

Supply Chain Management with Application of Lean Six Sigma and Artificial Intelligence: An Integrated Empirical Investigation

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ABSTRACT

The objective of this study is to establish a new business model for a business unit implementing the technology and methodology mentioned in 2.0 (visualised). It further encompassed the comparison with the benchmark snapshot between the quarter 01.10.2020 – 31.12.2020 and 01.1.2021 – 03.03.2021). The improvements due to the integration of lean six sigma along with artificial intelligence in conventional supply chain management system were quantified in terms of increase in percentage of profit, reduction in distributor attrition, failure of supply, excess or blocked inventory, and furthermore, reduction in operating losses and project completion tenure. Finally, the study identified areas of improvement with respect to the services rendered with supply chain, and suggested corrective actions for the same. The results derived in this study are explicit, conceptually stimulating and may provide guidance to managers engaged in supply chain management activities. The results showed that conventional supply chain management system is difficult to build, due to the complexities and uncertainties that exist across organizational boundaries. Hence, it is not surprising, therefore, that most alliances among partners fail to generate expected outcomes, especially in context to leveraging the potential of lean six sigma and Artificial Intelligence based SCM. It is hoped that our results provide a framework that may act as a blueprint for the manufacturing sector to assess and improve conventional supply chain management system with lean six sigma and AI-powered supply chain management, as well as increased organizational and financial performance.

Keywords: Supply Chain Management, Lean Six Sigma, Artificial Intelligence, Industrial Internet of Things, DMIAC, Client Relationship Management System, Operational Process

INTRODUCTION

Supply Chain Management (SCM) is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximise customer value and gain a competitive advantage in the marketplace (<https://qualitysupportgroup.com>). SCM is the management of a channel that starts from procurement of raw materials to production of the product, logistics, and distribution to customer (Stadtler, 2015). Enterprises plan, evaluate, improve, and optimise their supply chains as they help the enterprise grow over a period of time. They also help in reduction in costs, faster delivery, and increase in

customer satisfaction (Jayaram, 2016). This is done by keeping tighter control of internal inventories, internal production, distribution, sales, and the inventories of company vendors. SCM includes the management of product development, sourcing, production, and coordination of supply. Supply chains are "connected" together through physical streams and data streams (Yi-Tao, 2010, Sun et al., 2011).

SCM is based on the idea that nearly every product that comes to market is the result of the efforts of various organisations that make up a supply chain. Although supply chains have existed for ages, most companies have only recently paid attention to them as a value-add to their operations.

Moreover, supply chain analytics (SCA), via the use of cognitive technologies, such as artificial intelligence (AI), help improve complex supply chain process decisions (Akter et al., 2020; Asmussen & Møller, 2020; Boehmke, Hazen, Boone & Robinson, 2020). Even artificial intelligence-powered supply chain analytics (AI-SCA) have gained increased momentum during a pandemic (Dubey et al., 2021a). Srinivasan and Swink (2018) argued that supply chain analytics capability (SCAC) is an extension of traditional analytics capability that enables organisations to increase their information processing capability. Extending the arguments of Srinivasan and Swink (2018), Dubey et al. (2021a) speculated that the use of cognitive technology, along with SCAC, will lead to the decisions taken by the managers being more effective than in the past. Dubey et al. (2021b) explored the relationship between information alignment (IA), collaboration (CO), and supply chain agility (SCAG), under the moderating effects of artificial intelligence-driven big data analytics capability (AI-BDAC) and intergroup leadership (IGL); the outcome of their study helps advance the theoretical debates surrounding technology-driven supply chain agility in the context of humanitarian settings.

In this study, we have attempted to establish a new business model for a business unit, implementing the technology and methodology mentioned in 2.0 (visualised). It further encompassed the comparison with the benchmark snapshot between the quarter 01.10.2020 – 31.12.2020 and 01.01.2021 – 03.03.2021; the improvements due to the integration of lean six sigma along with artificial intelligence in conventional supply chain management system were quantified in terms of the increase in profit percentage, reduction in distributor attrition, failure of supply, excess or blocked inventory, and furthermore, reduction in operating losses and project completion tenure. Finally, it identified the areas of improvement with respect to the services rendered with supply chain, and suggested corrective actions for the same.

