

Review

A review of the Management Science theory and its application in contemporary businesses

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The Management Science theory is one of the theories of management that attributes management effectiveness to the application of scientific methods. It goes a step beyond the famous scientific management theory by applying operations research tools and techniques to solving practical problems. Its origin can be traced to the Second World War in Britain. Its method of expressing business factors in form of variables allows for the accurate prediction of business phenomena and overall optimization of profits. The management science approach uses computer applications and operations research tools to solve business problems around quantitative management, operations research, total quality management and management information systems. Its major limitation is its inability to accurately predict business phenomena that contain behavioral elements. The theory ignores the importance of people, relationships and other non-quantifiable factors. Overall, the management science theory provides a new and proactive way of solving business problems by identifying relationships among different business variables that were previously considered unrelated and so, have provided modern businesses with a better way of doing things.

Key words: Management Science theory, scientific management theory, operations research, total quality management, linear programming.

INTRODUCTION

Several theories of management have evolved since the nineteenth century. The view of management both as an art and a science has led several management scholars to attribute management effectiveness to certain factors and circumstances. Some theories have been developed that try to apply scientific methods into addressing management issues (Jones and George, 2014). The first of these theories was the theory of scientific management propounded by Frederick Winslow Taylor. However, other

theories have adopted this scientific approach to solving specific management problems. The Management Science theory is one of these theories that apply operations research and other quantitative analysis tools to maximize the utilization of the organization's resources in the production of goods and services.

The Management Science theory is often confused with the scientific management theory. The confusion may be as a result of the similar nomenclature. However both

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theories, even though they have some similarities, are not one and the same. Also, contemporary businesses use many techniques that have their origin in the Management Science theory; however there is scarcity of studies in existing literature that identify this linkage. As a result of this, the 'Management Science' concept is slowly creeping away from the minds of scholars as a theory of management. Instead, it is often simply regarded as a group of disciplines or fields of study. To address this problem, the study tried to situate the Management Science theory by discussing the following; the history of the Management Science theory and its different branches, its contribution to the body of management theories, its relevance for contemporary management practices and the limitations of its application in decision-making.

HISTORY AND OVERVIEW OF THE MANAGEMENT SCIENCE APPROACH

Management Science theory is a school of management theories that is characterized by the use of operations research techniques and other quantitative tools to maximize the utilization of organizations' resources in the production of goods and services (Schutts, 2011). It uses such techniques as economic order quantity (EOQ), linear programming, queuing theory, and game theory to solve problems in business operations. It specializes in solving technical problems rather than behavioral ones. Management Science theory focuses on achieving precision by expressing the relationship between variables using quantitative models (Hussain et al., 2019). It is a contemporary approach to management, an extension of the scientific management theory that applies scientific procedures (e.g. division of labor and specialization) in managing the worker-to-task fit so as to improve organizational efficiency (Taylor, 1911). The Management Science theory shares some characteristics with the scientific management theory in that it makes use of scientific methods, assumptions and procedures in uncovering and learning better ways of doing things. Management Science simply applies this method to business problems like decision-making, design processes and strategic planning (Sridhar, 2017). It identifies an operational problem, comes up with possible explanations for the cause of the problem and then suggests possible solutions. This process is similar to the way scientists create models to test their theories and then obtain information from the results. Analysis of such information then leads to possible solutions for solving problems. Although, the scientific management theory was propounded in the nineteenth century, the Management Science theory, which builds on some of the premises of this theory, came later in the mid-twentieth century (Figure 1).

The first practical application of the Management

Science approach started in Britain during the Second World War. The complexity of some of their war-related problems called for special solutions that involved the coming together of several expert scientists (in the area of Mathematics, Physics etc.) into what was later referred to as the 'Operations Research Team' (Jeanty, 2019). The team used the primitive computer system available at the time to build mathematical models for efficient allocation of available resources within military operations. With this model, Britain gained significant success in the war and their model was soon copied by the United States.

