International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

A Study to Enhance Supply Chain Performance in Online Merchandising by Integrating Digitalization to SCOR Model using Artificial Neural Network (ANN)

Avula Akhila Ramya[1], Stephan Thangaiah I.S *[2]

Submitted: 10/09/2022 **Accepted:** 20/12/2022

Abstract: Supply chain operation reference (SCOR) model delineate the business endeavors associated with all the stages for customer satisfaction and it plays a major role in online merchandising by integrating digitalization. This study aims to integrate digitalization to SCOR model for enhancing the supply chain performance (SCP) in online merchandising (SCPOM). There are numerous studies on this area which indirectly uses few of the digital strategies and tools like IoT, RFID, GPS, etc., to enhance SCP. This study has analyzed the impact of digitalization in enhancing the SCPOM. A questionnaire with 24 items has been collected from 310 respondents in India, using purposive sampling method and collected the responses from tech geeks who are using online retail platforms on a regular basis. The model validation has been done using a machine learning application (MLA) called artificial neural network (ANN) and a confusion matrix. This study has found that digitalization along with SCOR model influences the SCPOM with R2 in training is 86.98% and in testing is 93.68%. Also, in confusion matrix the accuracy, specificity, and sensitivity of the model is 98%, 94.5% and 98.2% respectively.

Keywords: *Artificial neural networks, confusion matrix, digitalization, SCOR model, supply chain management.*

1. Introduction

This Through machine learning, various supply chain management (SCM) specialties and patterns have been elucidated. Contextual intelligence of machine learning is being sought by the entire industrial world in order to observe several new practices of the supply chain network. Since the supply chain is critical to an organization's ability to make profit, supply chain management plays a vital role in business operations. When working with suppliers to procure high-quality materials, it is essential to understand market supply and demand. However, the ability to manage the supply chain has recently been enhanced by the digital revolution, the implementation of artificial intelligence and machine learning [1].

Artificial neural network (ANN) method is a data analysis method that replicates neuronal array that processes information. The efficacy of ANNs has been demonstrated over the course of many years by their use in a wide variety of problems, each of which possessed a varying level of complexity and were applied to diverse fields. [2], has stated that neural networks are a representation of the way in which arrays of neurons most likely operate in the biologic processes of memory and learning. The universal approximations and computational models are referred to as these networks, and they possess precise qualities as the capability to adapt or learn, to organize, or to generalize data. ANN's acquire their knowledge through the process of training with examples, which "involves the utilization to adjustment of connection weights among neurons by a training algorithm to achieve the desired input–output relations"[3]. It has found widespread application in the fields of calibration, optimization, modelling, and pattern recognition.

Nodes in an ANN are referred to as neurons in the scientific community. The neurons are organized into a series of layers, and the connection weights between them can change depending on how they are linked to one another (Jouyban et al., 2004). Each layer may contain a diverse assortment of neurons, each of which may have a particular transfer function. The first layer, which consists of 5 nodes, is called as input layer and the final layer is called the output layer, and it only has one node. Hidden layers are inserted in the middle of the input and output layers. All of these layers are responsible for the learning process that the network goes through.

In the late 1990s, the Supply Chain Council (SCC) came up with the idea for what is now known as the supply chain operations reference (SCOR) model. This model places an emphasis on SCM's operational aspects [4]). The SCOR-model is also known as the "Process Reference model" due to the fact that it encompasses established concepts and methods, such as business process redesign and benchmark analysis that are considered to be best practices [5]. It is currently familiar and coherent SCM framework available, and it consists of seven essential business processes. SCOR is a tool that can be used in management. It's a supply-chain management process reference model that goes all the way up to the customer of the customer of the supplier.

The SCOR model was developed to represent the various business activities that are required to fulfil the demands of a customer at each stage of the process. Supply chain performance (SCP)

[1] *VIT Business School, Vellore Institute of Technology, Vellore, Tamilnadu – 632014, India*
ORCID ID : 0000-0003-3369-9869
[2] *VIT Business School, Vellore Institute of Technology, Chennai, Tamilnadu – 600127, India*
ORCID ID : 0000-0003-0425-9629
** Corresponding Author Email: Stephan.thangaiah@vit.ac.in*

metrics, that supports the business to establish a standard by which they will judge the work done by their business partners along the supply chain [6]. Business analytics, is a methodical and all-encompassing metric that can be used to evaluate the performance of a supply chain. A wide variety of models have been utilized for the purpose of business analytics. The SCOR model is one of the most well-known ones, and it is one that researchers have utilized quite frequently [6]. The SCOR model provides a comprehensive approach to discovering, analysing, and following the progress of supply chain performance. Using SCOR as an independent variable and SCP as a dependent variable, [7]found a significant impact of plan, source, make, and deliver on SCP.

