SUPPLY CHAIN MANAGEMENT : A REVIEW OF ANOMALY DETECTION TECHNIQUES AND THE BENFORD'S LAW

LUSI ELVIANI RANGKUTI [1] , FARIDA KHAIRANI LUBIS [2] , ISKANDAR MUDA [3]

[1,2] Universitas Islam Sumatera Utara, Medan, Indonesia
[3] Universitas Sumatera Utara, Medan, Indonesia
Email :
[1] Email: lusi.elviani@fe.uisu.ac.id
[2] Email Coresponden: farida_khairani@fe.uisu.ac.id
[3] iskandar1@usu.ac.id

Abstract.

With technological advances and continued economic growth in modern society, this is just one of many implementations that can turn the tide of the supply chain industry. Traditional models of managing the transfer of physical goods have failed to overcome inefficiencies. Machine learning measures offer another way to ensure that goods are delivered to customers faster with fewer delays and damage. clearly there is a huge gap between traditional data monitoring practices and the demands of modern enterprises. In the supply chain space, insights must be delivered instantly to ensure deliveries are made on time. Machine learning will not only help improve visibility of the supply of goods but will also actively improve the transfer of goods from suppliers to customers. The results of this literature survey on supply chains using anomaly detection are that more use of LSTM LSTM Autoencoder and OCSCM algorithms also use methods to optimize hyperparameters for hybrid algorithms to detect anomalies located in time series data.

Keywords: Supply Chain Management, Anomaly Detection Techniques

1. PRELIMINARY

In today's highly competitive global economy, giving a good first impression is very important for the success of every business venture, a good first impression will increase the chances of success of the business venture (Acharya et al., 2018). Supply Chain Management sometimes referred to as "supply chain", can be understood as the activities arising from procuring raw materials from suppliers and manufacturers, converting raw materials into finished goods ready to be shipped to customers using efficient and effective methods. Supply chain management or supply chain is an order or system in the economic industry which has the aim of turning raw materials into finished goods so that the supply chain management mechanism includes the flow from upstream to downstream. To maintain supply chain resilience and avoid dissatisfied customers, companies must continuously monitor the supply chain and detect anomalies. Anomalies can be defined as changes in expected values or variability. Advances in computer and network technology make it possible to accumulate data and information very quickly.

These are the factors that will lead to the right decision making approach regarding forecasting and anomaly detection in supply chain management which will be a very important task and the existence of a good forecasting method will help in balancing demand and supply and will Avoid fraud or excess inventory in retail inventory planning (El Sima, 2020). Auditors have long applied various forms of digital analysis when conducting procedural analysis (Sihombing et al., 2019). Benford Law as applied to auditing is simply a more complex form of analysis. An economist's variant, suggesting that Benford's Law could be used as a test of the veracity or validity of purportedly random scientific data in a social science context, was not picked up by accountants until the late 1980s. At that time, two studies relied on digital analytics to detect earnings manipulation.

When auditors choose to use digital analysis in an effort to detect fraud, consideration should be given to which types of accounts may be Benford analysis is expected to be effective. While most accounting related data sets conform to the Benford distribution because digital analysis is only effective when applied to appropriate sets, Auditors should consider a particular data set should be expected to fall into the Benford distribution before performing digital analysis. Problems that often occur in supply chain management and are important include reducing the decision making cycle even though large amounts of data are generated at each stage. The presence of excessive data will result in difficulties in distinguishing useful signals that enable decision making. Based on the literature of a number of studies that focus on detecting abnormal events in supply chains based on

