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The use of game theory in building sustainable competitive advantage

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ABSTRACT: Creating sustainable competitive advantages is central to both the success and longevity of firms competing in today's business environment. One powerful tool that businesses can learn from and utilize to potentially foster such advantages is game theory. Further, we have thoroughly researched previous studies and determined three areas in which competitive advantages can be derived from the implementation and understanding of game theory principles. These include improved decision-making, supply chain management, and employee management. Our goal is to analyze the works of experts on the subject to further our understanding of the topic. This research will provide a foundation for the subsequent justifications on how game theory can be utilized to create the competitive advantages we specified. Reviewing our findings has led the researcher to believe that firms of any variety looking to improve their decision-making, supply chain management, and/or employee management could find great value, if not create fully realized competitive advantages, from taking game theory and its observations into consideration.

KEYWORDS: game theory; supply chain management; competitive advantage

1. Introduction

Whenever a firm is facing a decision that hinges upon the actions of other parties, game theory becomes vital toward understanding how to achieve the most optimal outcome[1]. For this reason, its applications are extensive and can assist organizations of all types in building sustainable competitive advantages. By understanding the structure of a game-like situation and how participants will act, companies can begin to understand how they should act optimally as well as how to change the game to their advantage. Such advantages stem from both broadly improving decision making strategies and its applications for managing employees and the supply chain.

Game theory and its ideas have evolved and expanded since its inception in the early 20th century, and it continues to be intrinsically important in optimizing success in increasingly complex situations. It was notably expanded on by mathematician and economist John Nash, a Nobel laureate in economics for his development of the Nash equilibrium and other contributions to game theory[1]. By utilizing the theory's principles to optimize success in foundational business areas, either by consistently making optimal decisions or by changing the rules of the game, businesses can ensure they occupy the most advantageous position available to them[1]. Such outcomes are vital toward building sustainable competitive advantages over rivals. We will begin our analysis of this topic with a comprehensive examination of published literature regarding game theory's ability to improve in decision making, supply

chain management, and employee management to subsequently build competitive advantages. This will be followed by a review supporting the topic. We will then conclude with a summation of game theory's ability to create sustainable competitive advantages and advice to capture such benefits.

Methodology

To capture the ways in which game theory may supports creating a competitive advantage, this analysis takes on a methodology that reviews a research-based approach and the ways a disruption can impact both suppliers and consumers. The present study is seeking to explain the different approaches that both suppliers and consumers play when a disruption to the supply chain occurs. It is through this methodology that impacts on the supply chain come into perspective and how different parties involved truly are impacted.

2. Literature review

Game theory is the process of two players anticipating which decisions other players will make to find the best decision and strategic outcome. Most literature outlines that we assume all players make rational decisions for their own self-interest and see the game in the same way[1]. After completing some research, history has proven this is not always the case. What became apparent in reviewing the literature is that there are strategies players can focus on to optimize and create better decision making by using game theory. In this section of the literature review, the primary goal is to discuss creating a competitive advantage using optimal decision making with strategies such as analyzing Nash Equilibrium, and using the Tit-for-Tat strategy, and leveraging games to create an advantage.

There have been numerous studies that start by explaining the concept of Prisoners Dilemma and how this relates to Nash Equilibrium and game strategy. In brief, prisoner's dilemma is a mix of motives to compete or cooperate in order to achieve one self's interests. The equilibrium is when they conclude that each player's choice is the best response to the other player's choice[2]. In general, the literature teaches us about the prisoner's dilemma so that companies avoid these bad outcomes and avoid the logistical structure of the prisoner's dilemma[1]. One consensus is that the literature tends to focus on Nash Equilibrium, invented by John Nash, as an important concept in game theory to create optimal decision making creating a competitive advantage. Nash Equilibrium can be helpful to find the strategy where both players are playing the best response to what their rivals are playing[1]. By computing the equilibrium, players can determine where they will likely end up and can try to change this to their advantage. Much of the literature agrees that the Nash Equilibrium is a solution concept of a non-cooperative game.

