Proceedings of the International Conference on Industrial Engineering and Operations Management
Washington DC, USA, September 27-29, 2018

Green Supply Chain Management and Sustainable Industrial Practices: Bridging the Gap

Peter Onu and Charles Mbohwa
Department of Quality and Operations Management
Faculty of Engineering and the Built Environment, University of Johannesburg, P. O. Box 524, Johannesburg, South Africa.
onupeter@kiu.ac.ug, cmbohwa@uj.ac.za

Abstract

Recent prevalence in production and operations management to transform various industrial processes using cloud innovation, Radio Frequency Identifiers (RFID), and sensor technologies, to achieve green supply chain while meeting consumers' expectations receives appraisal over conventional methods. The new paradigm of energy efficiency and emission control initiative, and the expectations of businesses to engage in sustainable practices to compete favorably in the emerging fourth industrial revolution, fueled by the internet of things and its applications to drive industrial operations in the future – Industrial Internet of Things (IIoT) cannot be overemphasized. In this paper, the authors discuss technological approach, benefits, and barriers towards achieving the Green Supply Chain Management (GSCM) as a sustainable precursor. The focus is on consumers' tendency to influence the market mix and a company's desire to meet customers' satisfaction. Hence, the interplay of technology, its improvement, and applications receive insights. We evaluate measures which are practicable in a general industrial perspective, capable of reducing anthropogenic effects while increasing productivity. The researchers juxtapose the changing trend of technology and infer that businesses must become conscious of environmental impacts and use information technology and energy conservative techniques to remain relevant in the future.

Keywords
Energy efficiency; Green Supply Chain Management; Industrial Internet of Things; RFID

1. Introduction

The unrest and persistent abnormality report on environmental changes, increasing global population figure, economic and resource crisis, among other life-threatening issues, have become alarming. The reality of current weather phenomena and variations, stimulates global interest in managing the causatives of the anthropogenic activities and develop remedies to end them before it becomes detrimental. Hence, addressing these concern about climate disruption calls on governments and concerned stakeholders to establish new regulations mainly toward reducing GHG emission. While some countries are actively involved in mitigating climate change, many consumers, public and private businesses are becoming increasingly worried and joined the growing green campaign (Lakshmi Meera and Chitramani, 2014). Current outlook in the industry for technical requirements and socio-economic sustainability has gone beyond remanufacturing, reverse logistics, and closed-loop supply chain, as it now focuses on low-carbon issues (Li, 2014). With increasing awareness of management practices and standards, customer loyalty will shift to environmentally friendly products, and prompt organizations to intensify their efforts in transforming their supply chain to become sustainable. Due to the various industrial operations and practices, which leads to the release of carbon-dioxide in both commercial and small-scale basis, it is timely to overview the emission levels across the value chain. Hence, GSCM presents a sustainable approach to integrating environmentally favorable pathways into the supply chain management process (Meera, 2016). The assurance of a future wherein carbon emission reduces to the minimax will require robust strategies and practical methods, as such carbon footprint of goods and services are managed from the company and through the complete lifecycle, and the means which they pass through. To reduce carbon footprint, minimize waste, conserve energy and ensure sound environment, companies must introduce and engage in the continuous development of novel techniques, review regulations on environmental sustainability, and

sensitize all parties involved. The energy consumed and GHG emission during heat and electricity generation from fossil and non-fossil fuel sources amount to 40% and 37% respectively and on a global scale from the industrial sector alone according to (Worrell et al., 2009) and this figure has not changed much ever since.

The coalition of international Governments to attain sustainable socioeconomic height through a 'green' economic approach and practice has brought about a new shift in modern thinking for a green, supply chain and logistics. Hence, designing for implementation, new economic development strategies, regulations and achievable targets (Li, 2014). So far, the current European Union (EU) statistics on GHG emission from buildings stands at 36%, linked to total energy consumption of 40%, despite the strategy currently used (three-pronged), where improvement of energy efficiency, insulation, and control system performance are vital issues (Gilchrist, 2016). Other research addresses the imperativeness of supply chain performance from the perspective of energy efficiency and eco-friendly initiatives (Geng et al., 2017; Rajeev et al., 2017). The moral is that more innovations and global collaboration is required to achieve even more significant impacts. General industrial operations must include quality in its working processes to meet end-user expectations at the final stage of the supply chain. Although concepts like quick response and agile supply and demand chain management are breaking boundaries and helping companies remain highly efficient and productive, there is little or no concern as to how these activities impact the society and environment by-and-large. This paper highlights technological options imminent to lead future industrialization amidst reduced hazards, minimizing losses and increasing efficiency. The Authors explore a broader view of GSCM which emphasizes customers capability to influence industrial operations, in a future where internet on thing dominates, and everybody is a direct player towards sustainable development. Overall, the research is a contribution to the understanding of how the role of technology in monitoring the general industrial operation and processes can improve performance in a GSCM scenario. The article is structured as follows: the subsequent section (2) gives a brief review about GSCM, while section 3 discusses the role of technology in attaining sustainable supply chain, with special regards to possible gains within the workspace (factory), to man, and the larger workspace (environment). The conclusion (section 4) summarizes technological initiative as a sustainable tool to improve industrial productivity and highlights both the benefits and challenges to be overcome.

