

# Inventory Optimization Model Design with Machine Learning Approach in Feed Mill Company

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**Abstract.** This article aims to address the impacts that companies can have with the application of machine learning to carry out their demand forecasts, knowing that a more accurate demand forecast improves the performance of companies, making them more competitive. The methodology used was a literature review through descriptive, qualitative and with bibliographical surveys in International Journal from 2010 – 2022 by different authors. Findings show that the references prove that demand forecasting with the use of machine learning brings many benefits to organizations, for example, since the results are more accurate, there is better inventory management, consequently customer satisfaction for having the product at the right time and place. Further, this article concludes and suggests that the use of machine learning is able to identify variables that affect the demands, with this it makes a forecast closer to reality and helps managers to make more accurate decisions, improving strategic planning and supply chain management. of company supplies.

Keyword: Machine Learning, Artificial Intelligence, Small Medium Micro Enterprises (SMEs), Inventory.

**Abstrak.** Artikel ini bertujuan untuk mengatasi dampak yang dapat dimiliki perusahaan dengan penerapan pembelajaran mesin untuk menjalankan perkiraan permintaan mereka, mengetahui bahwa perkiraan permintaan yang lebih akurat meningkatkan kinerja perusahaan, menjadikannya lebih kompetitif. Metodologi yang digunakan adalah literature review secara deskriptif, kualitatif dan dengan survey kepustakaan di Jurnal Internasional tahun 2010 – 2022 oleh penulis yang berbeda. Temuan menunjukkan bahwa referensi membuktikan bahwa peramalan permintaan dengan penggunaan pembelajaran mesin membawa banyak manfaat bagi organisasi, misalnya karena hasilnya lebih akurat, ada manajemen inventaris yang lebih baik, akibatnya kepuasan pelanggan karena memiliki produk pada waktu dan tempat yang tepat. Selanjutnya, artikel ini menyimpulkan dan menyarankan bahwa penggunaan pembelajaran mesin mampu mengidentifikasi variabel yang mempengaruhi permintaan, dengan ini membuat perkiraan lebih dekat dengan kenyataan dan membantu manajer untuk membuat keputusan yang lebih akurat, meningkatkan perencanaan strategis dan manajemen rantai pasokan. persediaan perusahaan

**Kata Kunci:** Pembelajaran Mesin, Kecerdasan Buatan, Usaha Mikro Kecil Menengah (UMKM), Inventaris

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## 1. Introduction

In recent years, machine learning has become a concept on the rise due to the expansion of computing power with the cloud and the exponential increase in stored data. Large online retailers already use these techniques to increase their profitability, collecting various information from their customers while using the sites and performing predictive analysis with the data collected, such as item recommendations, buyer behavior analysis, ad effectiveness, and identification of new markets.

On the other hand, small online retailers or new entrants in this market, do not have the knowledge or do not know the advantages that machine learning techniques can bring to their business. In order to encourage the use of machine learning in small retailers, its application in sales will be demonstrated in a simple and objective way [1].

Currently, there are several companies in the same field of activities, which means that there is strong competition between them. The main challenge they face is to be able to satisfy the customer, so that they can guarantee the product or service available at the moment they want. The company that is able to serve the consumer at the moment he wants, having the item he is looking for, certainly has a great differential in the market, consequently more competitiveness [2]

The demands of companies are always changing and that is why it is important to identify the variables that affect them, so that you have the most realistic forecast possible. Without an effective forecast, some factors fail to make a profit for the company, being the stock stopped, where the product is available, but there is no sale of it. And also the lack of the product in stock, where the product is not available to the customer, leading him to look for it in competing companies [3].

Artificial Intelligence (AI) is increasingly present in our lives, in order to streamline processes and save time with a very low percentage of errors. Machine Learning is one of the great inventions involving AI and it is quickly becoming a fundamental instrument for several professional areas, such as, in the financial area, its use has been applied to detect fraud, in the area of health to identify diseases, in the area of logistics for an effective demand forecast, which in turn will be the subject of this article [4].

Artificial intelligence shows promise, among the technologies that can benefit the most in this sector, as it has a range of tools that can automate logistical processes and help companies with the agility and precision, which are indispensable today [5].

Later progresses within the field of machine learning (ML) – a category of manufactured insights methods – can contribute to decreasing vulnerability in deals by anticipating them from accessible information and by finding complex connections between different components and past exchanges. Through ML, it is possible to model how these elements influence sales and make daily forecasts in the case of small companies, bringing greater clarity to the planning and

operation of the business, as well as improving the definition of commercial policies, strategies and tactics [6].

The use of Machine Learning can contribute to organizations, in order to make an efficient prediction, with the least possible error for decision making on how much to produce in their inventories. This forecast is carried out through algorithms that use as a basis, the history of past sales, there are also some variables that influence consumer behavior, these in turn can be identified, this is what makes the demand forecast through machine learning a differentiator from other existing tools. Therefore, the research problem that this article seeks to answer is: How can the application of machine learning impact the demand forecast of companies?