SCM aims to maximise chain effectiveness by providing superior customer service[8]. Despite the fact that SCP is the foundation of supply chain strategies, assessing it is difficult because it involves both economic and qualitative factors like costs and sales volumes [9]. The primary objective of performance assessment is to provide helpful information that enables businesses to better fulfil the requirements of their clients and achieve the goals that they have set for themselves strategically [10]. During the course of the past ten years, there has been a meteoric rise in the popularity of online shopping as a result of the fact that compared to conventional shopping, it is both more convenient and less expensive. However, the transition from one purchasing method to another, more modern one initially caused customers to be concerned about a number of issues, including the following: the disclosure of private information, the possibility of falling victim to online fraud, a disparity between the quality of the product purchased and the quality desired, and failed shipments, among other issues [11]. Consumers have an advantage when they shop online because it provides them with more information and the opportunity to compare products and prices, in addition to providing them with the convenience and the simplicity of finding the products that they want[12]. It has been hypothesised that modern consumers who value convenience and swiftness will be more content with their shopping experiences if they take place online.

A radical transition from a purely operational function to an independent supply chain management function has taken place in supply chains over the course of the past ten years. As a result, this shift took place. More advanced planning processes such as analytical demand planning are now being used by supply chain management to ensure that customers and suppliers are working together seamlessly.[13].

The supply chains of traditional businesses are being significantly disrupted by the digital economy. The internet and various mobile devices are the primary tools for conducting business in today's digital economy, which is based on digital computer technology. In the current economy, value is created through connections made possible by technological advancements between individuals, machines, channels, and organizations. Consumers are able to conduct research and make purchases for what they want through the use of digital platforms such as mobile networks, social media, and online shopping. Companies are able to collect information in real time about consumers' shopping habits, and this includes everything from their shopping habits to their purchases of specific goods. The custom packaging and shipment of individual units of a product is rapidly becoming the industry standard across the world[12]. The advent of the digital era required significant adjustments to be made to traditional supply chains. At this time, essential aspects of the processes involved in supply chain management are going through an enhanced digitalization process [14].

The 1970s saw the first widespread adoption of microprocessor controllers and distributed control systems, which marked the beginning of the digitalization process. This era is considered to be the beginning of the information age because of the widespread adoption of information technology (IT) and the use of the Internet, both of which have undergone rapid development since the 1990s. What is currently commonly referred to as "digitization" [15] could also be referred to as "the second Digital Revolution." It will lead to an increase in Information Technology, as well as a significantly tighter integration of Operational Technology (OT), in addition to a shift in the daily lives of private consumers.

Digitalization in supply chain management divisions helps develop a market-based structure (Hartley & Sawaya, 2019).Large corporations across a wide range of industries are therefore investing heavily in the incorporation of cutting-edge technology to improve supply chain management capabilities [1]. Technology advancement, particularly the growth of AI technology in business operations, is a key component of the digital revolution. Technology trends in Industry 4.0 have had a significant impact on encouraging businesses to incorporate advanced technologies into their operations [16].

2. Research Gap

Supply chain management has been studied extensively. The integration of digitalization to SCOR model and, its importance in enhancing the supply chain performance in online merchandising has been critical to find among the existing literature. Additionally, since the digitalization and machine learning are relatively new topics in the field, there is a lack of literature. In the field of supply chain management using machine learning and other digital revolution modes, a lack of adequate information has thus been identified as a problem to be solved.