LITERATURE REVIEW

During the last year many researchers, viz., Riahi et al. (2021), Rejeb et al. (2020), Ben-Daya et al. (2019), Yang (2018), Witkowski (2017), Barreto et al. (2017), Jayaram (2016), Stadler (2015), Kuei et al. (2011), Liu and Wu (2010), Clegg et al. (2010), and Bendell (2006) have made an extensive empirical study on the application of lean six sigma and artificial intelligence in traditional supply chain processes.

Frohlich and Westbrook (2001) investigated supplier and customer integration strategies in a global sample of 322 manufacturers. Scales were developed for measuring

supply chain integration and five different strategies were identified in the sample. Each of these strategies were characterised by a different “arc of integration”, representing the direction (towards suppliers and/or customers) and degree of integration activity.

Kuei et al. (2011) presented a global supply chain quality management (SCQM) framework as an extension of the traditional supply chain operations and quality management. The presented framework adopted a systems approach and ensured that quality-conscious products are designed, manufactured, and distributed. Liu and Wu (2010) answered the following questions: Why do global companies need to implement supply chain management? How do global companies conduct it? When implementing it, what problems do they encounter? And how do they deal with the problems?

Antony et al. (2003) compared and contrasted the lean and six sigma approaches, and found that greater benefits can be reaped by blending the best of each. The focus was on value from a customer perspective, and flowing this through the entire supply chain. Clegg et al. (2010) examined the integration of lean principles with six sigma methodology as a coherent approach to continuous improvement, and provided a conceptual model for a successful integration. They suggested that a clear integration of the two approaches must be achieved, with sufficient scientific underpinning. Bendell (2006) focused on six sigma and lean programmes in practice, rather than the theoretical basis or motivationally-based argument. Martin (2006) offered six sigma practitioners and managers a powerful, 10-step solution process for identifying and solving the root causes of supply chain problems in industrial organisations, thus increasing profitability.

Stadler (2015) explained how companies use e-reputation systems and social media to select their global trusted suppliers. Zhang and Zhang (2016) focussed on the topology and some learning algorithms of infinite deep neural networks, and introduced some successful applications in speech recognition and image understanding. With the new rising technology of Internet of Things (IoT), Sun et al. (2011) established an information real-time sharing platform architecture of the manufacturing industry supply chain based on IoT, to improve the efficiency of information collection and sharing. The study also provided a new solution for the information transparency construction of the supply chain. Witkowski (2017) discussed some “smart” solutions in logistics and supply chain management according to new technology development of IoT, big data, and Industry

4.0. Barreto et al. (2017) illustrated the application of the advanced technologies in the Industry 4.0 era on smart logistics from the aspects of warehousing, intelligent transportation, and information security.

According to Jayaram (2016), lean six sigma eliminates unnecessary processes and defects, which can benefit an enterprise from reduced costs and less wastage of resources. Industry 4.0 refers to the automation of industries through the exchange of data between the supply chain and logistics. Industry 4.0, along with Industrial Internet of Things (IIoT), can make a big revolution in the management of global supply chain. Rejeb et al. (2020) reviewed Internet of Things (IoT) research in supply chain management (SCM) and logistics. A thorough review and bibliometric analysis were conducted to analytically and objectively unearth knowledge development in IoT research within the context of SCM and logistics. Ben-Daya et al. (2019) explored the role of Internet of Things (IoT) and its impact on supply chain management (SCM) through an extensive literature review.

Yang (2018) took artificial intelligence in the background of big data era as the research object, exploring its application in computer network technology, which provided some reference significance for the research and application of artificial intelligence in computer network technology. The research undertaken by Riahi et al. (2021) on AI applications in supply chain from a process perspective provided a decisional framework for adequate use of AI techniques in the different SC processes.

DATA, SAMPLE, AND METHODOLOGY

In this study, a new business model has been attempted to establish implementing the technology and methodology mentioned in 2.0 (visualised) for S. C. Trading & Co. This business mainly operates on a simple model, where the products are procured from a single manufacturer at a preset profit percentage after excluding costs, and supplied according to order. It operates for the global market. Observations and variations will be recorded and reported at the end of the project.

