The Impact of the Game Theory in Supply Chain Management

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In the progress of time purchasing and the supply chain management evolved into an inherent part of every company and represent an important possibility to increase the company's performance and competitive advantage. It is embedded in the corporate processes and contains the transformation from raw materials to final products. Parallel to the development of the supply chain management numerous theories evolved which facilitate managerial processes 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 analyse the added value the combination generates. Next to the origin of the history this literature review will illustrate main variable, assumptions and statements. It also includes a categorisation of the game theory into the life-cycle approach developed by Vos and Schiele (2014). With the outlined knowledge basis the game theory will be used to analyse its influence in the four major decision point of supply chain management: make or buy decision, sourcing strategies, supplier selection and contracting. Evolving from these finding a matrix is developed that outlines key competences of the game theory in regard to the four decision points.

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1. INTRODUCTION

The appropriate positioning and management of purchasing and supply chain has an increased recognition in organisations 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 categorised 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 utilisation. Theories are an important fraction of the economy and serve as a foundation for organisational 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 in consideration 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). So far only some parts of the game theory have been applied to the supply chain since some practical problems prevent a complete adaption. Primarily simple games can be found and complex game approaches still need to be further exploited (Cachon & Netessine, 2004, p. 229; Zamarripa et al., 2012, p. 180). This literature review therefor seeks to determine the contribution to purchasing and supply chain management of the game theory. Therefore the following question was designed and leads trough 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.

2. GAME THEORY

2.1 The game theory as mathematized 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. It was therefore used with the zero-sum approach in which one person wins and one person loses (i.e. how one party can destroy the other one before they are destroyed). The first mathematical version of the game theory was developed by John von Neumann in 1928 but did not get a lot of devotion. After a collaboration with the economist Oskar Morgenstern the theoretical framework generated a "radically new approach to economic theory" (Von Neumann & Morgenstern, 2007, p. vii)

in which they showed how a social theory can be mathematized. This new strategy described the interaction of two or more individuals in a mutually influencing decision process and the possible outcomes. Through this pioneering approach Von Neumann and Morgenstern got an enormous devotion and outstanding reviews (Von Neumann & Morgenstern, 2007, p. vii). Due to the mathematical background of John von Neumann the original game theory was dedicated for mathematical approaches and not for empirical science. Nevertheless, with some mathematical understanding the motivation, principles and conclusions were already studied and tested by some social scientists (Luce & Raiffa, 1957, p. 3). The publication of Raiffa and Luce in 1957 gave a first non-mathematical approach of the game theory which made it further accessible for all other social scientists (Von Neumann & Morgenstern, 2007, p. ix). Since the game theory deals with human interaction there are always several parties involved. In order to facilitate the perception, the term 'agent' will be used throughout the remaining paper in order to talk about the different involved parties with individual expectations. Agents can be categorized as an individual, a firm, a government or whole entities like social organisations (Manski, 2000, p. 6). The behaviour of these agents is examined in the process of the game theory in regard to the choices they should make in order to reach the best outcome for all participating agents (Luce & Raiffa, 1957, p. 4). As a means of reaching this it is assumed that the agents are rational in a way that they are continuously pursuing their own purposes (Myerson, 2013, p. 2).

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). Figure 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.

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

Figure 1: Payoff overview for the Prisoner's Dilemma

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 behaviour 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 maximise 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 uses ad device to analyse human interaction and is applicable in different game settings. The following section discusses the underlying assumptions of the game theory.

2.2 A game setting needs to fulfil 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 behaviour is dependend by the agent's amount of knowledge about the possible statetic opions he can take (Von Neumann & Morgenstern, 2007, p. 9) or affected by the amount of knowledge about the opposing agent (Rosenthal, 1981, p. 93).