radio frequency identification (RFID) technology, Deusen 2010 in Phuc Tran , et al (2019) suggests a quality control approach to detect anomalies in annual inventory data analysis. Meanwhile, two anomaly detection techniques including a statistics-based approach and a clustering-based approach are used to detect outliers in sensor data for a real-time monitoring system for perishable supply chains in Alfian et al (2017).
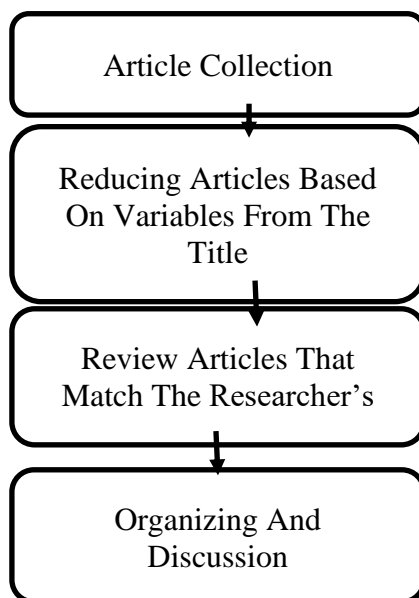
The detection used uses a Long Short Term Memory (LSTM) network which is an effective detection for learning long-term dependencies and representing the relationship between current events and previous events effectively. Maholtra et al . (2015) suggest the use of stacked LSTM networks for anomaly detection in time series. There is also research that uses LSTM Autoncoder with vector machine algorithms to separate anomalies from data issued based on the network. As well as for anomaly detection using quantitative SCR modeling such as agility which is one of the most effective ways to achieve resilience in the supply chain. With so many articles and findings used to detect anomalies in supply chain management, researchers need to conduct a literature review so that researchers will find out about other studies that have been conducted on the same topic.

2. METHOD

The method used in this research is literature review. Literature review is the most important step in compiling all research. According to Afifuddin (2012) Literature review is an important tool as a contact review, because literature is very useful and very helpful in providing context and meaning in the writing that is being done and through this literature review researchers can also state explicitly and the reader knows why something is happening. wanting to be researched is a problem that must be researched, both in terms of the subject to be researched and any environment in terms of the relationship between the research and other relevant research. Literature review is also a literature review that supports the problems in the research that we will carry out, so this study is very useful for researchers, for example to provide an overview of the problem that will be researched, provide conceptual theoretical support for researchers and furthermore as material for discussion or discussion in a study.

There are two main objectives of the literature review. First, a literature review is carried out with the aim of writing a paper to introduce new studies on a certain topic that those who are active in that scientific topic need to know. This study may be published at any time for the public interest. Examples of studies of this kind can be seen, for example, in the Annual Review of Anthropology, Annual Review of Sociology, and so on. Those who are just beginning researchers on a particular topic can use this annual review publication as initial reading (Tjahjono, H., 2018). The second purpose of the literature review is for its own research purposes. With this, making a literature review is to enrich our insight into our research topic, help us in formulating research problems, and help us in determining the appropriate theories and methods to use in our research. By studying other people's studies, we can determine whether to imitate, repeat, or criticize a particular study. We use other people's studies as comparison material for our own studies. By criticizing other people's writing, we then create something new.

Based on the description above, the researcher used a literature review by analyzing articles or international journals published from 2014 - 2023 as a research method to achieve the research objectives. The stages in this literature are as follows:
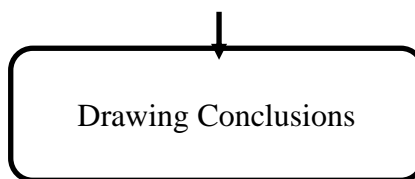
Article Collection

Reducing Articles Based On Variables From The Title

Review Articles That Match The Researcher's

Organizing And Discussion

370

```
┌─────────────────────────┐
│                         │
│    Drawing Conclusions  │
│                         │
└─────────────────────────┘
```

Figure 1: Stages of literature review
(Source: (Marzali, 2016)