When the war ended, the effectiveness of this approach immediately made its way into the industry. The industrial revolution was a period of technological progress and economic growth, and thus efficient allocation of resources became a salient problem for managers (Jeanty, 2019). The innovations associated with the Management Science theory (high-speed computers and communication among computers) provided an effective means for efficient allocation of resources and analysis of complex business problems. Robert McNamara (who was once the Secretary of Defense in both the Kennedy and Johnson Administration) tried to implement the Management Science theory at Ford Motor Company in the 1950s and 1960s as well as in his assignment as Secretary of Defense. As his young operations research team members moved up management positions, the Management Science approach flourished and was more appreciated among managers for its effectiveness and precision (Jeanty, 2019). Today, if one finds himself in a firm where "crunching the numbers" is the major way that management decisions are justified, it is thanks to McNamara and his team.

Some of the earliest tools that are utilized in the Management Science approach (e.g. linear programming) can be traced to William Cooper and Abraham Charnes. William Cooper was an American operations researcher and a professor of accounting from Harvard University. He was nicknamed 'Mr. Linear programming' with his work on optimal blending of aviation gasoline using shadow prices in Gulf Oil Corporation (Charnes and Cooper, 1959) and is often regarded as the father of the Management Science approach (although, the invention of the simplex method of generalized linear programming is credited to George Dantzig). William Cooper was the founding president of the Institute of Management Sciences. As years went by, more techniques and models were included in the Management Science approach (Banker, 2006).

Branches of the management science theory

Over the years, four main branches of Management Science approach have gained ground. Each branch of the Management Science approach addresses a specific

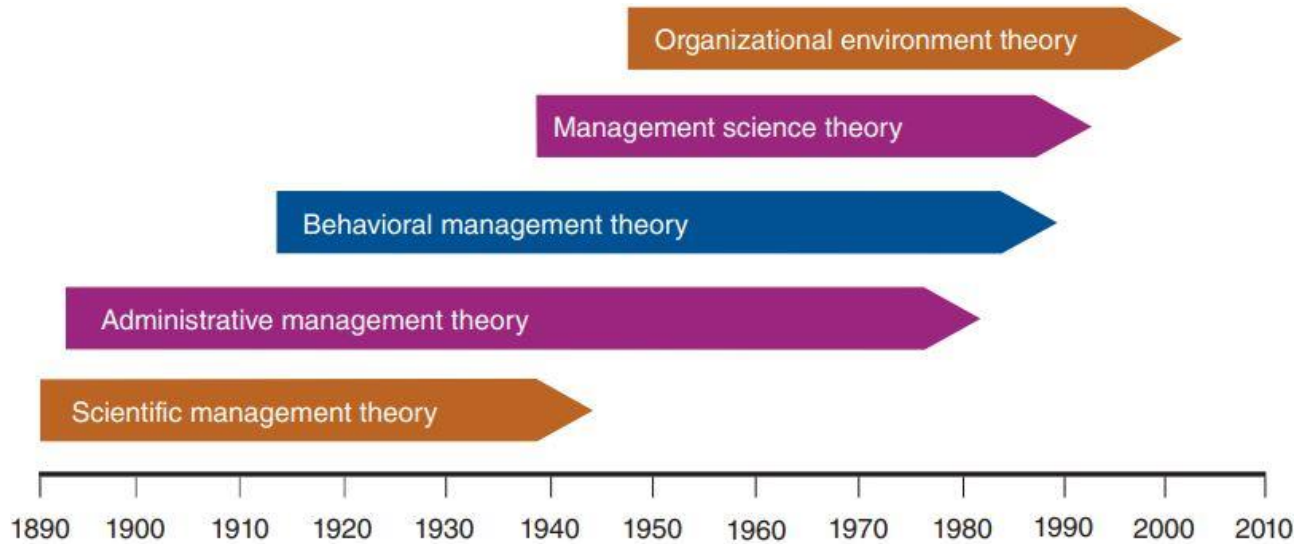


Figure 1. The evolution of Management theories.
Source: Jones and George (2016).

set of problems. The branches include the following;

Quantitative management

This branch of the Management Science school makes use of mathematical tools (such as linear programming, financial modeling, simulation, queuing theory, etc.) to help managers make the strategic or tactical decisions (MeroSpark, 2014). For instance, financial modelling can help a manager decide how to invest his capital in the most rewarding way.

