

GAME THEORY AND BUSINESS INTELLIGENCE IN STRATEGIC BUSINESS DECISIONS- A REVIEW

¹VIOLET ASIKOMURWA, ²MANAR MOHAISEN

^{1,2} Graduate school of Computer Science, Korea University of Technology and Education
E-mail: ¹violetajoy@koreatech.ac.kr, ²manar.subhi@koreatech.ac.kr

Abstract- Game theory and business intelligence are two mature areas of research; game theory being the study of strategic decision-making brings together several disciplines such as philosophy, mathematics and psychology. On the other hand, business intelligence is a set of techniques and tools that are used to transform raw data into meaningful and useful information for business analysis purposes which can be used to create new business strategic direction. Making business decisions is a balance between data and opinion: opinion being the best possible professional judgment. The paper further looks at game theory strategies based on prisoner's dilemma concept and Cournot model that can be used for strategic decision making and gives an insight into the possibilities of using game theory to look at the past using current data and predict the future for a business.

Key words- Game theory, business intelligence, strategy, prisoner's dilemma, Cournot strategy

I. INTRODUCTION

Business intelligence study has emerged as an important area for research both practitioners and researchers are investing a lot of resources to explore the opportunities it presents, reflecting the magnitude and impact of data related problems to be solved in contemporary business organizations. [1]

Business analysts from time to time are asked frequently to identify the likely and unlikely consequences of alternative course of actions for specific, real-time strategy problems in the business. With limited time and potentially critical consequences, managers must sort through uncertainties surrounding the specific problem. They must provide the best estimate of what is likely to happen, and estimate the probability of outcomes different from the best estimate, and assessing contingencies that might lead to alternative outcomes. In each instance, there is an interest to work through the logic of a situation to ascertain what might be done to alter or facilitate particular outcomes, then use this information for strategic business planning. [2] The task of the business analyst is formidable. Every case has unique features, the time for examining each instance is limited, and the potential always exists for detrimental consequences if the analysis proves incorrect. Expert knowledge is the realistic starting point for understanding any specific instance, but area or problem of expertise should not be the only means of analyzing important complex problems. Such a scenario provides an independent perspective that informs and stimulates debates in the board rooms. How can game theory reasoning, combined with empirical (mostly quantitative), analysis, help inform managers on fostering reliable predictions about the likelihood of alternative outcomes? How can game theory be used on assessing how alternative tactics and strategies might improve the expected results?[3], [4]

Game theory is the solution that we seek to help us understand how strategic decision making can be done. For example, managers are always confronted with constraints such as limited resources, time, very low budgets and sometimes incomplete information. Game theory models can help us examine choices under these constraints while also specifically attending to strategic interaction in which decision makers select their actions and of course taking into account expectations about how others will respond to them taking; they should also factor in their own possible actions.[4]

Understanding game theory strategies- both the popular and the lesser-known ones - is important to enhance one's reasoning and decision-making skills in a sophisticated and complex world. Consider the evolutionary analysis on adoption of e-Government services: the interaction between a government and the citizens, where both the government and the citizens chose their own actions according to the cost benefit which arises from the application of e-Government services. [5], [6] under the assumption that players are instrumentally rational and act in their own best interest. In some cases a solution may fail, this explains why e-Government initiatives in many countries before they became stable, failed in one way or the other [7] The BI analytical synthesis itself can illuminate different facets of the problem. Either way, game theory offers an interesting perspective on the nature of strategic selection in both familiar and unusual circumstances. However, the problem with game theory emotions and feelings are not considered. It is a win-lose situation, one party has to lose for the sake of the nation to move forward. It can further be argued out that there is some kind of natural selection at work which inclines a group of decisions towards the rational and optimal[8]In such a case game theory should not be used as a substitute for good judgment in strategic decision making, especially where citizens, are involved.

The following sections will focus on previous research, and have a discussion based on various cases and on how authors used game theory in strategic decision making.

II. PREVIOUS RESEARCH

Though a lot of research is ongoing on game theory and business intelligence, however, not much has been done to explore exhaustively on the role of game theory in relation to BI. Focus will be on a few cases that will help us build a foundation for the discussion

1.1 Strategy

We ask what a strategy is and why does it matter in strategic decision-making in organizations? We cannot rely on a single definition of strategy. Organizational strategy is the specific policy made by the organization by taking into account the specific policies the competitors might take and this includes their own cause of action. [9]

Strategy according to Henry Mintzberg in his 1994 book, "The Rise and Fall of Strategic Planning", points out that the term strategy is used in several ways: strategy as a plan, strategy as a pattern of action, strategy is a position and strategy as a perspective. Michael porter idea also cannot be ignored in his book 1986 "Competitive Strategy" he argues out that strategy is about being different and deliberately choosing a different set of activities to give value to customers. A point in case strategy in its everyday meaning plays a role far beyond business. For example the military may have a strategy for war, a government may have a strategy to improve on citizen e-Government services and an economic zone may have a strategy to deal with economic crunch. Clearly we see that in every sector, strategy is very important.

