

APPLICATION OF OPERATIONS RESEARCH IN ECONOMICS

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Abstract

In this paper, we are exploring the use of Operations Research in Economics and how different sectors viz., Business and Government use it to optimize their output. An overview of the economic sector is briefed in this paper. A lucid explanation of the Game Theory Model is also provided with help of an illustration and how it is used by analyst for forecasting and decision making.

Key words: Operations Research, Economics, Game Theory Model, Management Science, Nash Equilibrium.

Introduction

“You can’t just call it a company anymore, can you? – it’s more of an economy into itself”, claims a recent CBS news article on P&G’s well being. With \$76 billion in annual sales, 138000 employees in more than 80 countries P&G (Procter & Gamble) has become successful in its operations due to the application of OR techniques. As Brenda Dietrich, an IBM fellow at IBM's Watson Research Center, explains, "There's a gap between the math professionals and the non-math executives in many companies. The companies who have people who can walk into a business meeting and tell executives how to use OR tools are the ones who've got the edge.” (HINES, 2008)

In the private sector, OR is said to be the secret weapon that helps companies deal with complex problems in manufacturing, supply chain management, health care, and transportation. In government, OR helps the military create and evaluate strategies. It also helps the Department of Homeland Security develop models of terrorist threats. That's why Operations Research is increasingly referred to as the *science of better*.

Management science (MS) is the broad study of problem solving and decision making in human organizations, with applications to management, economics, business, engineering and management consulting

MS is used to solve the decision-making problems that confront managers by developing mathematical models of those problems

The main goal is to demonstrate solutions to various problems that managers face every day. From maximizing profitability, minimizing transportation costs, to optimizing employee scheduling, management science can be applied to most strategic decision key areas in a business.

The two fields: Economics and Operation Research have common interests in the 4 broad areas:

public policy analysis, finance, game theory and decision analysis.

OR's optimization models are used by politicians to study impact of policy alternatives.

In the area of finance, OR is used to study financial markets and its efficiency.

Reason for the common interest of economists and operations researchers in game theory is its universality in understanding conflict and cooperation, where rational decision making encompasses game theory.

Through this research paper, we want to understand the significance of OR techniques in key areas of Economics and the interdependence of both the fields in real life situations.

Overview of the Industry

Economics is one of the oldest and most influential of cognitive disciplines. All of the great innovator and thinkers from Aristotle to Einstein have tried their hand on it. There are great economist such as Adam Smith, John Maynard Keynes and Milton Friedman who rank among the most influential minds in our history. The economic paradigm permeates our thinking about each and every aspect and area of human activity. Our thinking and reasoning about politics and social behavior draws heavily on ideas about incentives, maximization and trading that come from economics.

Modern economics provides the foundation of business administration today. Successful executives and innovators often say that the principles and idea they draw every day in analyzing and making plans are those that they learned in their first courses in economics.

What are the economy and economics?

Every society must provide sufficient goods and services for the welfare for its citizens. The economy consists of all the activities that are involved in the production and distribution of these goods and services.

Economics, as the study of economy, seeks to address these three fundamental questions:

- Are there any underlying principles that help us understand how the economy works?
- How well does the economy perform in attaining the social objectives?
- How would changes in law and political institutions influence or affect the performance of an economy?

Quantitative Development in the field of economics

Econometrics is the application of quantitative methods to economic data in order to give empirical result to an economic relationship. The quantitative analysis of an actual economic phenomenon is based on the concurrent development of theory and observations.

The basic quantitative tool for econometrics is the multiple linear regression model. Econometric Theory uses mathematical statistics to evaluate and develop econometric models and analyzing economic history and forecasting. The other approaches used are scoring method and systematic approach.

Research Objectives

1. To understand the idea of operations research being implied in the real life scenarios, and how its relevance helps calculate or find the necessary outputs.
2. To find several operations research techniques and their uses in order to portray the same to the economical aspect chosen for this research paper.
3. To elaborate on past knowledge of economics and current findings, with regards to how they can be related to operations research. Making specific, the broader view of economics into several concepts that typically cater to the techniques and feasible enough.
4. To outline different existing scenarios and happenings that have used operations research in the past and how it impacted the situation or specific calculation. Analyzing this through several articles and research papers to get a broader view.
5. To describe both economics and operations research as 2 broad objectives and further showing the relation or reference at each stage of the research paper.

Research Methodology

With consideration to OR beyond just a subject, the idea of carrying out a research for applications in the real world was the basic motive behind this research paper. Having looked at several real life examples and operational theories, the choice of OR in economics was with complete relevance to the existing knowledge of economics and its functions. Economics being so vast as a curriculum, the assortment of concepts within economics were more relatable. Specific concepts such as demand and supply, agriculture, Businesses and E-business; put together have greater relevance. The idea came across due to the self-realization of how operations research can be put to work in these fields. Moreover, the concept of Game Theory which in itself is considered to be an OR technique, aided the idea of OR in economics. Analyzing statistical data and numerical relevance in accordance to the known OR techniques was also a part of the process, further simplifying the idea of the actual application of the respective, considering both quantitative and qualitative factors. The collection of data involved several existing research papers to the relevant topics and articles of real life happenings of the same. This could prove the point with evidence for carrying out the research. Although, looking at the time frame of the research data (publish year), the data could be old or have a different impact in today's scenario considering it as a possible weakness for this research paper, taking into account that this is not the most standard topic of research.