3. Game theory and supply chain management

Supply chain management becomes increasingly important as corporations rely on a global economy. "Supply chain management is concerned with efficient and effective integration of suppliers, manufacturers, warehouses and retailers, so that an improved global performance of the supply network can be achieved"[3]. Hosseini-Motlagh et al.[4] identify that most participants in a supply chain will try to maximize personal profits using a decentralized system in an attempt to gain a competitive edge. However, approaching this problem as a cooperation game, and sharing information across the supply chain, has demonstrated relevant cost reduction[5].

Mateo and Aghezzaf[3], identify cooperative games as those involving "several decision-makers willing to coordinate their strategies and share the payoff". These groups are often referred to as coalitions and they may consist of manufacturers, distributors, and retailers up and down the supply chain, and in

some instances, they will include competitors on the same level of the chain. For a coalition to be considered 'stable,' the participants must determine a fair allocation of the joint cost savings such that all members of the coalition are better off participating than they would be operating independently[6]. In a simplified two player game, intuition would involve two or more players in which each player is assumed to know the other strategy, and no player can gain more by changing their own strategy only[7]. Research finds that organizations should work on long-term strategies so that payoffs are determined less by your opponent and more by the control of the organization[1].

What also became apparent in the process of researching this review is that Tit-for-Tat strategy is one of the most successful strategies for decision making in game theory to create a competitive advantage. This is an optimal strategy for optimizing a prisoner's dilemma and used in repeated games[1]. The literature concludes that repeated games allow someone to condition the future behavior of opponent's past behavior. Tit-for-Tat is a strategy that is played in repeated two-player games, in which one player chooses the opponents action from the previous round[8]. The literature supports the following characteristics are important for Tit-for-Tat to be successful in repeated games like these. First, it is important for players to be nice by cooperating with fellow players. This is necessary to prevent trouble between players and increases the likelihood of cooperation[9]. One should be easily provoked by responding immediately to rivals. It is important to be forgiving and not punish other players, along with not being envious. Players should instead focus on their own success and be clear so that other competitors can easily interpret each other's actions. Tit-for-Tat focuses on cooperation and sustaining cooperation between players in the long term. Research explains that one reason this strategy is so successful is it can hardly be exploited by an opponent who may have various complex decision rules[8]. It is important to recognize that cooperation between players can be stable or unstable and cooperation can breed a "dividend"[9]. The literature collectively agrees that Tit-for-Tat is one of the most effective strategies in game theory. Of the 63 decision rules that were tested, Tit-for-Tat was the most successful against all the other rules[9]. It can be concluded that the focus of Tit-for-Tat is maximizing one's own profit and not limiting your competitors' profit which, results in this strategy being easily understood by its rivals.

Froeb et al.[1] concludes that although these games may have downfalls, they also have outcomes that can be leveraged to create an advantage for the player, including Monitor/Shirking, the game of chicken, and the dating game. For example, the game of chicken has an obvious solution but requires players to foreshadow each other's moves but if it is not in favor of the player then they should exit the game[10]. The goal is to alter the game in your favor but if that cannot be done then one should leave the game; thus Athenarium[10] suggests that splitting the savings 50/50 is the best solution; however, real world applications are more complicated and benefit from applying the Nash arbitration scheme, nucleus solution, and Shapley value to develop a unique allocation solution[6].

Information sharing across the supply chain can take several forms. Hosseini-Motlagh et al.[4] present a case study of a large consumer electronics manufacturer and retailer sharing information. Under this example, the manufacturer innovates products, and the retailer innovates marketing, for both parties to maximize profits the two entities need to be aligned. The research goes on to explain that a highly innovative product with limited marketing, and an extraordinary marketing effort for a neutral product, fails to maximize profit and in fact may damage both parties. Modeling data from this arrangement converged on a coordination effort, demonstrating that the evolutionarily stable strategy is for the two entities to collaborate. This analysis also concluded that "collaboration of supply chain parties not only results in a win-win condition for all involved parties (i.e., the manufacturers who choose to collaborate,

and the retailer) but also results in more benefits for customers (by improving the innovation and sales efforts of SC parties)[4].

