Project Dissertation Report on

Role of ICT in manufacturing supply chain: An experimental method using TOPSIS for selection of best fabrication method

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CERTIFICATE

"This is to certify that the work titled **"Role of ICT in manufacturing supply chain: An experimental approach using TOPSIS for selection of best fabrication method"** as part of the final year Major Research Project submitted by N. Yuvaraj in the 4th Semester of Executive MBA, Delhi School of Management, Delhi Technological University during January-May 2020 was conducted under my guidance and supervision".

"This work is her original work to the best of my knowledge and has not been submitted anywhere else for the award of any credits/ degree whatsoever".

"The project is submitted to Delhi School of Management, Delhi Technological University in partial fulfillment of the requirement for the award of the degree of Master of Business Administration".

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DECLERATION

“I hereby declare that the work titled ‘Role of ICT in manufacturing supply chain: An experimental method using TOPSIS for selection of best fabrication method’ as part of the final year Major Research Project submitted by me in the 4th Semester in Executive MBA, Delhi School of Management, Delhi Technological University, during January-May 2020 under the guidance of Prof. P.K. Suri is my original work and has not been submitted anywhere else”.

“The report has been written by me in my own words and not copied from elsewhere. Anything that appears in this report which is not my original work has been duly and appropriately referred/cited/ acknowledged”.

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N. YUVARAJ

ABSTRACT

The Information and Communications Technology shows dominant role in manufacturing and supply chain for improving the business. This report focuses on recent applications and challenges of big data analytics with IoT enabled in smart connected products in supply chain and interlinking with global operations. It discovering the operational constraints, and understanding the different IT techniques in supply chain and smart manufacturing. The project focuses on approach of multi-criteria decision model for finding the order of preferences in production of surfaces.

Finally, TOPSIS is successful method to recognize the order of preference in various alternatives. In this study experiments are conducted to fabricate surface layer on the materials by Friction Stir Processing method which is based on green welding process. Different six environment conditions such as (i) dry air (ii) with dry ice (iii) submerged with water (iv) cryogenic (v) ultrasonic vibration and (v) ultrasonic vibration with cryogenic conditions has been selected. The material properties such as, microhardness, grain size, tensile strength, wear rate and friction coefficient has been investigated from the fabricated surfaces.

Based on the experimental results and importance of the specific applications to the properties the weights have been assigned. From the TOPSIS technique best method fabricating method of ultrasonic vibration with cryogenic conditions has been identified to fabricate surface layer.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Nowadays ICT has become major element in managing logistics, operations, inventory management, quality management systems in networks, and will be growing over the period of time. The ICT based uses in supply chains is of leading interest in the industries for efficient managing operations across the networks. The most of the organizations are investing funds in growth and recommendation of new IT based supportive things such as big data analytics, RFID, Internet of Things (IoT) in the supply chain. The project explores the budding area of ICT benefits in supply chains and reverse logistics. In addition, how industries are adopting the various types of IT based web-solutions in their applications. Green supply chain actions have come up as a standard measurement approach in manufacturing sector to balance the economic and environmental conditions (Geng et al., 2017, Sarkis, 2003, Salam, 2008). In this report how ICT uses effectively in supply chain and the importance of big data analytics in manufacturing & integration with supply chain.

Finally, an experimental method using TOPSIS decision technique adopted for selection of best environmental manufacturing approach for selection of suitable applications. Friction stir welding method has been used for surface modification of aluminum alloys, which is suitable for wear resistant applications. In the experimental work various environmental conditions such as (i) processing in dry air (ii) with dry ice (iii) submerged with under water (iv) cryogenic (v) ultrasonic vibration and (v) ultrasonic vibration with cryogenic conditions has been selected. Fabricated specimens grain size, microhardness, tensile strength, wear rate and friction coefficient has been investigated. Based on results TOPSIS method is applied for identifying the best manufacturing conditions.

1.2 Supply Chain Management

Supply chain states that the of movement of raw materials to the manufacturers, manufactured goods to the end user through distributor or warehouse. The information and financial funds also flows across the supply chain. It involves to handling of sales & services, returns of defected products, remanufacturing and recycling of goods (Seuring, and Muller, 2008, Mehrjerdi, 2009). Figure 1.1 displays the schematic representation of a supply chain with integration with management. SCM concerns with coordination of materials and information among various firms. Recent days' supply chain grow enormously in the organization due to top management to operations is directly involved. Firms are progressively intelligent in terms of better coordination with their suppliers and consumers (Stanley, et al., 2008, Christopher, M. 2007, Shore, B. 2001).

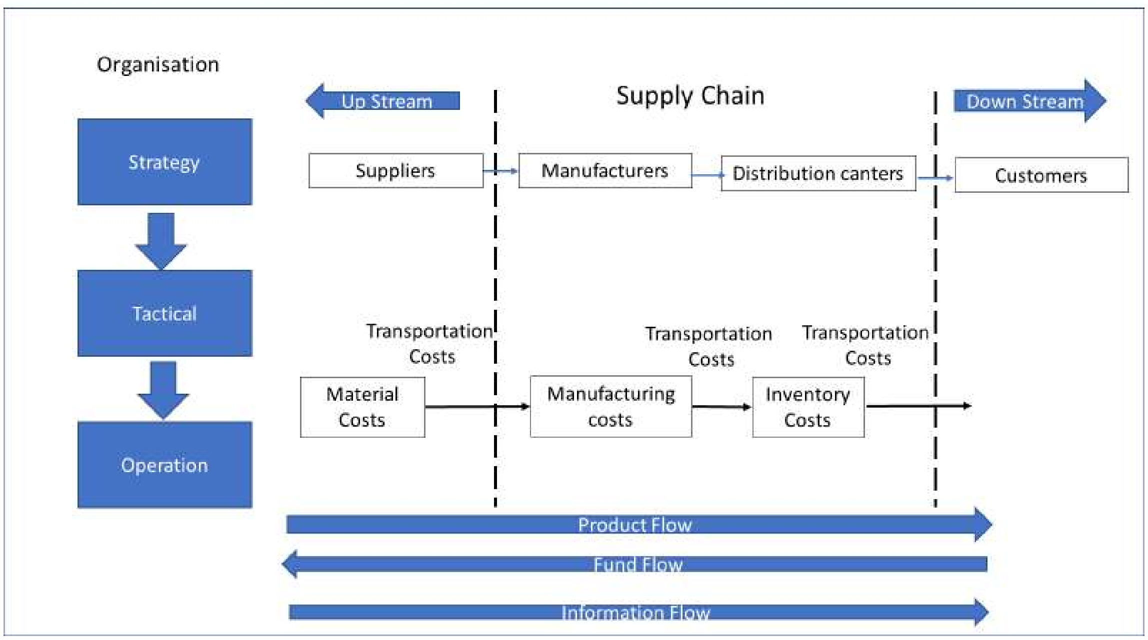

Figure 1.1 Schematic of a Supply Chain (Adopted from Zang et al., 2016)

1.3 Importance of IT in Supply Chain

- IT plays major role to reduce cost of product through efficient distributions.
- Communication Technologies supports the SCM through efficient network distributions.
- Innovative technologies provide information method of employment.
- Supply chain integration assists the challenges in coordination of physical flow of materials (Zang et al., 2016).
- IT makes trouble-free procurement and easier to identify the track data.