Operations research

This branch of the Management Science approach provides managers with a set of techniques (e.g. stepping stone, economic order quantity) that can be used to analyze different aspects of an organization's production system with the aim of increasing efficiency (Jones and George, 2016). With the advent of information technology, regular communication and benchmarking has been made easier and this has impacted on the effectiveness of input sourcing and output marketing.

Total quality management (TQM)

This branch of Management Science focuses on analyzing an organization's value chain (input, conversion and output process) to increase the overall quality of the product or service (Lawrence and Steck, 1991). Once again, sophisticated computer-controlled processes like

machine vision and three-dimensional printing help to enhance precision in production process and overall quality (Deming, 1986).

Management information system

Management information systems generally refer to the collection of information systems that provide managers with information on both internal and external events. Information reduces uncertainty, thus managers make more quality decisions when there is more information available. This branch of Management Science theory helps design information systems (e.g. Transaction Processing Systems, Decision Support Systems, Office Automation Systems, etc.) that provide managers with both internal and external information to make quality decision. IT offers managers new and improved ways of handling information to help them make more accurate assessments of the situation and informed decisions (Dewett and Jones, 2001).

DISTINGUISHING FEATURES OF THE MANAGEMENT SCIENCE APPROACH

Unlike the management theories before it, the Management Science approach applies mathematical models and techniques in a scientific manner to enhance business processes. Mathematical models uncover relationships among several variables within industries (Jeanty, 2019). A mathematical model such as limiting factor technique and linear programming can uncover bottlenecks that slow down the production process and

suggest the best way to circumvent such bottlenecks. The results obtained are often re-inputed back into the model so as to improve the model accuracy (such is the case with machine learning) and this improves the overall quality of decision making.

The Management Science approach involves some underlying assumptions (Rahman, 2013). First, it regards an organization's management structure as a problem-solving mechanism. Secondly, it assumes that all management problems can be expressed in a quantitative form. It assumes that most decision outcomes and human behavior are predictable.

CONTRIBUTIONS OF MANAGEMENT SCIENCE SCHOOL TO THE THEORIES OF MANAGEMENT

One of the major contributions of the Management Science approach to management theories is the increase in precise prediction of certain aspects of the business process. Business processes and systems are expressed in measurable terms and fitted into a model that can predict possible outcomes when there are changes in its constituent variables. The Management Science approach brings a new and practical perspective on how the different aspects of the business, which were previously regarded as unrelated, depend on one another for the overall effectiveness of the organization (Jeanty, 2019). This school of thought provides a new and proactive method of dealing with complex managerial problems. The possibility of identifying existing relationship among the organizational variables gives managers a better understanding of the overall organization's process. Also, giving that organizational variables are expressed in measurable terms, it becomes easier to monitor processes and evaluate performance with a lot of precision, order and objectivity.

RELEVANCE OF MANAGEMENT SCIENCE THEORY IN CONTEMPORARY BUSINESS OPERATIONS

According to Zand and Sorensen (1975), the aim of Management Science is to improve the effectiveness of an organization by persuading managers to use the conclusions of rigorous quantitative analysis to allocate resources, design information systems, and make policy decisions. These rigorous quantitative analysis are still quite relevant today. Hassan (2013), in his study, showed that many of the management theories and philosophies are relevant in addressing contemporary management issues for both small and large businesses. The Management Science theory is not merely a tool that can be used to improve efficiency and effectiveness of firms' operations. It refers to a category of methods that use quantitative tools and techniques to achieve optimum quality. There are many such methods that are currently

being used in contemporary businesses. For instance, the Management Science approach has brought about the development of computer technology which has had enormous impact on the contemporary business world (MeroSpark, 2014). According to Luthans and Stewart (1977), the complexity of organizational problems facing contemporary managers requires a more calculative approach to taking rational and effective decisions, thus basic computer applications can and have been developed to analyze and predict some management issues that may crop up at various organization levels. For instance, computer applications can determine the threshold on wages for different positions that will optimize employee motivation without wasting resources unnecessarily (Chron Contributor, 2020). This is currently helping businesses to optimize labor costs.