2. Overview of Green Supply Chain Management (GSCM)

Luthra et al., (Luthra et al., 2014) provide elaborate definitions from a broad spectrum of research covered in thirteen literatures by different researchers on the meaning of GSCM. In their conclusion, they defined it as a multidisciplinary area of study which holds in high regard, the environmental and economic performance and suggests the need to direct future research attention to performance improvement in the industry. Most areas covered in literature focuses on theoretical performance models and records residual knowledge of organization and poor, top management interest, resulting in the remedial implementation of GSCM (Mudgal et al., 2010). Most developing countries still struggle to conceptualize the GSCM, the practice has reached maturity in few developed nations and have found usefulness in the manufacturing industry (Mudgal et al., 2010), automobile and construction industry (Qadri et al., 2011; Wu and Pagell, 2011), and also the power generating and electrical industry (Qadri et al., 2011). Consider a green steal manufacturing supply chain which will comprise a factory, production line, warehouse, distribution and retail centers. The achievement of an optimum production planning and control scenario of an environmentally friendly plant should implement the initiative across the general activities (forecasting, planning, purchasing, inventory management, information management, quality assurance, scheduling production, distribution, delivery, disposal and customer services). For the material flow through the supply chain, irrespective of whether it is a green supply chain operation must be established on coherent strategies that examine the tradeoffs between environmental expectation, economic gains, and, efficiency across the supply chain lifecycle.

In our world today, GSCM has become 'every bodies business,' shoppers and investors now sort to patronize green compliant companies to support climate mitigation. However, achieving the initiative is hindered by challenges which range from the cost required to undertake the transformation process, to the uncertainties involved. Regardless, these challenges can be reduced by developing a technologically compatible strategy for execution of green supply chain pathway. These will shape a powerful and positive future, one that ensures a secure competitive supply and sustainable operations across the value chain (Lakshmi Meera and Chitramani, 2014). It is therefore of great importance for organizations to aspire towards environmentally sustainable social responsibility premise guiding regulations and for the company's economic benefits backed by customers and public expectation to successfully drive the GSCM. Whereas, most researchers focus on the specifics about GSCM and its applicability in particular industrial areas and

with respective studies, investigating the degree of adoption of the concepts (Ahi and Searcy, 2013), other authors (Luthra et al., 2015; Tseng, 2011; Yu et al., 2014) investigate operational performances from the spectrum of sustainability and environmental impacts. However, few studies have researched about the nitty-gritty of the applications of technology intervention, used as a monitoring instrument to guarantee sustainable practices and GSGM.

3. Technological Transformation in Supply Chain

The optimism of the specifics and how effectively technology can drive green supply chain still leaves room for further research. There is an excellent chance that technological influences and operational improvements can rapidly affect profit gains and time savings among other environmental and standardization biddable factors. The revolution in the manufacturing industry preceded by the introduction of the German concept; the industry 4.0, has sprung global re-evaluation of manufacturing practices and innovations in production and other service providers -operations. This section of the article explores the features as they affect technological choices for adequate performance in the supply chain process. Building from the expectation that a sustainable supply chain will cut energy consumption, indirectly reduce the pressure of GHG in the atmosphere, increase serviceability of industrial utility, from manufacturing to agriculture, transport, and to the power sector, etcetera. Technologies are fast evolving. However, it is vital to comprehend the technicality of applying, through what approach, and the areas of implementation. This section also discusses the relationship between IIoT and the conceptualization of the fourth industrial revolution and adoption, among other sustainable practices.

3.1 Industrial Internet of Things

Technology no doubt plays a generalized role in the supply chain structure (supply, manufacturing, and distribution) figure 1. The green proposal is, however, changing the playing field and increasing the dependency on information technology. The search for fast portable and comparatively cheap information solution that will drive future industries is not farfetched. The integration of information technology innovation with GSCM is breaking grounds on design optimization of materials and operation flow, as tracking and monitoring become more efficient and reliable (Gružauskas and Vilkas, 2017). It is arguable that the future of manufacturing will adopt closed-loop business model and will require robust information technology systems (Koppius et al., 2014). Big data management schemes, cloud computing, RFID application, machine automation and intelligent control systems, make up the industry 4,0 concept and embedded therein, the IIoT initiatives on technology for achieving sustainable industrial development. Further utilization of the IIoT will be through the application of radar sensors and proximity cameras installed on factory operating systems for monitoring purposes, to self-report and safeguard against accidents. 3D-Printing manufacturing processes will also become even more flexible and time efficient from the perspective of IIoT. Hence leading the path to an automated sustainable production process under the GSCM practice.