1.4 Objectives

- To study the challenges and opportunities of ICT in intelligent manufacturing, supply chain and green supply chain.
- To review the importance of big data with analytics in supply chain with IoT enabled in smart connected products and interlinking with global operations.
- To fabricate Aluminum surface layer using Friction stir processing (green processing) surface modifying technique with different green environment conditions and finding the suitable method as per sustainable development using TOPSIS decision-making technique.
- Environmental conditions such as (i) processing in dry air (ii) with dry ice (iii) submerged with under water (iv) cryogenic (v) ultrasonic vibration and (v) ultrasonic vibration with cryogenic conditions selected for producing surface. Fabricated specimens grain size, microhardness, tensile strength, wear rate and friction coefficient has been investigated.
- TOPSIS model applied on the results and order of preference has been assigned as per ranking of order.

CHAPTER 2
LITERATURE REVIEW

2.1 ICT and Supply Chain

The various prominent ICT applications such as (i) voice system, (ii) radio frequency tags (iii) big data (iv) IoT (v) cloud computing used in supply chain. The various IT-Web based technology used for efficient functioning of procurement, operations, logistics, inventory, supply chain and handling of returns. These integration intranet and extranet with ERP data-based management widely used in the supply chain loops. The Figure 2.1 shows the integration ERP system with supply chain (Papetti et al., 2019). Recent days the role IoT with cloud computing is most successful in supply chain networks. Upstream supply chain means to that the raw materials are used for making sub-assemblies and then to finished goods. In the downstream supply chain, the how the finished goods are distributed to the customers (Mokhtar et al., 2019). Integrating of various ICT in the upstream and downstream supply chain is shown in Figure 2.2.

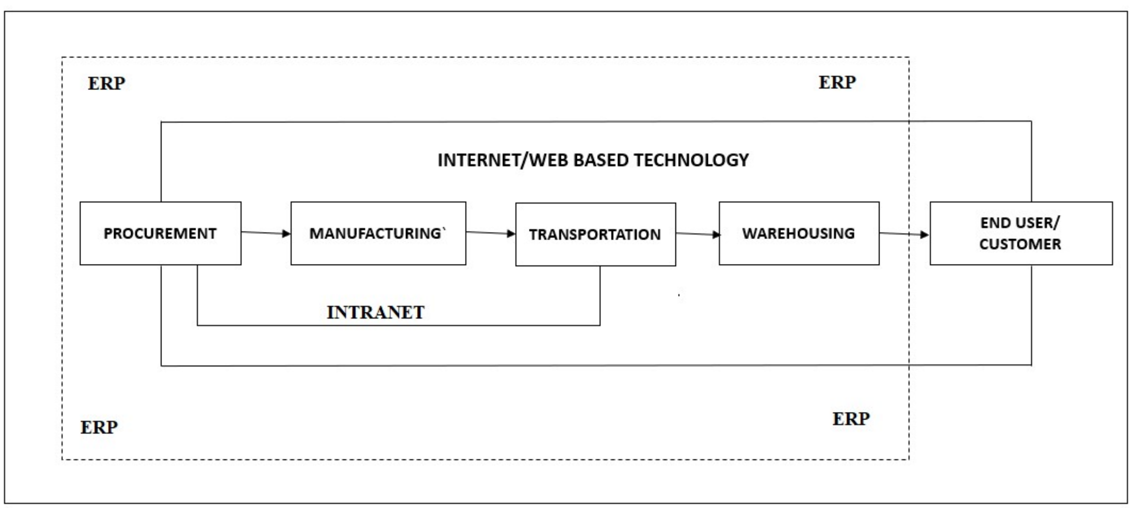

Figure 2.1 IT Solutions in supply chain

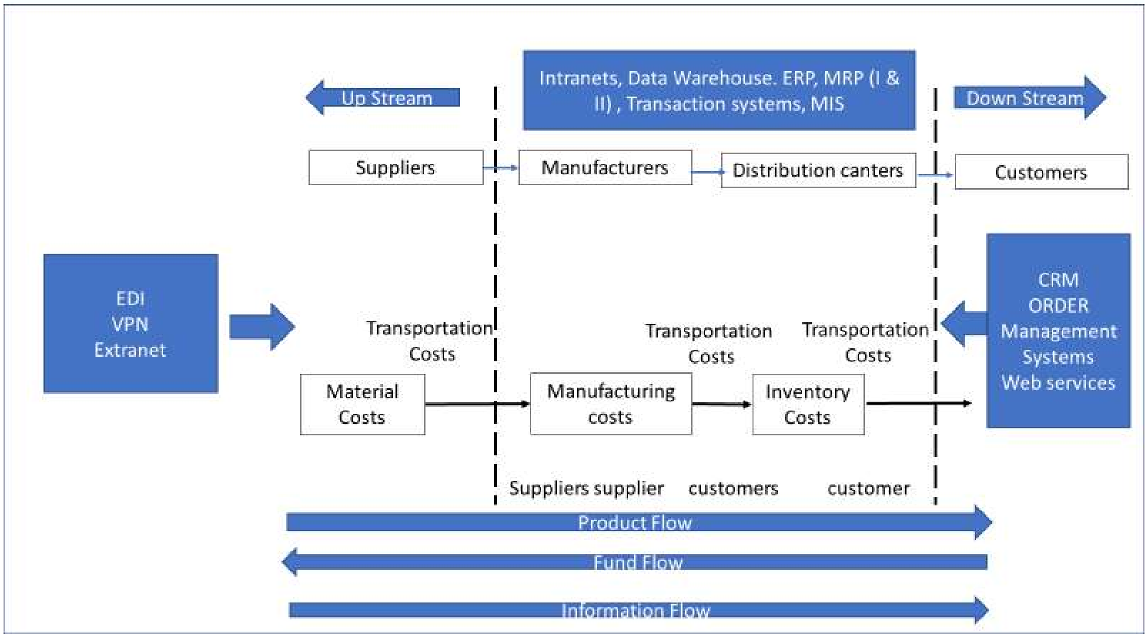

Figure 2.2 Integration of IT in supply chain

2.2 Big data in Supply Chain

In the modern world Big Data is used to analyze, extract information from various sources and deals various data sets larger volume of data. The data are collected from internet like reviews, recording sales, CCTV footages, GPS enabled services etc. Various software's are exercised for analyzing data. By using the big data, one must have to adopt in certain industry specific knowledge. For that good data analyst is required with specific sound knowledge in the respective field. Recent days Big data analytics have inherent implementation in supply chain area such as logistics, materials management, customer and supplier relationship management, handling of returned goods etc.

2.3 Green supply chain

Green supply chain is the movement of raw materials from suppliers to manufactures and to final consumers by using environmentally friendly manner. After the life of the products which can be reused, remanufactured, recycled or easily disposed. Green supply is adopting to sustainable environment (Ho et al., 2009). In some strategies compensation among enterprise based on low environmental issues and enhances the competence of the whole supply chain. Wang et al., 2011 proposed the manufacturing units into decentralized type and the adaptive type implemented in green supply chain operations. Similarly, Pinto et al., 2011 proposed model with profit maximization with considering all environmental issues through eco benchmark methods.