While the aforementioned example demonstrates the advantages of information sharing up and down the supply chain of partner entities, benefits can also be found when competing parties share supply chain information. Any single seller desires to carry the minimum inventory required to meet demand without missing sales opportunities; as an example, a franchise owner must determine how much on-site inventory to hold[3]. Mateo and Aghezzaf[3] also suggest that "one possibility to achieve these two contrasting goals is to allow cooperation among the sales-points and trade the product at some fair price". If a coalition agrees to 'share' inventory, it can be performed through a lateral transshipment, a movement of goods between entities on the same level of the supply chain[11]. "Transshipments are effective to reduce inventories if the transshipment cost is smaller than the holding and stockout costs"[3]. Participating in this cooperation game allows each member of the coalition to increase profit, suggesting it is in their best interest to remain in the coalition[6].

Mateo and Aghezzaf[3] propose another method of reducing inventory and improving overall supply chain efficiency by allowing suppliers to accept the responsibility of maintaining inventory levels, known as Vendor Managed Inventory (VMI). For this to be effective, the retailer needs to share information about sales, real time inventory levels, and marketing strategies. Under a VMI arrangement, retailers spend less time managing inventory and reduce the risk of missing sales due to lack of inventory while vendors can optimize distribution schedules saving on shipping and handling expense[3].

4. Game theory and employee management (recruiting, compensation, and retention)

Recruiting is a crucial portion of any corporation. Ensuring that, employees are happy and offered the best possible perk when they start the job. If you can match or top their perks, fine; just be careful not to be getting caught up in the "out gift" game[12]. Each employer is playing a game with one another and does not know what the other company is offering. You need to put as much energy and thought into keeping employees motivated[12]. Having high turnover is expensive for a company and could prevent the company from getting ahead and not gaining that competitive advantage in the market. According to the Society for Human Resource Management (SHRM)[13], recruiting is anything that is bringing on a new employee into the company. This can include attracting, identifying, and engaging potential employees[13]. Hiring managers will be assessing background information, conducting interviews, and officially sending the job offer. Applying the fundamentals of game theory to find the right candidate will give the company a competitive advantage over its competitors.

Even the ability to make a single counteroffer can increase a person's bargaining power in this repeated game[14]. Bargaining power is a portion of game theory. Employers can use this to their advantage. Hiring managers are there because they are good at making smart hiring decisions and keeping salaries low allowing the company to reduce cost[14]. This can hurt their competitive advantage because they will not be able to obtain the talent needed to push the company ahead of their competition. Each firm is playing a game with one another and are trying to out talent each other. The better your outside options are, the more attractive the offers your bargaining partner must make to keep you around[14]. If an employer really wants to keep an employee, they need to ensure that they express and elucidate their support for them when evaluating the bargaining strategies. Hiring managers know this and try their best with the resources that they are given to retain the best talent and to get rid of the ones falling behind.

Continuously satisfying the employees is another challenge that the employers are facing today[15]. Customer satisfaction, organizational performance in terms of increased sales, satisfied colleagues, and reporting staff, effective succession planning, etc., is dependent upon the ability to retain the best employees in any organization[15]. Encouraging employees to remain in the organization for a long period of time can be termed as employee retention[15]. All types of factors influence employee retention. This ranges from compensation, rewards, and opportunity for growth, work-life balance and many more. Recruiting new staff is costly due to advertising and administrative expenses; time and resources for on boarding and training; as well as loss of productivity[16]. In moving toward creating a competitive advantage, a company must act for itself and anticipate the moves from its competitors. All employees must be committed to the organization's vision, mission, and objectives for its operations[16]. Employees need to understand what the company truly stands for. Achieving this will allow the company to grow the competitive advantage. Gamification uses game mechanics (points, levels, challenges) to tap into essential human desires (rewards, status, competition) to meet employees where they are while delivering a powerful mix of skills development, culture, and trust[17]. Engaging in the bargaining game correctly will allow the employer to have the best human capital to keep the company ahead of its competitors.

