Supply Chain Management and Economic Order Quantity Model

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ABSTRACT: In this Paper mainly I focused on Supply Chain Management and Economic Order Quantity (EOQ) model. International studies on the optimal reorder quantity based on EOQ, which takes into account carbon emissions, will be examined in this study. Since 2010, it has been carried out through a systematic review procedure. The major components of EOQ models under the carbon emission policy examined in the literature are identified in this study. This study organizes the articles it has studied into categories depending on their included elements. It also outlines the most important aspects of the articles in question, such as the frequency they appear in print each year and the industry they fall into. Researchers hope that this study will make their jobs easier by pointing them to new areas of investigation and research prospects. These are English-language publications from journals that Scopus index. The study gathered, sorted, and analyzed 893 articles. The scope of this study necessitated the analysis of 29 related articles. EOQ model development with carbon emission problems still relied on deterministic demands, according to the findings. Assets that are ready for sale are referred to as inventory, including raw materials, work-in-progress, and finished products. An industry's biggest challenge is figuring out the best way to manage inventory. While the field of inventory management has been around for a while, it is still a hot topic in the scientific community today. The reliability of any method is a crucial consideration in research. Some factors' values are difficult to pin down or even unreachable. Such situations need the use of fuzzy models for inventory management. Existing inventory control models are examined in this research.

KEYWORDS: Supply Chain, EOQ, Carbon emissions, Uncertainty

INTRODUCTION: The construction of mathematical models and the determination of the ideal inventory control method are frequent tasks associated with this issue. Inventory management models have the advantage of producing optimal solutions that can be put into action in rapidly changing environments, such as those where conditions vary daily. Modeling inventory management systems in the face of uncertainty necessitates new and improved approaches. It's not always possible to get all the information you need about the item you're trying to handle. System analysis and the development of a systematic approach to the management challenge in general are required to solve such complicated jobs. Demand, cost structure, and physical characteristics of the system are only a few of the components that go into inventory models. There is a possibility that these assumptions are incorrect. There is a lot of ambiguity and fluctuation in this situation. Models of inventory control under uncertainty are the focus of this study. More than 30 research publications are reviewed in this paper, and the goal is to categorise the models into distinct categories and discover new avenues of study.

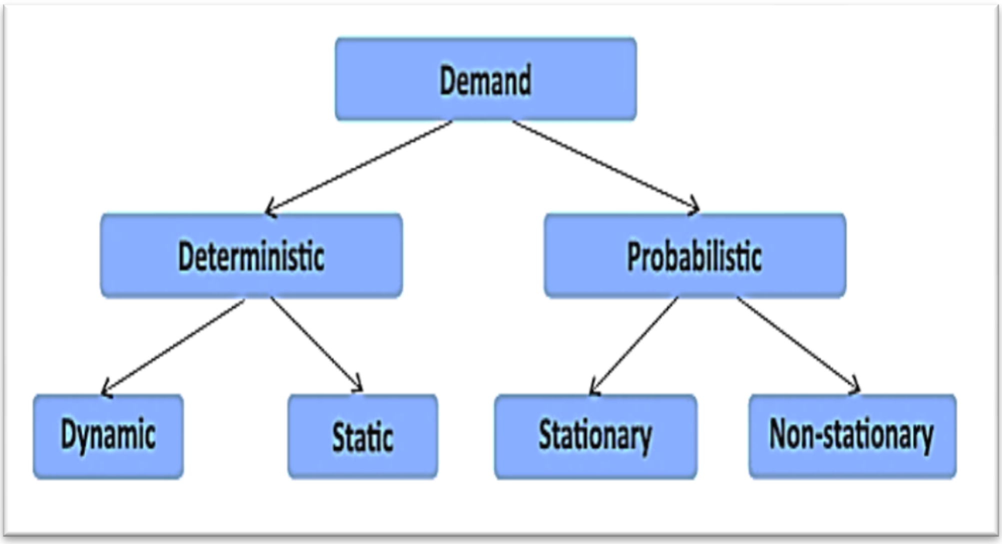
Research on inventory and supply chain models that take carbon emission policies into account has been published often in the recent decade. Some researchers are inspired to do a literature review as a result. A variety of study publications discussing different inventory models with carbon emission issues served as the basis for the researchers' collection and analysis of various research data. There has been a review of the literature on a management model under carbon emission policy undertaken by Su et al. The newsvendor model, economic order quantity (EOQ), and lot sizing were all brought up in the context of operational management under carbon emission legislation. On the supply chain management under carbon emission policy, Chelly and colleagues (2019) did a review of certain logistics decisions (operational management, technology investment, and supply chain design coordination).