Recently Chen et al., 2020 reported that pricing and equity in supply chain of firms operating from cross-border or domestic operations. Products manufacturing with higher carbon emission not only affects the revenue growth, but also reduces the equity of the firm through various environmental issues. Panja et al., 2019 Studied the implementation of inferior inventory system in four-layer green supply chain and sensitivity analysis has been proposed. Yavari and Zaker, 2020 reported that five types of mitigation actions may be considered while implementing the perishable nature of products re-silent green supply chain. The end-of-life of the products the retailer is responsible for taking necessary actions for recycling and for remanufacturing or refurbishing of the goods the manufacturer is responsible (Chen et al., 2019). For cooperation among the retailers and manufacturers the stakeholder’s decision is significant (Agarwal et al., 2018). The activities in green supply chain is exhibited in Figure 2.3.

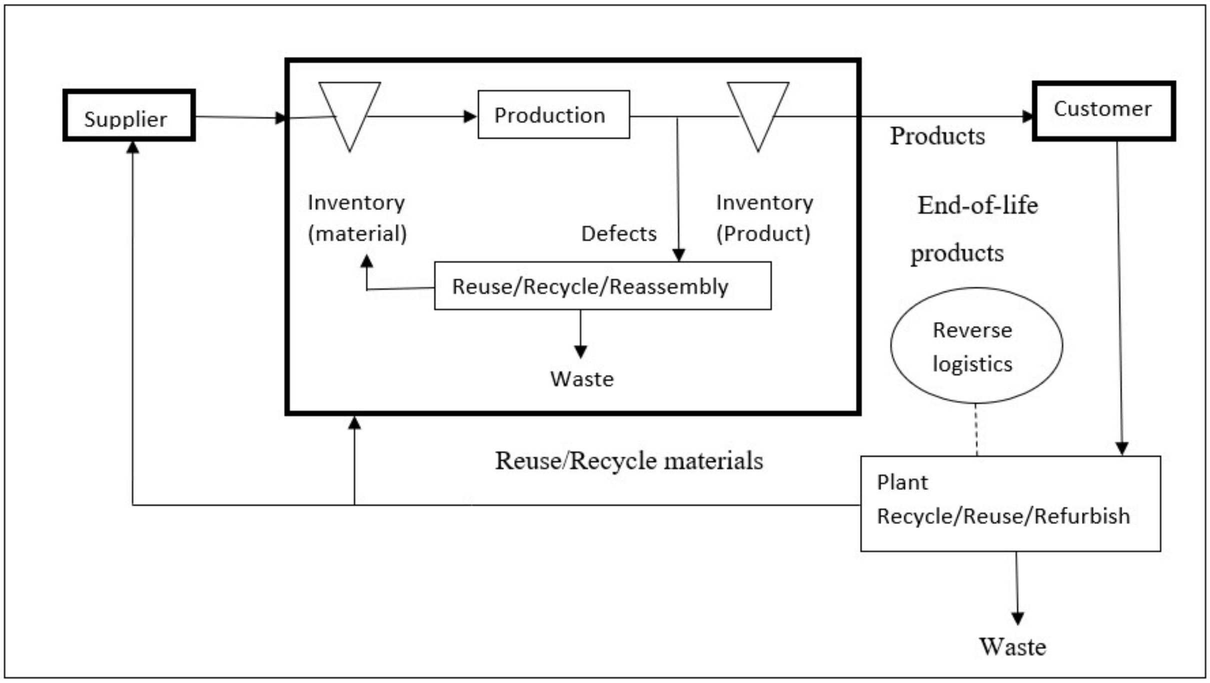

Fig 2.3 Green supply chain activities (Ninlawan et al., 2010)

2.4 Effects of Information and Communication Technology in Logistics

Logistics is about bridging the time, space with value adding tasks of persons in firms. Logistics is mainly concerned with market and cost for enhancing customer service with minimum possible time and cost. It managing three types of flows – (i) physical (ii) information and (iii) financial (Van Goor et al. 2016). Zhang et al., (2016) reported that web-based technology or computer mediated (extranets and intranets) were used in logistics management. By adopting the Electronic Data Interchange in the logistics services the business and consumer exchanges has become very effectively. With the help of Mobile based internet communication devices, tracking-and-tracing systems with barcoding systems are used effectively. The Global Positioning Systems (GPS) successfully used for tracking of vehicles with Automatic Equipment Identification (AEI) Zang et al., 2011. Figure 2.4 shows the integration Internet and IT based solutions in logistics management. The empirical review in the domain of IT in supply chain were reported by the various researchers is depicted in Table. 2.1.

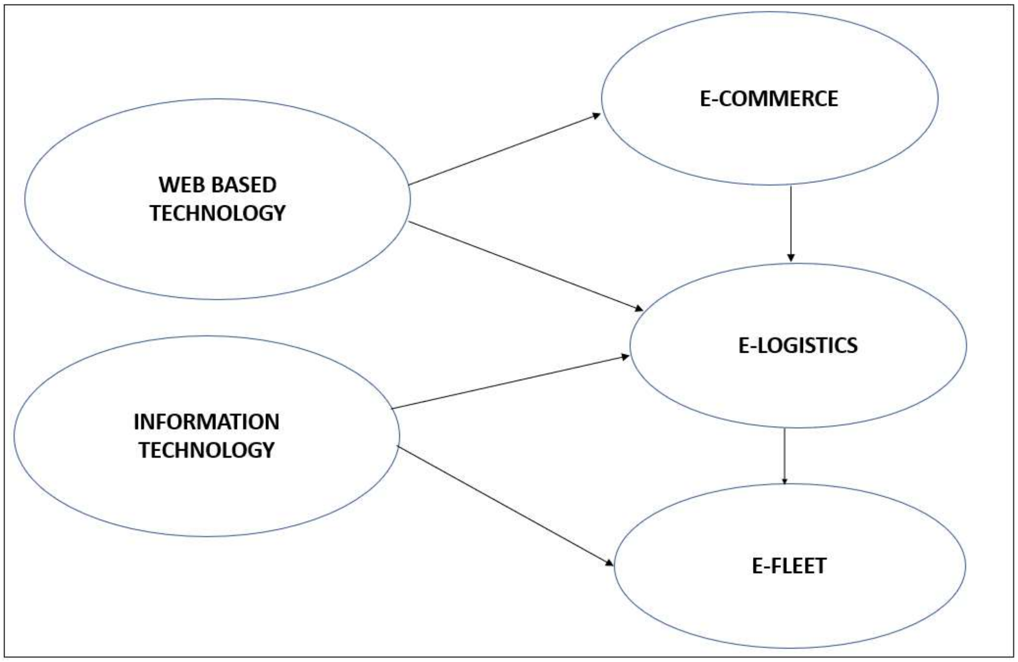

Figure 2.4 Internet-based electronic transactions (Yu et al., 2008)

Table 2.1 Recent empirical studies on ICT in manufacturing and supply chain management

Reference	ICT flexibility	Major Findings
(Zeraati et al., 2019)	IT based technologies used for knowledge sharing and for success of supply chain	The use of vehicular ad hoc network (VANET) is the success for Supply chain. Application RFID, ICT are the potential parametrs for successful in supply chain.
(Vahdani, et al., 2019)	ICT is using in the supply chain for Integrating the place, inventory and pricing strategy.	Sensitivity method is used to find the impact of ICT for maximum selling of the products.
(Muerzaa, et al., 2017)	Use of IT in product service supply chain and identification of diversification.	ICT is used in the freight transport industry for reducing the functional inventory. The Analytic Hierarchy Process (AHP) multicriteria selection technique is adopted for best diversification strategy in order to improving competitiveness.
(Cragg and McNamara 2018)	To improve the global supply chain and for integration of small medium enterprises, the ICT based technologies used.	IT in global supply chain.
(Heidari et al., 2018)	The risk model in the product life cycle using fuzzy AHP & TOPSIS techniques.	The fuzzy based AHP and TOPSIS model is used to formulate to decrease the risk and enhance the supply chain in the firm.
(Rathore et al., 2017)	Using TOPSIS algorithm for finding the quantitative risk in the typical supply chain in food products.	To minimize the disruptions in supply chain AHP and TOPSIS method was adopted. The risk mitigation strategies applied at different tactical level in the supply chain.