Messick & Thorngate (1967) on the other hand emphasise in their study about two-person two-strategy research that is also common not only to maximise the payoff but to maximise the relative gain. This behaviour is aiming towards the biggest achievable difference between the payoffs where a positive sum of payoffs is attractive for an agent and a negative sum is aversive (Messick & Thorngate, 1967, p. 98). At the same time agents are expected to express a certain altruistic behaviour which implies that they do not solely focus on their own best outcome but also care about the other agent's well-being (Camerer et al., 2011, p. 297). With an altruistic character trait it is not implied that agents will always consider their opponent's objectives, but also damage them if necessary. This, in turn, is based on the assumption that people are likely to address people in the same way as they are being treated and are therefore

willing to harm other agents if necessary or even forgo their own bell-being (Camerer et al., 2011, pp. 297-298).The way an agent's behaviour is changing with the amount of information in the beginning of the game is also assumed to have an influence on the final outcome. Therefore the game theory assumes a common knowledge that enables an agent to conjecture the opponents behaviour and strategic choices (Colman, 2003, p. 139) This information can either concern the probability of strategy choices (Kreps & Wilson, 1982, p. 254) or the amount of characteristic information (Rosenthal, 1981, p. 93). If there is an uncertainty towards the motivation of at least one agent, the whole game might change (Kreps & Wilson, 1982, p. 275). Concerning the given information, it can be stated that it is assumed for both agents to know everything about the strategic decisions in the perfect information game (Rosenthal, 1981, p. 94; Von Neumann & Morgenstern, 2007, p. 112). In the extensive game form this indicates the agents being informed about every strategic decision that was already made, no simultaneous or surprising choices can be taken and therefore no information obstacles can occur (Rosenthal, 1981, p. 94). Since a state of perfect information is rarely compliable, it is an accepted approach to assume that all involved agents are completely informed about their opponents characteristics and strategic choices (Von Neumann & Morgenstern, 2007, p. 30). Another key assumption is the ability of the involved agents to express their satisfaction towards different results with numerical values in order to create either a table or a decision tree (Camerer, 2003, p. 26).

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

2.3 The Core model of the game theory is linked 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.

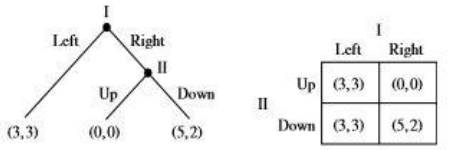

Figure 2: Extensive vs. normal form according to Cachon & Nesseine (2004), p.201

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 allow 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 choses 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 both 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 analyse 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 behaviour. 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 as 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 analysed. The characterisation 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.

2.4 The game theory represents an established theoretical basis

Vos and Schiele (2014) developed a framework that enables researchers to analyse theoretical framework and test whether a theory is adequate enough to be labelled as theory(Vos & Schiele, 2014, p. 4). It is stated that a theory should be built out of five basic elements and a suitable application feasibility in order to be considered as a valid theory (Vos & Schiele, 2014, p. 5). The analysis starts by identifying the units, laws, boundaries, system state and the why question in order to capture the five characteristics of the theory. After analysing these elements it needs to be assured that the theory can be used in practice and that it is applicable to real life phenomena since a theory makes sense of reality and explain aspects of life (Babbie, 2012). Therefore the theory is tested in terms of hypotheses, proposition, empirical indicator and empirical testing (Vos & Schiele, 2014, p. 5).