There are major differences between our new research and the previous review studies. Carbon emission policies are examined in this study's single-echelon EOQ inventory model. Under the carbon emission constraints examined in the literature, this study is looking for essential features of EOQ and identifying research gaps for future studies. Global warming has been caused by the accumulation of carbon emissions for many years. Most carbon dioxide emissions are caused by the materials and energy used during production, according to numerous studies (Tsiliyannis, 2015). Carbon emissions can be produced via inventory activities, industrial activities, and transportation (Chelly et al., 2019). It was proposed by Bonney & Jaber (2011) to investigate how inventory decisions affect carbon emissions. Additionally, vehicle emissions and waste disposal costs are included in a new inventory cost model that incorporates these additional expenses. An EOQ model built as part of the research points to a larger minimum order quantity. For the past ten years, the concept has been steadily expanding. Optimal decision-making is examined in a variety of managerial contexts by a number of researchers. However, a complete literature evaluation of this idea's development is still lacking. Thus, our research tries to fill this need."Literature review is a systematic, explicit, and reproducible design for the identification, evaluation, and interpretation of the existing body of recorded documents," as claimed by Fink (2014a). A literature review aims to synthesize previous studies by identifying commonalities, themes, and issues. The second goal of a literature review is to aid in the identification of relevant conceptual content in the subject and to aid in the development of theoretical frameworks.

INVENTORY MANAGEMENT:

If a proper and timely inventory control plan determination is made, it is possible to free up a considerable quantity of frozen assets in the form of stocks. This ultimately boosts the efficiency of resource utilisation. Regarding inventory management, despite the fact that our civilization produces literally millions of different sorts of things, there are just two key choices: How much inventory should be replenished at a time? Do you know when it is appropriate to place an inventory replenishment order? Inventory management goals are typically reduced if it is more lucrative to accomplish rapidly but more expensive or slower but cheaper. optimum inventory control reduces the total cost of milestones relating to the production, storage, and inventory shortfall per unit of time or for a specified (including infinite) period of time. Management models differ in the information they provide about the simulated system's features. The nature of a mathematical model is deterministic when the values of the model parameters are well-defined. Distribution models are stochastic if the parameters of the system are random values with a known probability (probabilistic). It is a static model if all of the model parameters remain the same across time, whereas dynamic models change with time. A one-time choice on reserve levels for a specific period necessitates static models, whereas subsequent decisions about stock levels necessitate dynamic models, which are used to account for current changes. In the face of uncertainty, the inventory management challenges must be solved when static patterns of change in system parameters cannot be installed. Inventory management models take into account the following characteristics: Singles vs. a group of numerous objects. A single item might be utilised in isolation for calculations, or numerous interdependent goods must be taken into account because of collective budget or space limits, coordinated control or substitutability between things, and this dimension takes this into consideration. The amount of time it takes for something to happen. When the selling season for a product is short, extra stock at the end of the season cannot be utilised to meet the demand for the following season. A single-period model is necessary in these instances. A rolling horizon implementation strategy is a standard method for dealing with different time periods. At the beginning of each period, decisions are made that take into account only a small number of future periods. If all goes according to plan, we'll have a problem-free next period when we implement our decisions. The total number of points at which stock can be stocked. On occasion, a single stocking point can be treated separately from the rest of the system. A lot of the time, there are multiple locations where you can find the same thing. During multi-tiered circumstances, one site's orders become part or all of the demand at another location (e.g., a branch warehouse) (e.g., a central warehouse). Additionally, many locations at the same echelon level (e.g., several branch warehouses) with the capability of transshipments and redistributions might be considered horizontal multiplicity. The product's nature. A product's kind is one of several criteria that the product type dimension takes into account. Perishable, consumable, repairable, and recoverable are just a few examples of product attributes. It is normal for an item to degrade as it is being stored. As a result, it must be included in the inventory strategy. Depending on where it is stored, it could be slightly different. Demand in terms of its nature. The demand process can be modelled in a variety of ways. The demand types depicted in Figure 1 can be broken down further. There is no room for error with deterministic demand. It comes in two varieties. One of them is inert, meaning it doesn't change. How much demand is already known or can be accurately estimated. The second category is dynamic, meaning it can change. This form of demand fluctuates throughout time, although the pattern of fluctuation is well-established. Distribution using fixed parameters in a fixed location. This sort of demand follows a known or estimated probability distribution. The normal, gamma, and Poisson distributions are all often utilised. Probabilistic demand that isn't stationary. This form of demand is like a random walk that changes direction and rate of increase or drop on a regular basis over time. Demands are classified as either independent or reliant on the source of the demand. Individually felt needs are what we mean by "independent" demand, which is the demand that comes from customers acting on their own. Demand for finished items depends on the producer's production plan, and each component's need is linked to and dependent on the demand for the other components. Characteristics of the supply chain. There may be restrictions or constraints put on supply chain incoming procedures as a result of their nature. Typical criteria taken into account in this dimension include minimum and maximum order sizes, replenishment lead times, and so on. Lead-time can take three different forms, according to Silver (2008). The first version has a defined lead time for each replenishment; the second has a random lead time; and the third has seasonal factors that may impact the time it takes to fulfill an order. Order size constraints are taken into account because suppliers typically have restricted capacity. Additional assumptions include a fixed and predictable lead time. Deficit and penalty. In order to avoid a scarcity of a specific product type that is handled by the system, a warehouse is built. A lack of stock at the correct time might result in downtime, irregular production, and other losses. Losses incurred due to the shortfall will be referred to as "penalties." Any model is a representation of reality that has been abstracted. As the number of dimensions increases, the model's ability to meet real-world needs increases as well. Input values for the mathematical inventory model parameters are difficult to come by. The individual in charge of making decisions in this situation is frequently working in an environment with a variety of unknown variables. Uncertainty in consumer demand, manufacturing lead times, and delivery lead times are all factors that go into inventory control. Existing theories of inventory management rely on deterministic parameters and modules for decision-making, which does not account for all of the variables in the real world. Such situations need the use of fuzzy models for inventory management Quantitative approaches to dealing with imprecision and uncertainty are proposed by fuzzy set theory. Fuzzy logic is utilised extensively in risk analysis, expert system development, and in conjunction with artificial neural networks. The fuzzy sets introduced by Zadeh are the theoretical foundation of fuzzy logic (1965). Increasingly, it is being used in production management software to model ambiguous data. A task's level of uncertainty can be measured by comparing the quantity of knowledge needed to complete it with what is already known, according to Galbraith (1973). A variety of sources of uncertainty hampers real-world production processes. Ho (1989) divides them into two categories: uncertainty about the environment and uncertainty about the system. Demand and supply uncertainty are examples of environmental uncertainty that go beyond the industrial process. Some examples of system uncertainty include operational yield uncertainty, production lead times, product quality uncertainty, system failure, and product structure change. Inventory management theory has entered a new phase with the development of models that account for uncertainty.

Figure 1: Types of demand classification



ECONOMIC ORDER QUANTITY MODELS:

The economic order quantity (EOQ) model is the most well-known of the fixed order size inventory models. With this approach, you can figure out the smallest possible order size while still keeping all of the associated expenditures to a minimum. The following assumptions constrain the model's development: No shortages are allowed, lead times for orders are consistent, and the entire order amount is received at once. Demand is known with confidence and remains steady throughout time. T Ford W. Harris first proposed the EOQ model in a piece published in Factory, The Magazine of Management in 1913. (Harris, 1913). This model served as the foundation for a slew of investigations. However, the model's coefficients may be a little iffy. Fuzzy theory was pioneered by K. S. Park, who suggested a single product inventory model based on the Harrison model with fuzzy parameters (Park, 1987). Fuzzy EOQ inventory models have been developed by Chen and Wang (1996), Roy and Maiti (1997), Yao et al. (2000), and Chang (2004).