5. Review of competitive advantages

5.1. Decision making

Game Theory is the process of decision-making using choices and considering outcomes that exhibit interdependence between two or more decision makers, or players[2]. It is important to understand that the Prisoners Dilemma is a case where players strive for the best outcome for themselves. However, it is in one's best interest to use a cooperative strategy where each player agrees to work together towards one's goal[2]. In the long run, this strategy is best for decision making and reduces conflict between players. To achieve a long-term competitive advantage, an organization may start by achieving the Nash Equilibrium for a cooperative strategic initiative. This is a scenario where each person's choice is the best response to the other player's choice[2]. Another cooperative strategy to consider is the Rational Choice Theory. The Rational Choice Theory can help with decision making because it results in players considering the profit and loss of other players and making decisions that are desirable to the decision maker[2]. Using the Nash Equilibrium and rational choice theory can help to make long term decisions that will create a competitive advantage.

Next, the Tit-for-Tat strategy is a strategy that some believe can be used to make an unbeatable decision-making strategy to create a competitive advantage. Repeated games allow a player to condition future behavior on the opponent's past behavior with a trigger strategy[1]. It is described as unforgiving for one move but more forgiving for the next move[9]. To be successful players need to start by considering cooperation. To further explain Tit-for-Tat, if you are playing a game with someone who is using this strategy you can imagine that you will know exactly what your opponent will do and how they will react to your initiations making this strategy deterministic[8]. This strategy for decision making is shown to be unbeatable if no other strategy exists that their opponent can leverage with a payoff difference that is more than the maximal payoff difference between outcomes in the one period game[8]. This is the case for exact potential games which observe pure Nash Equilibria. For the Tit-For-Tat strategy to create successful decision-making players must be nice, easily provoked, forgiving, worry about one's own success, and be clear. In Kopelman[9], Axelrod explains that niceness prevents getting into trouble, retaliation prevents the other player from persisting when defection is tried, and forgiveness helps restore important cooperation. Lastly, its clarity makes it easy for other players to know the players next move

and creates long term cooperation[9].

There are other game theory strategies that can be leveraged in decision making to create a competitive advantage. These games must be played strategically but include monitor and shirking, the game of chicken, and the dating game. The game of chicken can be used as a last chance option to make the other player to swerve away[10]. This would require the other player to be aware of your commitment and is rational about their own ability to be successful[10]. The dating game is about cooperation, self-interest, and finding a compromise that makes both parties can earn high payoffs. With repeated games like the dating game, one can figure out an easy way out of the prisoner's dilemma[1]. In the monitor and shirking game between and employee and employer can be leveraged if the employer reduced shirking by combining monitoring with increased pay, that way the employer can reward the employee when they work hard[1]. In conclusion, by mixing game theory strategies and playing them strategically it can create more options for decision making to create a competitive advantage.

5.2. Supply chain management

Creating a sustained competitive advantage would suggest acting independently and withholding information to create an edge over the competition. However, when it comes to supply chain and inventory management, considerable advantages can be found from sharing information. When approaching supply chain from the perspective of game theory the players are commonly identified as manufacturers, distributors, and retailers, and in a collaborative game these entities can form a coalition. A simplified version of the game contains two strategies, share information in a centralized model or go at it alone in a decentralized model. Finally, the payoffs can present favorably as profits or savings, or negatively as increased costs or lost revenues. Following this approach, Serkis[18], Mateo and Aghezzaf[3], and Zambujal-Oliveira[5] all found that collaboration and information sharing was a best response in the game of supply chain and inventory management.