The *units* of importance in the game theory are the agents involved in strategic decisions (individuals, companies, social entities) (Manski, 2000, p. 6; McCain, 2010, p. 5). The *laws* that can be identified concerning the process of interaction in the game theory are for one thing the maximisation of expected utility (Luce & Raiffa, 1957, p. 4) and the necessity of knowing the opponents preference patterns and characteristics (Luce & Raiffa, 1957, p. 5). In the game theory it is assumed that by incorporating the antagonist's attributes and by the variety of knowledge that is available, the agent is likely to align his actions to the given situation (Rosenthal, 1981, p. 93). The game theory is concerned with at least two involved parties with the focus being on the observation of the decisions makers who are interacting with one another (*Space boundary)* and their strategic bargaining behaviour (Moss, 2001, Abstract; Sanfey, 2007, p. 599). These interactions are influenced by the constrained actions each player can take and the distinctive objectives of every agent (MacKenzie & Wicker, 2001, p. 127). Through this game theoretical analysis, an interaction can be optimized until an equilibrium can be reached (*value boundary)* (Camerer et al., 2004, p. 120). The interaction that is being observed deals with the process of one decision but can be spread over a longer period of time (*time boundary)* depending on the nature of the game, if it is a one-shot game or repeatedly performed (Andreoni & Miller, 1993, p. 582). The *system state* in the game theory is no solitary solution since there are different possible applications. In general the game theory can reflect all kinds of situations in order to analyse the outcome in regard to the solution concepts (Myerson, 2013, p. 107; Osborne & Rubinstein, 1994, p. 177). The question of *why* can therefore be answered with the emerging opportunities of reflecting the world, representing certain situations and testing predictions with the information that emerge from the game theoretical approach (Gintis, 2000, p. xxiv). The main *hypothesis and propositions* derive from the added value the game theory provides for social interactions based on the rationality assumption (McCain, 2010, p. 19). Since rational agents are assumed to have a more predictable behaviour towards a pursued equilibrium the complete game is easier to forecast (McCain, 2010, p. 89). An ascending focus is additionally laid on the exploration and distribution of the game theoretical approach and *empirical research* has been conducted in several areas and settings. For example Linde et al. (2014) developed an approach to categorise the strategic adjustments of involved agents (Linde et al., 2014, p. 91). During the research they designed a qualitative experiment to identify different strategic behaviours, including different *empirical indicators*. In sum is becomes clear that thus far the game theory was proved with sufficient data concerning the theory characteristics developed by Vos and Schiele (2014) and represents an established theoretical basis. In a subsequent section the theory will additionally be tested in terms of internal and external virtues. The main statements the game theory is based on are addressed in the subsequent section.

2.5 The analysis and forecast of interactions can be stated 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 chose 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 of 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.

2.6 Empirical Findings

2.6.1 Method: Literature Review Approach

This theory framework is built on the existing body of knowledge about the game theory in general and its practice in purchasing and supply chain. In order to find the appropriate literature the library of the University of Twente was in order to find books like McCain's 'Game theory: A nontechnical introduction to the analysis of strategy'. Furthermore online resources like Google Scholar and Science Direct supported the search for further lierature, books as well as articles. In the beginning 'game theory' and 'game theoretical approach' were solely taken as search items that attain more than 130,000 results on scienece direct and more than 3,000,000 on Google Scholar. In order to limit and concentrate the articles and books that are suitable additional search items were added to filter the vast amount of hits. A key word filter was therefore used to link the game theory and to limit results to 'supply chain', 'variables', 'assumptions', 'application', 'organisation' or 'economics'. An additional language filter was implimented to restrict the results to Englisch and German publications. To avoid unqualified publications as a basis the given results were first scanned for appropriateness, quality and continuity (if older researches have been taken into account). Additional the abstracts were checked for an added value to this research. If all chriteria were met the article was chosen to be reviewed. Using this approach a total of 75 suitable articles and books are used as a basis for this research. The given literature is among others published in the 'Strategic Management Journal', 'Journal of Ecoomic Literature', Journal of Operational Research', 'Journal of Economic Theory', 'European Journal of Operational Research', 'European Economic Review' or 'Journal of Management'.
Thes subsequent section will give an insight into the application of the game theory and some empirical findings.