3. Methodology

Research methods used included a cross-sectional study and the application of machine learning to investigate the relationship between proposed SCOR model (which includes source, plan, deliver, return and digitalization) and Supply chain performance in online merchandising (SCPOM). For this study we have used an e-questionnaire, and collected the data from online e-commerce customers in India. A total of 310 responses have been collected using purposive sampling method. Then the data collected has been cleaned and imported into python using spider interface to analyse the data using machine learning applications. Then the data has been cleaned, standardised and then predicted the correlation and descriptive statistics. Further, the data has been splitted into training set with 75% and testing set with 25% of the data. Then the data has been analysed using Artificial Neural Network (ANN) to predict the influence of digitalization in SCOR model to enhance SCPOM. Then the predicted and actual values that were analysed using ANN model were used to find the accuracy, sensitivity and specificity using confusion matrix.

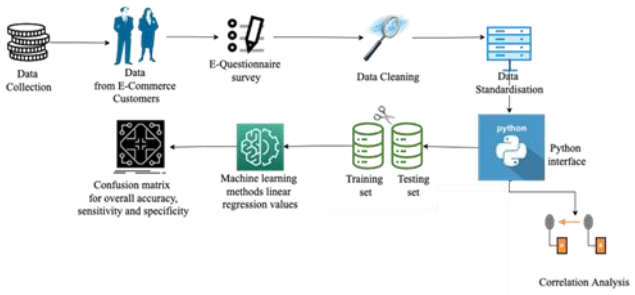

Fig. 1. Process flow chart

3.1. Data Analysis

In order to perform data analysis, the Scientific Python Development Environment version 5.1.5, known as Spyder, was utilised. In order to clean the data, we had to first remove the extreme values, then replace them with values that were more typical, and finally replace the outliers with values that were more typical. Those values that are outside of the range of the interquartile range (Q1–1.5 IQR) and Q3 + 1.5 IQR are considered outliers. Extremes that go beyond the range covered by the Q1–3 IQR and the Q3+3 IQR. Interquartile range (Q1–1.5 IQR or Q3 + 1.5 IQR) was used to change the values of any outliers that were found nearby. Outliers and extremes were eliminated by the utilisation of a function known as "Outliers." Standardization of all continuous inputs was accomplished by first subtracting the mean score, followed by division by the standard deviation (sd). The ANN model that had the highest overall accuracy and AUC (area under the ROC curve) was the one that was selected for further study in order to determine the relationship between the proposed SCOR model and the enhancement of SCPOM. After that, at the division node, it was separated into two datasets: the Training set (consisting of 75 percent) and the Testing set (25 percent). Both the training dataset and the testing dataset are utilised in order to construct the model and identify trends.

When conventional methods are unsuccessful, artificial neural networks are able to process nonlinear input-output interactions (Golnaraghi et al., 2019). After training, the performance of the ANN was evaluated with the help of a test dataset. It is utilised by forecasting algorithms to determine features that separate a sample population from others on a target variable up until the point where it reaches one of the terminal nodes (Agresti, 2006).

The performance of the model was evaluated based on its accuracy, sensitivity, specificity, and receiver operating characteristic (ROC) (AUC). It is given as a percentage, and sensitivity is a measurement of how well the model detects the performance of SCPOM without integrating the digitalization. The percentage of digitalization in SCPOM that corresponds to an accurate identification in SCOR is referred to as the specificity. The sensitivity and specificity of a prediction or identification tool can be determined by the estimation of the ROC curve. The area under the curve (AUC) can range from 0 to 1, with 1 representing perfect discrimination and 0.5 representing chance (Hanley & McNeil, 1982). In order to test the generalisation capabilities of the ANN model, a five-fold random state-standard scale was utilised.

4. Results

4.1. Correlation Analysis

Source is positively correlated with produce with the significance of 0.98, showing a strong relationship among source and produce. Source is positively correlated with deliver with the significance of 0.86, showing a strong relationship among source and deliver. Source is positively correlated with return with the significance of 0.92, showing a strong relationship among source and return. Source is positively correlated with digitalization with the significance of 0.98, showing a strong relationship among source and digitalization. Source is positively correlated with SCPOM with the significance of 0.98, showing a strong relationship among source and SCPOM. Produce is positively correlated with deliver with the significance of 0.78, showing a strong relationship among produce and deliver. Produce is positively correlated with return with the significance of 0.88, showing a strong relationship among produce and return. Produce is positively correlated with digitalization with the significance of 0.94, showing a strong relationship among produce and digitalization. Produce is positively correlated with SCPOM with the significance of 0.94, showing a strong relationship among produce and SCPOM. Deliver is positively correlated with return with the significance of 0.97, showing a strong relationship among deliver and return. Deliver is positively correlated with digitalization with the significance of 0.93, showing a strong relationship among deliver and digitalization. Deliver is positively correlated with SCPOM with the significance of 0.92, showing a strong relationship among deliver and SCPOM. Return is positively correlated with digitalization with the significance of 0.97, showing a strong relationship among return and digitalization. Return is positively correlated with SCPOM with the significance of 0.97, showing a strong relationship among return and SCPOM. Digitalization is positively correlated with SCPOM with the significance of 0.97, showing a strong relationship among digitalization and SCPOM.

