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https://doi.org/10.5109/6793671

出版情報：Evergreen. 10 (2), pp.1113-1119, 2023-06. 九州大学グリーンテクノロジー研究教育センター
バージョン：

Implementation of Machine Learning in Supply Chain Management process for Sustainable Development by Multiple Regression Analysis Approach (MRAA)

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(Received February 1, 2022; Revised May 14, 2023; accepted May 14, 2023).

Abstract: In the digital technology environment, business enterprises are focusing in enhancing the precision on marketing efforts so as to remain more competitive and enhance profit margins. The application of Machine Learning, Deep Learning, Data analytics in supply chain management (SCM) is getting more popular due to the growing consumer demand and organisation are identifying various ways in order to lower the cost of transportation of goods from one location to another. Through the enhancement in theology across SCM process, the data is highly critical for analysing the location and movement of the networks so as to reduce the overall cost involvement in the goods and services. The supply chain process is highly interconnected through physical flow of goods from raw materials to finished goods, hence there are more volume of data and financial flow across the supply chain. Therefore, it is highly important in analysing the increasing complexity in supply chain and also to understand the implementation of ML in enhancing the SCM process for sustainable development and growth among the various companies. The study is an empirical investigation on the key factors influencing the design and implementation of ML in the SCM process by major companies located in India for achieving sustainable development. A total of 132 respondents were chosen and closed ended questionnaire were distributed to them, based on the data collected the researchers performed detailed statistical analysis like Correlation analysis, Multiple regression analysis using SPSS package.

Keywords: Machine Learning, Supply Chain Management, Regression Analysis, Sustainable development, Deep Learning

1. Introduction

The world is rapidly entering a high-end digital era that will enable quick decision-making by utilising cutting-edge technology like artificial intelligence, big data analytics, machine learning, etc. With the availability of these technologies, business leaders in different industries are now transforming their decision making in an effective manner, manage the daily operations, achieve competitive advantage, lower operational cost, support in deploying the resources effective so as to realise the stated objectives.[1)]. The decentralisation of the network, system connectivity, and rapid operational decision-making for improved growth and development have all been made possible by the application of artificial intelligence, machine learning, and other tools. The role of digitisation is to make the supply chain management system from point of procurement until it reaches the end customers in an effective manner. Machine learning is regarded as a subset of artificial intelligence (AI) that helps management and users analyse and compile information based on patterns found in massive amounts of data and information. The ML supports in applying various algorithms which can focus in detecting the available and unknown patterns based on the information, analyse newer insights t the management and also aids in enhancing efficiency of the operations.. ML techniques are mainly used in different industries ranging from manufacturing companies, supply chain systems, healthcare, financial risk management, infrastructure, retail and other industries.

However, it can be stated that ML is mainly applied by various supply chain management companies so as to understand the movement of goods and services, track the location of the vehicles, enable in speedy delivery of goods to the customers and achieve sustainable development. The extensive application of ML in the supply chain management has supported in reducing the cost, support in quick decision making, enhancing operational management and deploy the resources effectively which leads to increasing the profits of the company in a sustainable manner. Traditional methods of tracking the movement of goods are cumbersome and increases cost related to supply chain process as it involves more manual work. Moreover, the traditional methods cannot handle the various issues which are unique in the real-world supply chain management systems, however, ML enable in analysing and forecasting the non-linear issues and support the management to take quick and effective decisions.

Secondly, the traditional methods are not equipped in collating and analysing the unstructured data, which are being sourced from internal and external sources. Whereas ML can enable in analysing the data effectively, understand the patters and prepare quick dashboard reports to support in organisational decision making. The ML is highly focused in applying different models and techniques which assist in forecasting the supply chain performance, enable in measuring the effective utilisation of assets related to supply chain and provide means in reducing the cost for fostering development, Hence, ML is considered as the key aspect in supporting the companies to analyse the large volume of data available in SCM.

Supply chain management focuses in planning, directing and supporting all the activities which are involved in the overall movement of materials from the source of procurement to manufacturing plant, distribution of the goods to the end customers, enhancing relationship with the vendors and customers so as to achieve better growth and profitability.[2].