The hypothesis raised is that progressively technological advances are present in companies, giving them more competence and capacity for better solutions, machine learning technology may be proficient, allowing companies to forecast their demands with greater accuracy [7].

The general objective of this article is to analyze whether there are advantages of using machine learning to forecast demand in companies, since good strategic planning is what makes companies more competent today. Therefore, the specific objectives consist of: conceptualizing machine learning, identifying the importance of demand forecasting for the company's strategic planning and, finally, analyzing the results that companies can have with the application of machine learning in demand forecasting.

The research justification will contribute to decision making in relation to the demands of companies and how they can become more competitive. The methodology used for the development of this study consists of a literature review based on bibliographic research on scientific articles published from 2010 to 2022, focusing on the application of Machine Learning in SMEs.

Small retailers and new entrants to the online retail sector often do not have the necessary technical knowledge [9] or do not know how to measure the benefit of applying machine learning techniques in their operations. Among these operations, warehousing is able to take advantage of several techniques aiming at the balance between cost and availability of products, starting from "the premise that high levels of inventory generate high logistical costs" [10] and low levels can lead to breakage.

Out of stock is a major trap for retailers and the industry as it negatively affects the relationship with the customer, as "consumers postpone the purchase or buy another similar product that affects the sales of the product supplier" [11] and "in the long term, consumers want to change stores if they cannot find the products they are looking for" [11].

The main objective of this article is to present and identify concepts and methods of machine learning with various case studies with applications of artificial intelligence techniques in the inventory planning and control sector, especially in the management of the inventory scope of SMEs, which is directly impacting the costs of products and company results. Making it one of

the key factors for improving competitiveness in a market where customers are very demanding and the pressure for prices and quality reduces margins.

## **2. Theoretical Review**

Due to technological advances, many benefits such as process improvement are caused in companies, this is because the use of technology facilitates and speeds up the development of their activities, that is, it causes the optimization of processes and, as an effect, the maximization of profit [12]

Companies have as a goal, to reduce the costs of their products and maximize their profits, so that this becomes possible, the management of their supply chains is essential, because managers will be able to have control of the entire process of their services. However, for better management, it is important to carry out strategic planning in the company, so that the managers' decision-making in relation to the demands are correct [13]

The S&OP (Sales and Operations Planning) process allows organizations to become more competitive, as it is done with the participation of various sectors of the company (sales, marketing, demand management, production, inventory management and introduction of new products). products) providing a strategic vision that results in a good performance for the organization as everyone is focused on achieving the goals. According to [14] S&OP contributes to balancing the supply and demand of companies, in order to avoid: excess or lack of inventory, reduced sales, loss of customers, etc.

In a study carried out by [15] he developed a prediction through a Neural Network known as Long Short – Term Memory (LSTM), which generated predictions with the most accurate results. [16] also made a prediction through the LSTM model and the results were more satisfactory compared to the statistical models. [17] using XGBoost, one of the machine learning algorithms, created a prediction model that had a lower margin of error compared to the statistical models generally used by companies. As well, [18] that using another type of Neural Network, called Multilayer Perceptron, had viability of the predictions.

### **2.1. Artificial Intelligence**

Currently, artificial intelligence is divided into two subdivisions:

First, Machine Learning: the machine learns from data informed through evaluation and categorization, allowing pattern recognition [19]. With this, it manages to generate conclusions, decisions and even insights. [20] The algorithm acquires knowledge through this data and can be improved over time. There are several subdivisions, such as concept learning, decision tree, perception learning, By as learning and reinforced learning [19].

In general, learning goes through the detection stage, where data is passed to the AI system (artificial intelligence) through texts, images, sounds or information from machines (sensors).

And for continuous learning, it is necessary to enter data cyclically [21]. Then, processing takes place, a step in which the algorithms organize the data. Finally, there is the output of data in the format of patterns or trends, where they become insights and generate value for the execution of a task or decision making [17].

According to [14] learning can be supervised, unsupervised or by reinforcement. In the supervised system, the human being performs the indication or classification of what is being learned. The unsupervised system can verify grouped data and recognize patterns in them [9]. The system by reinforcement occurs with the entry of game-like rules, hence the system learns by trial and error until it specializes in the task, it can also be considered a technique of positive reinforcement [6] and also have transfer learning, which corresponds to the reuse of an algorithm that was used for a task that can be reused in another without the need for development from the beginning [12].

Second, Deep Learning: refers to the concept of continuous learning from information obtained by categorizing patterns into specific divisions [13]. There is evidence that over time the system improves in proportion to the data entered. [8] cites that this system is based on neural networks and can get closer to the functioning of human cognition, learning is reinforced as the experience repeats, improving every day [18]

According to the task to be performed, the machine can learn in different categories of intelligence: detection, reasoning and communication [9] being able to be based on image recognition, natural language processing, information retrieval. and reasoning with logic of evidence.