One option for collaboration across supply chain involves a marketing and innovation between manufactures and retailers. Serkis[18] evaluated the innovation efforts of an electronics manufacture and the marketing from retailers and found that an innovative product that did not receive the sales effort resulted in missed opportunity and reduced revenues for both parties. Likewise, a retailer may suffer from large investments in sales efforts on electronic products that are less innovative. When modeling a two-level supply chain relationship of offer[13]. Each employer is playing a simultaneous game, moving before knowing what the competition does to get the best talent[1]. To attract the talent, the company needs to "sell" themselves within the game and encourage people first to apply for the job. People want to work at a place that appreciates them and helps them continue to grow their career. After a company finds potential candidates, the next step is interacting with them.

Scheduling interviews and getting to know them will be able gauge whether they will fit within the company culture. A candidate may be interviewing at different companies at the same time and each company wants to get the employee to take their job. Each company is going back and forth with the candidate, similar to a repeated bargaining game. Each employer is playing a game without knowing the others move and only going directly to the candidate. The last step is picking the right candidate. Each company has different ways and techniques on evaluating who is the best fit for the job. While hiring managers will never know exactly if they hire the best candidate for the job, doing extensive research could help improve candidates when playing the game. This will result in more candidates with stronger resumes and skills compared to rivals. Hiring managers also may need to understand when they need to reject a candidate. Just because a candidate sounds great on paper or was impressive in an interview, they

may have certain characteristics about them that make them less ideal, and companies may need to evaluate how their actions within the game. While recruiting is a very normal thing for a corporation, it is one of the most make-or-break for the success of any company.

Gaining a competitive advantage with the acquisition of talent is achieved with compensation and benefits. Hiring managers are there because they are good at making smart hiring decisions and keeping salaries low for the company to save money[14]. Potential employees know this and that gives the ability to negotiate with the new employers. Even the innovation and sales efforts, the evolutionarily stable strategy involves coordination and alignment between manufactures and retailers. This is one example of how a collaboration game can increase revenues.

Collaboration games can also be applied to supply chain and inventory management as a tool to reduce cost. Retailers aim to carry the minimum required inventory without missing sales opportunities[3]. Each retailer operating in a decentralized strategy can only rely upon in house inventory and must balance the costs of loss sales due to low inventory and the opportunity cost of having too much capital invested in inventory to ensure always on hand stock. Forming a coalition allows individual retailers to reduce their inventory levels if every participant agrees to transshipments, a movement of goods between entities on the same level of the supply chain[11]. Sharing information with manufacturers and distributors can also work to reduce inventory levels; when modeling a three-tier game of manufacturers, distributors and retailers, the more information that is shared results in "higher percentage of inventory reduction and consequently higher cost savings"[5]. By taking this strategy further leads to Vendor Managed Inventory (VMI). VMI reduces retailer risk of stockouts and reduces overall inventory management costs for a retailer[3]. Suppliers can optimize delivery schedules and transportation costs and both parties are able to benefit from the surplus created[3]. The authors present an example of wine distribution in the UK servicing 116 sales location in 49 cities; when a VMI model was simulated it predicted an 11% increase in sales with respect to a decentralized strategy[3].

When a coalition commits to sharing information along the supply chain, a surplus is created, and fair distribution of this surplus is critical to the stability of the coalition[6]. If any single participant in the coalition can increase performance with a decentralized strategy, they will leave the coalition. Manufactures with low bargaining power may be hesitant to participate in a centralized strategy because they receive less benefit than other parties[18]. For all parties to benefit from the coalition, a fair distribution is often more complicated than an even split across all participants. Modeling a unique allocation scheme in a three-player game as Leng and Parlar[6] determined that a nucleus solution resulted in the most stable coalition. Employing a coordination scheme with the appropriate surplus allocation results in every participant benefiting, creating incentive for the coalition to continue in the collaboration game. Introducing a game theory approach to supply chain and inventory management creates a surplus at every level of the chain and allocating that to coalition members will create a competitive advantage.