Reference	ICT flexibility	Major Findings
(Freeman and Chen, 2015)	AHP-Entropy TOPSIS model adopted for supplier selection in green network frame work.	Green supply chain model was suggested to Chinese small medium enterprises for selection of green suppliers. AHP Entropy TOPSIS method was adopted for to access the potential suppliers more scientifically and comprehensively.
(Wang and Zhang, 2016)	Big Data in planning and production.	Application of Big Data analytics theories and tools in Production planning control.
(Tiwari et al., 2018)	Big Data uses in industries.	Implementation of IT based analytics in the different areas of supply chain in industries in between 2010 to 2016.
(Addo-Tenkorang et al., 2016)	Big data applications	Big/Data IoT (Internet of Things) in efficient management of Operations and SCM
(Delen et al., 2011)	Big Data adaptation	Use of sensors for Monitoring and controlling in product industries.
(Krumeich et al., 2016)	Big Data analytics in quality control	Use of analytics in quality control in manufacturing.
(Mensah et al., 2015)	ICT application in Resilient Supply Chain	Six Sigma strategy was recommended to integrate with ICT based SCM in order to order to enhance its efficiency.
(Madenas et al., 2014)	Information flow in SCM	The most common themes proposed in the product lifecycle are service oriented approaches and Extensible mark-up Language.
(Shi et al., 2016)	Application of Mobile Internet in supply chain.	Tracking the goods supply using Mobile internet.
(Han et., 2017)	IT importance in supply chain.	Focuses on IT flexibility and Technology Service providers in supply chain
(Yu et., 2008)	ICT in SCM	Supply chain network structure in Chinese industry.

2.5 Summary

This chapter has presented the literature available in the area of ICT in manufacturing, supply chain, green supply chain and analytics. Supply chain mainly concerns with coordination of materials from suppliers to manufactures and through distributors to the final consumers. The integration of intranet and extranet with ERP data-based management were used in the operations. IoT with big data analytics through cloud computing extensively used in the supply chain loops. Finally, the TOPSIS technique were identified and gives a solution for finding the best alternatives and hypothetically best and worst from the ideal solutions.

CHAPTER 3

IT BENEFITS IN SMART MANUFACTURING AND SUPPLY CHAIN

3.1 Role of IT in smart manufacturing

- IT and Communication Technologies supports smart manufacturing and integrating with SCM (Cui et al., 2020) through reduction of cost of product through efficient distributions. The application of various data formats in smart manufacturing is shown in Figure 3.1.

- Innovative technologies provide complete information of the inventory, customer relationship management, quality management system, product life cycle management and method of employment.

- Supply chain integration assists the challenges in coordination of physical flow of materials between suppliers to customers (Cragg and McNamara 2018, Papetti et al., 2019)

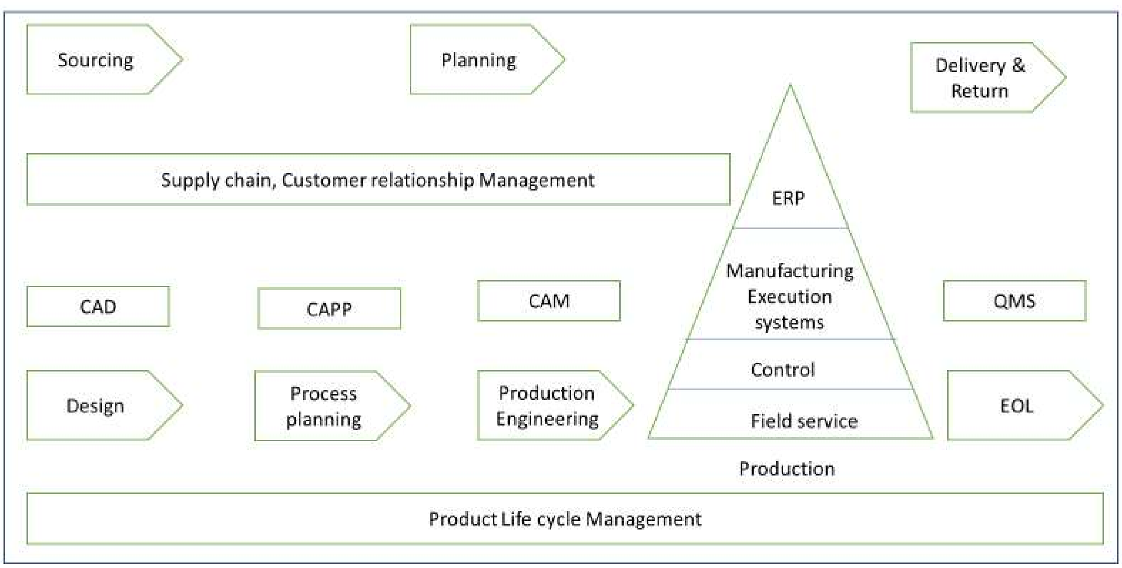

Figure3.1 Application of various data formats in Smart manufacturing (Adopted from Cui et al., 2020)

3.2 Advantages of analytics in supply chain

- Amazon analyses the customer's choice on every click on their products to predict demand and maintain stock accordingly. Loyalty cards data is used to estimate consumption patterns of the products, consumer choices, brands, price bracket etc (Mckinsy & company, 2015).
- IBM uses big data for maintain quality in the production. The system warns about any quality deviation in the process at an early stage.
- In DHL, a logistics company for enhancement of the delivery process and promptly delivering of their goods to their customers, Big Data is used for knowing the movement of vehicle from warehouse to customer as per plan which is real-time data collection sensors attached with vehicle. Future requirement also assessed through Big Data. Feedback is taken from customer and necessary action may take in future for improvement of their service continuously (Manner's-Bell, J. 2017).
- A large milk and milk-product selling company connected with data and maintains connectivity of small, big collection and distribution centers.
- In manufacturing processes, Big Data is also used for knowing root causes problems, measuring performance, pricing, optimization, flexible production set-ups, automation etc.
- In planning, big data helps in measuring consumption, determining supply strategy, assessing raw materials requirement, forecasting demand of new goods, emergency requirement of goods etc.
- In Logistics, it helps in planning the capacity, selection of right choice from available, tracking of the product movement, developing network of stores, vehicles movement etc (Christopher, 2007).
- In service, it helps in estimate the customer requirements, customizing services, designing new services, taking actions from customer feedback, differentiate between types of customers.
- In Return of goods, it helps in knowing root causes for defects, assessing the return process performance.
-

3.3 Big Data Analytics in Supply chain

- For adopting various IT technologies such as IoT, RFID, barcodes etc. in supply chain the analytics contributing significant role in supply chain achievement.
- The analytics adoption in supply chain is to enhance the performance of network. The recent studies reported that only 17% of companies have applied analytics in supply chain. The use of big data with IoT enabled in smart connected products in supply chain and interlinking with departments is depicted in Figure 3.2 (He et al., 2020). The big data applications in various fields is presented in Figure 3.3 (Cui et al., 2020, Nguyen et al., 2018).