3. RESULTS AND DISCUSSION

The results of this literature review are that there are 16 journals that are comparative journals for supply chain management in anomaly detection. Based on (Nguyen et al., 2021a) Making the right decisions is indeed a key factor to help companies face today's supply chain challenges. In this paper, we propose two data-driven approaches that enable better decision making in supply chain management. Specifically, we suggest a Long Short Term Memory (LSTM) network-based method for forecasting multivariate time series data and an LSTM Autoencoder network-based method combined with a one-class support vector machine algorithm for detecting anomalies in sales. Unlike other approaches, we recommend combining external and internal company data sources for the purpose of improving the performance of forecasting algorithms using multivariate LSTM with optimal hyperparameters. In addition, we also propose a method to optimize hyperparameters in a hybrid algorithm to detect anomalies in time series data. The proposed approach will be applied to benchmarking datasets and real data in fashion retail. The results obtained show that the LSTM Autoencoder based method provides better performance for anomaly detection compared to the LSTM based method suggested in previous research. The proposed forecasting method for multivariate time series data also performs better than several other methods based on datasets provided by NASA , while according to (Hosseini et al., 2019) Supply chain resilience (SCR) is realized when the network is able to survive, adapt, and recover from disruptions to meet customer demand and ensure performance. this article conceptualizes and comprehensively presents a systematic review of the current literature on quantitative modeling of SCR while specifically linking it to the original concept of resilience capacity. Decision makers and researchers can benefit from our survey because it introduces structured analysis and recommendations regarding which quantitative methods can be used at different levels of capacity resilience.

According to (Antic et al., 2023) we discuss the complementarity between static security monitoring in rule matching and the application of self-supervised machine learning to cybersecurity. Additionally, we analyze the context and challenges of supply chain resilience and smart logistics. Furthermore, we situate the interaction between these two complementary methods in the context of self-directed learning and self-healing approaches. Different from research results (Aljohani, 2023) This research, on the other hand, promotes a futuristic methodology that uses predictive analytics to estimate possible disruptions. Based on contextual and historical data, machine learning models can be trained to find patterns and correlations as well as anomalies that indicate imminent danger (Liu et al., 2023). Organizations can identify emerging risks and take preventative action by incorporating these models into real-time monitoring systems. This study examines various predictive analytics methods, showing how they can be used to identify supply chain risks. These methods include time series analysis and anomaly detection as well as natural language processing. In addition, risk assessment models are continuously improved and optimized using machine learning algorithms, ensuring accuracy and adaptability in changing contexts. This research clarifies the symbiotic relationship between predictive analytics and machine learning and supply chain agility using a synthesis of theoretical discourse and practical evidence (Habbe et al., 2023).

(Hosseini et al., 2019) The rapid development of new technologies such as machine learning and data mining is driving many intelligent applications, for example the Internet of Things (IoT). Supply chain management and communication is a key research direction in the IoT environment, while inventory management (IM) is increasingly becoming a core part of the entire supply chain life cycle management process. However, today's long supply chain life cycle situation, complex supply chain management, and frequently changing user demands have all led to a sharp increase in logistics and communication costs. Therefore, as a core part of the supply chain, effective and predictable IM

is critical. experimental results show that DIM's average inventory demand prediction accuracy exceeds about 80%, which can reduce inventory costs by about 25% compared with other state-of-the-art methods and detect anomalous inventory actions quickly.

(Chen et al., 2023) The complexity of collaborative food supply chains results in frequent food safety incidents that are detrimental to people's health and lives. Therefore, maintaining food safety is a primary value. This study is expected to solve food safety problems and provide more benefits for people using intelligent systems. To meet the security needs of a collaborative food supply chain, this research designs a food safety protection system architecture that collects supply and sales data from various suppliers, as well as data on equipment used in production. The architecture can perform anomaly detection with machine learning to make an initial assessment of whether a problem has occurred with this batch of food during a transaction, and then apply deep anomaly detection with supplier tools to determine the stage at which this problem occurred. The proposed system can help food operators achieve effective food monitoring, prediction, prevention and improvement, thereby improving food safety.

(Tran et al., 2019) The complexity of collaborative food supply chains results in frequent food safety incidents that are detrimental to people's health and lives. Therefore, maintaining food safety is a primary value. This study is expected to solve food safety problems and provide more benefits for people using intelligent systems. To meet the security needs of a collaborative food supply chain, this research designs a food safety protection system architecture that collects supply and sales data from various suppliers, as well as data on equipment used in production. The architecture can perform anomaly detection with machine learning to make an initial assessment of whether a problem has occurred with this batch of food during a transaction, and then apply deep anomaly detection with supplier tools to determine the stage at which this problem occurred. Appear (Rajan et al., 2022). The proposed system can help food operators achieve effective food monitoring, prediction, prevention and improvement, thereby improving food safety.

