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Application of Operations Research in Election Voting System

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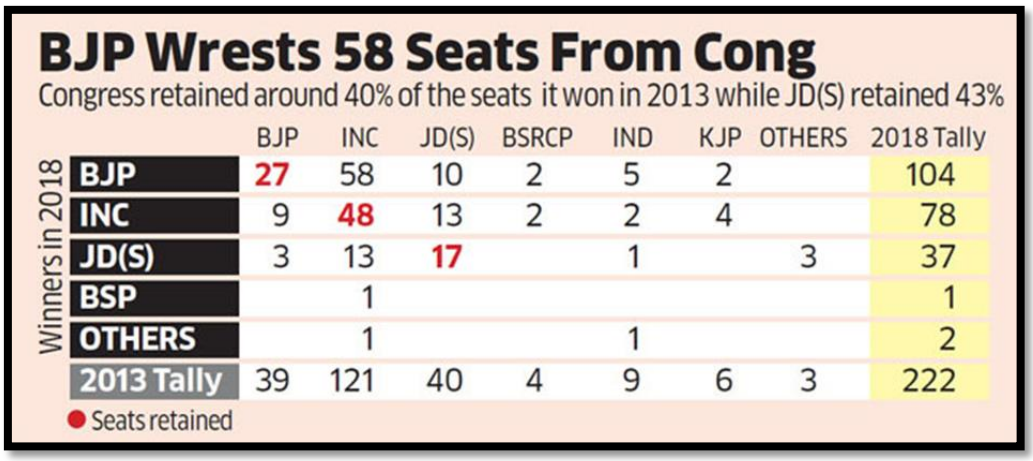
Abstract:- Voting during elections is one major operation that requires time co-ordination and management, considering the mammoth number of voters waiting for their turn in a long queue and the responsibility of conducting the operation with utter care and in a confidential manner. The main reason behind conducting this research is to understand the flow of events that form the operation and to use the high degree of application of operation research to bring an optimum solution that can ease the work of both voters and government officials. The first part of this paper will provide an overview on voting process in India and methodology used to collect secondary data. Second part will show the analysis on data collected and conclude on this paper. Overall, this paper made an attempt to understand the application of operation research in voting process.

I. INTRODUCTION

➢ *Recent News*

After falling short of numbers in Karnataka Elections 2018, BJP revisits 'Operation Kamala' of 2008. "Operation Kamala" was a term coined in 2008, when BJP was in a situation similar to the current one and was three seats short of majority to form the government under BS Yeddyurappa. Former minister and mine lord G Janardhana Reddy worked out a method to circumvent the Anti-Defection Law and secured the support of legislators needed to take BJP past the 112-mark. BJP sources pointed out that Reddy was "very much in the game again" as he was said to be operating behind the scenes to get more seats for the party. "We have won several seats in central Karnataka only because of Reddy's operations". (Economic Times,2018)



The above articles state the application of Operation Research for the political parties to predict their winning probability, analyse their performance in every election and to get that magic number of majority.

Elections are often described as the largest and most complex logistical operation a country undertakes in peacetime. While Election Management Bodies are expected to conduct elections that are free, fair and transparent to all stakeholders, they face a lot of difficulties in handling the different phases of the electoral process.

By offering an end-to-end election solution to election operations, operation research also helps Election Management Bodies reduce risks and costs, maximize productivity, increase efficiency, enhance transparency and standardize the election workflow. Operation Research also provides us with the capability to adapt to existing infrastructure, overcome constraints and language barriers, as well as to accompany Election Management Bodies step by step in their electoral modernization projects.

➢ *Need for Research*

Need for research on operation research in elections is to understand the methods to conduct the largest elections with around 717 Million electorates as in 2009 general elections fluently fulfilling tasks like the following: -

- In every State, the elections in all constituencies in it should be held on a single day
- As far as possible, States in which elections are held on a day must be contiguous
- Set of States in which elections are held on consecutive polling days should be contiguous
- General elections over the whole country should be completed using the smallest number of polling days
- At every polling station, 4 CPF personnel should be deployed on the election day
- The total number of CPF personnel available for deployment at polling stations on any polling day is at most 1,500,000 or 1.5 million.
- This research is also important for political parties to predict their winning probability, analyse their

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performance in every election and to get that magic number of majority.

II. OVERVIEW

India's general election is the largest democratic exercise in history with over 814 million voters eligible to cast ballots. The Indian voting pool is larger than the total population of US and Western Europe combined.

After India attained independence, there was a need to hold General Elections. Election Commission was formally constituted and functioned as a single member body for a period of time but since 1993 is functioning as a three-member body. For the first and second GE, 'Balloting System' of voting was adopted but the third GE used 'Marking System' of voting. The political parties make use of different variables such as caste, community, religion, money, power, etc. during elections which also have to be considered in the entire electoral process.