Machine learning along with Big Data and high performance computing technologies were implemented with the aim of developing new possibilities to unravel, quantify, and understand a large amount of structured and unstructured data arising in the age of modern technology [3]. Machine learning was an evolution of a subfield of artificial intelligence with the purpose of developing self-learning algorithms to obtain knowledge from data and make predictions [10].

The methodologies that involve machine learning seek the acquisition of knowledge in order to learn from experience to perform a task, and for that, it shares an interdisciplinary field with statistics, information theory, game theory and optimization [11]. To capture and use the acquired knowledge, machine learning uses tasks that are classified into two main categories defined as supervised and unsupervised learning [19].

The application of machine learning assumes knowledge of the type of variables in the database in values of predictors and classes (outputs). Inputs and outputs can be defined as quantitative or qualitative variables [5]. Some methods are intensively defined for quantitative variables, others for qualitative variables, and others for both. In the case of supervised learning, the regression method is common to quantitative variables, and the classification method is common to categorical or qualitative variables [16].

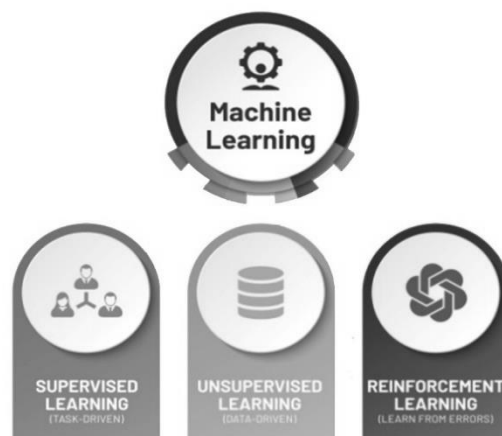
## 2.2. Machine Learning

Intelligent systems capable of predicting events and states and suggesting ideal solutions for future problems in the manufacturing environment are defined as predictive manufacturing systems [2]. These manufacturing systems depend both on advances in the fields of computer science, information technologies, statistics, modeling and simulation, and on the development of manufacturing science and technology [7].

Cleverly frameworks, which look for to anticipate future states to decrease superfluous issues, are a column for prescient frameworks connected to Industry 4.0. Machine learning as an necessarily portion of cleverly frameworks is broadly connected in different zones of fabricating such as optimization, control and quality. The objective of the machine learning method is the discovery of designs that depict connections and structure between information components [6].

The machine learning method offers solid contentions for lovely arrangements to fabricating issues able of learning and adjusting to changes [4]. Characteristics such as the capacity to bargain with issues with tall dimensionality, the competence to decrease the complex nature of the issues, the adjustment to changes within the environment with sensible exertion and taken a toll, the change of existing information by learning from the comes about itself, the capacity to work with fabricating information without the prerequisite of uncommon prerequisites and the capacity to distinguish pertinent intra and interrelationships, make machine learning a total strategy for application in prescient frameworks connected in fabricating [14].

Machine learning is a branch of artificial intelligence that, using algorithms, trains computer systems, making it able to identify patterns and make decisions with minimal human intervention, in addition to providing faster and more accurate results for organizations [2]. There are many algorithms that can be used, according to [8] issues such as the amount of data to be analyzed, the expected objective, the time available for training the model, among others, must be taken into account in order to be successful. the choice of the most recommended algorithm to use is made. The most common algorithms are: Linear Regression, Decision Tree, Support Vectors, Random Forest, Artificial Neural Network etc can be seen in Figure 1 [4].



**Figure 1** Types of Machine Learning

Machines learn through writings, pictures, sounds or data from machines (sensors), which are passed to the Manufactured Insights framework [9]. Machine learning can be isolated into three learning methods, 1) Administered Learning; 2) Unsupervised Learning; 3) Support Learning. Within the to begin with learning handle, the calculations make expectations based on the information given, these information in turn are labeled, that's , when it is as of now known how the result will be. The moment is the inverse of the primary, the information are not labeled, that's , it isn't known what the comes about will be like, its function is to organize the data so that they are separated by things with comparative characteristics. Within the third, the calculations are prepared to distinguish what activity to require depending on the result [18].

According to [2] [22] [24], for the development of the application of machine learning it is necessary to go through 6 steps, from the collection of data to be analyzed to solve the problem to the application of the algorithm:

Data collection: gathering the data of the problem to be solved;

Preparation of input data: at this stage, it is observed whether the data are in the appropriate format for the algorithm that will be applied;

Analysis of input data: here a study is carried out to better understand the information of this data;

Algorithm Training: the algorithms begin to perceive patterns through statistical methods, thus forming the model that will predict the data;

Algorithm Test: this test is the analysis of previously developed models in order to observe if the model performs the predictions correctly;

Application of the Algorithm: Finally, if the model is giving good results, apply the algorithm to solve the problem. At this stage, it is essential to always monitor the model so that new data are collected and the process restarted, if a performance decrease is identified.