Fig 1: Role of Machine Learning in Supply Chain Management

The SCM is highly recognised in manufacturing, retailing and related industries as manufacturers tend to procure the raw materials from the suppliers, convert them into finished products and then move the products to the wholesalers, distributors so that it reaches the end customers, With rapid growth in digitisation customers are looking to get the products delivered at quick span in time and also at lower cost, hence the companies are forced to rethink their strategy related to supply chain management so as to meet therein needs of the customers[3]. This study is more focused in understanding the overall design and implementation of ML in enhancing the supply chain process for sustainable development, the study focuses in analysing the key aspects related to implementation of ML in SCM and thereby enhancing the sustainable development.

2. Literature Review

Customer, shipping, freight, orders, sales, stores, and product data are the different categories of supply chain data. SC data therefore originates from various (and divided) sources, including sales, warehousing, production, warehousing, and transportation. In this sense, projections of demand may be under- or over-estimated due to factors such as competition, price volatility, technical advancement, and changes in customer commitments.

Finding the right business partner, such as customers or suppliers, is still one of the most important challenges at SCD to seize new opportunities. This is especially true in connection with globalization and the rapid development of technology. The most important determining factors for the customer-supplier relationship are the number of employees or industry category[4].

Demand projections have improved significantly in quality over the past six months as a result of artificial intelligence algorithms, allowing industry partners to make considerably more detailed plans. As a result, delivery security and product availability can be greatly improved with the help of an automatic flow of information about future requirements to industry partners. Market participants in the pharmacy sector and industrial partners can see the advantages of employing algorithms[5]. Industry partners may rely on better scheduling and order security because of accurate forecasts, while the pharmacy network provides safe product availability and less redundant inventory. Customer satisfaction and cost savings are the end results.

RFID recognition facilitates shipping and automatically updates inventories, however it has a significant flaw. All pallets within range, pallets that need to be transferred, and pallets that have been stored in intermediate storage are detected thanks to the port antennas' extensive range. This implies that it is impossible to distinguish between a mobile pallet that has been loaded into a truck and a static pallet that is unrelated to the shipment in question and, for example, has been scanned by mistake, during a picking cycle. Relevant pallets are indicative of false-positive RFID port readings. To overcome the issue of dynamically predicting the availability of catastrophic items, researchers apply

machine learning (6).

Supply chain risk management (SCRM), which refers to the coordinated and collaborative actions of all supply chain actors, aims to increase resilience and flexibility, reduce supply chain vulnerability, and ensure continuity. and financial achievement. A variety of metrics and choices in SCRM have produced a variety of answers that many scholars have sought after[7]. Therefore, careful analysis of the supply chain data is required to better understand market trends, consumer behaviour, suppliers, and technological advancements in order to improve the accuracy of demand projections[8]. By identifying trends and patterns in this data and using them to improve the accuracy of future forecasts, supply chain expenses can be decreased[9].

Formulation Of Hypothesis

Hypothesis 1: There are no statistically significant differences between supply chain management's sustainable development and operational efficiency as measured by machine learning.

Hypothesis 2: There are no statistically significant differences between supply chain management's sustainable development and competitive advantage through machine learning.

improving profitability through machine learning and sustainable growth in supply chain management do not statistically differ from one another.

3. Methodology

This research is an empirical investigation into the planning and application of machine learning in supply chain management to advance organisational growth[10]. Since the paper is more focused on understanding the design and implementation of extensive machine learning techniques, it is necessary to understand the current measures taken by the Organization for enhancing supply chain network and how the implementation of ML can provide the necessary support in enhancing the sustainable development of the companies[11]. The researchers plan to use a descriptive research design to carry out the study.

ML approaches are mainly applied to handle the large pool of information which are sourced by the management, the ML uses algorithms and other tools so as to analyses the data effectively, forecast the future needs and requirements, enable in enhancing the efficiency in operations, support in moving the goods at lower cost through deployment of assets and achieve competitive advantage[12]. The increase in availability of large volume of data has resulted in increasing the application of ML in different industries mainly in SCM companies[13],

The study is more quantitative in nature because both primary and secondary data sources were used to collect the study's data and information (15). The respondents work for or own businesses that are supply chain-focused manufacturing firms with offices in the United Arab Emirates. A 5-point Likert scale was employed in the questionnaire that the researchers produced in order to conduct a complete analysis (1 for strongly disagreeing and 5 for strongly agreeing). The researchers used a non-probability sampling technique to collect the data from the respondents. There were about 150 surveys handed out, and 132 of them were returned filled out.

Companies in the manufacturing and supply chain industries are currently dealing with a number of difficulties in meeting consumer demands that enhance sustainable development in terms of economic, social, and ecological focuses.