Hence, the entire process becomes very complex. The election management bodies face a lot of issues handling all the complex logistical operations of the electoral process. Thus, operation research, politics and elections are integrated with each other. In this paper, we will see how using operations research helps the election process and can help the elections be more efficient.

III. LITERATURE REVIEW

There have been discussions in the past about the use of different game theory methods in Operations Research keeping in mind the possible developments in the future. Game Theory is about analysing situations which consist of conflicting interests where one player stands to gain while the other stands to lose. It has progressed significantly in the fields of behavioral economics, simulation and computer science to overcome the hindrances of limited data and lack of knowledge and expertise (Shubik, Game Theory And Operations Research Reseacrh, 2002) .

Some authors have tried solving the question posed by Domingo's and Richardson - which set of individuals need to be targeted in order to convince them to adopt a new product or innovation, with the goal of triggering a large cascade of further adoptions. They have examined the extent to which family and peers' opinions affect purchase decisions and word-of-mouth plays an important role in these decisions, and used approximation algorithms and computational experiments as guarantee of proofs that they are able to outperform the node-selection heuristics(Kempe, Maximising the Spread of Influence through a Social Network, 2003) .

Other papers highlight the importance of Game Theory in theoretical computer science and how it can prove to be an important tool while using the internet. The socio-economic complexity of the internet – its uniqueness and varied usage for different interactions, strongly hints at the importance of collaboration between the methods and algorithmic ideas of Game Theory and Mathematical Economics to provide valuable insights into better understanding and using the Internet. Past collaborations between Game Theory and Computer Science in the context of bounded rationality as well as in learning games and repeated games, together with the nature of Game Theory being an intelligent model with deep insights makes the use of these tools very suitable in this field. Although, adhering to these norms are difficult. Mechanism design, a branch of microeconomics that explores how businesses and institutions can achieve desirable social or economic outcomes given the constraints of individuals' self-interest and incomplete information, also known as inverse game theory, could also be used as a scope to perceive rational behaviour in competitive situations. For example, with a desired goal of maximizing a company's total welfare, mechanism design sets strategies in such a way that the individuals aiming to maximise their personal satisfaction end up achieving the company's goals. Yet, this field is too complex and advanced to interpret. The necessity of the existence of a path of any artefact, from its present to its prevalent situation, and the pivotal role of adequate incentives along this path, so that the individuals concerned continue to use and directly interact with this path has also been mentioned(Papadimitriou C. , 2001) .

There is focus on allocation in those auctions which have multiple distinguishable or indistinguishable items. Analysing existing approaches for tackling the problem of determining winners so as to maximise revenue in combinatorial auctions (bidders bidding on a combination of items) can be done through:

- Exhaustive enumeration
- Dynamic programming
- Restricting the allowable combinations

Next, determination of the possibility of approximate winner determination and proving in approximatability in the general case is done. This yields the result that combinatorial auctions lead to more efficient allocations than the traditional auction mechanisms, as the buyers can reveal correspondence in their bids, which is picked up by the winner determination algorithm (Sandholm, Algorithm for optimal winner determination in combinatorial auctions, 1999) .

Research has also been done on how Operations Research and analytical models are used to forecast election polls and results. State-level outcomes are usually predicted by simulations while considering different variables such as economic data, momentum and poll biases. Operations Research has been used extensively for converting uncertainty in polls to likely election outcomes. The analysis measures how even a slight change in any of the variables can adversely affect the outcome. Operations Research has been considered the real winner of the 2012 US Presidential elections. The use of analytical data combined with the technological advancements in computer science played a pivotal role in ascertaining the winner of the elections. Candidates used the internet, mobile phones, television and other social media to target potential voters and hired programmers and statisticians to forecast swing voter

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segmentation based on the data collected through the analytical models(Albert, 2014)(Shen, 2013) .

Bennett Miller's 2011 movie Money ball, based on Michael Lewis' book- "Moneyball: The Art of Winning an Unfair Game", incorporated statistical analysis as the basis to overcome their payroll disadvantage. Their research redefined baseball in the hope of finding the real skills required to win the game. They focussed only on certain key areas in an attempt to revalue their players who were being insufficiently paid. Hence, they managed to come up with a strategy to maximise their player budget whilst also identifying and solving new market inefficiencies (Sharma, Moneyball : A new beginning in OR!, 2011) .

IV. SIGNIFICANCE

A. Party Loyalty

This deals with the relationship of the voter's decision or loyalty with the party identification. For electoral majority first the geographic segments are identified which are most likely going to be a loyal support base and the marginal segments on which the outcome of the election depends. A strong relation exists between identification of party and the way the people vote. Candidates are very interested in gaining a political advantage from this but the fact is that the systematic incorporation of this in their campaigning strategy is very low.