(Lorenc et al., 2021) In this research, automated Big Data analysis and mathematical modeling are used to identify interference. Artificial Neural Networks (ANN) are used to predict possible temperature-related disruptions in transportation. The research provided proves that further prevention is possible

82% disruption in the cold chain. ANN allows analysis of temperature curves and prediction of disturbances before they occur. This research is limited to transporting food with coolboxes below -20oC, but this method can also be used for Full Transport Load (FTL) in refrigerated transport. The research is based on real data, and the methods developed help reduce waste in the cold chain, improve transportation quality and supply chain resilience. The presented method not only allows to avoid cold chain breaks but also reduces product damage and improves the transportation process. This can be used by cargo expedition companies, Third Party Logistics (3PL) companies to reduce costs and waste. A review of the literature confirms that there are no similar methods to prevent disruptions in the transport chain. The use of Internet of Things (IoT) sensors to collect data connected with Big Data analysis and ANNs makes it possible to provide chain resilience.

According to (El-Khchine et al., 2018) this research was conducted on Twitter which was distributed in several countries, namely Australia, Canada, Georgia, India, Kenya, Malaysia, New Zealand, Nigeria, Pakistan, Scotland, Singapore, South Africa, UK, USA, The thing studied is the supply chain of food products such as chicken products. In this regard, we propose an analytical approach, based on a comparison between three machine learning models: K-Nearest Neighbors (KNN), Logistic Regression, and Support Vector Machine (SVM) with the use of Twitter data related to chicken supply chains. This article aims to explore the application of social media big data and its analysis in supply chain management, especially for the chicken supply chain. The proposed approach can be extended to other topics such as anomaly detection and customer codification. The results identify key issues related to chicken products and enable the development of consumer-centric supply chains. Based on the results of the analysis, it shows how consumers react on Twitter regarding the topic of the chicken supply chain. Twitter provides several metadata that can be used for further analysis such as geographic data, date and time for time series analysis of the development of opinion polarity, users , etc. Each point in the data visualization above is one of 6,417 tweets, in which 49% of consumers on Twitter expressed a positive opinion about the chicken supply chain. On the other hand, 51% of the feedback was negative.

Based on the results (Nguyen et al., 2021b) Data processing techniques: Using LSTM, LSTM Autoencoder network, and OCSVM algorithm. Combining external and internal company data sources for the purpose of poses improves the performance of forecasting algorithms using multivariate LSTM with optimal hyperparameters. Apart from that, it also uses methods to optimize hyperparameters

for hybrid algorithms to detect anomalies in time series data. Fashion Retail, focuses on the downstream supply chain of fashion retailers. The research location was not mentioned in the study Reasons for choosing fashion retail as the research object: 3 main factors that make fashion retail very specific (Thomassey, 2014), namely

1. Variation of products is very high

2. Consumer demand is very volatile and sensitive to fashion trends, weather and prices

3. The supply chain for fashion products is very complex and long compared to the short product lifespan.

The result of this research is that the LSTM Autoencoder based method produces better anomaly detection performance compared to the LSTM based method suggested in previous research. The proposed forecasting method for multivariate time series also outperforms several other methods based on datasets provided by NASA.

Meanwhile, according to (Garvey et al., 2015) the research method uses a Bayesian Network (BN) approach and develops a risk distribution model in the supply network. This model takes into account the interdependencies between various risks, as well as the peculiarities of the supply chain network structure. Specific measurements are taken from these models and simulation studies are used to illustrate how these measurements can be used in a supply chain setting. The results of this research are that Bayesin Network is suitable for the purpose of measuring supply chain risk if it is built based on the supply network structure. Bayesian Networks represent a picture of a company's supply chain risk profile.