The study will be taken forward using the DMAIC methodology: define, measure, analyse, improve, and control (Fig. 2).

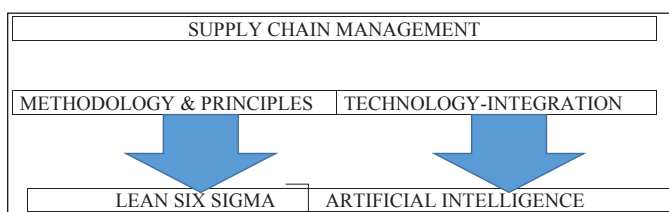


Fig. 1



Fig. 2: Initiating the Project using the DMAIC Methodology

The Define Phase: This phase will properly define the project and place a project charter to the stakeholder of the concerned business, explaining the business case and the project milestones and promises, mainly establishing the purpose of undertaking the project and its promised profitability. The signature of the stakeholder on this document will act as the permission or a go ahead for this project.

The Measure Phase: This phase mainly concentrates on the tools and methodology of collecting old data and setting a benchmark that can be used to compare new output, after project implementation. This phase is also concerned with MSA (Measurement System Analysis). Proper MSA reduces the chance of errors in the benchmarked data.

The Analyse Phase: This phase will mainly concentrate on root cause analysis, identifying the critical ‘X’.

The Improve Phase: This phase concentrates on generating and implementing solutions, and further optimising implemented solutions. Tools like Failure Mode Effect Analysis (FMEA) are used.

The Control Phase: This phase mainly monitors the implemented solution for any undesired errors and variations. Poka-yoke, shutdown control, warnings, and control charts are used. Transfer and closure are two important steps of this phase.

ANALYSIS AND FINDINGS

The Define Phase

The voice of the customer and the voice of the business are taken into account, along with other details. The project charter (Table 1) is then created and placed for approval.

Table 1: Six Sigma Project Charter

Project Title	
Integrating lean six sigma along with artificial intelligence to alter and evolve for betterment the current.	
Business Case	Opportunity Statement
This project will ensure better procedures of supply chain operations with reduced cost and waste as an added advantage, with a supreme goal of increasing the current profit percentage and operating efficiency of the business as a whole.	The pain area is mainly in the haphazard operations and processing of orders with huge waste generation, accompanied with reduction in profit margin. Improvement in these areas is an unexplored opportunity that needs to be addressed urgently.
Goal Statement	Scope
The goal will be specific, as improving the current haphazard supply chain and increasing the profit percentage by 10-15%, both percentages denoted as milestone 1 and 2, and improvement will be recorded from 01-01-2021 to 31-03-2021. The last quarter of 2020 will be taken as the old benchmark and calculated at the end of the project timeline.	OUT OF SCOPE: Vendor training for new process or technology implementation. IN-SCOPE: Planning, executing, and implementation of the project throughout the company's supply chain and other required areas as per the needs or decisions of the stakeholder.
Team Members	Project Timeline
Team members will include the normal operating staff of the company, and a certified lean six sigma green belt, to further this project.	Expected project end date: 05-03-2021 [Based on progress recorded on 02-01-2021]. Maximum date of extension: 31-03-2021.

The approval from a stakeholder in the form of a signature on the project charter officially ends this phase and furthers the project towards the measure phase.

The Measure Phase

This phase mainly records or takes into account the 'as is' performance or the current performance.

For this project, the metrics of the last quarter of 2020 will be considered and the data will be benchmarked for referencing in the 'improve' and 'control' phases. As electronic data input is used for collecting the previous data, no measurement system analysis is being done, as it is not required for this particular project. Table 2 reflects the outcome of the traditional supply chain management process existing currently.

Table 2: The Data (Snapshot from 01.10.2020 – 31.12.2020)

Quarter (2020)	P&L in %	Distributor Attrition (Unit)	Failure of Supplier in Supplying (Unit)	Excess or Blocked Inventory (Value in INR)	Loss or Issues Reported during Operations (Logistics included) (Value in INR)
Oct. to Dec.	23%	3	6	6,70,000	43,000

This data mainly shows the snapshot of some pain areas which are targeted for improvement. This data is therefore benchmarked and the data obtained after closure of project denoted by the successful completion of the pilot phase will be observed, recorded, and compared, to quantify the project deliverables or project output.