By balancing inventory holding costs with average fixed ordering costs, the Economic Production Quantity (EPQ) model predicts how much a corporation or store should order in order to minimise total inventory expenses. E.W. Taft created the EPQ model in 1918 (Taft, 1918). The EOQ model has been extended to include this method. Many economists still utilise the traditional economic production quantity model (EPQ). There have been numerous initiatives to extend the EPQ model by releasing various assumptions and/or putting in place new ones so that the model better reflects the reality of the world. Because of the scarcity of natural resources and the consequent rise in the price of raw materials, rework has recently gained substantial attention. Lee and Yao have developed a new set of fuzzy input parameters for modified Economic Production Quantity models (1998). The writers are fuzzed out characteristics such as demand amount and production quantity per day. In the actual world, both of them are subjected to daily inconveniences. A model of production inventory in which the product quantity is a fuzzy number is considered by Chang (1999). Chang (1999). An example numerically-based comparison was made between fuzzy and crisp solutions to this problem. Lin and Yao (2000) address the production inventory model optimal solution in their paper. Fuzzy inventory models with fuzzy parameters were introduced by Hsieh (2002), who developed two models: one for crisp production quantity, and one for fuzzy production quantity. Models of the production inventory costs under the fuzzy arithmetic operations of the Function Principle were proposed. Fuzzy total production inventory cost was defuzzified using the Graded Mean Integration Representation method The inequality constraint problem was solved using the Extension of the Lagrangean method. Lee and Yao fuzzed up the daily demand and output quantities (Lee, 1998).

JOINT ECONOMIC LOT-SIZING MODELS:

Many studies have been done on inventory models that deal with the issue of inventory coordination between a buyer and seller. Joint economic lot-sizing (JELS) models fall under this category of inventory models. Models aimed at developing a buyer-seller inventory plan that is better for each member's non-coordinated approach are the primary goal of these models. Lam and Wong (1996) made one attempt to extend Dolan's approach. This joint economic lot size problem with various price breaks was solved by using fuzzy mathematics. Fuzzy numbers are used to model both single- and multiple-incremental price reductions. Das, Roy, and Maiti suggested a buyer-seller fuzzy inventory model in which degradation is discounted (Das, 2004). This paper uses both crisp and fuzzy environments to create multi-objective joint economic lot size models. In this case, the goal is to reduce the average cost to the buyer while increasing the average revenue to the supplier. The model is solved using a fuzzy goal programming method. Defective elements were incorporated into Ouyang et al. (2006) model. As part of an integrated vendor-buyer inventory model, the researchers used many modelling methodologies to regulate the faulty rate. Crisp faulty rate, triangle fuzzy defective rate, and statistical fuzzy defective rate are all examined in this study. We can approximate these two fuzzies' combined total expected cost using the signed distance approach. Yang devised a stylized model for an integrated vendor-buyer inventory model with a fuzzy annual demand and a fuzzy changeable production rate (Yang, 2007). The signal distance ranking approach for fuzzy number is used in the model to determine the estimation of joint annual total expected cost in the fuzzy sense and the associated buyer order quantity.

SINGLE-PERIOD MODELS:

Newsvendor is a single-period probabilistic inventory model, to determine the least amount of orders necessary to minimise the projected underage and overage costs (costs caused by a shortfall) (costs due to holding inventory). D. Petrovic (1996) created the first single-period inventory models, which he based on his concept of a second-level fuzzy set and his s-fuzzification and arithmetic defuzzification approaches. The classic newsboy dilemma was expressly fuzzed by Ishii and Konno (1998) because of the ambiguity of the shortfall cost. Using an L-shaped fuzzy number, they calculated the scarcity cost of the so-called "fuzzy newsboy." It was then that the total expected profit function was thought to be a fuzzy number. Fuzzy max order of profit function (Fuzzy min profit function order) was found and compared to the non-fuzzy newsboy problem's best order. A single-period inventory model with fuzzy demand was suggested by Kao and Hsu (Kao and Hsu, 2002). This study focuses on possibilistic circumstances in which the needs are described by membership functions that are subjectively specified. There is a fuzzy total cost associated with each order quantity Q, including procurement, shortage, and holding costs. One-period inventory problem in an uncertain and imprecise mixed environment is presented by Dutta and colleagues (Dutta, et al., 2005). The purpose of this work is to introduce demand as a random variable that is vague. A new methodology was devised for this model with fuzzy random variable demand to calculate the best order quantity using a graded mean integration representation. The traditional newsboy problem was used to demonstrate the model.