3.4 Big data analytics areas in supply chain

- Logistics
- Network planning
- Monitoring of logistics
- Coordination between production and logistics.
- Procurement area

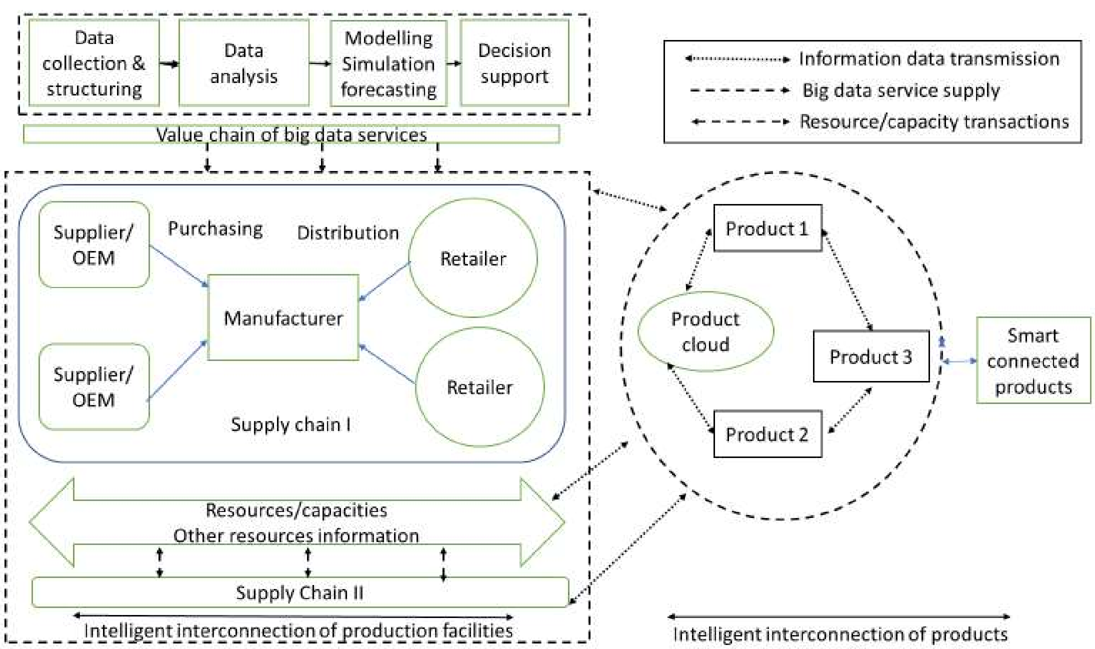

Figure 3.2 The big data with IoT enabled in supply chain (He et al., 2020)

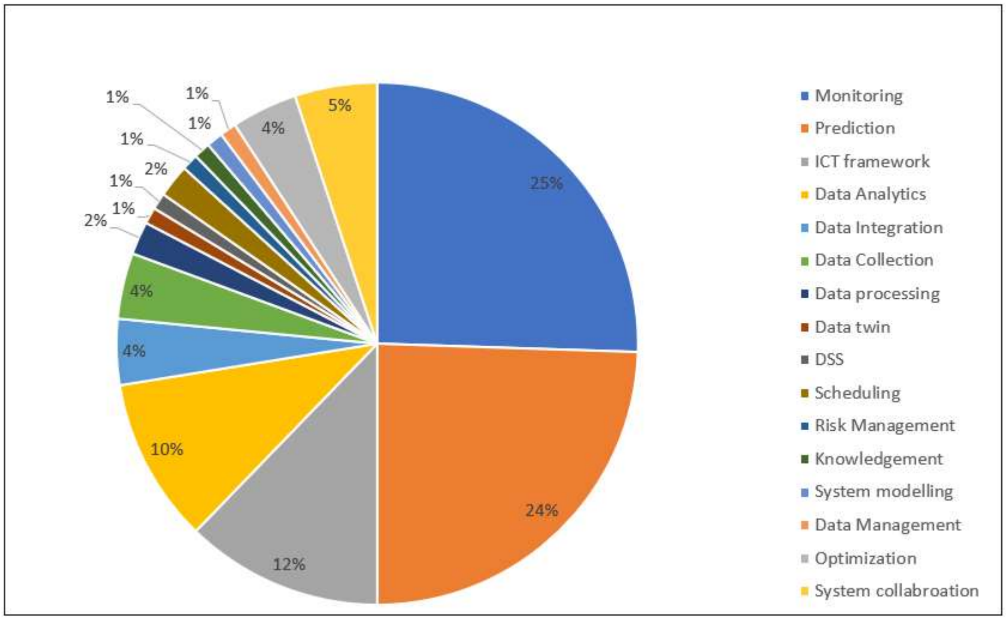

Figure 3.3 Big data applications in percentage (Adopted from Cui et al., 2020)

3.5 Use of IT in Supply Chain

IT for business

- IT changes the enterprises structures, creates new business opportunities.
- Improving the customer services
- Improving critical business activities efficiently
- Enhancement of information quality.
- It supports the planning collaboration with improved supply chain network.
- Process re-design and strategic gain benefits (Auramo et al., 2005, Sweeney et al., 2018).

IT in SCM anticipates the cycle time reduction, minimizes the inventories, limiting in work in progress inventories, effective distribution channels. Various researchers reported that various benefits of IT in SCM and reverse logistics (Cragg and McNamara, 2018).

CHAPTER 4
AN EXPERIMENTAL METHOD USING TOPSIS FOR SELECTION OF BEST FABRICATION METHOD

4.1 Green manufacturing

Green manufacturing includes the production of goods with highly efficient with low environmental impacts. Green manufacturing reduces the raw material costs, increases the production with reduction of environmental issues and elimination of hazardous. It improves the industrial safety issues with improved corporate image (Li and Zhang, 2018).

4.2 TOPSIS Formulation

TOPSIS is decision making tool with multi criteria used to find the best alternatives from the given problems. It provides an solution closer to the ideal solution based on the parameters we get based on experiment done and farther to the less ideal or negative ideal solution (Rao, 2007). The TOPSIS evaluation procedure is explained below (Rao, 2007).

Step 1: Identify the attributes from the experimental results.

Step 2: Decision table matrix formulation.

Step 3: Normalize the attribute matrix R_{ij}.
$R_{ij} = n_{ij}/[\sum_{j=1}^{M} n^2_{ij}]^{1/2}$

Step 4: The weights are decided for the attributes with respective to their importance. The summation of weights $\Sigma W_j = 1$. where W_j (for j=1,2, …., N)

Step 5: Evaluate of matrix with normalized values and with assigned weights X_{ij}. Multiplication of Each component in the column of the matrix is multiplied by assigned weights. R_{ij} with its assigned weight W_j. $X_{ij} = W_j R_{ij}$

Step 6: Determine the best positive ideal (X^+) and worst negative ideal (X^-) solutions.