The aim of this research was to develop a data warehouse design that supports forensic analysis using Benfort's law to detect fraud (Saragih et al., 2022). This approach relies on common, reusable storage procedures for data analysis. The data warehouse was tested with two data sets collected from operational supply chain databases from inventory management and warranty claims processes, although this study only used data from inventory management and warranty claims processes, the proposed storage procedures can be extended to any process in the supply chain that making the results generalizable to supply chain management processes (Darmawan et al., 2022). The research results show that the analyzed supply chain data adheres to Benford's theory and stored procedures parameterized with Dynamic SQL provide an excellent tool for analyzing data in the supply chain for possible fraud detection. The implication of the research results is that Benford's law can be used to detect fraud in the supply chain with the help of parameterized stored procedures and data warehouses, this can lighten the workload of fraud analysts in the supply chain function. The results of this study are in line with Tödter (2009), who stated that Benford's Law is a potentially useful instrument for discovering fraud and manipulation" because implementation and application to documented data sets demonstrate general compliance with Benford's law (first digit and first two digits) as a whole and allows researchers to detect anomalies, perhaps only in the form of oddities for further analysis (Kraus & Valverde, 2014) .

According to (Kraus & Valverde, 2014) Research Objectives: This research is to detect crucial inventory management (inventory that is not physically visible or called 'ghost inventory'). Research results : We show that for any given budget of false positive rate (FPR), our approach achieves a true positive rate (TPR) that approaches the TPR of the (unachievable) optimal algorithm at min-max optimal rate. Using data from a large consumer goods retailer, we show that our approach provides significantly improved, data analysis techniques using the EW algorithm. (Tran et al., 2019) stated that the data analysis technique used was LSTM (Long short term memory) and the quantile function kernel estimator. This research uses a sample with a training data set of 2810 normal samples and a validation data set of 148 normal samples which represent normal consumer demand. The results of this research are that LSTM and quantile function kernel estimators can overcome the problems of anomaly detection and customer demand prediction.

According to (Li et al., nd) The experimental results show that the proposed model has excellent accuracy, precision, recall and F-score, which shows that the model is feasible and has strong robustness. In addition, based on the successful detection of potential corner market risks, this model can then be used to clarify its characteristics, data analysis techniques use LOF, SVM & RF anomaly detection algorithms, the data used comes from data relating to the market and investment prices, data The download includes daily trading data from April 1983 to October 2020, containing the opening price (open), closing price (close), highest price (high), lowest price (low), rate of change (rate and trading volume (volume) There are also other opinions regarding simple chain management with anomaly detection, namely those that focus only on utilizing a clustering-based anomaly detection approach for analyzing time series sales data collected from warehouse management systems developed for medium to large logistics companies in Bosnia and Herzegovina.

The algorithm shows significant results in anomaly detection in company orders and improves a number of processes in the operation of smart warehouse management systems. The algorithms described can also be used in other areas where transaction data is collected, such as sales and banking and data analysis techniques used algorithms to detect anomalies in historical sales data used as part of an intelligent warehouse management system implemented in several distribution companies spread across the world. Bosnia and Herzegovina (Zunic et al., 2020) .

CONCLUSION

In this survey conducted to formulate the problem of supply chain management with anomaly detection, we bring together the notion of anomaly to provide a clear theoretical understanding of the problem at hand. The methodology behind this research is driven by the mission that a comprehensive review of anomaly detection techniques should facilitate the reader not only to gain information about the motivation behind the use of a particular model but also its advantages and limitations when applied to a particular area of fraud. We achieve this by detailing a comparative analysis of the different approaches implemented in each application. The importance of fraud detection and its adverse impact on the financial economy is highlighted in this paper, as well as the challenges associated with applying anomaly detection techniques to address this growing problem.

In this research, it focuses on anomaly detection in supply chain management. It is proven that the challenges faced vary greatly based on different types of fraud applications. such as those that use LSTM (Long short term memory), OCSVM algorithm, Artificial Neural Network (ANN), -Nearest Neighbors (KNN), Logistic Regression, and Support Vector Machine (SVM) , LSTM Autoencoder. Additionally, we show that there is no single universally applicable anomaly detection technique or approach to fraud in the supply chain described in this survey.