1.2 Business Intelligence

Business intelligence (BI) is the broad category of skills sets, processes, technologies, applications and practices used to support better decision making. Mostly business intelligence offers insight on the here and now and when the data is analyzed then we can predict the future. [10]

This can also be defined as the ability to access to access the right data needed at the right time to make informed strategic decisions[11]

Kumar et al. also brings in another school of thought and defines BI as the ability of the organization to assemble all processes and capabilities, this includes human capacity and technology and converting this into knowledge, getting right information for the right people and the right time. [12] This includes the effective data warehouses with components capable of monitoring the time critical processes that allows for tactical and strategic decision makers to tune their actions according to the organization's strategy.[13]

BI can also be defined as an in-depth analysis of data and this would include application technologies and databases[14] He further expands and says that business intelligence is one of the sources of competitive advantage for businesses, because operational data is turned into a business asset for strategic decision. To crown it all: within the industry Howard Dresner of Gartner Research who is widely recognized as the father of BI suggested that "business intelligence as a broad category of software and solutions for gathering, consolidating, analyzing and providing access to data in a way that lets enterprise users make better business decision". Meaning BI is an umbrella under which all this systems and methods fall in order to improve business decision.

1.3 Game theory

Game theory is a very useful tool that can be used to study interactive decision-making where the outcome for each player, in this case a decision maker, depends on the actions of others. Game theory can be defined as a bag of analytical tools intended to help us have an understanding of the sensations that we see when decision makers interact. [15] The case of organizations they certainly consider other player's actions particularly their competitors while choosing their own strategies. That's why others compete, while others merge in order to remain relevant in the market. The more the success of a strategy the more it depends on anticipations and reactions of competitors, suppliers or customers, the more valuable it is to use game theoretic analysis[16]

To have a better understanding of the game theory principles it's important we look at some game theory strategies first.

III. GAME THEORY STRATEGIES

1.4 Prisoners Dilemma

Several strategies in game theory exist; these strategies can be used for strategic decision making. Some of these games include: Prisoners dilemma, Cournot competition, Matching pennies, Deadlock (Social dilemma), Centipede game, Travelers dilemma, Battle of the sexes, Peace war and Volunteer's dilemma.[17]

Prisoner's Dilemma is a very common game and it explores the decision making strategy of two people who by acting in their own individual best interests, end up with a worse outcome than if they had cooperated with each other. [18] This game is popularly known strategy that helps us to understand what governs the balance between competition and cooperation in business settings.

In these strategies, we have two suspects who have been accused of a crime and are being held in separate rooms and cannot communicate with each other. The situation at hand: the prosecutor informs (prisoner A) individually that if they cooperate and

confess against each other, they will go free, but if he does not cooperate and prisoner B does, prisoner A will be sentenced to three years in prison. He further tells them that both confess, they will get two years sentence, and if neither confesses they will be sentenced to one year in prison. In this case cooperation seems to be the best strategy for the two prisoners.[19]

1.5 Cournot Competition

This model is similar to Prisoners dilemma; it was introduced by Augustin Cournot: a French mathematician in the year 1838. It is a very old model but effective in making business decisions and it is used to describe an industry structure in which companies can compete on the amount of output they will produce and which they made a decision independent of each other and at the same time.[20]

Let us assume two companies X and Y produces homogeneous products and can produce both high and low quantities. If they both agree and cooperate to produce low levels, then limited supply will definitely result to high prices for the product on the market and substantial profits for both companies. In case they do the reverse, they defect and produce high levels, the market will be flooded hence low price for the product which will result in minimal profits. However for example if one company cooperates (Company X produce at low level) and the other defects (Company Y produce at high levels) then X breaks even while Y earns a profit that is higher than if they both cooperate.[21]

The payoff matrix for company's X and Y is given in Table 1 (the figures represent profits in millions of KRW, for the sake of clarity). If X cooperates and produces at low levels while Y defects and produces at high levels the payoff is shown in cell (b) - break-even for company X and 10 million KRW for company Y.