Machine learning goes distant past making brilliantly machines that are able of learning with designs to act without the require for human insights. [20]. The fast adjustment to the environment of machine learning calculations for the procurement of future information of a framework bolster supervisors in making choices in fabricating forms with the point of progressing the execution of fabricating forms [21]. Design discovery and acknowledgment of regularities of existing information connections are potential highlights of machine learning. In any case, it is vital to note that it isn't suggested to base choice comes about of a machine learning calculation exclusively on comparisons [23]. Each issue has distinctive examination factors and the execution of each calculation depends on the data accessible within the database, the pre-processing steps and the determination of parameter settings [23].

### **2.3. Importance of Demand Forecasting for the Strategic Planning of Companies**

Demand forecasting is important for the company as it helps improve in its supply chain. It helps to make decisions regarding production capacity, availability of labor, promotional campaigns, etc [18]. For [22], planning and forecasting are essential, since, for the control of activities in the supply chain/logistics.

Strategic planning is fundamental to the success of companies and demand forecasting is the basis for achieving this, it allows managers of organizations to have a futuristic vision, thus helping them to decide their actions [10] S&OP (Sales and Operations Planning) seeks to improve the company's competitiveness, so its purpose, according to [22] is vertical and horizontal alignment. Vertical alignment involves action plans and decisions, strategies that are in agreement between the lower level and the higher level. Horizontal alignment refers to the decisions made by each department (sales, operations, logistics, finance, marketing), which must be agreed upon [14].

The S&OP process involves 5 successive steps: the first step is the collection of historical data of the company regarding sales, production and stock, having this information it is possible to carry out the second and third steps which consist of Demand Planning and Production Planning, the fourth stage is the Pre-S&OP Meeting, held with representatives from each department in order to prepare an action plan, and the last stage, called the S&OP Executive Meeting, is the presentation of the plan to the executives [14].

Without planning, many things are affected in the company, such as out of stock, that is, it is the lack of the product when the customer is going to buy, with this he will buy from the competition, causing the company to lose an opportunity for gain. Another harmful factor for the organization is the idle stock, the accumulation of products that are not sold and cease to make a profit for the companies [20].

### **2.4. Machine learning on Inventory Management**

One of the biggest advantages of stock is the shortening of time and space. For this reason, the stock needs to be strategically located in order to benefit consumers and the industry [9]. Inventory is one of the logistics processes with the greatest need for investment. Its cost can vary between 40% and 50% of a company's logistics expenses [12]. Therefore, poor inventory planning or ineffective control can generate losses. Keeping the cost of inventory at a minimum level can be a very strong competitive differentiator, without letting stockouts occur.

Many variables interfere in the processing of logistical stock and evaluating them accurately and in real time becomes humanly impossible, for this artificial intelligence is applied in these situations where volume of data and dynamism are intrinsic. Artificial intelligence has the potential to greatly impact the logistics and transport sector [24]. Expert systems can be used for inventory control and planning, improving efficiency and inventory management by 8-18% due to reduced errors [21]. These systems can capture patterns and make them available for decision



making regarding the definition of stock levels, replenishment time, material requisition and purchase of inputs [16].

### **2.5. Impacts of Machine Learning Application on Business Demand Forecast**

[22] state that a more accurate forecast, that is, close to reality, companies invest only what is necessary in raw materials, generating better savings for them. Through the benefits that a well-made prediction can bring, machine learning contributes to a more realistic prediction. [20]. Artificial Neural Networks (ANN's) are the main advances in artificial technology, through which intelligent machines are built that are trained to predict demands [18], in addition to identifying the factors that affect the company's sales, such as consumer behavior. Machine learning algorithms, such as regression methods, allow a more effective result in demand forecasting, as their application identifies external variables that influence the decision-making of organizational managers [4].

There are several factors that affect the prediction of demand, namely: the price, since there is a lot of competition, consumers end up opting for those that offer the best price, special dates, weather factors, the quality of the product or service, among many others [16]. Given this, it is evident the importance of having a forecast with the least possible error, and how logistics can offer a product or service that customers want, with good quality, low cost and fast delivery [2]. For [9], trend patterns and seasonality are a challenge for the elaboration of an efficient forecast, with the use of machine learning it is easier to detect patterns in a large amount of data.

According to [9], these challenges are part of the time series, the time series is information observed sequentially over time. Seasonality is variations that may occur, such as holidays, weather conditions, etc. On the other hand, the trend is an increase or decrease of the variables in the observed period. In his research, [22] shows how demand forecasting is done using machine learning, initially the data to be studied are collected and analyzed, then features (variables that help the system learn the behavior of the time series) are created. and predict the future value of an output variable), then the model is tested, based on an evaluation metric (measures used to evaluate the accuracy and performance of predictive models) always trying different variables until the results are satisfactory.

