Mathematics, Operations Research and Management Science in Industry

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ABSTRACT *The best way to work to get the maximum production at the minimum costs is based on the principles of scientific management. It gained the recognition of the public when Mr. Louis D Brown de declared that it could save one million dollars a day. The term scientific means systematic analytical and objective approach. Management means getting the things done through others. Then scientific management is based upon careful observation, objective analysis and innovative outlook. Its aims and objectives are excellence, improvement, revolution, correlation, production, elimination sorting, harmony etc. there are so many workers' criticisms and employers' criticisms. Its two main elements are planning and doing are separate aspects and job analysis or work study. The principles of scientific management are Replacing Rule of Thumb with science, Harmony in Group action, Cooperation and maximum output.*

KEYWORDS *Scientific Management, Scientific Techniques, Correlation, Sorting, Harmony, Mental Cooperation, Workers Criticism, Employers Criticism, Time Study*

1 INTRODUCTION

Mathematics and Operations Research in industry. Operations Research can be define as the science of decision making it has been successful in presiding systematic and scientific approach to all kink of government, military, manufacturing and service operations. Operation Research is an exciting area of applied Mathematics.

Operations Research combines mathematics, statistics, Computer Science, Physics, engineering economics and social science to solve real world business problems.

KEY STEPS

Problem formulation*:* - Motivation, Short and long-term objectives, decision variables, control parameters, constraints.

Mathematical modelling representation of complex system by analytical or numerical models, relationships between variable performance matrices.

Data collection- Model inputs system observation, validation, tracking of performance metrics.

Solution methods optimisation, stochastic, process, simulation, heuristics

Validation and Analysis *model* testing, calibration, sensitivity, analysis, model robustness.

Interpretation and Implementation Solution ranges tradeoffs visual or graphical representation of results decision support system.

There all steps require a solid background in mathematics and familiarity with other disciplines such as Physics, economics and engineering. As well as thinking and intuition.

Many real world complex decision systems involve the optimization of several conflicting objectives: Such systems with multiple conflicting and non-commensurable criteria and termed as multiple criteria decision system. Multi-criteria decision problem is a generalization of traditional classical single objective optimization. There are many reasons for the increasing interest in the multi-criteria decision problems of the present society.

Firstly, most of the decision problems are inherently multi-objective in nature and hence decision making using classical methods does not reflect the underlying reality. Secondly, in many decision problems in which ranking potential alternative is required the ranking is based on multiple objectives. Thirdly, many problems that occur in classical single objective models can better be viewed as multiple in nature. The reason for the multiple objective natures of these problems is that the outcomes associated with the decision are multi-dimensional.

MEANING OF SCIENTIFIC MANAGEMENT

Literal Meaning The term scientific management contains two words-scientific and management. The term 'scientific' means systematic, analytical and objective approach while 'management' means getting the things done through others. Hence scientific management is based upon careful observation, objective analysis and innovative outlook. It is the art of knowing exactly what is to be done and the best way of doing it. Scientific techniques are applied in methods of work, recruitment, selection and training of workers. Scientific management implies the acceptance and application of the method of scientific investigation 'for the solution of the problems of industrial management.

Frederick Winslow Taylor. "Scientific management means knowing exactly what you want men to do and seeing that they do it in the best and the cheapest way."

Peter F. Drucker. The core of scientific management "is the organised study of work, the analysis of work into its simplest elements and the systematic improvement of the worker's performance of each element."

Harlow Person. "Scientific management characterises that form of organisation and procedure in purposive collective effort which rests on principles or laws derived by the process of scientific investigation and analysis, instead of on tradition or on policies determined empirically and casually by the process of trial and error."

Jones. Scientific management is "a body of rules, together with their appropriate expression in physical and administrative mechanism and specialised executives, to be operated in co-ordination as a system for the achievement of a new strictness in the control and processes of production."

Lawrence A. Appley. "Scientific management is a conscious
Orderly human approach to the performance of management responsibilities as contrasted with the day-in and day-out

rule of thumb, hit or miss approach."

Walter N. Polakoy. "Scientific management will be that kind of a process of directing human efforts which employs the scientific method and the management specialist, hence, could be defined as one which specialises .n application of modern scientific method to the solution of the problems arising in the process of management."