Sources of secondary research

- Previously published research papers
- Articles
- Blogs
- Books/Journals

Game Theory comprises a conflict between two or more competitors. Conflict or competition is based on achieving the goal. For example, to maximize market share.

Competitors can be of the following types i.e., management vs. workers or supplier vs. supplier etc.

Game theory provides systematic quantitative methods for analysing competitive situations in which the competitors (players) make use of logical processes and techniques in order to determine an optimal strategy for winning.

A strategy is an alternative course of action that a player knows in advance, based on which he decides his plan of action.

The games can be classified into two categories: *zero-sum* and *non-zero-sum*. In *zero-sum* games, the loss of one is gain of another.

Nash Equilibrium

It is defined as a proposed solution of a non-cooperative game involving two or more players in which each player is assumed to know the equilibrium strategies of the other players, and no player has anything to gain by changing only their own strategy

Rules/ Assumptions of the game:

- Players act rationally and intelligently.
- Each player has a finite set of possible courses of action
- The players attempt to maximise gain and minimise losses
- All relevant information is known to each player
- The players take individual decisions without direct communication
- The players select their respective course of action
- Pay-off is fixed and determined in advance

Real life example of application of Game theory by Apple and Samsung

A hostile patent litigation between Apple and Samsung started ever since Apple accused Samsung of copying its designs for smartphones and tablet PCs. In response, Samsung dodged back with patent lawsuits concerning the mobile technology. According to CNET News, this litigation chaos augmented into 50 lawsuits against each other in 10 different countries. Apple became wary of Samsung's ever-increasing market share of the smartphones and tablet PCs.

As Samsung's market power is increasing in both the smartphone and the tablet PC market, Apple has opened a Pandora's Box by filing a lawsuit against Samsung, as it was mentioned above. This has triggered the problem of Prisoner's Dilemma, of which the 'players' in a 'game' are forced to choose the option that makes both of them worse off. In this case, the 'players' are Apple and Samsung, and the 'game' they are playing is the chicken game of patent litigations.

		Samsung	
		Lawsuit	No Lawsuit
Apple	Lawsuit	Possibility of being kicked out Possibility of being kicked out	Possibility of being kicked out Status Quo (Market Gain)
	No Lawsuit	Status Quo (Market Gain) Possibility of being kicked out	Status Quo Status Quo

(Patent Lawsuit: Apple, Samsung and the Prisoner's Dilemma, 2012)

Literature Review

- E-Business

(Geoffrion & Krishnan, 2001). In their research paper mention about the successes in areas such as financial services, electronic markets, network infrastructure, packaged OR-software tools, supply-chain management, and travel-related services and that Electronic marketplaces could develop into important OR application venues.

The strengths of OR like coping with complexity and experimenting without risk help meet challenges of the digital economy. Applications of OR in E-business include Optimal Retirement Planner, Combinatorial auction bid selection, Fiber network planning and Investment portfolio analysis and many more. Real-time OR refers to decision technology embedded in software for e-business processes must often work in real time. The only requirement is to learn to work on Internet time.

- Business

(Hines, 2008), (Steffens, 2004), (Agrawal, Subramanian, & Kapoor, 2010), (Singla, 2016). In their article they talk about how P&G uses Operations Research to drive success. With \$76 billion, 138,000 employees, 300 brands in more than 80 countries, the company has raced to the forefront of data innovation in recent years with the help of Operations Research (OR). Glenn Wegryn, associate director of product supply analytics, explains that the consumer products industry is cost driven, and a lot of it is commodity type in nature so very efficient and effective supply chains are extremely critical for success and the profitability of the company. OR

techniques, when utilized effectively, save costs, reduce cash investments and inventory, and can even improve top-line growth. Hines further explains about the different OR techniques incorporated by the company and how it helped to save costs, maximize profits and accelerate growth.

- Game Theory

(L.Samuelson, 2016). In his article, he explains the history, concepts and applications in Economics of Game Theory. Though it was isolated niche in the 1960's and 1970's, a buzz of anticipation was surrounding it in 1980's and 1990's. Today, Game Theory is a standard tool for economics and contributions are made by economist across spectrums of field and interests. He further explains Nash Equilibrium using suitable illustration of 2 firms. In additions to this, Samuelson discusses the application of Game Theory beyond Economics, and its future.