## **3. Research Methodology**

First, a brief contextualization was written with the objective of this paper, and how the research problem, focused on seeks to present the importance of the research developed and how the proposed method (machine learning) and its impacts help SMESs in the management of inventory controll.

Chapter 2 describes the concepts associated with Artificial Intelligence, especially Machine learning and how this technique has impacted management and processes in the industry. This chapter also presents the machine learning concepts together with the impact in the SMEs, and

also exposes the process of building a predictive model, the machine learning technique and its fundamental steps.

Chapter 3 describes the methodology applied to the research based on machine learning models. The chapter aims to elucidate the paths taken to solve the SMEs problem in management of inventory.

Chapter 4 presents the results and discussions based on the analysis procedures performed, based on the theoretical basis, the research objectives and the applied methodology. The chapter aims to present the results of the applied machine learning model, presents how the management inventory problems were resolved. Finally, the Conclusions in chapter 5 of the research is presented, in which the main contributions, the relevant points of the machine learning technique acquired in the elaboration of the work, the difficulties encountered and the suggestions for future work are presented.

Identified of Machine Learning Applications on Previous Literature.

Eleven case ponder related to the application of Machine learning in Stock administration in Little and Medium Companies has looked into for encourage investigation. These articles are looked into in Table 1.

**Table 1** Selected Previous Research of Machine Learning Application in Inventory Management.

<b>Years/Authors</b>	<b>Title</b>	<b>Identified Approaches</b>	<b>Applied in</b>
(2022) Deniz Preil and Michael Krapp	Artificial intelligence-based inventory management: a Monte Carlo tree search approach	<ul style="list-style-type: none"> <li>- Monte Carlo tree search (MCTS);</li> <li>- Classical Beer Game</li> </ul>	Retailer, Distributor, Manufacturer and Supplier.
(2022), Khalil Namira, Hassan Labriji, and El Habib Ben Lahmar	Decision Support Tool for Dynamic Inventory Management using Machine Learning, Time Series and Combinatorial Optimization	<ul style="list-style-type: none"> <li>- XGBoost (eXtreme Gradient Boosting) regression model;</li> <li>- Auto Regressive Integrated Moving Average (ARIMA);</li> </ul>	Automotive Engine Oils Company
(2021), Chuning Deng and Yongji Liu	A Deep Learning-Based Inventory Management and Demand Prediction Optimization Method for Anomaly Detection	<ul style="list-style-type: none"> <li>- Deep Inventory Management (DIM);</li> <li>- Long Short-Term Memory (LSTM);</li> <li>- Crawler Software;</li> <li>- JAVA language on the basis of the Microsoft Windows 10.</li> </ul>	SMEs Warehouse
(2021), Daniel Kiefer, Florian Grimm, Markus Bauer, and Clemens van Dintner	Demand Forecasting Intermittent and Lumpy Time Series: Comparing Statistical, Machine Learning and Deep Learning Methods	<ul style="list-style-type: none"> <li>- Statistic</li> <li>- Machine Learning (Support Vector Regression (SVR)).</li> <li>- Deep Learning (Long Short-Term Memory (LSTM)).</li> </ul>	Walmart Store Inc.

Years/Authors	Title	Identified Approaches	Applied in
		<ul style="list-style-type: none"> <li>- Autoregressive Integrated Moving Average (ARIMA)</li> <li>- XGBoosting.</li> <li>- Support Vector Machine (SVM)</li> </ul>	
(2021), Fatima Zohra Benhamida, Ouahiba Kaddouri, Tahar Ouhrouche, Mohammed Benaichouche, Diego Casado-Mansilla, and Diego L'opez-de-Ipi~na	Demand Forecasting Tool For Inventory Control Smart Systems	<ul style="list-style-type: none"> <li>- Hybrid method Comb-TSB;</li> <li>- Clustering-Based pporach (ClustAvg);</li> <li>- Auto Regressive Integrated Moving Average (ARIMA);</li> <li>- Theta;</li> <li>- Multi-Layer Perceptron (MLP)</li> </ul>	Online Retail Store (Stock&Buy)
(2020), Hardik Meisheri, Vinita Baniwal, Nazneen N Sultana, Harshad Khadilkar, Balaraman Ravindran	Using Reinforcement Learning for a Large Variable-Dimensional Inventory Management Problem	Reinforcement Learning: <ul style="list-style-type: none"> <li>- Deep Q-network (DQN) algorithms.</li> <li>- Multivariable dynamical system control</li> <li>- Heuristic based on proportional control</li> </ul>	Brick and Mortar Stores
(2020) Praveen K B, Rateek J, Pradyumna Kumar, and Pragathi G	Inventory Management using Machine Learning	<ul style="list-style-type: none"> <li>- Artificial Neural Networks (ANN).</li> <li>- A decision support system (DSS).</li> <li>- XGBoost regression model.</li> </ul>	Small/Medium Businesses
(2019), Lolli Francesco , Balugani Elia, Ishizaka Alessio, Gamberini Rita, Rimini Bianca, and Regattieri Alberto	Machine learning for multi-criteria inventory classification applied to intermittent demand	<ul style="list-style-type: none"> <li>- Gaussian kernel (SVM);</li> <li>- Deep Neural Networks (DNN);</li> <li>- Multi-Criteria Inventory Classification (MCIC)</li> </ul>	Production Management of Industry 4.0 Systems
(2019), Souvik Paul, Atrayee Chatterjee, and Digbijay Guha	Study of Smart Inventory Management System Based on the Internet of Things (IOT)	<ul style="list-style-type: none"> <li>- Radio-Frequency Identification (RFID)</li> </ul>	Warehouse
(2018), Yashoda Kiran Lingam	The role of Artificial Intelligence (AI) in making accurate stock decisions in E-commerce industry	<ul style="list-style-type: none"> <li>- Machine Learning System (MLS);</li> <li>- ANN (Artificial Neural Network)</li> <li>- Support Vector Machine (SVM)</li> </ul>	Amazon Go Company
(2016), Tereza Šustrová	A Suitable Artificial Intelligence Model for Inventory Level Optimization	<ul style="list-style-type: none"> <li>- ANN (Artificial Neural Network);</li> </ul>	Company Ordering System