The use of supervised learning, Q learning, support vector machines (SVM), and other ML techniques by business leaders and others has made it possible to resolve supplier selection issues, support the formulation of sensible operational decisions, and consequently lower the cost of transporting goods from one location to another.

4. Analysis And Discussion

The data collected from the respondents are statistically analyzed in detail in this section of the study. IBM SPSS was used by the researchers to conduct the analysis.

According to the demographic study, 87.1% of the respondents were men and the remainder respondents were women. 33.3% of the respondents were in the age range of 31 to 40 years, 29.5% were under the age of 30, 23.5% were above 50, and the remaining 13.6% were in the age range of 41 to 50 years. The manufacturing industry accounted for 64.4% of the respondents, while the remaining 35.6% worked in the supply chain industry. Only 0.8% of them are business owners, while 74.2% of them work in lower-level management, 25% in middle-level management, and 25% in upper-level management.

26.5% of the respondents possess experience of less than 5 years, the same percentage of respondent possess experience between 5 – 10 years, 24.2% of the respondents have more than 20 years, 15.9% of the respondents were having experiences between 10 – 15 years and 6.8% of them were in the age group of 15 – 20 years. Digital technology is being used in the organization

Table 2: Table showing whether the digital technology is being used in the organisation

Digital technology	Frequency	Percent
Yes	96	72.73
No	36	27.27
Total	132	100

According to table 2, 72.7% of respondents claimed that digital technology was used in their organisation, specifically in the supply chain management domain. This indicates that businesses and business leaders are concentrating on utilising the potential of digital technology in order to improve sustainable development in the supply chain management systems.

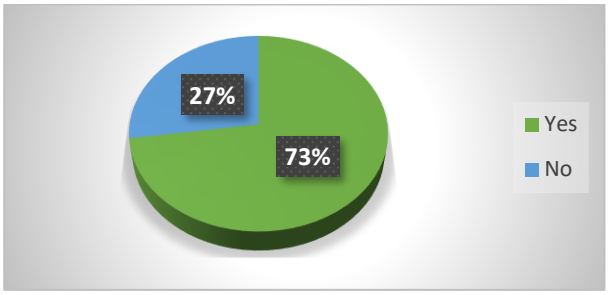

Fig 2: Chart depicting the application of digital technology in the organization

5.1 Impact of Machine learning on Supply chain management

Table 3. Table showing the impact of Machine learning on supply chain management

Impact of Machine Learning	Frequency	Percent
Yes	75	56.81
No	57	43.19
Total	133	100

From table 3, it can be stated that 56.8% of the respondents have mentioned that Machine learning is being applied in the supply chain process, this shows that most of the companies are now turning their investments towards digital technology and machine learning in order to enhance the efficiency in operations, attain sustainable development and enhance profits for the organisation.

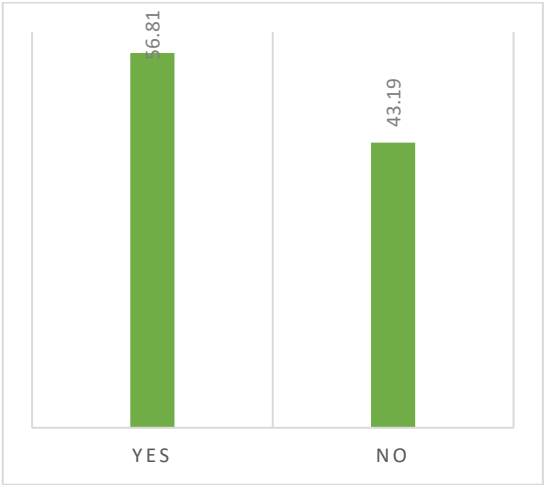

Fig 3: Chart depicting the impact of machine learning on supply chain management

5.2 Multiple Regression analysis

The expansion of the linear regression model, which employs one independent variable, the multiple regression analysis allows for forecasting the dependent variable based on the impact of the independent variables. In the current study, the dependent variable is sustainable supply chain development, whereas the three independent variables are operational efficiency, competitive advantage, and increasing profitability.

Table 4: Regression weights

Model Summary	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	0.297	0.166	1.79	0.076
Efficiency in Operations	0.367	0.086	4.289	0
Competitive Advantage	0.307	0.087	3.516	0.001
Enhancing Profitability	0.234	0.075	3.126	0.002
F Value	185.332			
P Value	0.00			
R	0.902			
R Squared	0.813			

Table 4 shows that the R square value is 0.813, or 81.3%, which is greater than the threshold level of 70%, indicating that the model is a best fit. Additionally, the F value is 185.332 and the p value is 0.00, which is less than the 5% level of significance, indicating that the data is statistically significant 15).