$X^+ = \{(\sum_i^{max} X_{ij}/j \in J), (\sum_i^{min} Xij/j \in J')/i=1, 2,\ldots,M\},$

$= \{X_1^+, X_2^+, X_3^+,\ldots, X_M^+\}$

$X^- = \{(\sum_i^{mIN} X_{ij}/j \in J), (\sum_i^{max} Xij/j \in J')/i=1,2,\ldots,M\},$

$= \{X_1^-, X_2^-, X_3^-,\ldots, X_M^-\}$

X_j^+ indicates best ideal value among the attributes. X_j^- indicates worst ideal value among the attributes.

Step 7: Find the of separation measures. It is calculated from the Euclidean distance of the ideal one of each alternative.

$T_i^+ = \{\sum_{j=1}^{M} (X_{ij} - X_j^+)^2\}^{0.5},$ i = 1,2,…….,M

$T_i^- = \{\sum_{j=1}^{M} (X_{ij} - X_j^-)^2\}^{0.5},$ i = 1,2,…….,M

Step 8: Obtain the proximity of ideal solution.

$P_i = T_i^- / (T_i^+ + T_i^-)$

Step 9: Rank the order from the performance score (P_i) in descending order.

4.3 Green Manufacturing (Fabrication) of surfaces under different environmental conditions

Friction Stir Processing (FSP) is a new surface enhancement technique which is based on the principle of Friction Stir Welding (FSW) which is known as Green welding Technique based on FSW which is patented by TWI (Thomas et al., 1991). FSP is a novel method for reduction of grain size and enhancement of properties of materials. FSP eliminates casting porosity and improves the strength of material, hardness, ductility, corrosive resistance, super plasticity, formability and wear resistance. FSP method has been extensively used for fabrication of the ultra-refinement of grain structure of aluminum ex-situ and in-situ composites (Mishra and Ma, 2005). In this work Al 5083-O rolled plates of 6mm thickness was used. The material is widely used in marine, automobile, aircraft wear resistant applications. The specimens were clamped on the hydraulic fixture of the FSW machine. The power and load capacity of the machine were 11 kW, and 40kN respectively. The FSW experimental setup and specimens extracted from fabricated surface are depicted in Figure 4.1 (a) and (b) respectively. For surface modification, the hardened H13 tool steel with a pin diameter of M6 x1.0mm and pin length of 3mm was used. After number of preliminary trials, the machine operating parameters such as the spindle rotational speed of 1000 rpm, tool traverse speed of 45 mm/min and number of passes of 3 were fixed. The Frequency of the ultrasonic vibration and amplitude were fixed at 20KHz and 10 µm respectively. The Manufacturing of surfaces under different environmental conditions is presented in Table 4.2.

The cross section of processed region of the samples was calculated micro hardness tester at load of 100 gm for 10 seconds. The tensile samples were cut in the longitudinal direction of processing direction as per ASTM/E8M -011 standards. The wear test of the following samples was investigated on disc speed of 1 m/s and at a normal load of 50N for distance of 1000m, using pin on disc tribometer. The coefficient of friction was recorded on the tribometer. The cross sections of the specimens were examined through optical micrograph for evaluation of the grain size.

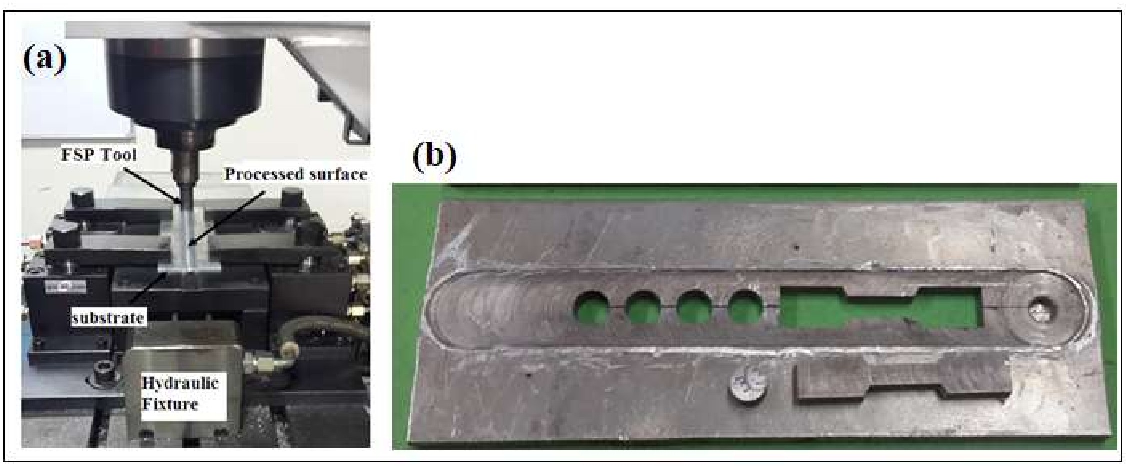

Figure 4.1 (a) FSW experimental setup (b) Specimens extracted from processed region

Table 4.1. Fabrication of surfaces under different environmental conditions

Exp. No	Manufacturing parameter/surface properties
1	Ambient temperature
2	Water cooling
3	Ice (Dry) Cooling
4	Cryogenic cooling
5	Ultrasonic vibration
6	Ultrasonic vibration with cryogenic cooling

4.4 Decision Problem: Assessment of surfaces through TOPSIS method

Step: 1

To evaluate the six different alternative methods of manufacturing by different environment conditions. The surface properties of the material are identifying and finding the best environment method is suitable for manufacturing.

Step: 2

Table 4.2 Data of the attributes (Experimental results of the fabricated surfaces)

Exp. No	Manufacturing parameter/ surface properties	Grain size (μm)	Hardness (Hv)	Tensile strength (Mpa)	Wear rate (mg/m)	Friction coefficient
1	**Air cooling**	15	107	312	0.00856	0.55
2	**Water cooling**	12	112	315	0.00784	0.5
3	**Ice Cooling**	11	113	317	0.00688	0.52
4	**Cryogenic cooling**	8	118	318	0.00552	0.42
5	**Ultrasonic vibration**	14	110	310	0.00754	0.51
6	**Ultrasonic vibration with cryogenic cooling**	6	120	325	0.00422	0.38

Step:3 Calculation of Normalized values

$R_{ij} = n_{ij}/[\sum_{j=1}^{M} n^2_{ij}]^{1/2}$

Table 4.3 Normalized values

Manufacturing parameter/surface properties	Grain size (µm)	Hardness (Hv)	Tensile strength (Mpa)	Wear rate (mg/m)	Friction coefficient
Air cooling	0.53503228	0.385136	0.402821488	0.505101342	0.464205274
Water cooling	0.42802583	0.403133	0.406694771	0.462616183	0.422004795
Ice Cooling	0.39235701	0.406733	0.40927696	0.405969303	0.438884986
Cryogenic cooling	0.28535055	0.42473	0.410568055	0.325719557	0.354484028
Ultrasonic vibration	0.49936346	0.395935	0.400239299	0.444914033	0.430444891
Ultrasonic vibration with cryogenic cooling	0.21401291	0.431929	0.419605717	0.249010241	0.320723644

Step:4 The weights are assumed as per the specific applications and material properties.

