BLOCKCHAIN FOR INDUSTRY: SELECT ISSUES

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by

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***in fulfilment of the requirements of the degree of* Doctor of Philosophy**

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CERTIFICATE

This is to certify that the thesis entitled **"Blockchain for Industry: Select Issues"** being submitted by **Sachin Yadav** to the Indian Institute of Technology Delhi forthe award of the degree of **Doctor of Philosophy** is a bonafide record of original research work carriedout by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or whole, to any other University or Institute for the award of any degree or diploma.

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(Sachin Yadav)

ABSTRACT

Over the past two decades, the overall product cost has been affected by an inefficient and ineffective processes associated with uncertainty of the supply chain (SC) at a global level. The traditional supply chain (TSC) in general fails to meet customers' demand at a reasonable price matching high quality. Therefore, organisations are working on their existing SC to improve their performance utilizing the digital technologies.

In continuation, the world has also been stuck in the prevailing COVID-19 pandemic for the last more than two years. COVID-19 pandemic has also added to the vulnerabilities in the SC and the possibility of the volatility of raw materials and finished product demand in the global market. Therefore, uninterrupted supply is a big challenge for the organisation in the competitive global market. Nowadays, outsourcing of materials has become trend globally. However, these outsourcings only emphasize making the organisation profitable rather than robust from the viewpoint of the SC's transparency, quality, and resilience.

Blockchain (BC) is seen as a recent technology that comes up with promising solutions to disruption, shortages, fraud, poor quality, etc. in the SC. The BC-based SC may eradicate disruption and achieve resilience and sustainability. Therefore, there is a need to develop a resilient digital SC to capture the fluctuating information at each stage of SC in real-time. The BC application in SC is still at the initial stage, and only limited investigation is available in the literature. The increasing popularity of Blockchain Technology (BCT) motivates to explore the application of BC in select issues of the SC to make it more resilience and sustainable. In the thesis, procurement stage of the SC is taken as a main issue to show the application of BCT.

To start the work, thirty nine variables related to BC are identified that are analyzed and modelled using PCA, Fuzzy-DEMATEL, Fuzzy-ISM, Fuzzy-MICMAC, and Fuzzy-ANP. PCA is applied to form the twelve principal factors from the thirty-nine variables based on possible correlation. Although the application of Fuzzy-DEMATEL is adopted to identify

significant causes that help achieve a sustainable supply chain (SSC) after the integration of BCT. Later on, the combined approach of both Fuzzy-ISM and Fuzzy-MICMAC is applied to identify the common drivers to integrate the BCT in the light of efficient SCM over twelve factors. Later, a comparative analysis between TSC versus BC integrated SC using Fuzzy-ANP is carried out, considering the common driving characteristics obtained from the Fuzzy-ISM, Fuzzy-MICMAC, Fuzzy-DEMATEL. The proposed integrated approach of Fuzzy-ANP showed that integration of BC with SC is better prioritized than TSC.

After comparing the TSC with BC-based SC, BC-based modelling of procurement in the SC is carried out. Here, the MILP model is proposed for optimizing overall procurement cost, including the BCT cost. In addition to this, two extensions are carried out. The first extension emphasizes the real-time records and other aspects of BC, like authenticity, time, etc., that are essential and considered for computing the procurement cost. In the first extension, Machine learning (ML) aggregates the value reported by the miners in real-time for developing authenticity dependent variable factors. The total cost hinges on the block's authenticity through the miner's signals. Here, the real-time authenticity factor is utilised to formulate the MINLP model. In the second extension, a stochastic MINLP mathematical model is proposed. The concept of ML is being introduced to determine discrete authenticity decision variables in the model to make the SC more robust and resilient. The fluctuation in demand, plant capacity, data flow in IoT devices, and the supplier capacity has been considered in the model. The uncertainties associated with mining blocks are also contemplated herein MINLP model. Finally, these three proposed models have been used for an India-based manufacturing firm running its fire and safety equipment business.

In addition to develop mathematical models, various barriers associated with implementation of BC in the SC is also studied. These BCT barriers are modelled and analysed using the ISM and MICMAC analysis. The analysis of the BCT barriers explain its importance

in integrating the BCT with the SC. Finally, a case study is also included to validate the proposed MILP (Integrated base model), MINLP (ML-based integrated mathematical model) and Stochastic MINLP model (ML-based Stochastic MINLP mathematical model). Eventually, this proposed work transforms the conventional SC into real-time digital SC. In future, the research work may provide guidelines and solutions in implementing the BCT in the SC to make digital SC in order to address resilience and sustainability.