B. Campaign Applications:

The decision of conducting campaigning activities depend on the geographic distribution of the area. After attaining a map of party loyalty and party identification the geographic locations are decided to carry out the campaigning activities. They are allocated to the locations where they will give maximum benefits. To optimize allocations rankings of these locations is done and then selected with respect to size of units and expenses.

C. Registration Drives

The aims are to increase the pool of votes in such a way that they are in the candidates favor. To get the maximum benefits two aspects are taken into considerations. The party loyalty in that area should be high and the turnout ratio should be low. Other combinations could have a negative impact as when there is high party loyalty and high turnout, the registration drive would be waste as voters might register and go for voting on their own along with which huge cost might be incurred whereas when there is low loyalty and low turnout, registration drive would increase the votes in favour of the opposition.

D. Canvassing and Candidate Appearances in Mid-Campaign

Candidates should focus on keeping the potential defectors in their favor along with attracting of the candidates in opposition. They must also seek to have a high turnover of the party loyalists. In geographic segments where number of voters of each party are same, the outcomes are mainly decided the defectors. Marketing is in segments ranked according to their size and focused on larger units.

E. Get-Out-the-vote drives:

They are done to ensure that the party loyalist and near loyalists actually vote. These are focused in the area where turnout is very low. The ranking of locations is done in like in the case of registration drives. Efforts are made to make the loyalist go to the poll on their own and vote.(Burno J. D., 1972) .

The above-mentioned methods are used by the candidates to gain a competitive advantage over their opposition through optimum allocation of their resources before elections to increase the turnout of the party loyalists.

Operations research can also be used by the committee conducting the elections in multiple ways to optimize the resources available and make the process smooth along with reducing costs.

The numbers of booths to serve the voters efficiently by reducing the waiting time at each booth. It is also ensured that only adequate booths are placed. This also helps in reducing queue. The transportation of EVM's in the least possible time at the right destination. Emphasis is also laid on the proper allocation of government officials for conducting elections efficiently by minimizing them to reduce costs.

V. METHODOLOGY

We have mainly focused on secondary data for our research analysis. We have referred to newspaper articles, published research papers and journals for our research. For analyzing the problem of allocating government officials, Hungarian method of Assignment Problem formulation has been used. The method helps in increasing productivity of the booth by using the minimum time to complete the entire process.

VI. ANALYSIS

In this phase, the data will be processed based on the information obtained about the problems defined:

- Matching the number of booths to serve the quantity of voters efficiently.
- Matching the transportation of EVMs to reach all places at least possible overall time.
- Minimize the requirement of government officials.
- Reducing the queue line.

It is very important to be aware of the required data for an operation research to be successful. The application of operation research instrument depends upon the nature of the problem.

A voting process goes through four different processes:

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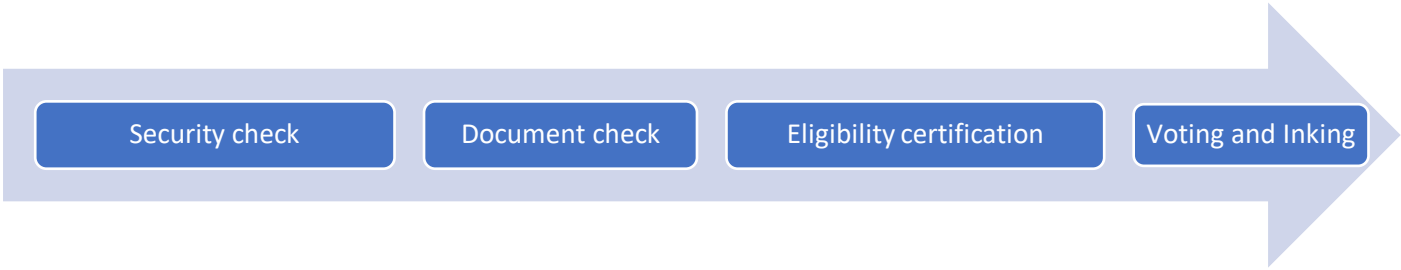


Every government official has certain prominent skills in management in a particular process. For instance, A takes 2, 10, 5, 3 minutes in security check, document check, eligibility certification and voting processes respectively. B takes 5, 7, 5, 2 respectively in processes. Similarly, we collect data on different officials' performance at the voting booth. The following matrix is an example:

A. Formulation

	Official 1	Official 2	Official 3	Official 4
Security check	2	5	3	4
Document check	10	7	8	7
Eligibility certification	5	5	7	6
Voting and Inking	3	2	4	4