2.6.2 A vast amount of empirical research exists for the application of the game theory

There is a vast amount of literature that can be found addressing the game theory and its adaption in several areas. Numerous researches have addressed the game theory to find and analyse coherences is all areas of life and business. In his research of social interaction, Charles Manski (2000, p. 19) discusses the development of different empirical findings and researchers about the game theory in the areas of marriage, welfare or reciprocity.
Several authors likewise addressed the general function and usage of the game theory. Pfeiffer et al. (2005) examined the probability of cooperation in small groups and the generalised reciprocity in larger groups and iterative game settings. Their simulations consist of groups interacting in one-shot situations (simultaneous and onetime decisions) and are finitely re-arranged with new opponents (Pfeiffer et al., 2005, p. 1116). The results show that a cooperation is likely to appear during an interaction within small groups even with an opponent that cannot be recognized. Furthermore they stated that generalised reciprocity can be an alternative for cooperation since less information is used to presume future behavioural patterns (Pfeiffer et al., 2005, p. 1118). While investigating the available strategies and strategy changes, Linde et al. (2014) conducted a multi-round experiment in order to limit and clarify the knowledge about the strategy an agent can use (Linde et al., 2014, p. 77). They designed an experiment building on a five-player minority game and every participant had to submit a strategy which was analysed and all possible strategy combination were tested in a simulation with 100 periods is being done. On the basis of these outcomes the researchers added the points a strategy could attain and ranked all strategies (Linde et al., 2014, p. 82). After each round the agents are informed about the results and are conceded to change their future strategy (Linde et al., 2014, p. 81). In the course of the experiment the number of submitted strategies decreased the further the game was evolving since the involved agents were able to test every potential strategy online in comparison to other submitted strategy (Linde et al., 2014, pp. 81,90). Eventually they come to the conclusion that a learning process is limited over the five rounds and that the most successful strategy is only to revise the strategy after losing. Additionally strategies can be categorised into the following 6 categories: (1) 'lose-shift', (2)'win-shift', (3) changing after a defeat, (4) half of the time, (5) very often or (6) never (Linde et al., 2014, p. 91). The influence of prior win or loss experiences was tested by Schade et al. (2010) who conducted their experiment on the basis of the two coordination games 'battle of the sexes' and 'simultaneous market entry' (Schade et al., 2010, p. 426). In the findings it can be seen that there is a difference of strategic decisions and prior experiences in regard to genders. Is seems that he results for male respondents are rather straightforward and corresponded with the researchers' forecasts. Male attendees are likely to aggregate past outcomes with future payoffs and therefore confirm social projections (Schade et al., 2010, p. 434). Female attendees were characterised as less predictable in regards to different prior outcome. These differences in the application of the game theory might be justified by females being uncertain about what to expect from their opposites or by a different way of interpreting prior gains or losses (Schade et al., 2010, p. 435). Sharma and Bhattacharya (2013) furthermore analysed the knowledge flow in common organisational situation in regard to the optimal solution (Sharma & Bhattacharya, 2013, p. 100). As a final result they stated the imperfection of the game theoretical approach due to assumptions like perfect rationality or risk neutrality the game theory implies (Sharma & Bhattacharya, 2013, p. 111). They also advise to use the game theory as a means to frame decision possibilities and not to predict an interest (Sharma & Bhattacharya, 2013, p. 112).
These empirical findings are only an extract of all research applications but rudimentary demonstrate the diversified research about the game theory. It can be used to examine cooperation probabilities, strategy successes or choice affections between different agents. In the next section this paper continues the insight into the game theory and will establish a connection to the field of purchasing and supply chain management.

2.6.3 The empirical research related to purchasing and supply chain is still limited

The supply chain is an important part of every business and can obtain competitive advantage if it is handled effective since the competition is not between the institutes but between the

different supply chains (Li et al., 2006, p. 107). An increasing number of authors devoted their work to emphasise the usefulness and advantages of the game theoretic approach in the purchasing and supply chain sector (Jalali Naini et al., 2011, p. 594). The following overview is an outline of the vast amount of existing literature and has been selected in virtue of the suitable content and appropriateness.