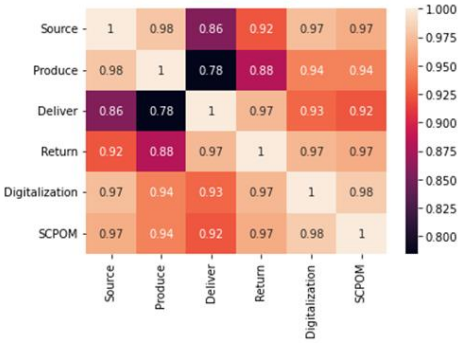

Fig. 2. Correlation Analysis

4.2. Artificial Neural Networks

A random method was used to divide all of the material into two completely separate groups. The first set was analysed to determine its suitability for application in the training process; it comprised 75% of the total data. The testing was performed on the second batch, which comprised twenty-five percent of the entire data collection.

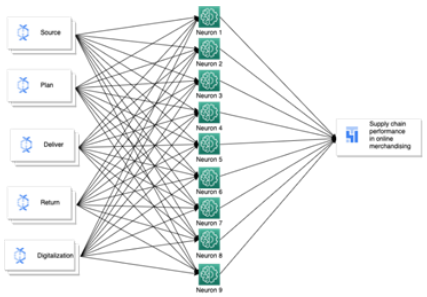

Fig. 3. ANN topology to predict the impact of digitalization in the SCOR model to enhance SCPOM

At the end of the process of training, it is required to undertake an examination of the ability of the ANN model to make accurate predictions using additional data. This must be done before the training phase can be considered complete. In order to stop the model from getting too accurate and to monitor how well it is doing while it is in the training phase, the validation set is used. This allows for both of these goals to be accomplished. At long last, the trained neural network is tested by making use of the test set in order to see how well it performed.

MLP Regression ML model was created with tuned up hyperparameters of 100 neurons in a hidden layer, adam weight-optimized solver for large datasets, relu linear activation function, and default epsilon value to maintain numerical stability [17]. Also included in the model were adam weight-optimized solver for large datasets, relu linear activation function, and default epsilon value. The difference between actual and predicted values is shown in the fig 4 and fig 5. After conducting training and testing on the ANN model, the indices R2 for enhancing the SCPOM in training is 86.98 and in testing is 93.68 were presented in the fig 6 (a) and fig 6 (b).

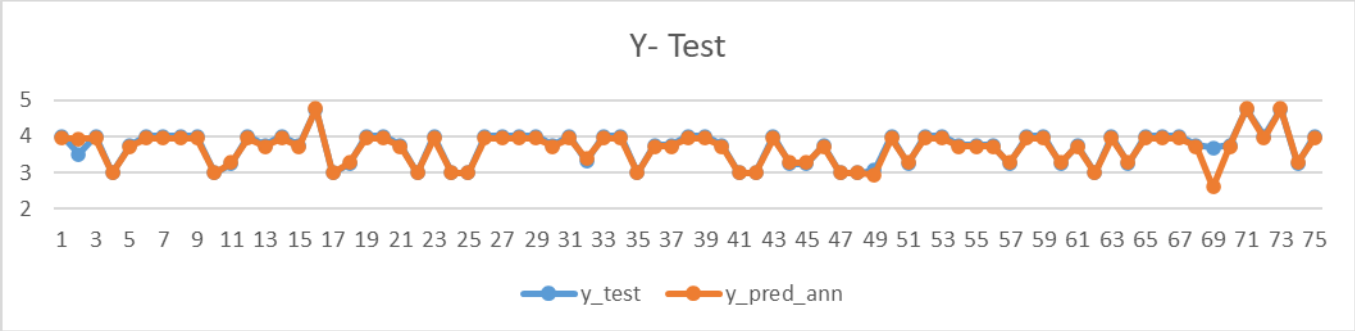

Fig. 4. Y-test ANN actual vs predicted values.