The Analyse Phase

In this phase, all potential X's are listed, and the critical X's are identified (Table 3).

Table 3: Identification of Potential and Critical X

P&L in %	Distributor Attrition	Failure of Supplier in Supplying (Manufacturer)	Excess or Blocked Inventory (Value in INR)	Loss or Issues Reported during Operations (Logistics Included)
1. Improper negotiations at the time of deal or purchase 2. Slack in supply chain operations 3. Product selection or product mix to be improved 4. Improper advertisement and marketing 5. Inadequate sales 6. Client acquisition 7. No focus on repeat purchases 8. Loss due to other un-optimised activities	1. Improper training and support 2. Logistical and other operational failures 3. Improper and unclear communication from parent company 4. Haphazard payment schedule and terms 5. 24x7 support not present 6. No VOD (voice of distributors) 7. Distributor guidelines or S.O.Ps not present	1. Unscheduled order placement 2. Absurd order quantity 3. Less SLOC (storage location) available 4. Single point of distribution from supplier's end 5. Improper agreement	1. No decided-upon EoQ or purchase strategy 2. Bad or absence of distributor and market feedback 3. Orders getting dropped 4. Bad forecast	1. Inadequate tracking or surveillance 2. Inadequate distribution network 3. Absence of distributed point of origin of ordered supplies 4. Improper training of staff and operations personnel 5. No set S.O.P for operations manager

The critical X's are identified, which can be done by various methods, like an old-fashioned discussion with the company, project stakeholders, or a company-wide survey including the distributors and other organisations associated with the company.

After concluding this phase, the project will move forward to the 'improve' phase, where the critical X will be addressed and improvements to the current state will be observed.

Critical X

- No focus on repeat purchases
- Improper agreement
- Bad forecast
- Distributor guidelines or S.O.Ps not present
- Unscheduled order placement
- Product selection or product mix to be improved
- Inadequate tracking or surveillance
- Haphazard payment schedule and terms

The Improve Phase

After identifying the critical X's from the list of potential X's, further work can be done with the agenda of improving these critical problems with appropriate solutions.

- No Focus on Repeat Purchases

This is a problem which proves to be a big hindrance in the path of the company's growth, and also negatively affects a company's goodwill in the market.

This directly affects the P&L of the company.

The Control Phase

This is the phase after the improvements have been implemented and output is achieved. The main essence of this phase is to control the level of improved performance. Certain steps to be followed are:

- Periodic audits
- Optimising activities
- Periodic meetings
- Use of control charts

Some other tools like Failure Mode Effect Analysis (FMEA) and Poka-yoke can also be used to control or stop failures and process or output deviation.

Proper shutdown protocol for different activities should be set, along with restarting process for those activities.

Comparison of the Outputs after Implementing the Project

Table 4 reflects the result after implementation of project in the traditional supply chain management process.

Table 4: The Data (Snapshot from 01.1.2021 – 03.03.2021) after Project Implementation

Quarter (2021)	P&L in %	Distributor Attrition (Unit)	Failure of Supplier in Supplying (Unit)	Excess or Blocked Inventory (Value in INR)	Loss or Issues Reported during Operations (Logistics Included) (Value in INR)
Jan. to Mar.	34%	1	2	2,40,000	18,000

DISCUSSION

On comparison with the benchmark snapshot from the quarter (01.10.2020 – 31.12.2020), we can see an improvement in the data from (01.01.2021 – 03.03.2021). The improvements are quantified as follows:

P&L%: 11%

Distributor Attrition: Reduced by 4 Units

Reduction in Failure of Supply: 4,30,000 INR

Reduction in Operating Losses: 25,000 INR

Project Charter Milestones

Goal Statement: 10 to 15% increase in P&L%. The goal statement of the project charter is satisfied, as the minimum goal was to increase the profit percentage by a minimum of 10%, and an increase of 11% is achieved.