Keywords: Blockchain, Drugs Supply Chain, Fuzzy-ISM, Fuzzy-DEMATEL, Fuzzy-AHP, Fuzzy-ANP, IoT, Procurement problem, Supplier selection, MILP, MINLP, Stochastic model.

सारांश

पिछले दो दशकों में, वैश्विक स्तर पर आपूर्ति श्रृंखला (एससी) की अनिश्चितता से जुड़ी एक अक्षम और अप्रभावी प्रक्रियाओं से समग्र उत्पाद लागत प्रभावित हुई है। पारंपरिक आपूर्ति श्रृंखला (टीएससी) सामान्य रूप से उच्च गुणवत्ता से मेल खाने वाले उचित मूल्य पर ग्राहकों की मांग को पूरा करने में विफल रहती है। इसलिए, संगठन डिजिटल तकनीकों का उपयोग करके अपने प्रदर्शन को बेहतर बनाने के लिए अपने मौजूदा एससी पर काम कर रहे हैं।

निरंतरता में, दुनिया भी पिछले दो वर्षों से अधिक समय से प्रचलित COVID-19 महामारी में फंसी हुई है। COVID-19 महामारी ने SC में कमजोरियों और वैश्विक बाजार में कच्चे माल की अस्थिरता और तैयार उत्पाद की मांग की संभावना को भी जोड़ा है। इसलिए, प्रतिस्पर्धी वैश्विक बाजार में संगठन के लिए निर्बाध आपूर्ति एक बड़ी चुनौती है। आजकल, सामग्री की आउटसोर्सिंग विश्व स्तर पर चलन बन गई है। हालांकि, ये आउटसोर्सिंग केवल एससी की पारदर्शिता, गुणवत्ता और लचीलेपन के दृष्टिकोण से मजबूत होने के बजाय संगठन को लाभदायक बनाने पर जोर देती है।

ब्लॉकचैन (बीसी) को एक हालिया तकनीक के रूप में देखा जाता है जो एससी में व्यवधान, कमी, धोखाधड़ी, खराब गुणवत्ता आदि के लिए आशाजनक समाधान के साथ आता है। बीसी-आधारित एससी व्यवधान को मिटा सकता है और लचीलापन और स्थिरता प्राप्त कर सकता है। इसलिए, वास्तविक समय में अनुसूचित जाति के प्रत्येक चरण में उतार-चढ़ाव वाली जानकारी को पकड़ने के लिए एक लचीला डिजिटल एससी विकसित करने की आवश्यकता है। एससी में बीसी आवेदन अभी भी प्रारंभिक चरण में है, और साहित्य में केवल सीमित जांच उपलब्ध है। ब्लॉकचैन टेक्नोलॉजी (बीसीटी) की बढ़ती लोकप्रियता एससी के चुनिंदा मुद्दों में बीसी के आवेदन का पता लगाने के लिए प्रेरित करती है ताकि इसे और अधिक लचीलापन और टिकाऊ बनाया जा सके। थीसिस में, बीसीटी के आवेदन को दिखाने के लिए एससी के खरीद चरण को मुख्य मुद्दे के रूप में लिया जाता है।

काम शुरू करने के लिए, बीसी से संबंधित उनतीस चरों की पहचान की जाती है जिनका विश्लेषण