Table No.4.4 Weights assigned for different properties

Weights (W_j)	
Grain size	0.1
Hardness	0.15
Tensile Strength	0.15
Wear rate	0.35
Friction coefficient	0.25

Step:5 Multiplication of weights with normalized matrix $X_{ij} = W_jR_{ij}$

Table 4.5 Normalized with weights matrix

Manufacturing parameter/surface properties	Grain size (μm)	Hardness (Hv)	Tensile strength (Mpa)	Wear rate (mg/m)	Friction coefficient
Air cooling	0.05350323	0.05777	0.060423223	0.17678547	0.116051319
Water cooling	0.04280258	0.06047	0.061004216	0.161915664	0.105501199
Ice Cooling	0.0392357	0.06101	0.061391544	0.142089256	0.109721247
Cryogenic cooling	0.02853506	0.063709	0.061585208	0.114001845	0.088621007
Ultrasonic vibration	0.04993635	0.05939	0.060035895	0.155719911	0.107611223
Ultrasonic vibration with cryogenic cooling	0.02140129	0.064789	0.062940857	0.087153584	0.080180911

Step:6 Determination of the best idea and worst negative ideal solutions based on the weighted normalized values.

$X^+ = \{(\sum_i^{max} X_{ij}/j \in J), (\sum_i^{min} Xij/j \in J')/i=1,2,\ldots,M\}$,
$X^- = \{(\sum_i^{mIN} X_{ij}/j \in J), (\sum_i^{max} Xij/j \in J')/i=1,2,\ldots,M\}$,

Table 4.6. Ideal values of Positive and Negative

X+	0.02140129	0.064789	0.062940857	0.087153584	0.080180911
X-	0.05350323	0.05777	0.060035895	0.17678547	0.116051319

Step:7 Euclidean distance

$T_i^+ = \{\sum_{j=1}^{M} (X_{ij} - X_j^+)^2\}^{0.5}$, i = 1,2,…….,M

$T_i^- = \{\sum_{j=1}^{M} (X_{ij} - X_j^-)^2\}^{0.5}$, i = 1,2,…….,M

Table 4.7 Measure of seperation

Ti+	**Ti-**
0.102013	0.000387
0.08192	0.021334
0.065002	0.070253
0.029085	0.111609
0.079408	0.023029
0.000001	0.102024

Step:8 Relative closeness value (P_i)

$P_i = T_i^- / (T_i^+ + T_i^-)$

Table 4.8 Ranking Table

Fabrication (Manufacturing) Environment conditions	Symbol	Pi	Rank
Air cooling	P(air)	0.003782	6
Water cooling	P(water)	0.206617	5
Ice Cooling	P(ice)	0.519409	3
Cryogenic cooling	P(cry)	0.793273	2
Ultrasonic vibration	P(vib)	0.224812	4
Ultrasonic vibration with cryogenic cooling	P(cry & vib)	0.999995	1

Step:9

Preference of Fabrication (manufacturing) environment method

P(cryogenic & vibration) > P(cryogenic) > P (ice) > P (vibration) > P(water) > P (air)

CHAPTER 5

CONCLUSIONS AND FUTURE RECOMMENDATIONS

Nowadays ICT have greatly influenced in the main functional area of the supply chain management – procurement, product development, manufacturing, distribution, retailing, and customer service. It reduces the time & cost, elimination of waste and clear visibility. ICT strengthens the value-added opportunities in the logistics, smart manufacturing, green manufacturing, supply chain management and reverse logistics. This report explained the efficient use of IT based tools, analytics, use of data's in manufacturing and supply chain.

Recent days sustainable manufacturing has become more importance in order to reduce the environmental issues. Green manufacturing, design for environment and green supply chain with ICT is an emerging area for manufacturing of goods or services. For executing the supply chain with green enviornment in the manufacturing or services the various decision-making models are used.

TOPSIS method is most common method for finding the best possible decision in Multi Criteria Decision Making Model MCDM methods. This technique involves in less calculations and simple method for finding the best possible order of preferences. To such a great extent TOPSIS method is suggested for finding the best environmental manufacturing conditions for suitable manufacturing methods of surfaces in wear resistant applications. From an experimental approach using TOPSIS model the order of best preference of fabrication methods are selected based on the green manufacturing conditions.

FUTURE RECOMMENDATIONS

1. Future study on big data service provider and various evaluation models for data types and value-added services and pricing.
2. Study of various supply chain network and selection of data analytics in specific IoT enabled models.
3. Study of GRA (Grey Relational Analysis) and Fuzzy TOPSIS in various applications for material selection in the area of polymeric composite materials, textile fabrics and critical engineering materials etc.

REFERENCES

1. Addo-Tenkorang, R, and Helo, P. (2016). “Big data applications in operations/supply-chain management: A literature review”, *Computers & Industrial Engineering* 101, 528-543.

2. Agrawal, S., Singh, R.K, and Murtaza, Q. (2018). “Disposition decisions in reverse logistics by using AHP-fuzzy TOPSIS approach”, *Journal of Modelling in Management*, 11(4), 932-948.

3. Auramo, J., Kauremaa. J, and Tanskanen. K, (2005). “Benefits of IT in Supply Chain Management-an explorative study of progressive companies”, *International Journal of Physical Distribution & Logistics Management*. 35(2), 82-100.

4. Chen, D., Ignatius, J., Danzi, S., Goh, M., Zhan, S. (2020). “Pricing and equity in cross-regional green supply chains”, *European Journal of Operational Research*, 280 (3), 970-987.

5. Chen, D., Ignatius, J.,Sun, D., Zhan, S., Zhou, C., Marra, M., Demirba, M. (2019). “Reverse logistics pricing strategy for a green supply chain: A view of customers' environmental awareness”, *International Journal of Production Economics*. 217, 197-210.

6. Christopher, M. (2007). “Logistics and supply chain management”, *Pearson Education (2nd ed)*. New Delhi.

7. Cragg, T, and Mc Namara, T. (2018). “An ICT-based framework to improve global supply chain integration for final assembly SMES”, *Journal of Enterprise Information Management*, 31(5), 634-657.

8. Cui, Y., Kara, S., Chan., K.C. (2020). “Manufacturing big data ecosystem: A systematic literature review”. *Robotics and computer integrated Manufacturing*. 62, 101861.

9. Delen, D., Erraguntla, M., Mayer, R.J., and Wu, C.N. (2011). “Better management of blood supply-chain with GIS-based analytics”, *Annals Operations Research*. 185 (1), 181-193.

10. Freeman, J., and Chen, T. (2015). “Green supplier selection using an AHP-Entropy-TOPSIS framework”, *Supply Chain Management: An International Journal.* 20, 327–340.

11. Geng, R., Mansouri, S.A., Aktas, E., Yen., D.A. (2017). "The role of Guanxi in green supply chain management in Asia's emerging economies: A conceptual framework". *Industrial Marketing Management.* 63, 1–17.

12. Han, J., Wang, Y, and Naim, M. (2017). "Reconceptualization of information technology flexibility for supply chain management: An empirical study", *International Journal of Production Economics*. 187, 196–215.

13. He, L., Xue, M., Gu, B. (2020). "Internet-of things enabled supply chain planning and coordination with big data services: certain theoretic implications", *Journal of Management science and Engineering,* https://doi.org/10.1016/j.jmse.2020.03.002.

14. Heidari, S.S., Khanbabaei, M., and Sabzehparvar, M., (2018). "A model for supply chain risk management in the automotive industry using fuzzy analytic hierarchy process and fuzzy TOPSIS", *Benchmarking: An International Journal.* 25, 3831-3857.

15. Ho, J.C, Shalishali, M.K., Tseng, T., and Ang, D.S. (2009). "Opportunities in green supply chain management", *The Coastal Business Journal*, 8, 18-31.