Zamarripa et al. (2012) address in their study the supply chain planning in competitive environments with the help of the cooperative and non-cooperative game theoretical approach (Zamarripa et al., 2012, p. 178). In their work it is stated that a supply chain is part of a complex and competitive whole where managers need to react to known or unknown third parties with decisions that influence the own supply chain's profit. In order to analyse the success of these decisions the game theory is applied (Zamarripa et al., 2012, p. 180). In order to analyse the impact of a cooperative and non-cooperative a network of several supply chains with production sites and distribution centres is considered. Depending on the scenario the different organisation are either allowed to form a coalition (cooperative game) or prohibited to align their strategies (non-cooperative game) (Zamarripa et al., 2012, p. 181). These concepts have been applied to a case study and were analysed with a combination of game theory and a mathematical programming based optimisation. Due to a setting with competition uncertainty the researchers were able to observe uncertainty and competitive behaviour through which they could detect the optimal solution for every scenario. By combining the game theory with a mathematical optimisation Zamarippa et al. provide an approach that enables a systematic analysis of competing supply chains as a linked source to the existing demand uncertainties. They furthermore consider these supply chains as either competitor or coalition partner in terms of cost, environmental impact or customer satisfaction (Zamarripa et al., 2012, p. 186). In a later publication Zamarripa et al. develop a framework on the basis of the game theory in combination with a multi-objective optimization to improve tactical decision making in supply chains of interest and to allow managers to specify objectives (Zamarripa et al., 2013, p. 1588). The framework is considering the tactical decision making in different supply chains regarding inventory, manufacturing and distribution profiles over a specific time period and identifies the optimal solution for given scenarios (Zamarripa et al., 2013, p. 1593). Zamarripa et al. here too, investigate the strategic decisions and reaction of involved agents in a cooperative and a competitive setting and test it in a case study. The results state the importance of delivering products in the most profitable way in the cooperative setting. Therefore the production costs will be reduced and consumer might profit from cheapest manufacturing policies. In the competitive setting on the contrary, the supplier is advised to consider several policy opportunities to satisfy the demand (Zamarripa et al., 2013, p. 1596). These results were obtained by using the game theory as an analytical tool and can improve strategic decision making for existing and future market trends like capacity changes or changes in logistic flexibility (Zamarripa et al., 2013, p. 1596).

Jalali Naini et al. (2011) combine the game theory with the balanced scorecard in order to evaluate business processes and measure performances. The framework is being tested and applied in the supply chain of an Iranian automobile industry (Jalali Naini et al., 2011, p. 593). The methodology merges these two approaches due to their ranks of being the best tool for analysing interactions and the best tool for measuring performance. With this combination it aims at obtaining the best performance strategy at a balanced point in the decision making. The agents have the choice of three mutually exclusive strategies which outlines a total of 81 possible interaction in this 4-player game (Jalali Naini et al., 2011, p. 596). The outcome of this research is an overview of strategies that should be focused on depending on the area in the balanced scorecard that needs improvement. The combined strategies are rather likely to reach the most appropriate solution (Jalali Naini et al., 2011, p. 601).

The attempt of using a horizontal cooperation with a cooperative game theory is analysed in the research of Lozano et al. (3013). Due to the high costs of logistics the researchers developed a framework that aims at the alignment of two or more suppliers with the objective of reaching lower costs (Lozano et al., 2013, p. 444). Before an alignment is taking place a cost estimation and allocation is necessary and indicated in this paper, next to an approach of a fair cost allocation (Lozano et al., 2013, p. 445). First a Mixed-Integer Linear Program is used to estimate costs and then the cooperative game theory is implemented to emphasise a fair cost allocation. The suggested alignment schemes evoke a monotonous game which indicates that collaboration bears incentives for the involved suppliers. Moreover a collaboration synergy is increasing with the size of the collaboration. The most suitable solution for cost allocation are mentioned to be minimax core and least core concept due to their comparable simplicity (Lozano et al., 2013, p. 451). Besides the aforementioned researches that focus on competitive relations there are also publishers that dedicate their work to the interaction of buyer and seller. Esmaeli et al. (2009) examine the relationship between seller and buyers considering cost factors and the component of competition and cooperation between these two entities. The authors expect a change of demand in connection with the unit price and marketing effort and analyse it with cooperative and non-cooperative game settings (Esmaeili et al., 2009, p. 442). The framework assumes a production rate linear to demand and marketing expenditure and a sensitive demand concerning both marketing expenditure and selling price. After introducing some parameters and giving numerical examples Esmaeli et al. come to the conclusion that in cooperative games the marketing expenditure and selling price are lower than in non-cooperative game approaches and therefore generates a higher demand (Esmaeili et al., 2009, p. 447).