और मॉडलिंग पीसीए, फ़ज़ी-डीमैटेल, फ़ज़ी-आईएसएम, फ़ज़ी-एमआईसीएमएसी और फ़ज़ी-एएनपी का उपयोग करके किया जाता है। संभावित सहसंबंध के आधार पर उनतीस चरों से बारह प्रमुख कारक बनाने के लिए पीसीए लागू किया जाता है। यद्यपि फ़ज़ी-डीमैटेल के अनुप्रयोग को महत्वपूर्ण कारणों की पहचान करने के लिए अपनाया जाता है जो बीसीटी के एकीकरण के बाद एक स्थायी आपूर्ति श्रृंखला (एसएससी) प्राप्त करने में मदद करते हैं। बाद में, फ़ज़ी-आईएसएम और फ़ज़ी-एमआईसीएमएसी दोनों के संयुक्त दृष्टिकोण को बारह कारकों पर कुशल एससीएम के आलोक में बीसीटी को एकीकृत करने के लिए सामान्य ड्राइवरों की पहचान करने के लिए लागू किया जाता है। बाद में, फ़ज़ी-आईएसएम, फ़ज़ी-एमआईसीएमएसी, फ़ज़ी-डीमैटेल से प्राप्त सामान्य ड्राइविंग विशेषताओं पर विचार करते हुए, फ़ज़ी-एएनपी का उपयोग करते हुए टीएससी बनाम बीसी एकीकृत एससी के बीच एक तुलनात्मक विश्लेषण किया जाता है। फ़ज़ी-एएनपी के प्रस्तावित एकीकृत दृष्टिकोण से पता चला है कि एससी के साथ बीसी का एकीकरण टीएससी की तुलना में बेहतर प्राथमिकता है।

बीसी-आधारित एससी के साथ टीएससी की तुलना करने के बाद, एससी में बीसी-आधारित खरीद की मॉडलिंग की जाती है। यहां, बीसीटी लागत सहित समग्र खरीद लागत को अनुकूलित करने के लिए एमआईएलपी मॉडल प्रस्तावित है। इसके अलावा, दो एक्सटेंशन किए जाते हैं। पहला विस्तार वास्तविक समय के रिकॉर्ड और बीसी के अन्य पहलुओं पर जोर देता है, जैसे प्रामाणिकता, समय, आदि, जो आवश्यक हैं और खरीद लागत की गणना के लिए विचार किया जाता है। पहले विस्तार में, मशीन लर्निंग (एमएल) प्रामाणिकता पर निर्भर चर कारकों को विकसित करने के लिए वास्तविक समय में खनिकों द्वारा रिपोर्ट किए गए मूल्य को एकत्रित करता है। कुल लागत खनिक के संकेतों के माध्यम से ब्लॉक की प्रामाणिकता पर निर्भर करती है। यहां, वास्तविक समय प्रामाणिकता कारक का उपयोग MINLP मॉडल तैयार करने के लिए किया जाता है। दूसरे विस्तार में, एक स्टोकेस्टिक MINLP गणितीय मॉडल प्रस्तावित है। एससी को अधिक मजबूत और लचीला बनाने के लिए मॉडल में असतत प्रामाणिकता निर्णय चर निर्धारित करने के लिए एमएल की अवधारणा पेश की जा रही है। मॉडल में मांग में उतार-चढ़ाव, संयंत्र

की क्षमता, और IoT उपकरणों में डेटा प्रवाह और आपूर्तिकर्ता क्षमता पर विचार किया गया है। खनन ब्लॉकों से जुड़ी अनिश्चितताओं पर भी यहां MINLP मॉडल पर विचार किया गया है। अंत में, इन तीन प्रस्तावित मॉडलों का उपयोग भारत की एक विनिर्माण फर्म के लिए किया गया है जो अपना अग्नि और सुरक्षा उपकरण व्यवसाय चला रही है।

गणितीय मॉडल विकसित करने के अलावा, अनुसूचित जाति में बीसी के कार्यान्वयन से जुड़े विभिन्न बाधाओं का भी अध्ययन किया जाता है। इन बीसीटी बाधाओं को आईएसएम और एमआईसीएमएसी विश्लेषण का उपयोग करके मॉडलिंग और विश्लेषण किया जाता है। बीसीटी बाधाओं का विश्लेषण एससी के साथ बीसीटी को एकीकृत करने में इसके महत्व की व्याख्या करता है। अंत में, प्रस्तावित MILP (एकीकृत आधार मॉडल), MINLP (ML-आधारित एकीकृत गणितीय मॉडल) और Stochastic MINLP मॉडल (ML-आधारित Stochastic MINLP गणितीय मॉडल) को मान्य करने के लिए एक केस स्टडी को भी शामिल किया गया है। आखिरकार, यह प्रस्तावित कार्य पारंपरिक एससी को रीयल-टाइम डिजिटल एससी में बदल देता है। भविष्य में, अनुसंधान कार्य लचीलापन और स्थिरता को संबोधित करने के लिए डिजिटल एससी बनाने के लिए एससी में बीसीटी को लागू करने में दिशानिर्देश और समाधान प्रदान कर सकता है।