Another practical application of the Management Science approach in contemporary management and business process is in lean manufacturing. Lean manufacturing is a manufacturing approach that places emphasis on the minimization of waste while maximizing productivity simultaneously. Waste refers to any input or activity that does not add value from the customer's perspective. In 1991, Toyota Motor Company developed the lean manufacturing method in its production system (Jones and George, 2016). Linear programming and Economic Order Quantity are very important tools in minimizing waste. Toyota Motor Company also adopted the Just-in-Time (JIT) production system which emphasizes efficiency by ordering raw materials and other inputs strictly on demand so as to avoid unnecessary storage costs and other forms of wastage (Toyota, 1995).

There are many other practical applications of the techniques and models associated with the Management Science approach in contemporary business decision-making. Examples include; scheduling of passengers and crew in the airline industry, decision on location of new facilities, managing flow of water from reservoirs, gaining access to information needs of health care customers and providing solutions and understanding and analyzing the effects of strategies adopted by competitors (Navarro, 2015).

LIMITATIONS OF MANAGEMENT SCIENCE THEORY

Although applications of Management Science are evident in many management practices (especially in planning, operations and controlling), it cannot be fitted to all kinds of management processes. The implementation of the Management Science theory involves some underlying assumptions (e.g. business processes can be quantified), and sometimes these assumptions fall short of real-world situations. Management problems that are more human than technical (e.g. staffing, leadership, organizing etc.) can hardly be solved using the

quantitative tools of Management Sciences. This is one of the biggest limitations of Management Science approach. Some studies view the Management Science theory as magnifying the need for technical managerial skills while downplaying the need for the human managerial skills (Katz, 1974; Weihrich, 1993) while others still believe that Management Science is a human science, in as much as it has man as both its object and subject (Zand and Sorensen, 1975). The theory ignores the importance of people, relationships and other non-quantifiable factors. Some aspects of management activities cannot be easily quantified because they involve some human elements which are unpredictable. For this reason, some have argued that it does not qualify as a school of management theories (Rahman, 2013). Also, the Management Science theory prescribes a limited number of tools for solving specific problems, and the effective utilization of these tools requires some level of expertise and technical skills.

CONCLUSION

The study set out to discuss the history of the Management Science theory and its different branches, its contribution to the body of management theories, its relevance for contemporary management practices and the limitations of its application in decision-making. The Management Science theory was linked with the earlier theory of scientific management in that it applies scientific procedures in minimizing costs and maximizing output. However, unlike the scientific management, the Management Science approach expresses business processes in form of quantitative variables and uses operations research, quantitative techniques and information systems to optimize the utilization of resources and make quality business decisions. The history of the Management Science approach can be traced to Britain during the Second World War while the industrial application of the theory is traced to Robert McNamara during his time at Ford Motors Company in the 1950s. The application of linear programming (one of the Management Science tools) to business decision making can be traced to William Cooper (Mr. Linear programming) also in the 1950s.

Over the years, several branches of the Management Science theory have been developed on the basis of the nature of problems that the tools address. The Quantitative Management addresses decision-making regarding planning and strategy. Operations Research addresses decision-making problems regarding the efficiency of production process. Total Quality Management (TQM) addresses problems regarding the quality of organizations value chain. Management Information Systems provides a framework for extracting and analyzing information with regards to the internal and external environment of the business. This branch uses more of computer applications than quantitative tools.

The major contribution of the Management Science theory is the increased precision in the prediction of different factors affecting businesses. This increase in precision is hinged on the assumption of measurability of business processes in quantitative terms. Business models produced using the Management Science tools can predict different business variables and suggest an optimal combination of resources that can maximize output. Many of the Management Science tools and assumption are still quite relevance in contemporary management decision-making (e.g. lean manufacturing, Just-in-Time production, aircraft passenger scheduling, reservoir flow calculations and analysis of the magnitude of competitors' strategies). However, this management theory also has some limitations. It focuses more on the quantifiable aspects of the business processes and ignores some qualitative factors and processes that cannot be easily predicted, like human behavior, intrinsic motivation and stakeholder relationships. Thus, its applicability is limited. Also, a high level of knowledge and skills is required to effectively utilize some of the Management Science tools and the training required to acquire such skills may be expensive.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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