Following these empirical findings in the purchasing and supply chain management sector is the classification in the life-cycle approach of theories.

2.6.4 After fulfilling internal and external virtues the game theory can be defined as organisational theory

The Life-Cycle model of theories is an approach developed by Vos and Schiele (2014) and tries to explain the possible progression or degeneration of a theory over time. The model categorises a theory into three different stages: theoretical & empirical construction, progression (virtues) and possible degeneration according to the aforementioned elements of characteristics and a theory's virtues. Building on these foundations the exact illustration varies per theory (Vos & Schiele, 2014, p. 9). Addressing the internal virtues it can be stated that the *internal consistency and coherence* appear to be fulfilled since the game theory offers a clear framework with

defined concepts that can be universally applied (Manski, 2000, p. 19). Several researchers from the field of economics, sociology, biology, political science or psychology studied the game theory and numerous empirical studies can be found (Gintis, 2000, p. xxiii; Schade et al., 2010; Sharma & Bhattacharya, 2013) that support the empirical *validity, verifiability and operationality.* The *scope and unity* can be identified as quite large due to the broad variety of problems and situations that can be analysed with the game theory (Lewis & Dumbrell, 2013, p. 29; McCain, 2010, p. 311). Due to the interdependency of time and space of application the game theory can be characterized as a grand theory with a high abstraction level (Cooper et al., 1990, p. 224). In terms of external consistency the game theory is highly supported by the existing body of knowledge in literature and experiments (e.g. Colman, 2003, p. 140). When it comes to *conservatism* the game theory might be seen as superior since there is no new theory building on the game theory. Nonetheless it can be added, that the game theory is criticised in some researches due to the rationality assumption but is mostly refuted (Camerer, 1991, p. 137). Considering the *fruitfulness* of the game theory is it observable that the progress is strongly directed towards the development of new knowledge and application ranges (Cachon & Netessine, 2004, p. 13).

Considering the characteristics of game theory discussed before (units, laws, boundaries, system state, why, propositions, hypothesis, empirical indicators and empirical testing) and the fulfilled internal and external virtues the conclusion can be drawn that the game theoretical approach fulfils all necessary points and can be considered an organisational theory according to Vos and Schiele's evaluation approach (Vos & Schiele, 2014, p. 5).

Subsequently, the chapter will give an insight into the criticism that can be found in the existing literature.

2.7 The rationality assumption is stated as biggest 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 this 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, Roszowka 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 realisable 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' behaviour (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 customised 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 behaviour and predictability in terms of rationality and risk-taking. They clarify that human decisions are based on consideration and a bounded rational behaviour 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) emphasises the usefulness of game theory as it creates a universal language of interaction for the behavioural 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.

2.8 The game theory provides a unique application

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-Gonczaryk, 2011, p. 62).

Based on the short aforementioned theory characterisations 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 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.

3. GAME THEORY AND THE DECISION POINTS IN SUPPLY MANAGEMENT

3.1 Decision Point 1: The game theory as supporting tool in the make or buy decision

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-analysing 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 analysing 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 a cooperation or non-cooperation (Bandyopadhyay & Pathak, 2007, p. 350). The influencing variables in this experiment are the increased payoff that can be expected if knowledge is shared and the investment of time and effort that needs to be raised for a sharing of knowledge. The game theory is useful during this decision making process as a high level of involvement and knowledge sharing (cooperation) leads to higher payoffs for both firms rather than in a non-cooperative game approach. This implies that companies can not only outsource to cut down costs but to benefit form a set of interconnected skills through an intensive preparation of the interaction (Bandyopadhyay & Pathak, 2007, p. 355). Therefore is can be stated that the game theory is no direct tool for the make or buy decision but can regulate the setting of cooperation when a decision is made. Elitzur and Wensley (1997) analyse the characteristics of the game theory as mediate in relationship maintenance. Hence, the game theory does not encourage the make or buy decision itself but provides frameworks for the relationship and process optimisation.