विशिष्टशब्द: ब्लॉकचैन, ड्रग्स सप्लाई चेन, फ़ज़ी-आईएसएम, फ़ज़ी-डीमेटेल, फ़ज़ी-एएचपी, फ़ज़ी-एएनपी, आईओटी, प्रोक्योरमेंट समस्या, आपूर्तिकर्ता चयन, एमआईएलपी, मिनएलपी, एमसीडीएम, स्टोकेस्टिक मॉडल ।

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i	Index for Product
j	Index for Supplier
t	Index for Period
α	Index for the purchasing process
β	Index for the transportation process
λ	Index for inventory management process
ψ	Index for the order process
List of Common Variables in Chapter 4, 5, and 6	
N_{ijt}^{α}	The number of blocks mined during the purchasing process for i^{th} product from j^{th} supplier in t^{th} period.
N_{ijt}^{β}	The number of blocks mined during the transportation from an i^{th} product from j^{th} supplier in t^{th} period.
N_{it}^{λ}	The number of blocks mined during the Holding process for an i^{th} lot in t^{th} period
N_{ijt}^{Ψ}	The number of blocks mined during the ordering process i^{th} product from j^{th} supplier in t^{th} period.
W_{it}	$\begin{cases} 1, \text{if } i^{th} \text{product available in the inventory section for } t^{th} \text{ period} \\ 0, \text{if } i^{th} \text{product is not available in the inventory section for } t^{th} \text{ period.} \end{cases}$
x_{ijt}	Procurement of Lot size of the i^{th} product from the j^{th} supplier in t^{th} period.
Y_{ijt}	$\begin{cases} 1, \text{if } j^{th} \text{ supplier is selected for the } i^{th} \text{product at any } t^{th} \text{ period.} \\ 0, \text{if procurement fails.} \end{cases}$
$\alpha_{\boldsymbol{ijt}}$	$\begin{cases} 1, \ if\ miner \geq 51\%\ gives\ Green\ signal\ for\ procurement\ process. \\ 0, \ else \end{cases}$
β_{ijt}	$\begin{cases} 1, if\ miner \geq 51\%\ gives\ Green\ signal\ for\ transportation\ process. \\ 0, \ else \end{cases}$
λ_{ijt}	$\begin{cases} 1, if\ miner \geq 51\%\ gives\ Green\ signal\ for\ holding\ process. \\ 0, else \end{cases}$
ξ_{ijt}	The number of the trucks involved for the supply of i^{th} product sent by the j^{th} supplier t^{th} period.
φ_{it}	Inventory for i^{th} product in t^{th} period.
Ψ_{ijt}	$\begin{cases} 1, \ if\ miner \geq 51\%\ gives\ Green\ signal\ for\ order\ process. \\ 0, \ else \end{cases}$
List of Common Parameters in Chapter 4, 5 and 6	
B_S	The size of the Block is constant for the whole procurement problem.
$N_{IoT,\alpha}$	The number of IoT devices installed for the purchasing process irrespective of i, j, t.
$N_{IoT,\beta}$	The number of IoT devices installed for the transportation process irrespective of i, j, t.
$N_{IoT,\lambda}$	The number of IoT devices installed for the holding process irrespective of i, t.
$N_{IoT,\Psi}$	The number of IoT devices installed for the order process irrespective of i, j, t.
$T_{d\alpha}$	Total time for receiving the information and consumed in data transfer for the procuring