Years/Authors	Title	Identified Approaches	Applied in
		<ul style="list-style-type: none"> <li>- MathWorks</li> <li>- MATLAB Neural Network Tool;</li> <li>- TRAIINGDX;</li> <li>- TRAINSCGL;</li> <li>- TANSIG;</li> <li>- LOGSIG;</li> </ul>	

#### 4. Results and Discussions

In the analysis of Table 1, it is verified that there is a great expressiveness of methods applied to machine learning that include artificial neural network algorithms, support vector models, and random forests. This proves the importance of machine learning in predictive modeling of lead-time in the industry. In order to deepen the knowledge of the works identified by Chart 1, key points of the research carried out are transcribed.

Deniz Preil and Michael Krapp (2022), proposed the a modern approach was proposed for stock administration that combines a demonstrate -based approach and information -driven strategies. Usually a demonstrate that decides the proper time to purchase stocks and the correct time to form extra benefits by offering unused stocks. The proposed demonstrate employments a measurable demonstrate to foresee crude fabric prices based on historical data, a machine learning calculation to anticipate request and at long last a combined optimization model is used to discover the leading choice to create for stock administration. At that point coordinated it into the combined optimization calculation to assist make the finest choices.

Khalil Namira et al. (2022), proposes the improvement of a show that combines time arrangement, machine learning calculations and combined optimization to distinguish openings to purchase stocks at a lower fetched and to offer a parcel of unused stock to create extra benefits for the organization. In this demonstrate, they utilize machine learning models and time arrangement to foresee stock costs and stock request figures to guarantee generation and after that coordinated them into a combined optimization algorithm to assist make the leading choices. They recommend a modern approach is proposed for stock administration that combines a demonstrate -based approach and data -driven strategies. Usually a demonstrate that decides the correct time to purchase stocks and the correct time to create extra benefits by offering unused stocks.

The proposed demonstrate employments a factual demonstrate to foresee crude fabric costs based on chronicled information, a machine learning calculation to foresee request and at last a combined optimization show is utilized to discover the most excellent choice to create for stock administration. The show proposed in this paper could be a choice bolster apparatus with a unused stock administration approach, and this Ponder employments two -year stock information from private companies that fabricate and convey car motor oil. The crude fabric utilized for their generation is Fundamental Oil In a choice bolster apparatus, this inquire about employments the ARIMA (autoregressive coordinates moving normal) show to anticipate crude fabric costs based on verifiable information. At that point, we utilized the XGBoost (eXtreme Gradient Boosting)

regression model to execute request determining. At long last, we coordinated diverse factors into the combined optimization show to assist make the most excellent choices.

This think about concludes that the execution of this choice bolster instrument can offer assistance any company that oversees stock. Estimate request will offer assistance keep up a well -overseen stock as well as minimize the hazard of running out of stock. It moreover makes a difference to maintain a strategic distance from stock surpluses which increment securing costs.

Chuning Deng and Yongji Liu (2021), on their investigate endeavored to analyzed to decrease costs amid the supply chain life cycle by optimizing the IM prepare. Particularly, the IM handle was to begin with defined as a scientific demonstrate, where the objective was to mutually minimize coordinations costs and maximize benefits. This work proposes a DIM profound stock administration strategy to address the challenges confronted by stock administration. In specific, by applying LSTM hypothesis, DIM offers cleverly choice -making capabilities for stock administration.