- Agriculture

(Carravilla & Olieveira, 2013), (Agrawal R. C., 1967) , (Bjorndal, Herrero, Newman, Romero, & Weintraub, 2007), (Johnson M. P., 2007) In their research paper, they all have tried to give an overview of the potential of application of Operation Research to agricultural and forestry decision problems. As agriculture is one of the fields in which Operation Research model is widely used and also it is the primary sector of an economy. They have strived to provide an insight over the different methodologies and techniques, ranging from risk analysis and uncertainty modelling to performance evaluation or agriculture production optimization. They have also reviewed some applications which were published in the literature, representative of the planning horizons that can be addressed from the more strategic decisions to the functioning ones, and from governmental planning to farm running issues. They have discussed about the modelling, algorithmic, and applications contribution of agriculture, fisheries and mining to the operation research literature. Even though linear programming models were the first model to be used in Operation Research in agriculture, many other OR related approaches had been widely used in farming from the past 70 years. There are also some significant areas in mining, example-environmental concerns that are already well developed in other natural resource sector. In each area the principle concern could be tackled with Operation Research. Thus, it concludes that OR would be in near future a fundamental science for everyone needing to make decisions in the agricultural sector.

- Economic Development

(Ebiefung & Kostreva, 2018), (Nelson, 2008), (Johnson & Jiang, 2018), (Mirowski, 1999), (Murphy, n.d.) In their research paper have talked about some of the ways in which Operations Research (OR) tools are used to facilitate the development of society and in the process alleviate poverty and foster social mobility. OR consists of tools that managers can use to make decisions on how to run the operations of an organization using limited resources. They talk about how OR enhances the decision-making process. They have put to light the ways in

which OR can be used to predict future needs (sustainable development). They conclude by saying that both Government and Non-Government Organizations use OR tools for project planning (future too) and its evaluation, efficient distribution of water and food, etc. and that OR should be used effectively, especially in poor countries for economic development and poverty alleviation and for future development too.

- Insurance

(Klinken), (Rajgopal, n.d.), (Kaplan, 2006) In their research paper have stated about the importance of OR in insurance. They mention that the OR methods have only value if the ends of the company and the insured people can be defined in a realistic manner. They said that OR is very efficient in deriving the solution of the important decision problems in an organization. Borch's solution to the determination of the optimal dividend policy and maximization of the expected discounted value of dividend payments is of importance in the field of Insurance which is done through OR. They also mentioned that the important liquidity aspects can be obscured if there is any mingling of orthodox actuarial concepts and techniques of OR which is a very big damper in the field.

Findings

The table above illustrates the situation that Apple and Samsung is facing. In the given table, whatever the opponent chooses to do, the best option for a player is filing a lawsuit against the opponent. For example, is the best option for Samsung is to file a lawsuit against Apple because the best-case scenario is that it might kick Apple out of the market. The worst-case scenario is that both the companies will possibly be kicked out of the market. However, this case is better than Samsung getting kicked out of the market while Apple stays with the market gain, in the point of view of Samsung. The reason Apple chooses to file a lawsuit is the same. As a result, Apple and Samsung reach a Nash equilibrium, in which both of them file a lawsuit against each other, thereby making them worse off. The patent lawsuit can be seen as a deadweight loss that is 'wasted' in a litigious process. Only people benefiting from this situation are lawyers. The ultimate victims of this patent war are consumers because the litigation burdens are passed through higher prices for the products Apple and Samsung produce.

Conclusion

Since the time of its origin before World War II, till date, OR has always been a boon to us and has helped in almost all the sectors. Its importance is increasing day by day and analysts are trying to include management science techniques in all sectors possible. In this paper, we have highlighted ways in which Operations Research can be useful to the economy. From a small job like assigning workers to jobs to as large as important decision making by the government, operations research has a prominent role. The Game Theory on Apple versus Samsung showed how operations research can be used in business for crucial decision making and

management. Managers face an endless list of complex obstacles each day in managing the firm. Operations research offers aid to solve such daily problems by encompassing a wide range of techniques to find the optimality of a solution by using various mathematical models. Efficient use of OR by creative analysts can lead to optimization of resources, maximization of profits and minimization of costs. Concluding, we would like to quote Mark Doherty, executive director of the Hanover, MD-based Institute for Operations Research and Management Sciences (INFORMS), "In the private sector, OR is the secret weapon that helps companies solve complex problems in health care, manufacturing, supply chain management, , and transportation,". "In government, Operations Research helps the military create and evaluate strategies. It also helps the Department of Homeland Security to develop models of terrorist threats. That's why OR is increasingly known as the 'science of better.'

Limitations

1. Due to the lack of primary data collection, there was major dependence upon the past information and research papers. The conclusions have been based upon the same and might lack some kind of accuracy.
2. The collection of research papers has also been done from some old papers (2004-05), the methods discussed might be out dated or no longer used as much. Innovation in the same has not been listed.
3. Since the research involved reading several papers, the data collection was based on varying information in different papers. Thus as a part of secondary research, it might not be as reliable.
4. Due to limited understanding of both economics and operations research, not every aspect of the secondary research was included in this research paper.
5. There is no self-conclusion and can be biased since it is based on previous researches and findings.
6. Economical aspect covered is a niche aspect and does not include everything pertaining to operations research used in economics.

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