory characterizations the difference to the game theory becomes clearer. While some economic theories are developed concrete for one area like the resource based view, other theories like social capital or game theory are originated in another sector but are applicable in numerous areas and add a novelty to existing approaches. It is more explicit now that the game theory has a unique position while comparing it to other theories. While the resource based view is especially designed to analyse a company’s resource advantages and values it can only be used in the same setting while the game theory can be transferred to various different situations as long as it involves at least two interacting agents. The comparison between the social capital and the game theory is observable in the underlying assumptions of both theories. While the game theory can be used between indiscriminately chosen oppositions, the social capital is theory based on a network between the involved parties that provides the advantages of interacting. The game theory was subject to a major development, from a mathematical origin it turned into a generalized approach for a variety of sectors (Cachon & Netessine, 2004, p.

200; Gintis, 2000, p. xxii). Throughout the development phase, additional and innovative concepts evolved and shaped the game theory as it is used today. After the introduction in the 1950’s game theory did not get a lot attention or appreciation but is successfully adapted in various disciplines nowadays (Cachon & Netessine, 2004, p. 200). Evolutionary considered the game theory matured over the time. After being applied, approved and explored in several sectors now, the game theory will probably remain a feature of economic theories.

After having discussed the body of knowledge the following chapter will examine the four major decision points in supply chain management and explain their correlation.

### III. GAME THEORY AND THE DECISION POINTS IN SUPPLY MANAGEMENT

#### A. *Decision Point 1: The Game Theory as supporting tool in the make or buy decisions*

The decision to make or buy can have a major influence on the company’s performance due to the associated opportunities. The purchasing department needs to decide if the incorporated possibilities and expertise suffice to produce the optimal product or if the supplier’s knowledge is exceeding theirs. With an outsourced expertise a company is able to focus on their core competencies (Heikkilä & Cordon, 2002, p. 183). In the make or buy decision the influence of game theory is limited due to the interaction-analyzing core of the theory. It might not be as useful as other theories since it does not discuss the advantages or disadvantages of an in-house or outsourcing decision. Furthermore does the game theory observe two or more agents with different objectives and the decision whether or not to outsource is made inside the organization and the agents involved have all the same objective – determine the best relation to the market (Humphreys et al., 2002, p. 568). A possible contribution to the make or buy decision of the game theory is a beneficial analysis of the interaction between an outsourcing firm and a potential hosting firm that provides an increased payoff possibility. Hence, the process of negotiation in the make or buy decision can be object to the game theory in analyzing the interaction and payoff progress between two companies. Bandyopadhyay and Pathak (2007) examine the knowledge sharing between the outsourcing firm and the supplier with a focus on the differences between cooperation and non-cooperation (Bandyopadhyay & Pathak, 2007, p. 350). Hence, the game theory does not encourage the make or buy decision itself but provides frameworks for the relationship and process optimization.

#### B. *Decision Point 2: The Game Theory provides no Added Value for Sourcing Strategies*

The second decision point examines the sourcing strategies a company could apply. Sourcing strategies are a significant part of a company’s strategic decision making and can influence the assurance and improvements of quality, cost reductions and competitiveness (Rendon, 2005, p. 12). Due to the influence sourcing strategies have on the final product or price it is important to carefully consider

their application and contribution to competitive advantage. Strategic sourcing embraces the careful assessment of opportunities, market analyses and an adjusted strategy design (Rendon, 2005, p. 14). Possible sourcing strategies involve dual-sourcing, multiple-sourcing or global sourcing. It is important for companies to identify the most valuable commodities and ensure their continuous with an optimal sourcing strategy. As previously mentioned, the game theory is not applicable in a situation with a single agent. Therefore, the game theory cannot be used to analyze the benefits or disadvantages of the different sourcing strategies since the setting is not designed to evaluate choices but to analyze the best outcome in an interaction. Therefore at least two agents need to be involved in order to evaluate the best equilibrium based on both players' choices. Since the process of selecting a sourcing decision is no explicit interaction the game theory has no direct use. Nonetheless, it can be used as a supporting tool in the external communication during this stage. Companies can utilize the game theories for example while inquiring potential suppliers' interest in a coalition.

### *C. Decision Point 3: Game Theory in Supplier Selection*

The appropriate strategy allocation and processing of supplier selection is addresses in the third decision point. After the successful election of a sourcing strategy, suppliers need to be chosen that add value to the company and can fulfill certain criteria. The focus of selecting the right supplier lies on the complexity of the situation and the supplier qualification since the consequences of an unfortunate decision can be severe (de Boer et al., 2001, p. 75). The supplier selection process can be divided into different steps of problem definition, criteria formulation, qualification and choice. The exact application varies additionally depending on the purchasing situation (New

task / rebuy) (de Boer et al., 2001, p. 77). The interactive nature of the game theory is convenient regarding the selection process that is often executed in game settings. Here, an example is Hsieh and Kuo's (2011) study about the dual sourcing game. A vendor introduces a two-stage game setting in which two different suppliers compete on quality level in the first period to outpace the weaker supplier and gain a larger share of the total amount in the second stage. As a result the client receives an increased effort and depending on the sector an increased service (Hsieh & Kuo, 2011, p. 3999). Through a game setting like this each supplier tries to maximise the offered value in order to win the game and the higher capacities. Researchers state that with a game approach like that a mixed strategy equilibrium exists and suppliers with lower marginal costs are more likely to irregularly change their service level.