Based on the model summary, the regression equation can be stated as

Y (Dependent variable) = Constant + a X1 + b X2 + c X3

Y (Sustainable development in Supply chain) = 0.297 + 0.367 x Efficiency in operations + 0.307 x Competitive advantage + 0.234 x Enhancing profitability

Therefore, it can be concluded that all independent factors in supply chain management have a favourable impact on the dependent variable, sustainable development.

a hypothesis test

The chi square test, which is one of the non-parametric methods developed to help researchers and others analyse the group differences among the variables, is used to test the hypothesis.

The researchers' hypotheses for the study are as follows:

Hypothesis 1

Null: There are no statistically significant differences between supply chain management's sustainable development and operations efficiency when using machine learning.

Alternative: There is a statistically significant difference between supply chain management's sustainable development and operational efficiency in terms of machine learning.

Table 5: Chi square analysis between efficiency of operation and sustainable development in supply chain management

Chi-Square Results	Value	Degree of Freedom	P Value
Chi-Square	273.73	16	0.00
Likelihood Ratio	200.297	16	0.00
Linear-by-Linear Association	98.414	1	0.00

According to the analytical output from Table 5, the null hypothesis is rejected and the alternate hypothesis is accepted because the test results' p value is 0.00, which is less than the 5% threshold of significance (16). As a result, it was found that the sustainable development of supply chain management and its operational efficiency differed statistically significantly.

Hypothesis 2

Null: There are no statistically significant differences between sustainable development and machine learning for competitive advantage in supply chain management.

Alternative: There is a statistically significant difference between supply chain management's sustainable development and competitive advantage through machine learning.

Table 6: Chi square analysis between competitive advantage and sustainable development in supply chain management

Chi-Square Results	Value	Degree of Freedom	P Value
Chi-Square	270.954	16	0.00
Likelihood Ratio	188.29	16	0.00
Linear-by-Linear Association	99.129	1	0.00

Based on the analysis output from table 6, which reveals that the test results' p value is 0.00, which is less than 5% level of significance, the null hypothesis is rejected, and the alternative hypothesis is accepted. Thus, it was found that the sustainable development of supply chain management and competitive advantage through machine learning differed statistically significantly.

Hypothesis 3

Null: There are no statistically significant differences between supply chain management's boosting profitability using machine learning and sustainable development.

Alternate: In supply chain management, there is a statistically significant gap between increasing profitability through machine learning and sustainable development.

Table 7: Chi square analysis between enhancing profitability and sustainable development in supply chain management

Chi-Square Results	Value	Degree of Freedom	P Value
Pearson Chi-Square	271.659	16	0.00
Likelihood Ratio	175.256	16	0.00
Linear-by-Linear Association	91.065	1	0.00

According to the analytical output from table 7, the null hypothesis is rejected and the alternative hypothesis is accepted because the test results' p value is 0.00, which is less than 5% level of significance (17–20). As a result, it was shown that employing machine learning in supply chain management, there was a statistically significant difference between fostering sustainable growth and increasing profitability (pp. 21–24).

From the overall analysis it can be stated that the independent variables like the application of machine learning towards efficiency of operations, competitive advantage and enhancing profits tend to support in creating sustainable development of supply chain management process[25-27]. Hence, can be concluded that the companies which adopt ML enable in enhancing the overall performance, support in meeting their customer requirements and thereby realise the goals of the stakeholders in an efficient manner[28].

5. Conclusion

Machine learning is seen as a subset of artificial intelligence (AI) that helps management and users analyze and collect information based on available samples in large amounts of information and data. ML supports the use of various algorithms that can focus on identifying patterns based on available and unknown information, analyzing new management information and improving the efficiency of the business. ML attaches great importance to applying a variety of models and techniques to help predict supply chain performance, measure the efficient use of supply chain assets, and provide methods to reduce costs and increase growth. Therefore, ML is an important factor that helps companies analyze the large amount of data available in SCM. From the comprehensive analysis, it can be seen that independent variables such as the application of machine learning for operational efficiency, competitive advantages and better profits generally contribute to a sustainable development of the business' process for managing the supply chain. From this, it can be concluded that companies that use ML improve overall performance, meet customer needs and thus effectively achieve stakeholder goals.

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