Spiegel. Viewed as a process or a method, scientific management "is concerned with the discovery of casual relationship between the efforts put in for a given objective and the results of such efforts with special emphasis upon the discovery of the best method in the light of the available man-power, materials and technology."

F.W. Taylor. "Scientific management does not necessarily involve any great invention or the discovery of new and startling facts. It does, however, involve a certain combination of elements which have not existed in the past, namely old knowledge so collected, analysed, grouped and classified into laws and rules that it constitutes science; accompanied by a complete change in the mental attitude of the working man as well as of those on the side of management towards each other, and towards their respective duties and responsibilities. Also a new division of duties between the two sides and intimate, friendly co-operation to an extent that is impossible under the philosophy of old management. And even all of this in many cases could not exist without the help of mechanisms which have been gradually developed."

"It is no single element, but rather this whole combination, that constitutes management, which may be summarised as: Science, not rule of thumb. Harmony, not discord. Co-operation, not individualism. Maximum output, in place of restricted output. The development of each man to his greatest efficiency and prosperity."

2. EXPLANATION

Business of Scientific Management

Increase in Production and Productivity. Scientific management involves planning of task and scientific methods of doing work resulting in the increase in production and the output per worker and per machine because of increased efficiency.

Reduction in Cost of Production. Scientific management ensures avoiding of all types of wastages and losses. Production is planned and production time is minimised. With economies of large-scale production this leads to reduction in cost of production.

Better Quality Products. An essential element of scientific management, standardisation ensures better quality products.

Benefits of Division of Labour. Scientific management gives benefits of division of labour. The work is simplified and carried in the most economical manner.

Mutual Co-operation between Labour and Management. Scientific management is instrumental in developing healthy co-operation between workers and management, thereby; it removes the cause of industrial disputes.

Proper Selection and Training of Workers. Scientific management involves proper selection, placement and recruitment of workers. Misfits are avoided and right man is given a right job.

Better Working Conditions. Scientific management provides better conditions of work to the workers, viz., proper working hours, rest pauses, ventilation, lighting, floor space, safety, etc.

Better Utilisation of Resources. Scientific management enables the optimal use of all resources by elimination of unnecessary movements of men and machines, elimination of wastages, motivating labour to work efficiently and effective supervision of all types of resources.

Increased Wages. Under scientific management, efficient workers get increased wages due to differential wage incentive plans as suggested by the profoundest of scientific management. The increased wages improve the standard of living of the workers.

Gains to Consumers. Due to scientific management consumers are benefited by the richer quality products made available at cheaper prices. This enables them to attain higher standards of living.

Gains to Community or Nation. To the community at large scientific management ensures industrial peace, increased production, maximum prosperity, increase in national income, higher standards of living, and rapid industrial development, etc.

Gains to Owners/Investors. Increased productivity, large scale production and reduction in costs lead to increase in profits to the investors or the owners.

Criticisms of Scientific Management

Even the theoretical thinkers of management Peter Drucker, March and Simon, Douglas McGregor have opposed scientific management on various grounds given below:

Worker's Criticisms

Speeding up of Workers. Scientific management is nothing but a device to force workers to a greater speed, without much regard for their health and safety. It creates a lot of physical and mental strain upon them.

Here it should be remembered that scientific management envisages reasonable working hours with adequate rest pauses, proper working conditions and other safety measures for the well being of workers.

Loss of Workers Skill and Initiative. Workers allege that, under scientific management, they are reduced to the position of machines as the work methods and operations are standardised. As a worker has to work according to the instructions of the foreman, it leads to loss of initiative from the workers and they cannot suggest better methods of work. Too much of standardisation, a prerequisite for scientific management, leads to higher productivity only in the short run, but in the long run, due to loss of worker's initiative it results into lower productivity.

The criticism seems to be genuine. In implementation, care should be taken to maintain, rather, increase worker's initiative in the work.

Monotony. Under scientific management the function of planning is separated-from that of doing and every worker is expected to perform his small part of a job due to specialisation. This makes the work monotonous and the worker tends to loose interest in his job. Hence, an attempt must be made to reduce monotony as far as possible.

Unemployment. Scientific management reduces the number of processes and motions of workers. It increases the hourly or daily output per worker, and their efficiency by standardisation and division of labour. Thus, it creates unemployment by requiring lesser number of workers. But it has been proved that increased production and reduced costs open more avenues of employment for the workers.