### *D. Decision Point 4: Game Theory in Negotiation and Contracting*

The next decision point is concerned with the step following the make or buy decision, the determination of an appropriate sourcing strategy and the qualified supplier selection: negotiation and contracting. These transactions define the framework and the foundation of the associated cooperation. Negotiations consider the adjustments and last changes of cooperation conditions and can be formal, informal, distributive or integrative. The consequential contracts can be, varying with the nature of cooperation, among others long term, short term or fixed price contracts. During the negotiation the game theoretical approach is a tool to select and negotiate an optimal coalition of partners (Hennet & Arda, 2008, p. 104). Through the imperfect allocation of information in most of the applications an immediate equilibrium is unlikely and the outcome of a game depends on who opens the game and how other agents negotiate (Hennet & Arda, 2008, p. 104). An equilibrium with one agent getting the maximal value of the utility function and the opponent is kept at the minimal satisfaction level is the result of a game with a dominant leader (Hennet & Arda, 2008, p. 405). As the aforementioned sections already discussed, the game theory estimates the human decision making process based on information and rationality assumptions. In the negotiation and contracting phase this application is of high value to companies due to the increased amount of interaction. Through the adaption of an extensive game theory the involved companies are able to assess all possibilities and can review the consequences of their decisions at all times. Moreover the game theory can support the process of attaining the highest possible payoff for all involved parties if they share their knowledge, information and preferences. Through the application of the game theory during negotiations in the contracting phase companies are able to attain higher payoffs due to the evaluation of best possible outcomes and payoff maximizations. Through analyzing the opponent's strategic choices and balancing the subsequent decisions against them, a company might attain better contracting conditions and complete negotiations with an improved equilibrium. Accordingly, it can be stated that the game theory is a useful and supporting tool in the processes of negotiation and contracting.

#### IV. DISCUSSION AND CONCLUSION

The purpose of this literature review was to answer the question: *In how far represents the game theory an added value to purchasing and supply chain management?*

Therefore this theoretical framework was started with an overview of the origin and history of the game theory. The mathematical starting point was introduced as well as the modification and implementation into a variety of other sectors like psychology, sociology or biology. A brief overview and introduction into the different kinds of games and representations were given as well. Afterwards the assumptions, main variables, underlying hypotheses and the core model were presented. Here it was shown that the game theoretical setting assumes a rational human behavior, an extensive and shared general knowledge about the counterpart as well as about possible strategic decisions and that numerous external variables can influence the game process. Following these basic information, the game theory was analyzed in terms of characteristics, internal and external virtues and was considered an underpinned social theory. A deliberate extract from the existing literature was then stated to give an insight into the general empirical findings. Additional four case studies from the purchasing and supply chain area were selectively analyzed. It was observable that the implication of game theory in the supply chain is not completely mature yet, but can be used to identify uncertainties or allocate costs allocations. The following comparison to the resource based view and the social capital theory shows the unique application and broad scope of the game theory in the economic sector. The last section of the paper discussed the application of the game theory in the four major decision points of purchasing that can be identified as (1) make or buy, (2) sourcing strategies, (3) supplier strategies and (4) contracting. Due to the original objective and application of the game theory in interactions there is no direct link or influence on the make or buy decision or in the strategic sourcing process. Both processes are rather internal and refer to a decision based on advantages and benefits the decisions could bring to the company but neither of them includes two contrasting parties with different objectives. Nonetheless, the game theory can be used to optimize the knowledge sharing in a potential collaboration or improve the monitoring of an existing relationship with an outsourcing agent. During the process of supplier selection the game theory is a powerful tool to deal with potential suppliers and select the one that can add the most value to the company through its expertise, quality or monetary value. Moreover, the game theory can be combined with other mathematical applications in order to attain an analysis that can precisely determine several preferences and their attached weight concerning the decision. The decision point of negotiation and contracting completes the core tasks of supply chain management and is supported through the game theoretical approach in analyzing and optimizing the coalition partner and attain the best possible contracting conditions.

As it is already mentioned earlier in this paper, the game theory expired into numerous areas, the game theory still

needs some further research efforts especially in the field of supply chain. The implication of the game theory in the supply chain is still limited and relatively new. Further case studies concerning the game theoretical approach in the supply chain sector could increase the absorption and understanding of the theory. Thereby, more general rules and guidelines would emerge and facilitate a further expansion of the game theory.

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