16. Krumeich, J., Werth, D., and Loos, P. (2016). "Prescriptive control of business processes". *Business and Information System Engineering*. 58 (4), 261–280.

17. Li., Y and Zhang, M. (2018). "Green manufacturing and environmental productivity growth, *Industrial Management & Data Systems"*, 118(6) 1303-1319.

18. Madenas, N., Tiwari, A., Christopher J., and Woodward, J. (2014). "Information flow in supply chain management: A review across the product cycle", *CIRP Journal of Manufacturing Science and Technology*. 7, 335–346.

19. Manner's-Bell, J. (2017). "Introduction to global logistics, kogan page Limited", London.

20. Mehrjerdi, Y. Z. (2009). "Excellent supply chain management", *Assembly Automation*. 29(1), 52-60.

21. Mckinsey & Company. (2015). "Marketing & Sales Big data, Analytics and the future of Marketing & Sales, Mckinsey on Marketing and sales.com".

22. Mensah, P., Merkuryeva, Y., Longo, F. (2015). “Using ICT in Developing a Resilient Supply Chain Strategy”, *Procedia Computer Science*. 43, 101 – 108.

23. Mirkovski, K., Davison, R.M., and Martinsons, M.G. (2019). “The effects of trust and distrust on ICT-enabled information sharing in supply chains”, *The International Journal of Logistics Management*, 30, 892-926.

24. Mishra, R.S., Ma, Z.Y. (2005). “Friction stir welding and processing”, Materials Science and Engineering R, 50, 1–78.

25. Mokhtar, A.R., Genovese A, Brinta, A, Kumar, N. (2019). “Supply chain leadership: A systematic literature review and a research agenda”, *International Journal of Production Economics* 216, 255–273.

26. Muerza, V., Larrode, E., and Moreno-Jimenez, J.M. (2017). “Identification and selection of ICTs for freight transport in product service supply chain diversification”, *Industrial Management & Data Systems*, 117, 1469-1484.

27. Nguyen, T., Zhou, L., Spiegler, V., Ieromonachou, P. (2018). “Yong Lin, Big data analytics in supply chain management: A state-of-the-art literature review”, *Computers and Operations Research*. 98, 254-264.

28. Ninlawan C., Seksan P., Tossapol K., and Pilada W. (2010). “The implementation of green supply chain management practices in electronics industry”, Proceedings of the *International multi-conference of engineers and computer scientists*, March 17-19, Hong Kong, Vol III.

29. Panja, S., Mondal, S.K. (2019). “Analyzing a four-layer green supply chain imperfect production inventory model for green products under type-2 fuzzy credit period”, *Computers & Industrial Engineering*. 129, 435-453.

30. Papetti, A., Marconi, M., Rossi, M., and Germani., M. (2019). “Web-based platform for eco-sustainable supply chain management”, *Sustainable Production and Consumption* 17, 215–228.

31. Pinto, T.B., Barbosa-Póvo, P.F.D., and Novais, A.Q. (2011). “Bi-objective optimization approach to the design and planning of supply chains: Economic versus environmental performances”, *Computers & chemical Engineering*, 35(8), 1454-1468.

32. Rao, V. (2007). “Decision Making in the Manufacturing Environment”, *Spriinger-Verlag, London.*

33. Rathore, R., Thakkar, J., Jha, J.K., (2017). “A quantitative risk assessment methodology and evaluation of food supply chain”, *The International Journal of Logistics Management.* 28, 272-1293.

34. Salam, M.A., (2008). “Green procurement adoption in manufacturing supply chain, *Proceedings of the 9th Asia Pacific Industrial Engineering and management Systems Conference (APIEMS2008)*”, 3-5 December 2008, Indonesia, 1253-1260.

35. Sarkis J, (2003). “A decision-making framework for green supply chain management”. *Journal of cleaner production,* vol. 11, 397-409.

36. Seuring, S, and Muller, M. (2008). “From literature review to a conceptual frame work for sustainable supply chain management”, *Journal of cleaner production.* 15, 1699-1710.

37. Shi, Q., Ding, X., Zuo, J., Zillante, G. (2016). “Mobile Internet based construction supply chain management”, A, critical review, *Automation in Construction.* 72, 143–154.

38. Sharma, V., Prakash, U., Manoj Kumar, B.V. (2015). “Surface composites by friction stir processing: A review”, Journal of Materials Processing Technology, 224, 117-134.

39. Shore, B. (2001), “Information Sharing in Global Supply Chains”, *Journal of Global Information Technology Management*. 4(3), pp. 27-46.

40. Stanley E. F., Gregory M. M., and Matthew W. M. (2008). “Benefits, barriers, and bridges to effective supply chain management”, *Supply Chain Management: An International Journal,* 13(1), 35-48.

41. Sweeney, E., Grant, D.B., and John Mangan, D. (2018). "Strategic adoption of logistics and supply chain management", *International Journal of Operations & Production Management*. 38(3) 852-873.

42. Thomas, W.M, Nicholas, E.D, Needham, J.C., Murch, J., Temple-smith, P., and Dawes, C.J. (1991). “Friction Stir Butt Welding, International Patent Application No. PCT/GB92/02203”.

43. Tiwari, S., Wee, H.M., and Daryanto, Y. (2018). “Big data analytics in supply chain management between 2010 and 2016”, Insights to industries, *Computers & Industrial Engineering*. 115, 319-330.

44. Vahdani, B., and Ahmadzadeh, E. (2019). “Designing a realistic ICT closed loop supply chain network with integrated decisions under uncertain demand and lead time”, *Knowledge-Based Systems.* 179, 34–54.

45. Van Goor, Amstel, P.L., and Amstel. P.L. (2016). “European Distribution and supply chain Logistics”, *Taylor & Francis*. London, UK.

46. Wang, J., and Zhang, J. (2016). “Big data analytics for forecasting cycle time in semiconductor wafer fabrication system”, *International Journal of Production Research*. 54(23), 7231–7244.

47. Wang, K.J., Makond, B., and Liu, S.Y. (2011). “Location and allocation decisions in a two-echelon supply chain with stochastic demand – A genetic-algorithm based solution”*, Expert Systems with Applications*. 38(5), 6125-6131.

48. Yavari, M. and Zaker, H. (2020). “Designing a resilient-green closed loop supply chain network for perishable products by considering disruption in both supply chain and power networks”, *Computers and Chemical Engineering*. 134, 106680.

49. Yu, L., Suojapelto, K., Hallikas, J, and Tang, O. (2008). “Chinese ICT industry from supply chain perspective—A case study of the major Chinese ICT players”, *International Journal of Production Economics*. 115, 374–387.

50. Zeraati, H., Rajabion, L., Molavi, H., Navimipour, N.J., and Amodel, (2019). “For examining the effect of knowledge sharing and new IT-based technologies on the success of the supply chain management systems, *Kybernetes.* DOI 10.1108/K-06-2018-0280”.

51. Zhang, X., Donk, D.P.V., and Vaart, T.V.D. (2016). “The different impact of inter organizational and intra organizational ICT on supply chain performance”, *International Journal of Operations & Production Management.* 36, 803-824.

52. Zhang, X., Donk, D.P.V., and Vaart, T.V.D. (2011). “Does ICT influence supply chain management and performance? A review of survey-based research”, International *Journal of Operations & Production Management*, 31(11), 1215-1247.