Table 1: Cournot Payoff Matrix

		Company Y	
		Cooperate	Defect
Company X	Cooperate	(a) 6,6	(b) 0,10
	Defect	(c) 10, 0	(d) 3,3

Oil extraction would be a good example of quantity competition - Organization of Petroleum Exporting Countries (OPEC). This is an international cartel that was formed in 1960 by five major oil-exporting countries: Iran, Iraq, Kuwait, Saudi Arabia and Venezuela who in 1971 agreed to take an active role to coordinate and unify petroleum policies among member countries, in order to secure fair and stable prices for petroleum producers.[22]

In this case cartels will fail if non-cartel members can supply consumers with large quantities of goods at the same time each member of the cartel has an

incentive to cheat on the cartel agreement. To keep organizations from violating the cartel agreement, the cartels must be able to detect cheating and punish violators and, in addition, keep their illegal behavior hidden from customers and governmental agencies in order to protect their image and hence interest. Rationally, it makes sense for both companies to cooperate and work together, however such behavior is never shown in real life from a strategic point of view why they exists is to make profits and the best option is take a risk and defect and maximize profits as they do so they need to focus also on the future and study the moves of their competing company, it's all about survival[22]

IV. DISCUSSION

Business is a high risk game. The way Managers approach this game is reflected in the language they use to describe it. Business language is full of expressions some borrowed from sports while others borrowed from military. However, the paradox is: unlike sports and war, business is not always about winning and losing, nor is it how well you play the game. When we look around the very successful businesses it is a fact that they have succeeded without requiring others to fail. It also true they can also miserably fail no matter how well they play if they make the mistake of playing the wrong game. Therefore, the essence of success in business mainly lies in making sure you are playing the right game, at the right time and the right place. You may ask how do we know it is the right game? What will you do if it is not the right game? Game theory as a mathematical construct is about to change the game of businesses, and this will help managers answer the two questions.

Game theory has come of age, as it all began in 1944 with the great mathematician Von Neumann and economist Oskar Morgenstern who published a beautiful book called "Theory of Games and Economic behavior". Their work has provided a systematic way to understanding the behavior of players.[3] They have clearly distinguished two types of Games: Rule-based games, players interact according to the specified "rules of engagement". These rules could come in form of trade agreements or contracts. The second type is "Freewheeling games", where players interact without any external hindrances, found in buying and selling, the buyers and sellers create value by transacting in unstructured fashion. But when we look at business whether small scale or large scale it is complex because they mix both strategies [23]

What has game theory got to offer in business strategy you may ask? Game theory focuses directly on the most pressing issue of all: finding the right strategies and making the right strategic decisions for the business. Game theory is effective when there are many self-governing factors, no decision can ever be

made in isolation from a group of other decisions. Amid the complexity of decision making, game theory breaks down the game into key manageable components which helps you see what going on and what to do about it.[3]

Examining the effect of Japanese generic milk promotion on sales. In Japan, milk prices are determined in individual negotiations between prefectural milk marketing boards (dairy cooperatives) and the processors they supply. The nationwide generic advertising is paid by voluntary assessments of retailers, farmers, wholesalers and by government subsidies. Many fluid processors have little influence on price negotiations, though the non-fluid manufacturing processors have power. They calculate the market power of the boards to be small and falling[24] The estimated marginal rate of return to promotion was 6.04 in 1981 and in 1989 it was 4.33. This fall was because market power fell. This can be likened to a game of milk promotion effectiveness and Suzuki proposes a good framework of its effectiveness with an Imperfect competition model.[24]The game of business is about value addition and can be put mathematically as follows:

$$\text{Total Revenues} = \text{Market Share} * \text{Market size}$$

Meaning a company can increase her revenue by increasing either the market share or by increase her market size. The reverse is true; the above equation if the companies' market share or market size reduces because of competition, the total revenues will also be affected negatively.[25]

Deciding how to conduct a business in an increasingly complex environment can be a challenge. Today's environment is characterized by high level of competition and globalization and alliances seems to be the best strategy for businesses and even researchers and PR actioners[26]

Coopetition is another new competition strategy based on a combination of various management theories, cooperation strategies, competition and game theory. This new approach is for companies to maintain a competitive advantage as the saying goes "if you can't beat 'em, join 'em". Cooperative strategies can be used to create new markets at the same time expand the existing market. Once created, competitive strategies can be deployed to play in the market.[27]Based on the previous statement, business is not necessarily a zero sum game where a win-lose situation exists. There can actually be scenarios where win-win is achieved by cooperation at the others where lose-lose occurs without it. The truth is, without cooperation there will be a lose-lose-lose situation because the competitors will end up losing on prospective market. The same market will also get undeserved because consumers would lose out on what would have been a potentially useful product. We can conclusively say cooperation has its theoretical foundations in game theory, managers can learn from this on issues pertaining to communication and ways to negotiate win-win scenarios. Finally

businesses must account for the self-interest of others instead of asking "what's in it for me?"... Managers need ask their competitors, "How can $1 + 1 = 3$?" the multiplying factor not addition.