Table 1: Classifications of different EOQ models

Key topics	Number of articles	Examples
Pricing & discount	1	Taleizadeh et al., 2018
Shortage	5	Taleizadeh et al., 2018; Lee et al., 2017; Sarkar et al., 2018; Lin, 2018
Multi-item inventory models	2	Lamba and Singh, 2018; Bozorgi, 2016
Inflation and time value of money	0	-
Credit and different payment Problems	2	Cao et al., 2018; Sarkar et al., 2018
Investments, Promotion or Budget Constraint	4	Lee, 2019; Toptal et al., 2013; Lin, 2018; Zhao et al., 2017
Out-dating, waste or shrinkage	7	Zadjafar and Gholamian, 2018; Kazemi et al., 2018; Shu et al., 2017; Lin, 2018; Soleymanfar, 2015
Product characteristics or customer specifics, including behavior, reservations, returns, etc.	2	Wu et al., 2017; Bazan et al., 2016
Issue policies (FIFO, LIFO, etc.) or substitutions of perishable items	0	-
Advances in technology (RFID, TTI) corresponding to inventory models	1	Toptal et al., 2013
Distribution, routing, transportation, and location problems	4	Lee et al., 2017; Wu et al., 2017; Bozorgi et al., 2014; Zhao et al., 2017
Rework, process breakdown, machine interruption, preventive maintenance, etc	3	Liao and Deng, 2018; Shu et al., 2017; Sarkar et al., 2018
Two-and multi-warehouses	0	-
Sources of emission		
Transportation	18	Wang and Ye, 2018; Tian et al., 2013; Gurtu et al., 2015; Bouchery et al., 2012; Shu et al., 2017; Purohit et al., 2013; Bonney & Jaber, 2011
Production	8	Zadjafar and Gholamian, 2018; Tao and Xu, 2019; Shu et al., 2017; He et al., 2014; Zhao et al., 2017
Inventory	19	Wang and Ye, 2018; Tian et al., 2013; Kazemi et al., 2018; Chen at al., 2013;

		Hovelaque and Bironneau, 2015; Purohit et al., 2013; Bonney & Jaber, 2011
Carbon emissions legislation		
Carbon cap	5	Liao and Deng, 2018; Lee, 2019; Toptal et al., 2013; Chen at al., 2013
Cap & Trade	10	Lee, 2019; Toptal et al., 2013; Cao et al., 2018; Lamba and Singh, 2018
Carbon tax	12	Liao and Deng, 2018; Gurtu et al., 2015; Lee, 2019; Toptal et al., 2013
Demand Type		
Deterministic	21	Bouchery et al., 2012; Lee, 2019; Toptal et al., 2013; Taleizadeh et al., 2018; Shu et al., 2017; Hovelaque and Bironneau, 2015
Stochastic (price, stock-level, or stock-age-dependent demand, etc.)	13	Zadjafar and Gholamian, 2018; Tian et al., 2013; Zhang et al., 2019; Lee, 2019; Toptal et al., 2013; Liao and Deng, 2018

MULTI-PERIOD MODELS:

It's important to note that there may be stock leftovers from earlier periods when using a multi-period model, making it more difficult to determine the best order quantity to use. Inventory and production decisions are linked and time-dependent in real-world applications. Models for multi-period lot-sizing have been developed using fuzzy logic. Table 3 summarises the analysis of multi-period models.

CONCLUSIONS:

Efficiencies in inventory management have grown in importance over the last few years. New inventory models are now available for managing inventory levels. In this study, we reviewed the existing literature on inventory control models that account for uncertainty. Almost all of the analytical models focused on a single form of uncertainty and assumed that the manufacturing process was simple to begin with. For the most part, demand and acquisition costs are treated as fuzzy variables. There are advantages and downsides to each model based on assumptions, but many writers develop inventory control models that employ fuzzy logic. The existence of such a large number of models demonstrates that fuzzy set theory is an effective strategy for inventory management, which could lead to a significant improvement.

Each assessment focused on identifying how the inventory model was developed using the fuzzy set theory. Model categorization and evaluation can be broadened in scope.

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