	process.
$T_{d\beta}$	Total time for receiving the information and consumed in data transfer for the transporting process.
$T_{d\lambda}$	Total time for receiving the information and consumed in data transfer for holding process.
$T_{d\Psi}$	Total time for receiving the information and consumed in data transfer for the ordering process.
$\alpha_{G_{ijt}}$	Strength of green signal in percentage required for the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the procurement process.
$\alpha_{R_{ijt}}$	Strength of red signal in percentage required for not making the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the purchasing process.
$\alpha_{Stups_{ijt}}$	Startup experience in 24+ months required for efficiently block mining in the purchasing process for making or not making the transaction of i^{th} product from a j^{th} supplier in t^{th} time.
$\beta_{G_{ijt}}$	Strength of green signal in percentage required for the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the transportation process.
$\beta_{R_{ijt}}$	Strength of red signal in percentage required for not making the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the transportation process.
$\beta_{Stups_{ijt}}$	Startup experience in 24+ months required for efficiently block mining in transportation process for making or not making the transaction of i^{th} product from a j^{th} supplier in t^{th} time.
Δ_{it}	Plant capacity of i^{th} product in t^{th} time.
η	Truck Capacity irrespective for i^{th} products loaded by the j^{th} supplier in t^{th} time.
$\lambda_{G_{it}}$	Strength of green signal in percentage required for the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the inventory management process.
$\lambda_{R_{it}}$	Strength of red signal in percentage required for not making the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the inventory management process.
$\lambda_{Stups_{it}}$	Startup experience in 24+ months required for efficiently block mining for inventory management process for making or not making the transaction of i^{th} product in t^{th} time.
$\Psi_{G_{ijt}}$	Strength of green signal in percentage required for the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the order process.
$\Psi_{R_{ijt}}$	Strength of red signal in percentage required for not making the transaction of i^{th} product from a j^{th} supplier in t^{th} time in the order process.
$\Psi_{Stups_{ijt}}$	Startup experience in 24+ months required for efficiently block mining in the order process for making or not making the transaction of i^{th} product from a j^{th} supplier in t^{th} time.
Ω_{ijt}	Supplier capacity for an i^{th} product from a j^{th} supplier in t^{th} time.
$℧_{it}$	The demand of an i^{th} product in t^{th} time.
$Ϙ_{\boldsymbol{i}}$	Volume per unit of i^{th} product.
$\$^{\alpha}_{\boldsymbol{ijt}}$	Cost of unit block mined during the purchasing process from j^{th} suppliers' combination in t^{th} time.
$\$^{\boldsymbol{\beta}}_{\boldsymbol{ijt}}$	Cost of unit block mined during the transportation process from j^{th} suppliers' combination

	in t^{th} time.
$\$^{\lambda}_{ijt}$	Cost of unit block mined during the holding process for i^{th} lot size in t^{th} time.
$\$^{\Psi}_{ijt}$	Cost of unit block mined during the ordering process from j^{th} suppliers' combination in t^{th} time.
$£^{\alpha}_{ijt}$	Purchasing Cost for an i^{th} product from a j^{th} supplier in t^{th} time.
$£^{\beta}_{ijt}$	Transportation Cost for an i^{th} product from a j^{th} supplier in t^{th} time.
$£^{\lambda}_{ijt}$	Holding cost for an i^{th} product in t^{th} time.
$£^{\Psi}_{ijt}$	Order Cost for an i^{th} product from a j^{th} supplier in t^{th} time.
$\mathfrak{K}_{\alpha}$	Average data transfer rate through IoT devices irrespective of device types for the procuring process and irrespective of i, j, t.
$\mathfrak{K}_{\beta}$	Average date transfer rate through IoT devices irrespective of device types for the transportation process and irrespective of i, j, t.
$\mathfrak{K}_{\lambda}$	Average data transfer rate through IoT devices irrespective of the device type for the holding process and irrespective of i, t.
$\mathfrak{K}_{\psi}$	Average data transfer rate through IoT devices irrespective of device types for the order process and irrespective of i, j, t.
List of Variables for ML in Chapter 5 and 6	
X_{Green}	Independent variable (Numbers of miners responsible for green signal)
X_{Red}	Independent variable (Numbers of miners responsible for red signal)
X_{Stups}	Independent variable (Startups experience in 24 months+)
Y	Dependent variable
List of Parameters for ML in Chapter 5 and 6	
₵$_{o}$	Constant Coefficient
₵$_{1}$	Coefficient of independent variable X_{Red}
₵$_{2}$	Coefficient of independent variable X_{Green}
₵$_{3}$	Coefficient of independent variable X_{Stups}
List of Special Parameters in Chapter 6	
$F^{-1}_{\Delta_{it}}$	The constant inverse cumulative probability distribution function for random plant capacity for given εp_{it} having mean (μ) and standard deviation (σ).
$F^{-1}_{\Omega_{ijt}}$	The constant inverse cumulative probability distribution function for random supplier capacity for given εs_{ijt} having mean (μ) and standard deviation (σ).
$F^{-1}_{\mho_{it}}$	The constant inverse cumulative probability distribution function for random demand for given ε_{it} having mean (μ) and standard deviation (σ).
ε_{it}	Level of probability that unit supplied satisfies the demand of an i^{th} product in t^{th} period.
εp_{it}	Level of probability that unit procured including inventory satisfies the plant capacity for an i^{th} product in t^{th} period.
εs_{ijt}	Level of probability that unit supplied satisfies the supplier capacity for an i^{th} product from a j^{th} supplier in t^{th} period.
Λ^{α}_{ijt}	Average data transfer per unit time for i^{th} product procured from the j^{th} supplier in t^{th} time.