From the surveyed literature, it is clear that there is a shift in trend, where the majority prefer to use LSTM Autoencoders and OCSCM algorithms also use methods to optimize hyperparameters for hybrid algorithms to detect anomalies located in time series data. Fashion Retail, focuses on the downstream supply chain of fashion retailers., The results obtained show that the LSTM Autoencoder based method provides better performance for anomaly detection compared to the LSTM based method suggested in previous research. With this system, it creates customers

REFERENCES

1. Acharya, A., Singh, S. K., Pereira, V., & Singh, P. (2018). Big data, knowledge co-creation and decision making in the fashion industry. International Journal of Information Management, 42, 90–101.
2. Adewumi, A.O., & Akinyelu, A.A. (2018). A survey of machine learning and nature-based credit card fraud detection techniques. International Journal of Systems Assurance Engineering and Management, 8, 937–953.
A. FarzadT and A. Gulliver. (2020). Unsupervised log message anomaly detection. ICT Express, 6(3):229–237.
3. Aljohani, A. (2023). Predictive Analytics and Machine Learning for Real-Time Supply Chain Risk Mitigation and Agility. Sustainability , 15 (20), 15088. https://doi.org/10.3390/su152015088
4. An, J., & Cho, S. (2015). Variational Autoencoder-based Anomaly Detection using Reconstruction Probability. SNU Data Mining Center.
5. Antic, J., Costa, J.P., Cernivec, A., Cankar, M., Martincic, T., Potocnik, A., Ratkajec, H., Elguezabal, G.B., Leligou, N., Lakka, A., Boigues, IT, & Morte, EV (2023). Runtime security monitoring by an interplay between rule matching and deep learning-based anomaly detection on logs. 2023 19th International Conference on the Design of Reliable Communication Networks, DRCN 2023 . https://doi.org/10.1109/DRCN57075.2023.10108105
6. Chen, Y.M., Chen, T.Y., & Li, J.S. (2023). A Machine Learning-Based Anomaly Detection Method and Blockchain-Based Secure Protection Technology in Collaborative Food Supply Chain. International Journal of E-Collaboration , 19 (1), 1-24. https://doi.org/10.4018/IJeC.315789
7. Das A., Gottlieb S., Ivanov, D. (2019). 'Managing disruptions and the ripple effect in digital supply chains: empirical case studies', in Ivanov D. et al. (Eds.) Handbook of the Ripple Effects in the Supply Chain. Springer, New York, pp. 261-285.
8. Darmawan, D., Kurniady, D. A., Komariah, A., Tamam, B., & Pallathadka, H. (2022). Introduce a new mathematical approach to inventory management in production processes under constrained conditions. Foundations of Computing and Decision Sciences, 47(4), 421-431.