This is an assignment problem which can be solved using operation research to allot the officials their respective jobs and attain minimum time usage across all processes. Assignment problems need to be first minimized on row and column basis and then the allocations are given. Below is the solution:

	Official 1	Official 2	Official 3	Official 4
Security check	0	3	0	2
Document check	3	0	0	0
Eligibility certification	0	0	1	1
Voting and Inking	1	0	1	2

B. Allocations

Official 1 performs eligibility certification, Official 2 performs Voting and inking, Official 3 performs Security check and Official 4 performs Document check. One full cycle gets completed in 17 minutes. This can be applied in all photo booths that can collectively save a lot of time. Thus, Operation research helps to analyze, present, compare and conclude on data with the best solution possible.

Assignment operation can also help in the allotment of EVMs in voting booths from the booth office. Machine 1, Machine 2, ….. can be taken in the across grid and polling booths can be taken in down grid. Values will be allocated based on time taken by EVMs to reach the booth from the office. This, again can be compared with data on density of population and average people traffic at a voting booth. Thus, the two comparisons will show you which EVMs to be sent to which booths to save time.

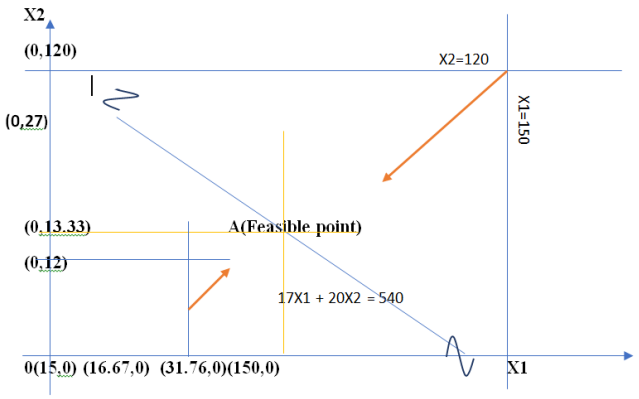
Another interesting use of operation research is Linear programming to analyze the pressure on voting booth on per machine basis. It can suggest whether the machines should be increased or decreased and put to use elsewhere. The aim of Linear Programming would be to maximize votes per EVM. The booth's past data. The booth will be in working for 9 hours. Every process has 540

C. Formulation

Let X1 be number of Men and X2 be number of women in the total voting process. Going according to the above data, a man will take 17 minutes divided as 3,7,5 and 2 minutes in respective processes. Let's consider a woman taking 3 minutes extra during the security check because of purse checking. Similarly, any time span could be considered according to minutes since each works independently. The booth plans to serve at least 150 men and 120 women on that day. The equations formed are:

Maximize Z= X1 + X2
Subject to,
17X1 + 20X2 <=540
X1>=150
X2>=120
X1, X2 >=0

The solution won't form a feasible region at first because one EVM cannot serve all voters, i.e. 270. We, thus, then divide the population by the no. of EVMs available at booth. For instance, over here X1=150 and X2=120 are divided by, let's say, 10 EVMs which brings the solution to a feasible region. But it is not optimal. So we reduce the no. of EVMs which, in turn, increases traffic on other EVMs to reach the point of intersection between all three constraints. This is called as feasible point co-ordinate (A).



Similarly, if the no. of EVMs is 5. It does not enter the feasible region. So we increase the no. of EVMs so that the constraints just enter the feasible region at the feasible point co-ordinate (A). So at point A(16.67,13.33), 16 men and 13women are provided service per EVM in 540 minutes total. Using 9 machines, we get (16.67+13.33)*9 = 270. Therefore, point A gives us the optimal utilization of EVMs to provide service to maximum people possible. If the booth wants to increase the capacity to, let's say, X1=170 and X2=150 we get new co-ordinates for A, i.e A' (18.89, 16.67) in which 17X1 + 20X2 is not = 540. Thus we have to add more EVMs so that the traffic per EVM reduces and constraints meet at a common point A. Thus, this method proves to adjust according to the data and provides the best solution possible. On the basis of this analysis, we can say that operation research proves to be useful in optimizing the voting system in different ways.

VII. CONCLUSION

Thus, through this paper, after a thorough research on voting system and electoral process, we were able to apply operation research to formulate better solutions and we realize that its application is important in elections as it can reduce government's inefficiency and save countless work hours.

VIII. LIMITATIONS

- Lack of primary data available for analysis - We have used secondary data for our analysis in the absence of first hand data which limits our scope of finding and analyzing new researches.
- Insufficient time to analyze the given data reduced the effectiveness of our research.
- There exists a level of uncertainty in the case of predicting election results through statistical analysis - to analyze the given data reduced the effectiveness of our research.

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