Exploitation of Workers. The workers allege that, there is an exploitation of workers by a scheme of scientific management. The gains of increased productivity are not shared with the workers. The major portion of increased profits is snatched by the investors and only an insignificant benefit is given to the workers by way of increase in wages and bonus. It may be ignored here that while raising this objection, workers appear to have ignored the fact that increase in productivity has been made possible by the

management by employing standardised tools, materials and methods of work under the scheme of scientific management. Hence, there is nothing wrong in the scheme of scientific management itself. Taylor pointed out that "both sides should take their eyes of the division of surplus as the all important matter and together turn their attention-towards increasing the size of the surplus until this surplus becomes so large that it becomes necessary to quarrel over how it shall be divided."

Discrimination between Workers. Under the scheme of scientific management, efficient workers get more wages as compared to the inefficient ones due to the differential wage incentive scheme as suggested by Taylor. This brings discrimination between workers. This argument, however, is not convincing. Efficient workers must be paid higher wages to prompt them to maintain efficiency and to encourage other workers who are not up to the mark at present. Minimum wages may be guaranteed to safeguard the interest of the workers.

Undemocratic in Nature. Workers allege that scientific management is undemocratic in nature as it gives absolute control over workers to the functional bosses. The workers have to follow the instructions of the bosses without thinking on their part. Scientific management forces the worker to depend upon the employer's conception of fairness, and gives the worker no voice in hiring and discharge in setting the task, in determining the wage rate or determining the general conditions of employment.
However, it is wrong to say that under scientific management, workers are not given any opportunity to say anything in the matter which vitally affects them.

Weakening of Trade Unions. Workers allege that the scheme of scientific management kills the very basis of trade union movement. The managers decided important matters like fixation of wages, work methods, working conditions, hours of work, etc. this weakens the process of collective bargaining and the formation of trade unions. Due to increased productivity, efficiency, incentive and wage payment schemes, workers get more and are satisfied. The differential wage plans create division among workers and strike at the very basis of trade union movement. Efficient workers who earn more wages always like to have peace and stable conditions rather than strikes and agitation. However, the experience in many advanced countries including U.S.A. has proved that trade unions exist with immense popularity and success even under the scheme of scientific management.

Employer's Criticisms

Expensive. The introduction of scientific management involves heavy expenditure on account of standardisation of materials, equipment, tools and working conditions. Expenses are incurred on conducting time, motion and fatigue studies. 'The planning department involves extra cost.

However, the employers seem to have ignored the benefits emerging out of scientific management. The elimination of wastes, reduction in cost of production, increase in efficiency and productivity, higher profits, etc., all lead to increased profits which provide for much more than the expenditure involved in the implementation of scientific management.

Re-organisation. The introduction of scientific management calls for a complete reorganisation of the whole set up of industrial unit. A majority of organisers, top executives, line managers are not mentally prepared for such major change. Moreover, the work for reorganisation. Results in loss of production and money.

The employers should have that scientific management should be introduced gradually in stages so that the change is not resisted and it does not upset the normal functioning of the industry.

Unsuitable for Small-scale Units. Some employers believe that scientific management is suitable for only large-scale units. The small-scale units cannot afford to introduce the scheme of scientific management. But, there is a scope for improvement by scientific management in every organisation-big or small.

Over-production. Employers allege that scientific management may lead to over-production or glut in the market, which, in turn, is bound to cause recession. This objection seems to have no valid grounds.

Principles of Scientific Management

Taylor evolved following principles of scientific management.

Replacing Rule of Thumb with Science. Rule *of* Thumb was the technique of pre-scientific management era. Taylor maintained that the rule of thumb should be replaced by organised knowledge. While rule of thumb emphasises estimation, scientific method denotes precision in determining any aspect of work. This should be done with the help of careful scientific investigation. Exactness of various aspects of work like day's fair work, standardisation in work, differential piece rate for payment etc. is the basic care of scientific management. Therefore it is essential that these should be measured precisely and not on mere estimates.

Harmony in Group Action. Taylor emphasised that harmony rather than discord should be obtained for group action. Harmony means that a group should work as a unit and contribute to the maximum. Within it there should be mutual give and take situation and proper understanding.