Project Timeline: The projected deadline for the project charter was 05-3-2021; however, the project closure and transfer were completed by 03-03-2021. Hence, the project is ahead of scheduled completion.

Implication to Theory

Firstly, our study enhances understanding of how integration of lean six sigma, along with artificial intelligence, are distinct and cannot all be grouped into one homogeneous category. Previous studies have not provided a clear understanding of how dynamic capabilities behave and under what conditions they generate better results. To address this, and building on previous studies, we extended the theoretical contribution to understand how integration of lean six sigma along with artificial intelligence, as a higher-order dynamic

capability, influences the conventional supply chain management system.

Secondly, our study provides empirical evidence that the conventional supply chain management system acts as an antecedent to AI-driven SCM. Our findings add to the theory by identifying that SMC, under the mediating effect of the AI, enhances operational and financial performance, despite poor demand and restrictions imposed by governments on the movement of products.

Thirdly, our study explored quantitatively how integration of lean six sigma along with artificial intelligence in conventional supply chain management system increases profit percentage, reduces distributor attrition, lowers failure of supply, decreases excess or blocked inventory, and furthermore, reduces operating losses and project completion tenure.

Managerial Implications

In terms of managerial implications, our results suggest that senior supply chain managers need to understand the details in terms of the *what, how, and when*. In this respect, the results of this study provide directions to managers engaged in exploiting the application of artificial intelligence, to enable them to extract useful information for decision making related to managing complex supply chain networks.

Based on the comparative study, the following suggestions were likely to be implemented:

- A proper client relationship management system (Fig. 3) may be implemented, which will enable the management to obtain a snapshot of the company's existing client base, including purchase date range, ensuring proper client follow-ups that are supposed to increase repeat purchases; as a result, higher revenue and a loyal client base can be observed.



Fig. 3: Client Relationship Management System

- Artificial intelligence as a technology can be implemented along with the above suggestion to further improve the efficiency and effectiveness of the suggested action. AI can be utilised as a chatbot service, where customer follow-ups and feedback collection can be automated, thus reducing any misses.
- *Improper Agreement*: This is a problem that can and will hurt an organisation, not only in a legal way, but also with the potential of stripping away a company's long-term earned goodwill. The problem further might strain the company's relation with its vendors and distributors. This will directly affect the suppliers' time taken or success rate of supplies.
- All agreements should properly be drafted and should undergo strict quality checks; any issues should be addressed with the help of a proper legal aide appointed by the management.
- Further improvements can also be achieved by using artificially intelligent document proofreading software, which are widely available in the market, resulting in less human error with the potential of saving millions for the implementing organisation.
- *Bad Forecast*: This proves to be a huge issue in most organisations today, as the race within an organisation towards optimisation of activities increases and various forecasting activities also increase. An organisation generally expects a good forecast to coincide with demand, supply, and sales with an acceptable range of deviation or tolerance previously set or decided by the company. This is the main reason for the bullwhip effect of the supply chain. This directly affects a company's finance through excess or blocked inventory.
- Proper business intelligence software capable of advanced analytics from collected data should be used.
- Proper training should be imparted to the people or staff involved in collecting and preparing raw data.
- Artificially intelligent software should be used for automated data annotations and classifications. Further, the analysis of raw data should be passed through a panel of experts and an AI software capable of processing customised data.
- The methodology and process of data collection should be audited and proper S.O.P should be established.
- Historical data based on facts, for example, past year sales and so on, should be taken into account during forecasting.
- Forecasts should only be treated as a guide and not some unchangeable rulebook, because of dynamic properties and potential changes in raw data and trends.
- *Guidelines or S.O.Ps not Present*: This proves to be a huge hindrance in terms of distributor's smooth functioning and optimizing, along with increasing efficiency of an organisation's distribution and distribution network. This not only adversely affects the company's revenue and other metrics, but also adversely affects the distributors, which when left unattended leads to distributor attrition.
- Systematic operating procedures for distributors may be implemented and established.
- Automated and AI-enabled support for the distributors may be set up.
- Proper training should be provided, accompanied with periodic knowledge review sessions with the mother organisation (S. C. Trading & Co.).
- *Unscheduled Order Placement*: This directly affects the whole supply chain, as unprepared vendors might not be able to supply the ordered items on schedule.