On this premise, a profound stock administration strategy is proposed to address this show by utilizing long- short term memory (LSTM) profound learning hypothesis. In specific, DIM changes a time arrangement issue into a administered learning issue and it is prepared employing a in reverse proliferation design, so that the preparing handle can be completed effectively. Their test comes about appear that the normal precision of DIM stock request figure surpasses almost 80%, which can decrease stock taken a toll by around 25% compared to other most recent strategies and distinguish bizarre stock activities rapidly.

This work summarizes supply chain and stock administration issues into a unused multiobjective optimization demonstrate that comprehensively considers different stock administration variables. In specific, the goals basically incorporate fetched diminishment and benefit maximization.

Daniel Kiefer et al (2021), centered on compare Deep Inventory Management (DIM), machine learning and profound learning employing a unused metric called Capacity-Arranged Prescient Mistake Fetched (SPEC), which addresses the inadequacies related with conventional measurements. To back the investigate, Daniel et al, utilized a freely accessible information set covering discontinuous and clumped time arrangement utilizing an exploratory plan custom fitted to the shortcomings famous within the past chapter with respect to suitable measurements as well as highlighted strategies. In this work, they utilize strategies from the most recent measurements, machine learning and profound learning procedures to foresee discontinuous and uneven time arrangement requests and we analyze the points of interest and drawbacks of each strategy agreeing to Plan Science Investigate.

This information is given by Walmart and it comprises of roughly 100,000 various leveled every day time arrangement at the SKU level with a length of 1,941 time steps for each arrangement (in spite of the fact that in the event that outside highlight information is accessible, we as it were

utilized univariate time arrangement in this explore). 30 haphazardly chosen time arrangement were anticipated utilizing measurable strategies, machine learning and profound learning. A major commitment of this work is factual execution examination, machine learning and profound learning strategies for anticipating discontinuous and uneven time arrangement.

Fatima Zohra Benhamida et al, (2021), endeavored to proposed: (1) a cross breed strategy, CombTSB, is proposed for discontinuous and knotty request designs. CombTSB consequently chooses the foremost precise demonstrate among a set of strategies. (2) a cluster -based approach (ClustAvg) is proposed to foresee request for modern items that have small or no deals history information. The instruments utilized have been displayed and the calculations behind the proposed APIs have been shared to serve the investigate community for future examinations. The in general comes about are exceptionally empowering and can be essentially progressed by: (a) Investigating other time arrangement pre-processing methods such as Moving Normal, Fourier Change (b) Evaluating demand for misplaced deals within the past and utilizing the coming about gauges to progress. request estimate precision. (c) Investigate the plausibility of utilizing request determining comes about as input for cost optimization apparatuses that will permit retailers to optimize their estimating techniques

Praveen K B, et al (2020) , considered a cross breed technique that coordinating multi-criteria decision making (MCDM) methods with distinctive machine learning calculations is utilized. The strategy employments ABC examination to decide classes and calculations of Artificial Neural Networks (ANNs), Bayesian systems and Support Vector Machines (SVMs) to anticipate diverse classes for stock things. Stock Administration case consider centers on recognizing variables affecting stock optimization among SMEs in steel segment through organized and unstructured surveys can offer assistance in compelling stock administration, and after that this inquire about Gathering variables into two sets as inner and outside factors. The proposed design is determined collectively from five components: Information Ingestion, Information Pre-Processing, Capacity, Include Extraction, ML demonstrate. The demonstrate utilized to perform the forecast is known as the XGBoost (Extraordinary Angle Boosting) relapse demonstrate. XGBoost is an gathering choice tree machine.

Hardik Meisherii et al, (2020), attempted to be analyzed utilizing evaluating the pertinence of fortification learning (RL) to multi -item stock administration within the supply chain utilizing Deep Q-network (DQN) in with evaluated activity space for issue fathoming and Support Learning calculation. The proposed approach appears that there's no slack between the calculation of the expansion comes about and its execution within the store. This inquire about utilized open information sets for brick and mortar stores [21] as the premise for the tests. The initial information set incorporates buy information for 50,000 item sorts and 60,000 special clients.

The most commitments of this paper are (i) defining a parallel RL approach to understanding multi -item imperative stock administration issues, (ii) counting reasonable trade objectives such as accessibility of whole item run and minimizing squander, and (iii) appearing that approaches and arrangements learned can be exchanged without extra preparing, for illustration with a diverse

number of items. A secondary commitment is the near relationship between current issues and nonexclusive control issues in framework flow. We accept it is conceivable to utilize a comparative approach to fathom other stranded asset allocation problems. The proposed approach appears that there's no slack between the calculation of the expansion comes about and its usage within the store.

Souvik Paul, Atrayee Chatterjee, and Digbijay Guha (2019), displayed a investigate of a unused sort of cleverly Stock Administration Framework based on IoT and clarifies its standards and structure. This framework has incredible points of interest over the conventional mode, and we anticipate great prospects for its improvement. The reason of their term paper is to discover the appropriate level of stock to preserve an great level of benefit. To attain this objective, the key is to get it the request and supply it employing a parcel of information preparing. This paper built a supply chain reenactment stage framework based on IoT innovation, analyzes key innovation applications within the framework, and plans a keen rack subsystem, a shrewd shopping cart subsystem.