Λ_{ijt}^{β}	Average data transfer per unit time for i^{th} product transported from a j^{th} supplier in t^{th} time.
Λ_{ijt}^{Ψ}	Average data transfer per unit time for an i^{th} product ordered from a j^{th} supplier in t^{th} time.
Π_{ijt}^{α}	No. of IoT devices installed for i^{th} product procured from the j^{th} supplier in t^{th} time.
Π_{ijt}^{β}	No. of IoT devices installed for i^{th} product transported from a j^{th} supplier in t^{th} time.
Π_{it}^{λ}	No. of IoT devices installed for the inventory management process for the i^{th} product in t^{th} time.
Π_{ijt}^{Ψ}	No. of IoT devices installed for an i^{th} product ordered from a j^{th} supplier in t^{th} time.
$\coprod_{ijt}^{\alpha}$	The upper limit of data flows in the purchasing process for an i^{th} product from a j^{th} supplier in t^{th} period.
$\coprod_{ijt}^{\beta}$	The upper limit of data flows in the transportation process for an i^{th} product from a j^{th} supplier in t^{th} period.
$\coprod_{it}^{\lambda}$	The upper limit of data flows in the holding process for an i^{th} product from a j^{th} supplier in t^{th} period.
$\coprod_{ijt}^{\Psi}$	The upper limit of data flow in the order process for an i^{th} product from a j^{th} supplier in t^{th} period
Γ_{ijt}^{α}	The lower limit of data flows in the procurement process for an i^{th} product from a j^{th} supplier in t^{th} period.
Γ_{ijt}^{β}	The lower limit of data flows in the transportation process for an i^{th} product from a j^{th} supplier in t^{th} period.
Γ_{it}^{λ}	The lower limit of data flows in the holding process for an i^{th} product from a j^{th} supplier in t^{th} period.
Γ_{ijt}^{Ψ}	The lower limit of data flow in the order process for an i^{th} product from a j^{th} supplier in t^{th} period

LIST OF TABLES

LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
BC	Blockchain
BCT	Blockchain Technology
BCSC	Blockchain-Based Supply Chain
DEMATEL	Decision Making Trial And Evaluation Laboratory
FSCM	Food Supply Chain Management
DSCSA	US Drug SC Security Act
EOQ	Economic Order Quantity
ERP	Enterprise Resource Planning
HBC	Holding Block Cost
HC	Holding Cost
ILP	Integer Linear Program
IoT	Internet of Things
ISM	Interpretive Structural Modelling
MCDM	Multi-Criteria Decision Making Techniques
MILP	Mixed Integer Linear Program
MIP	Mixed Integer program
ML	Machine Learning
MINLP	Mixed Integer Non-Linear Program
NPB	Number of Purchasing Blocks
NOB	Number of Ordering Blocks
NTB	Number of Transportation Blocks
NHB	Number of Holding Blocks
OBC	Order Block Cost
OC	Order Cost
OSCM	Operations And Supply Chain Management
PBC	Purchasing Block Cost
PC	Purchasing Cost
PCA	Principal Component Analysis
RO	Research Objective
SC	Supply Chain

SCM	Supply Chain Management
SSC	Sustainable Supply Chain
SSIM	Structural Self Interaction Matric
TBC	Transportation Block Cost
TC	Transportation Cost
TISM	Total Interpretive Structural Modelling
TOPSIS	The Techniques for Order of Preference by Similarity to Ideal Solution
WIP	Work In Progress
WML	Without Machine Learning
RFID	Radio Frequency Identification
GA	Genetic Algorithm
COVID	Coronavirus Disease
IF	Intuitionistic Fuzzy
FDA	Food And Drug Administration
NFC	Near Field Communication
MRP	Maximum Retail Price