5.3. Employee management (recruiting, compensation, and retention)

Recruiting and retaining employees is an essential part in ensuring that businesses can continue to stay competitive in a fast-moving market. Employees are the most crucial part of any business. Finding the best fitting employee for the right job is crucial. In today's competitive world, both with people and the industries that they operate in, recruiting has become more important than ever. Recruiting can include everything such as benefits, compensation, and overall fulfillment with work. Once the employees are in the company, the company must push to keep them at the company, especially if they do a great job and are a positive impact for the business. Implementing game theory will help push the

company into a competitive advantage versus its competitors when it comes to recruiting, compensation, and retaining.

Recruiting is one of the most important aspects of an organization. Today most employees are found in many ways such as online websites, recruiting agencies, networking, or just simply word of mouth. According to the Society for Human Resource Management (SHRM) (2012), recruiting encompasses all aspects of hiring. This includes attracting, interacting, gathering information, and selecting the right candidate for the positions that the company must fill.

6. Conclusion

After thoroughly researching current literature on game theory, we have come to the consensus that there is great potential in its application due to its capacity to build sustainable competitive advantages in three areas specifically. Beginning broadly, game theory can help to create such advantages through its ability to provide improved decision-making frameworks and strategies that adapt to the behaviors and actions of external parties. Through utilization of the Nash Equilibrium, Tit-for-Tat strategy, and rational choice theory, companies can consistently arrive at more optimal long-term decision outcomes compared to rivals. The second way in which competitive advantages may be built through game theory is by creating a collaboration game that results in a more cohesive, collaborative, and informed supply chain coalition. Such optimized supply chain coalitions result in lower risks and costs while improving overall profitability by creating surpluses. It is recommended that firms determine a strong distribution system for this surplus, such as a nucleus solution or Nash arbitration scheme, to ensure the rules of the game favor coordination and participation in the centralized supply chain coalition. The last area involves employee management, in which game theory can be utilized to recruit superior talent, compensate at optimal levels, and retain top employees. By viewing these aspects of employee management as sequential-move or repeated bargaining games, companies can manage incentives and outmaneuver rivals to maintain superior talent capable of creating sustainable competitive advantages.

The ability to make a single counteroffer can increase a person's bargaining power[14]. Employers understand that once an employee starts to negotiate for compensation, they are now in a game of bargaining. Bargaining allows the employee and the employer to get what they want. Usually, the employer is the one needing to be a bit more aggressive when it comes to giving compensation. If you can match or top their perks, fine; just be careful not to be get caught up in the "out gift" game[12]. Employers need to ensure that in order to save money they do not overcompensate the benefits when giving out job offers. Companies need to do market research to find what a similar salary is for a certain position and see what the company can afford. After the employee takes the offer, the company needs to make sure that they follow through on the promises that they made[12]. Compensation is essential for both the employee and the employer. The employee wants as much as possible, and the employer wants the talent, but also save money in the long run. Finding a good balance will allow the company to push forward and be the best possible.

Continuously satisfying the employees is another challenge that employers are facing today[15]. Retaining good talent and getting rid of the low performers is the only way to move a company to maintain a competitive advantage. All employees must be committed to the organization's vision, mission, and objectives for its operations[16]. Every company has a strategy and a way that they wish to operate. Game theory can help align employee needs with these values so that they contribute to the strategy. Managers can use game theory techniques to ensure that employees want to stay. One example is gamification, which uses game mechanics (points, levels, challenges) to tap into essential human

desires (rewards, status, competition) to deliver a powerful mix of skills development, culture, and trust[17]. If the employee is giving full effort to the company, the company needs to recognize this and ensure that the employee is feeling satisfied with their everyday work. Employees are the main powerhouse behind a company, and they are the best people to be able to create a competitive advantage in the industry in which the company operates. In addition, understanding game theory can help companies to anticipate when employees try to "game" compensation[1].

Conflict of interest

The author declares no conflict of interest.

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