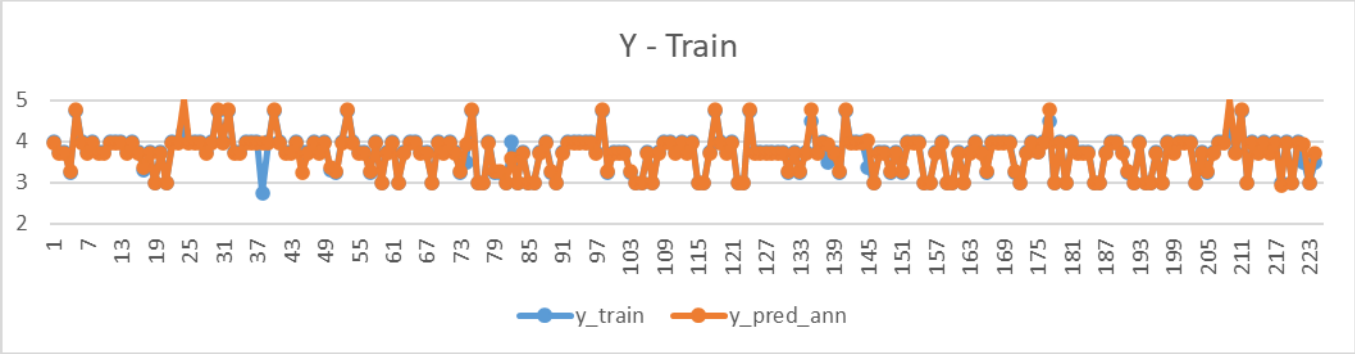

Fig. 5. Y-train ANN actual vs predicted values

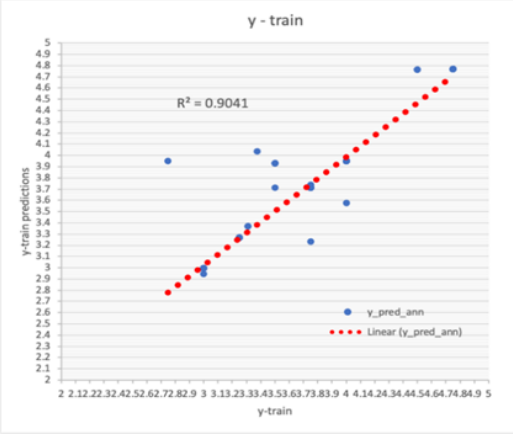

Fig. 6(a). R^2 train plot

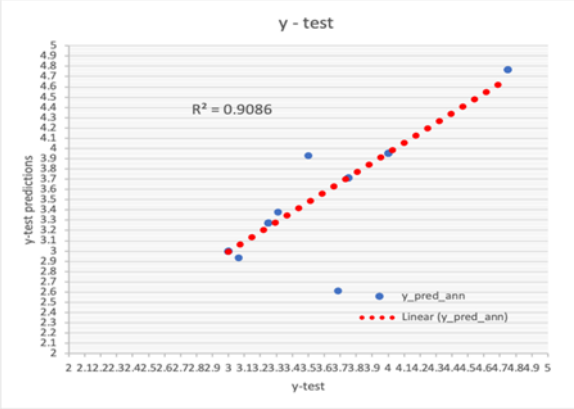

Fig. 6(b). R^2 test plot

4.3. Confusion Matrix

The performance of a classifier can be evaluated using a confusion matrix. The elements of the confusion matrix are used to determine three important parameters, which are referred to as accuracy, sensitivity, and specificity, respectively. In a classification problem, determining the best boundary between classes helps predict the data classes. The ideal boundary can be found by comparing the accuracy, sensitivity, and specificity values. The following expressions assess Accuracy, Sensitivity, and Specificity in light of the confusion matrix:

$$\text{Accuracy\_ANN} = \frac{TP + TN}{TP + FP + FN + TN} \quad (1)$$

$$\text{Sensitivity\_ANN} = \frac{TP}{TP + FN} \quad (2)$$

$$\text{Specificity\_ANN} = \frac{TN}{TN + FP} \quad (3)$$

where,
TP = True positives

TN = True negatives
FP = False positives
FN = False negatives

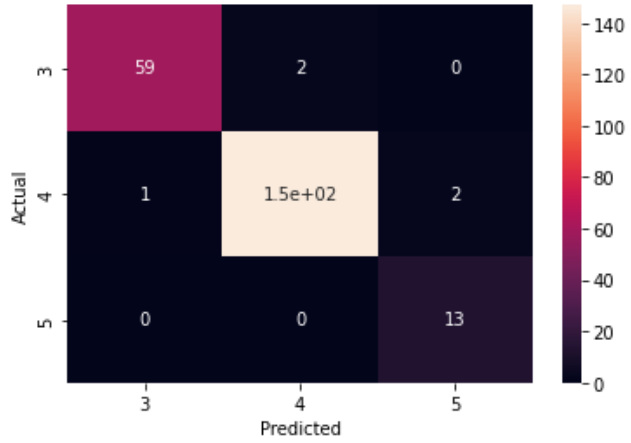

Fig. 7. Confusion Matrix

Confusion matrix shows values that have been correctly classified as True Positives (TP), as well as values that are in the relevant class when they should be in another class, as well as False Negatives (FN) values that are in a different class when they should be in the relevant class. Accuracy, sensitivity, and specificity are the three most commonly used performance metrics for classification based on these values. The confusion matrix yielded 98 percent, 94.5 percent, and 98.2 percent of the values used to calculate these performance metrics.

Relative Standard Deviation:

The relative standard deviation (RSDe) is the absolute value of the coefficient of variation.

$$\text{sd} = \sqrt{\frac{1}{M-1}\sum_{k=1}^{m}(y-\bar{y})} \quad (4)$$

$$\text{RSDe} = \frac{sd}{y} \quad (5)$$

where,
sd = standard deviation
RSDe = relative standard deviation
$y_1, ..., y_N$ = sample data set
$\bar{y}$ = mean value of sample data set
M = size of sample data set

The previous R2 value of SCOR model with supply chain performance is found to be 79% extracted from [7]. The RSD for training set and previous R2 value is 6.80%, and RSD for testing set and previous r2 value is 12.02%, which shows that digitalization has positive influence on SCPOM.

5. Conclusion:

This study is aimed to find the influence of digitalization to the SCOR model to enhance supply chain performance in online merchandising (SCPOM). We have used a machine learning approach called artificial neural network (ANN) and identified the R2 value of 86.98% in training and 93.68% in testing. Whereas, [7] has found that the R2 value of SCOR model with supply chain performance is 79%. The relative deviation for training and testing is 6.80% and 12.02% respectively. Further we have used the predicted values to find the accuracy, sensitivity and specificity as 98%, 94.5%, 98.2% respectively using confusion matrix. Thus, the ANN model developed integrating digitalization to the SCOR model enhances SCPOM.

Author contributions

Avula Akhila Ramya: Conceptualization, Methodology, Software, Field study **Stephan Thangaiah I.S:** Data curation, Writing-Original draft preparation, Validation, Writing-Reviewing Editing, and Field study.

Conflicts of interest

The authors declare no conflicts of interest.

References

[1]. W. Wisetsri, S. Donthu, A. Mehbodniya, S. Vyas, J. Quiñonez-Choquecota, and R. Neware, "An Investigation on the Impact of Digital Revolution and Machine Learning in Supply Chain Management," *Materials Today: Proceedings*, vol. 56, 2022, doi: 10.1016/j.matpr.2021.09.367.

[2]. A. Buciński *et al.*, "Artificial neural networks analysis used to evaluate the molecular interactions between selected drugs and human α1-acid glycoprotein," *Journal of Pharmaceutical and Biomedical Analysis*, vol. 50, no. 4, 2009, doi: 10.1016/j.jpba.2008.11.005.

[3]. Bulla, P. . "Traffic Sign Detection and Recognition Based on Convolutional Neural Network". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 10, no. 4, Apr. 2022, pp. 43-53, doi:10.17762/ijritcc.v10i4.5533.