When we further look at BI and analytics critically, we seem to have a lot of good things to talk about from problem identification and predicting the future. This gives very smart solutions at the shortest time possible. However, as companies invest on these tools for BI, there are challenges that they might face. Data volumes are increasing, this data are not useful not until it is processed. As organizations start to process this unstructured information, the need to process more and more data rises. This poses big data challenge (data deluge).[1]

From IBM big data analytics report on evolution of data things are changing, consider the history; how we have evolved in terms of data from the 19th century. We are not only handling terabytes of data but sometimes handling zettabytes of data. Think about sensor networks increasing in volumes[28], how about the whole use of internet that keeps increasing in volumes? [29]Put this into a personal perspective, today how often do we go to the ATM to pick up money? How often do we go to the store and take your products through a point of sale? Your mobile phone: how often do we make calls or generate text messages? [29]Compare this to how often we use the Internet. We cannot do without internet and mobile phones anymore they have become part of us. This gives a perception of even at a personal level we are increasingly producing data which is leading to data deluge. From a business perspective, the use of this information is extremely useful to actually analyze for business purpose. Solutions are already available; every company has to make a decision on what tools are appropriate for their business needs. The truth of the matter is that data in the future will transform how we live, work and think. [30]

1.6 Recommendations and future work

The area of BI and game theory has not been exploited fully, most researchers have focused mainly on game theory in decision making without considering any tools that could be used to enhance and speed up decisions such as BI tools and analytics. This area can be explored further and also focus can be given to government institutions in the area of e-Government to predict the future trends in e-Governance. It would be incredible if an experiment/research can be conducted to prove the following concept: How can we use game theory to report the past and monitor the current? Secondly, given Business intelligence data and tools, how can we remodel the future of a business using game theory? This gives a good avenue for future researchers to explore the possibility of using game theory and BI data to look at the past, present and be able to predict the future.

4.2 Limitation of the study

As with any piece of research, this study has limitations. We have studied only prisoner's dilemma and focus on business strategy.

The area of Game theory in relation to Business intelligence has not been explored fully. Further research could investigate other Game theory strategies such as but not limited to: ultimatum games and battle of the sexes in order to make a comparative study in decision making. It would be interesting to study Ultimatum games and find out how important this type of game plays in strategic decision making since if focus mainly on human feelings.

CONCLUSION

CEOs and managers using business intelligence tools can benefit by using this insights from game theory perspective to design a game that is right for their organizations. The outcomes can be far more rewarding than when the organization maintaining the present state of affairs. No specific game theory strategy is perfect because different situations or problems within the organization have to be handled in different unique ways. The bottom line is that game theory can be used very effectively as a tool for decision making whether in political, psychological, economical, personal or business setting. However, this should not be used as a substitute for good judgment in strategic decision-making; it is just an enabler in critical thinking. Game theory only sheds a light on why businesses behave the way they do and why they go for specific strategies available through transparency.

ACKNOWLEDGEMENTS

The authors acknowledges Korea International Cooperation Agency (KOICA) for sponsoring this work.