- Forecast analysis must be properly integrated with planning and order scheduling.
- Support to suppliers from the mother organisation may be needed.
- Automated and AI-enabled inventory management systems may keep the suppliers in the loop via proper communication.
 - *Product Selection or Product Mix to be Improved:* This is a strategic decision, and any uncalculated or understudied decision will hurt the company in the long run and have huge adverse financial effects. This will directly have an effect on the P&L of the company.
- Proper analytics and market study should be conducted before selecting or deciding upon a product mix.
- The knowledge and discipline of digital marketing can be used, integrated with AI, to selectively target a particular market segment based on behavioural purchases and other relevant fields.
- Based on all the above collected data, and taking into account the pricing and market trends, the product mix should be adjusted. This process of optimising the product mix should be done in regular intervals to keep up with the market trends.
 - *Inadequate Tracking or Surveillance:* This problem creates an opportunity for business rivals, dishonest people, and unseen or unthought of, or unestimated events, which in turn causes problems during insurance claims and unnecessary delays, loss of good will, and so on.
- Each consolidated shipment (long-range shipments) should be fitted with proper GPS trackers and alert systems.
- The vehicles should be fitted with cameras and AI software, which are capable of assessing risks and alerting in time to avoid or reduce loss or damages.
- *Haphazard Payment Schedule and Terms:* This jeopardises the existing relationship of the mother company with its vendors, distributors, and other associated entities, including staff. In addition, this proves to be a hindrance in terms of record keeping, calculating taxes, and so on.
- The management should review, and if required, revise the existing payment terms.

- A proper software or SAAS should be used to automate record keeping and release payments on schedule in accordance with payment terms, viz., SAP.

CONCLUSION

Our results offer guidance to policymakers involved in formulating policies for developing countries, to understand how dynamic capabilities can be exploited to gain advanced outcomes. The results derived in this study are explicit, conceptually stimulating, and may provide guidance to managers engaged in supply chain management activities. The results showed that the conventional supply chain management system is difficult to build, due to the complexities and uncertainties that exist across organisational boundaries. Hence, it is not surprising that most alliances among partners fail to generate expected outcomes, especially in the context of leveraging the potential of lean six sigma and Artificial Intelligence-based SCM, especially during a pandemic. It is hoped that our results provide a framework that may act as a blueprint for the manufacturing sector to assess and improve the conventional supply chain management system with lean six sigma and AI-powered supply chain management, as well as increased organisational and financial performance.

However, we believe that budding technologies as dynamic capabilities, such as lean six sigma and AI, are far more complex in terms of their management, than capabilities based on traditional and well-established technologies. Hence, our findings suggest that future organisational scholars seeking to expand the restrictions of the theory should target on illuminating how some dynamic capabilities yield advanced results beyond expectations, while other such capabilities produce poor outcomes. To do this, we believe a more integrated approach, supported by other organisational theories, may be a fruitful roadmap for further future research.

REFERENCES

- Akter, S., Michael, K., Uddin, M. R., McCarthy, G., & Rahman, M. (2020). Transforming business using digital innovations: The application of AI, blockchain, cloud and data analytics. *Annals of Operations Research*, 1-33. doi:https://doi.org/10.1007/s10479-020-03620-w
- Antony, J., Escamilla, J. L., & Caine, P. (2003). Lean sigma [production and supply chain management]. *Manufacturing Engineer*, 82(2), 40-42. doi:https://doi.org/10.1049/me:20030203