9. Dubey, R., Altay, N., Gunasekaran, A., Blome, C., Papadopoulos, T., Childe S.J. (2018) 'Supply chainagility , adaptability and alignment: empirical evidence from the Indian auto components industry'. International Journal of Operations & Production Management 38 (1), 129-148.
10. El-Khchine, R., Amar, A., Guennoun, Z.E., Bensouda, C., & Laaroussi, Y. (2018). Machine learning for supply chain's big data: State of the art and application to social networks' data. *MATEC Web of Conferences* , *200* . https://doi.org/10.1051/matecconf/201820000015
11. El Sima, A.H, Siregar, C (2020). Inventory Accounting System Analysis and Design (Overview about Providing Good Service to Consumers). *Turkish Online Journal of Qualitative Inquiry*. 11(4). 1088-1097.
12. Garvey, M.D., Carnovale, S., & Yeniyurt, S. (2015). An analytical framework for supply network risk propagation: A Bayesian network approach. *European Journal of Operational Research* , *243* (2), 618–627. https://doi.org/10.1016/j.ejor.2014.10.034.
13. Habbe, A. H., Prawira, I. F. A., Hasibuan, R. M., & Dhumale, N. R. (2023, February). Machine Learning Pose Detection Kit Implementation in Taspen Android Application. In *2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS)* (pp. 554-558). IEEE. https://ieeexplore.ieee.org/abstract/document/10073816
14. Hosseini, S., Ivanov, D., & Dolgui, A. (2019). Review of quantitative methods for supply chain resilience analysis. *Transportation Research Part E: Logistics and Transportation Review* , *125* (December 2018), 285–307. https://doi.org/10.1016/j.tre.2019.03.001
15. Ivanov, D., Dolgui, A., Sokolov, B. (2019). 'The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics'. International Journal of Production Research, 57(3), 829-846.
16. Kraus, C., & Valverde, R. (2014). A data warehouse design for the detection of fraud in the supply chain by using the Benford's law. *American Journal of Applied Sciences* , *11* (9), 1507–1518. https://doi.org/10.3844/ajassp.2014.1507.1518
17. Li, DUN, Crespi, N., & Minerva, R. (nd). *Detecting Potential Market Corner Risk of WTI: A Hybrid Algorithm Anomaly Detection Approach Detecting Potential Market Corner Risk of* . 0–22.
18. Liu, K.-S.; Lin, M.-H.; Dwijendra, N.K.A.; Carrillo Caballero, G.; Alviz-Meza, A.; Cárdenas-Escrocia, Y. (2023). An Application of Machine Learning to Estimate and Evaluate the Energy Consumption in an Office Room. *Sustainability*. 15, 1728. https://doi.org/10.3390/su15021728
19. Lorenc, A., Czuba, M., & Szarata, J. (2021). Big Data Analytics and Anomaly Prediction in the Cold Chain to Supply Chain Resilience. *FME Transactions* , *49* (2), 315–326. https://doi.org/10.5937/fme2102315L
20. Nguyen, H.D., Tran, K.P., Thomassey, S., & Hamad, M. (2021a). Forecasting and Anomaly Detection approaches using LSTM and LSTM Autoencoder techniques with the applications in supply chain management. *International Journal of Information Management* , *57* (October), 102282. https://doi.org/10.1016/j.ijinfomgt.2020.102282
21. Nguyen, H.D., Tran, K.P., Thomassey, S., & Hamad, M. (2021b). Forecasting and Anomaly Detection approaches using LSTM and LSTM Autoencoder techniques with the applications in supply chain management. *International Journal of Information Management* , *57* (November). https://doi.org/10.1016/j.ijinfomgt.2020.102282
22. Rajan, S. D., Vavilapalli, S., Hasan, S., Kumar, R., Rafa, N., (2022, December). A Survey on the Impact of Data Analytics and Machine Learning Techniques in E-commerce. In *2022 5th International Conference on Contemporary Computing and Informatics (IC3I)* (pp. 1117-1122). IEEE. https://ieeexplore.ieee.org/abstract/document/10072652
23. Saragih, F., HS, W. H., & Sumitra, A. (2022). Public Perception of Fraudulent Financial Statements in Pharmaceutical Sub Sector. *Journal of Pharmaceutical Negative Results*, 1577-1584. https://doi.org/10.47750/pnr.2022.13.S09.194
24. S. Chen and H. Liao. Bert-log: (2022). Anomaly detection for system logs based on pre-trained language models. Applied Artificial Intelligence, 36(1):2145642.
25. Sihombing, E., Erlina, & Rujiman (2019). The effect of forensic accounting, training, experience, work load and professional skeptic on auditors ability to detect of fraud. *International Journal of Scientific and Technology Research*, *8*(8), 474-480. https://www.ijstr.org/paper-references.php?ref=IJSTR-0819-20847
26. Tran, K. P., Nguyen, H. Du, & Thomassey, S. (2019). Anomaly detection using Long Short Term Memory Networks and its applications in Supply Chain Management. *IFAC-PapersOnLine* , *52* (13), 2408–2412. https://doi.org/10.1016/j.ifacol.2019.11.567
27. Zunic, E., Tucakovic, Z., Delalic, S., Hasic, H., & Hodzic, K. (2020). Innovative Multi-Step Anomaly Detection Algorithm with Real-World Implementation: Case Study in Supply Chain Management. *2020 IEEE/ITU International Conference on Artificial Intelligence for Good, AI4G*

2020 , 9–16. https://doi.org/10.1109/AI4G50087.2020.9311045