REFERENCES

- [1] H. Chen and V. C. Storey, "Business Intelligence and Analytics : From Big Data To Big Impact," vol. 36, no. 4, pp. 1165–1188, 2012.
- [2] T. Sonteya and L. Seymour, "Towards an Understanding of the Business Process Analyst: An Analysis of Competencies," *J. Inf. Technol. Educ. Res.*, vol. 11, pp. 43–63, 2012.
- [3] T. L. Turocy and B. Von Stengel, "Game Theory," *Encycl. Inf. Syst.*, 2003.
- [4] F. Allen and S. Morris, "Game Theory Models in Finance," in *Game Theory and Business Applications*, 2001st ed., Kaylan Chatterjee Pennsylvania University and William F. Samuelson Boston University, Ed. Kluwer Academic Publishers Boston/Dordrecht/London, 2001, p. 33.
- [5] S. B. S. Bai and M. M. M. Mei, "Evolutionary game analysis on adoption of e-government services," *Web Soc. (SWS)*, 2010 IEEE 2nd Symp., 2010.
- [6] A. Schellong, "Extending the Technology Enactment Framework," John F. Kennedy Sch. Gov. Harvard Univ., no. PNG Working paper No. PNG07–003, 2007.
- [7] R. Heeks, "Information Systems and Developing Countries: Failure, Success, and Local Improvisations," *Inf. Soc.*, vol. 18, no. 2, pp. 101–112, 2002.
- [8] C. Bicchieri and E. Xiao, "Do the right thing: but only if others do so," *J. Behav. Decis. Mak.*, vol. 208, pp. 191–208, 2008.
- [9] G. A. J. and P. J. Reny, *Advanced_microeconomic_theory.pdf*, Second Edi. Pearson.
- [10] J. Ranjan, "Business Intelligence: Concepts, Components, Techniques and Benefits," *J. Theor. Appl. Inf. Technol.*, vol. 9, p. 60, 2009.
- [11] R. J. and G. R. Stackowiak Robert, *Oracle Data Warehousing and Business Intelligence Solutions*. Indianapolis: Wiley Publishing, Inc, 2007.
- [12] N. Kumari, "Business intelligence in a nutshell," *Int. J. Innov. Res. Comput. Commun. Eng.*, vol. 1, no. 4, pp. 969–975, 2013.
- [13] M. Golfarelli, S. Rizzi, and I. Cella, "Beyond Data Warehousing: What 's Next in Business Intelligence?," 7th *Int. Work. Data Warehous. Ol.*, pp. 1–6, 2004.
- [14] G. R. Gangadharan and S. N. Swami, "Business intelligence systems: design and implementation strategies," *Inf. Technol. Interfaces*, 2004. 26th *Int. Conf.*, pp. 139–144 Vol.1, 2004.
- [15] M. J. Osborne, *A course in game theory*, vol. 29, no. 3. 1995.
- [16] F. Oberholzer-gee and R. Eichenberger, "The B . E . Journal of Economic Analysis & Policy Contributions Experiments Fairness in Extended Dictator Game," vol. 8, no. 1, 2008.
- [17] J. Watson, *STRATEGY*, Third Edit. New York: W.W Norton & Company, 2013.
- [18] W. Poundstone., "Prisoner ' S Dilemma," *Publ. BY DOUBLEDAY a Div. Bantam Doubleday Dell Publ. Group, Inc. 666 Fifth Ave. New York, New York 10103*, no. Printed in the United States of America February 1992, p. 23, 1992.
- [19] P. Aldhous and M. Reilly, "Friend or Foe?," *New Scientist*, vol. 192, no. 2573. pp. 21–23, 2006.
- [20] B. Nebel, "An Introduction to Game Theory Part I: Strategic Games."
- [21] A. Mukherjee, "Bertrand Vs Cournot Competition in Asymmetric Duopoly: The Role of Licensing," no. 03, pp. 1–5, 2003.
- [22] J. Khusanjanova, "OPEC's Benefit for the Member Countries," *Res. World Econ.*, vol. 2, no. 1, pp. 14–23, 2011.
- [23] J. Marshchak, "Neumann's and Morgenstern's New Approach to Static Economics," *J. Polit. Econ.*, vol. LIV, No. 2, 1946.
- [24] N. Suzuki and D. H. Judson, "An Assessment of Deficiency Payments to Milk Producers in Japan," *J. Agric. Resour. Econ.*, vol. 16, no. 1, pp. 119–131, 1991.
- [25] A. M. Brandenburger and H. W. J. Stuart, "Value Based Business Strategy," *Journal of Economics & Management Strategy*, vol. 5, no. 1. pp. 5–24, 1996.
- [26] N. P. Leek, Sheena, Turnbull W Peter, "Interactions , Relationships and Networks – Past , Present and Future," vol. 1, no. Easton 1992, pp. 1–13, 1996.
- [27] F. Garaffo, "Types of coepetition to manage emerging technologies," ... *Manag. Track "Coopetition Strateg. Towar. a ...*, p. 14, 2002.
- [28] T. Palpanas, "Real-time data analytics in sensor networks," *Manag. Min. Sens. Data*, pp. 1–29, 2013.
- [29] A. Global and U. Trends, "Mobile Internet Traffic ;," 2010.
- [30] S. Lavallo, E. Lesser, R. Shockley, M. S. Hopkins, and N. Kruschwitz, "Big Data, Analytics and the Path From Insights to Value," *MIT Sloan Manag. Rev.*, vol. 52, no. 2, pp. 21–32, 2011.

★★★