[4]. S. Yamamura, "Clinical application of artificial neural network (ANN) modeling to predict pharmacokinetic parameters of severely ill patients," *Advanced Drug Delivery Reviews*, vol. 55, no. 9, 2003, doi: 10.1016/S0169-409X(03)00121-2.

[5]. S. H. Huan, S. K. Sheoran, and G. Wan, "A review and analysis of supply chain operations reference (SCOR) model," *Supply Chain Management*, vol. 9, no. 1. 2004. doi: 10.1108/13598540410517557.

[6]. "Das Supply Chain Operations Reference Model (SCOR-Modell)," in *Spitzenleistungen im Supply Chain Management*, 2007. doi: 10.1007/978-3-540-71185-8_3.

[7]. S. Mandal, "Supply Chain Performance: Review of Empirical Literature.," *Romanian Review of Social Sciences*, vol. 3, no. 3, 2012.

[8]. Gill, D. R. . (2022). A Study of Framework of Behavioural Driven Development: Methodologies, Advantages, and Challenges. International Journal on Future Revolution in Computer Science &Amp; Communication Engineering, 8(2), 09–12. https://doi.org/10.17762/ijfrcsce.v8i2.2068

[9]. N. Kamarudin and N. Zarirah Nizam, "The Mediating Effect Of Jit On The Relationship Between Scor Model And Supply Chain Performance," 2022. [Online]. Available: http://myjms.mohe.gov.my/index.php/ijssrJournalwebsite:http://myjms.mohe.gov.my/index.php/ijssrhttp://myjms.mohe.gov.my/index.php/ijssr

[10]. D. J. Bowersox, D. J. Closs, and M. B. Cooper, *Supply Chain Logistics Management*. 2002.

[11]. R. I. van Hoek, "'Measuring the immeasurable' - Measuring and improving performance in the supply chain," *Supply Chain Management*, vol. 3, no. 4, 1998, doi: 10.1108/13598549810244232.

[12]. Paithane, P. M., & Kakarwal, D. (2022). Automatic Pancreas Segmentation using A Novel Modified Semantic Deep Learning Bottom-Up Approach. International Journal of Intelligent Systems and Applications in Engineering, 10(1), 98–104. https://doi.org/10.18201/ijisae.2022.272

[13]. F. T. S. Chan and H. J. Qi, "An innovative performance measurement method for supply chain management," *Supply Chain Management*, vol. 8, no. 3. 2003. doi: 10.1108/13598540310484618.

[14]. N. Vasic, M. Kilibarda, and T. Kaurin, "The Influence of Online Shopping Determinants on Customer Satisfaction in the Serbian Market," *Journal of theoretical and applied electronic commerce research*, vol. 14, no. 2, 2019, doi: 10.4067/s0718-18762019000200107.

[15]. André Sanches Fonseca Sobrinho. (2020). An Embedded Systems Remote Course. Journal of Online Engineering Education, 11(2), 01–07. Retrieved from http://onlineengineeringeducation.com/index.php/joee/article/view/39

[16]. C. Chase, "How the Digital Economy is Impacting the Supply Chain.," *Journal of Business Forecasting*, vol. 38, no. 2, 2019.

[17]. M. Attaran, "Digital technology enablers and their implications for supply chain management," *Supply Chain Forum*, vol. 21, no. 3. 2020. doi: 10.1080/16258312.2020.1751568.

[18]. E. Geisberger and M. Broy, *agendaCPS:Integrierte Forschungsagenda Cyber-Physical Systems (acatech STUDIE)*, vol. 1. 2012.

[19]. T.-K. Yu and G.-S. Wu, "Determinants of Internet Shopping Behavior: An Application of Reasoned Behaviour Theory," *International Journal of Management*, vol. 24, no. 4. 2007.

[20]. G. Baryannis, S. Dani, and G. Antoniou, "Predicting supply chain risks using machine learning: The trade-off between performance and interpretability," *Future Generation Computer Systems*, vol. 101, 2019, doi: 10.1016/j.future.2019.07.059.

[21]. R. Gollangi and K. Nagamalleswara Rao, "Energetic, exergetic analysis and machine learning of methane chlorination process for methyl chloride production," *Energy & Environment*, p. 0958305X221109604, 2022.