- Barreto, L., Amaral, A., & Pereira, T. (2017, June 13). Industry 4.0 implications in logistics: An overview. In *Proc. Int. Conf. Manuf. Eng. Soc. (MESIC 2017)* (pp. 1245-1252).
- Ben-Daya, M., Hassini, E., & Bahroun, Z. (2019). Internet of things and supply chain management: A literature review. *International Journal of Production Research*, 57(15-16), 4719-4742. doi:<https://doi.org/10.1080/00207543.2017.1402140>
- Bendell, T. (2006). A review and comparison of six sigma and the lean organisations. *The TQM Magazine*, 18(3), 255-262.
- Clegg, B., Pepper, M. P. J., & Spedding, T. A. (2010). The evolution of lean six sigma. *International Journal of Quality & Reliability Management*, 27(2), 138-155.
- Dubey, R., Bryde, D. J., Blome, C., Roubaud, D., & Giannakis, M. (2021a). Facilitating artificial intelligence powered supply chain analytics through alliance management during the pandemic crises in the B2B context. *Industrial Marketing Management*, 96, 135-146.
- Dubey, R., Bryde, D. J., Foropon, C., Tiwari, M., Dwivedi, Y., & Schiffling, S. (2021b). An investigation of information alignment and collaboration as complements to supply chain agility in humanitarian supply chain. *International Journal of Production Research*, 59(5), 1586-1605.
- Frohlich, M. T., & Westbrook, R. (2001). Arcs of integration: An international study of supply chain strategies. *Journal of Operations Management*, 19, 185-200.
- Guofu, J., & Shumeng, H. (2015). Artificial intelligence in computer networks [J]. *Digital Technology and Applications*, (7), 100-103.
- Jayaram, A. (2016). *Lean 6 sigma approach for global supply chain management using industry 4.0 and IIoT*. 2nd International Conference on Contemporary Computing and Informatics (IC3I). Retrieved from <https://www.researchgate.net/publication/314114889>
- Kuei, C. H., Madu, C. N., & Lin, C. (2011). Developing global supply chain quality management systems. *International Journal of Production Research*, 49, 4457-4481.
- Liu, S., & Wu, B. (2010). *Study on the supply chain management of global companies*. International Conference in E-Business and E-Government (ICEE). doi:10.1109/ICEE.2010.829
- Martin, J. (2006). *Lean six sigma for supply chain management*. McGraw Hill Professional.
- Rejeb, A., Simske, S., Rejeb, K., Treiblmaier, H., & Zailani, S. (2020). Internet of things research in supply chain management and logistics: A bibliometric analysis. *Internet of Things*, 12. Elsevier.
- Riahi, Y., Saikouk, T., Gunasekaran, A., & Badraoui, I. (2021). Artificial intelligence applications in supply chain: A descriptive bibliometric analysis and future research directions. *Expert Systems with Applications*, 173. Elsevier.
- Srinivasan, R., & Swink, M. (2018). An investigation of visibility and flexibility as complements to supply chain analytics: An organizational information processing theory perspective. *Production and Operations Management*, 27(10), 1849-1867.
- Stadtler, H. (2015). Supply chain management: An overview. *Supply Chain Management and Advanced Planning*, 3-28. Springer.
- Sun, Z. W., Li, W. F., Song, W., & Jiang, P. (2011). Research on manufacturing supply chain information platform architecture based on internet of things. *Advanced Materials Research*. doi:<https://doi.org/10.4028/www.scientific.net/AMR.314-316.2344>
- Witkowski, K. (2017). Internet of things, big data, industry 4.0 – Innovative solutions in logistics and supply chains management. In *Proc. 7th Int. Conf. Eng. Project Prod. Manag.*, 182, 763-769.
- Yang, L. (2018). Research on application of artificial intelligence based on big data background in computer network technology, IOP Conf. Series: *Materials Science and Engineering*, 392. doi:10.1088/1757-899X/392/6/062185
- Yi-Tao, D. E. N. G. (2010). The internet of things technology application in the supply chain management. *Logistics Sci-Tech*, 9, 92-94.
- Yumei, H. (2017). Analysis of application of artificial intelligence in computer network technology. *Electronic World*, (11), 38-39.
- Zhang, L., & Zhang, Y. (2016). Big data analysis by infinite deep neural networks. *Journal of Computer Research and Development*, 53(1), 68-79.
- Zixing, C. (2016). *Artificial intelligence and its applications* (5th ed.). Beijing: Tsinghua University Press.

Website References

Retrieved June 29, 2021, from <https://qualitysupportgroup.com/supply-chain-management-scm/>