Co-operation. Scientific management requires that parts of industrial body co-operate with each other. Scientific management is based on mutual confidence, co-operation and goodwill. It requires a complete mental revolution on the pact of both workers and management as to their attitude and outlook towards one another and also towards their work. Taylor suggested, "Substitution of war for peace, heard and brotherly cooperation for contentment and strife, replacement of suspicious watchfulness with mutual confidence, of becoming friends instead of enemies."

Maximum Output. Scientific management requires scientific selection of workers and their proper training and development. Workers should be selected on the basis procedure scientifically developed. Scientific selection also implies proper placement of workers. After selecting the worker should be trained and developed to the fullest extent possible for his own and for the company's highest prosperity. Workers should be able to distinguish between wrong and right, so that they may avoid wrong methods of work and improve upon their performance. They should be fully developed to undertake the task assigned to them by the management. Taylor himself summed up scientific management principles as follows: Science, not rule of thumb, Harmony, not discord, Co-operation, not individualism, Maximum output, in place of restricted output, the development of each man to his greatest efficiency and prosperity. But opposition to scientific management was so grave that Taylor had to defend it before a special Congressional Committee in 1912. However, Taylor's thinking had created awareness among various managers and thinkers to bring changes in old

methods of working.

3 CONCLUSIONS

The Phases of an Operations Research Project:

Any Operations Research project that has a happy ending goes through five major steps or phases:

Formulating the problem;
Deriving a solution to the model;
Testing the model and evaluating the solution;
Implementing and maintaining the solution.

The phases are normally initiated in this order they do not necessarily terminate in the same order. In fact, each phase usually continues until the project is successfully implemented. All phases overlap subsequent as well as preceding phases. For example, the successful formulating of the problem depends on having at least tentatively considered each of the other four phases. Interrelationships between various aspects of the operation may suggest a form of model. This in turn may dictate what data are needed for problem formulation, testing, and implementation. The complexity of the solution to a model may call for additional simplification. Testing the model and consideration of the implementation may reveal obstacles that lead to a reformulation of the original problem. So, even, if we must discuss each phases separately, it should be borne in mind that they overlap.

As pointed out earlier, the objective of the Operations Research project is to improve that effectiveness of the system as a whole. This improvement can, however, only be secured if the solution to the problem is fully implemented. Securing the implementation of the solution is thus the prime concern underlying the first four phases. All measures that enhance the chances of implementation have to be initiated and planned for from the very outset of the project. In fact, Professor C.N. Churchman one of the wise men of Operations Research states that "securing implementation is the first any Operations Research project.

During all phases, it is crucial to record for future reference: all assumptions made (e.g., the basis for all simplifications introduced into the model): all data used and their sources; and a complete description of the various steps of the analysis made, including any weaknesses and uncertainties in the assumptions and in the data. This point cannot be stressed enough. As the Operations Researcher gets more familiar with the problem and as a project progress through its various phases it invariably will undergo minor and major revisions and corrections. Assumptions, simplifications, and shortcuts in the logic introduced a few weeks or months earlier are easily forgotten unless they have been documented in detail. It is also a prerequisite to establish effective maintenance procedures for the solution. As is true for most technical professional ethics of any Operations Researcher.

Most Operations Research project is not the sole effort of a single analyst, but the fruit of a term effort where team members complement each other with specialized knowledge. The composition of the team may change as the project progresses. However, the team should include at least one person intimately involved with the operation being studied, to provide the necessary physical and technical know-how about the operation, as well as the likes and dislikes of the people affected by the project. This may be decision maker, a close assistant, or one of the persons who will actually be in charge of using the solution of the model. Not only will this person serve as the liaison between the Operations Research team and the sponsor of the project, but also as a sounding board for the other members of the team. His or her participation throughout the project will improve the changes of successful implementation.

Although there are numerous possibilities for using some of the Operations Research techniques for small projects that can be completed within a few days, most Operations Research project that have a major impact on the operations of any organization require a few months to several years from project initiation to a successful conclusion. The total manpower invested may easily be a multiple of the total time span. Even a routine inventory control problem may involve 2 to 3 man months of problem formulation and model construction, followed by 3 to 9 man months of computer programming and data collection, and take several months to be properly implemented. The sponsor of a project should be made aware from the outset of these realities. He should be warned that unforeseen factors (such as missing, or bad data, or unexpectedly complex relationship will invariably result in deadlines being overshot. The discussion in the following subsections is relevant mainly for projects of such scope.

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