The proposed approach appears that the framework can give a full run of look administrations

for clients through WEB administrations and realize visualization administration of the whole versatile exchanging prepare so that clients can track the whole prepare of products for security and accomplish more effective supply. chain administration. Lolli Francesco et al, (2019), in their article "Machine learning for multi-criteria stock classification connected to irregular demand", attempted to bridge the gap between stock hypothesis and multi -criteria stock classification because it is an interrelated field of inquire about. This inquire about centered on thing classification for stock control. When a classification system is connected to an stock, it decides the importance of the thing and the level of control placed on the thing. So employing a particular reorder arrangement of each course instead of each thing streamlines the approach to tending to each viewpoint of stock control.

This paper moreover investigation the utilize of directed machine learning classifiers as viable ICT apparatuses for MCICs, in specific back vector machines with Gaussian bits (SVM) and inside neural systems (DNNs). Machine learning devices speak to a challenge for shrewd fabricating, too known as Industry 4.0 - see Wuest et al. (2016) for a audit of machine learning applications in cleverly fabricating. In this paper, discontinuous request designs are considered, which require an advertisement hoc stock framework in terms of determining approaches, likelihood suspicions and ensuing numerical modeling. From a methodological point of see, this investigate detailed that a two-stage programmed classification approach (i.e. classification through recreation of things within the test and classification through machine learning for things exterior the test) can be expanded to any stock framework.

Yashoda Kiran Lingam (2018), proposed the Amazon Machining Learning Calculation strategy: Double Classification Demonstrate, Multi -Course Classification Demonstrate, and Relapse Show to discover out (1) The impact of AI on the e-commerce division in overseeing and determining

stock precisely, (2) The Essential e-commerce models and stock procedures embraced by online retailers, and (3) The Machine learning strategies and AI apparatuses utilized by one of the online retail mammoths, Amazon. In his inquire about, Yashoda utilized program devices counting: Sellics, Determining, Oversee by Stats, Fasten Labs, Restock Master, Ecomdash, Vender Dynamic, Telemetrics, Appath, Stock Labs. Yashoda claims that the machine learning handle received by Amazon and the AI devices utilized by Amazon for stock administration. Machine learning calculations have revolutionized the e-commerce division with a tall profile of accuracy and plan. AI has empowered organizations to track client movement frequently and increment productivity levels.

Tereza Šustrová (2016), conducted a inquire about to inspected and explored and fitting manufactured neural arrange strategies and their application in commerce operations, in specific to supply chain administration to consider suitable fake neural arrange strategies and their application in trade operations, in specific to supply chain administration, conjointly create neural organize models to decide the ideal sum of products requested for optimizing the current stock volume. The objective of inquire about was outlined the arrange cycle of an undertaking. This paper examines the advancement of an ANN demonstrate that can be utilized to optimize stock levels and, in this way, make strides an enterprise's stock administration and requesting framework.

To bolster the inquire about, Teresa utilizing counterfeit neural systems and ANN -based modeling. For information investigation and preprocessing, MS Office Exceed expectations program was utilized. As an instrument for neural arrange forecast MathWorks MATLAB Neural Arrange Apparatus was utilized. Deductive quantitative strategies for investigate were moreover utilized. The input factors for this demonstrate are the 6 most critical components impacting the comes about on the sum requested. These are current request (month to month), request within the next 3 months, request within the another 3 months, current stockroom esteem, buy cost per unit and transportation taken a toll per unit.

This paper claimed that the fake neural arrange show can be utilized for stock administration and parcel measure issues effectively. Systems with the TRAINGDX preparing work and the TANSIG exchange work and the 6-8-1 engineering can be considered most reasonable for manufactured neural systems, as they appear the finest comes about for consequent expectations.

## 5. Conclusion

This paper reviews the literature from 2010-2022 covering the classification and application of Machine Learning methods that were used in inventory management. A total of 11 literatures among the 23 literatures examined, including theses, were identified as relevant in the writing of this literature review article. Predicting demand with greater accuracy is a difficult task, as there are several factors that end up influencing to reach the expected result. However, this task becomes possible when performed by machine learning algorithms and at the same time with the experience of managers, facilitating the observation of variables that can affect demand. Machine



learning is trained based on information from previous sales histories, predicting the quantity of products to be produced, in a non-exaggerated way, so that there is no accumulation in stock, but also that the customer does not run out of product. It is concluded, then, that the use of machine learning for demand forecasting is very useful, due to the variables capable of observing that make managers make better decisions, contributing to better strategic planning and better management of the chain. company supplies. From the research results, it is known the benefits of several Machine Learning techniques used in inventory management, namely Robotic Automation, Data Mining, Inventory management, Intelligent Warehousing, Human & Humanoid, and Business Forecasting.

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