3.2 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 identity the most valuable commodities and ensure their continuous with an optimal sourcing strategy. As already mentioned before, the game theory is not applicable in a situation with a single agent. Therefore, the game theory cannot be used to analyse the benefits or disadvantages of the different sourcing strategies since the setting is not designed to evaluate choices but to analyse 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.

3.3 Decision Point 3: The most valuable supplier can be identified and selected through the game theory

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 fulfil 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. The 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.

Moreover, the incentive of an increase in proportions provides a higher general performance level (Hsieh & Kuo, 2011, p. 4006). The competitive output optimisation can be transferred to the selection of suppliers and can not only be used in a contracted situation. The game theory can therefore be adapted to analyse purchasing bids combined with the use of integer programming (Talluri, 2002, p. 174). The combination of buyer-seller game together with liner programming facilitates the incorporation of different buyer preferences and relatively more attributes can be used with a corresponding weight (Talluri, 2002, p. 179). Companies in the supplier selection can also make use of the game theoretical approach in single auction settings. In a single-shot, non-cooperative game two suppliers can announce the selected strategy and the best bid wins. Given a perfect information game the Nash-equilibrium appears to be the most suitable solution concept (one agent choses the strategy that offers the highest payoff given the other agent's choice) (Kang et al., 2007, p. 636). Comprising the game theory can be a valuable supporting tool in the supplier selection due to the given outcome optimisation the application proposes. Moreover, the game theory can be used to monitor the relationship between the two companies after the supplier selection has been made. Elitzur and Wensley (1997) analyse the characteristics of information &risk sharing, contract duration, relationship management and fee determination by means of the game theory. Here, the results state the value of game theory through explaining the features of outsourcing and delivering recommendations to efficiently handle these complex situations (Elitzur & Wensley, 1997, p. 59). The authors compare an outsourcing relationship to an agent-principle game and

Decision Points				
Theory	Make or Buy	Sourcing Strategies	Supplier Strategies	Contracting
Game Theory	- provides framework for knowledge sharing - Addresses the maintenance and integrity of the relationship	- No direct use - Supporting tool for external communication	- Selection game - Auction framework - Ability to evoke a performance increase - Relationship support and maintenance	- Increased negotiation insight - Selection of optimal coalition - Possibility of dominated equilibrium - Assumptions and estimations concerning agents' behaviour

therefore emphasis knowledge transfer between both parties as it also represents the transfer of value (Elitzur & Wensley, 1997, p. 59). Hence, the game theory finds acknowledgement and application possibilities in the supplier sourcing.

3.4 Decision Point 4: Game theory is a useful tool in negotiation and contracting

The next decision point in 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 maximisations. Through analysing 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.

4. 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 behaviour, 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 analysed 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 analysed. 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 optimise 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 analysing and optimising the coalition partner and attain the best possible contracting conditions.

Despite the great interest and expansion of the game theory in various sectors some criticism can be found. A major point of criticism is the assumption of rationality that seems to be too unrealistic and not compliable due to human emotion, risk adversity or interdependence (e.g.Burns & Roszkowska, 2005, p. 9; Camerer, 1991, p. 137). Another hindrance researcher perceive while using the game theory is the assumption of complete knowledge possession. It is even stated by the developers of the theory that some assumptions are rather utopian and unrealistic. Summarising, the game theory is an effective and successful theory that emerged in the 1950's but is still growing and being explored. Even though some criticism exists, the advantages of the approach are still prevailing. Therefore it can be stated that the game theory represents a limited added value to the supply chain management that can be further exploit.

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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