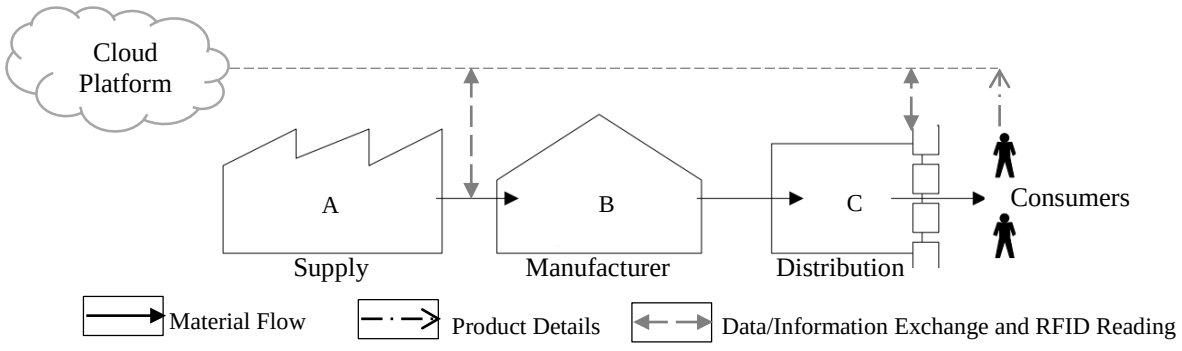

Figure 1: Simple Supply Chain Structure Integrated with RFID

3.2 Traceability and Transparency

The future is geared towards customer's patronage, on sustainable practices and compliance, thereby leading to controlled buying and selling (Consumers become responsible for their item purchased). These raise the expectation of long-term business companies to embrace sustainability solution through RFID technology (Wu et al., 2011), and invariably result in advance inventory flow management and reliable information sharing. RFID tags are gradually growing cheaper and better, as they replace the use of barcodes, it becomes possible to implement quality management in production and sales processes, and in real-time with each component having self-configuration and self-management capability. Although a lot still needs to be understood about GSCM, the concept when enabled by technology will also guarantee product traceability and safety. Food industries and beverage industries, as well as agro suppliers, are on the verge of a new dawn (Wognum et al., 2011). Company profiling will become a common thing, and assessments of products and service processes across the tiers of supply chain and including the production, processing and distribution processes, giving consumers the privilege to identify reliability, outstanding performances and evaluate company's integrity. Companies can now reduce demand risk, and also, raise their profile, assuring consumers of quality and originality as they show-off their brands while consumers also assess detailed information on products, and manufacturing cycle. The future of GSCM will look toward sustainable strategy guaranteed by the adoption of cost-effective sensor technologies to play viable roles for monitoring improvements, accuracy, and speed, and ensure compliance with safety and security. Hence, incorporating information communication technology is pivotal to increase efficiency, promote effective operation management, receive and stores data about the total supply chain and initiate decisions where the need arises.

3.3 Energy Savings and Smart Systems

Already, 40% of energy consumed in the EU is by buildings and at the same time, contributing up to 36% of the share of carbon emission to the atmosphere (Gilchrist, 2016). On the global scale, buildings are the second largest contributors of GHG preceded by the industrial sector (IEA, 2016). The constructions and transport industries combined are significant contributors to the world GHG emission, leading to strong agitation for energy efficiency measures, renewable and alternative energy utilization, and smart designs as part of the campaign for sustainable development (United Nations, 2016). Contingent on the versatility of industrial operations, it becomes difficult to adopt specific technological preferences which may find applicability in all areas of the industry. However, the focus in on monitoring and assessment of intense energy systems and processes. Thus, the incorporation of robust sensing and control systems in the general industrial process, targeted at increasing building energy efficiency is a viable GSCM approach. The concept of efficient energy devices is gradually finding their grounds in the industries, although significantly hindered by high implementation cost. Regardless, energy consumptions are drastically managed through fitted power sensors that intelligently coordinate and manage energy performance. Similar considerable benefits can be registered through optimizations in routing, processing information from a cloud platform and analyzing the best cost-effective path to transport products/services. In other cases, innovations in smart devices with the capability to harvest sustainable energy sources from the wind and sun, and small hydropower plant are being integrated to the operational supply chain, and at every point, bent on increasing sustainability through the whole process. Hence, the best practice of IIoT integration with GSCM will ensure combination of cyber-physical system and device sensing technologies to facilitate cost-effective and optimum energy connectivity.

3.4 Environmentally friendly biodegradable materials and fuels

Emphases have been given severally on the utilization of efficient technologies and smart systems in the previous section. However, while behavioral practices have so far received little attention, it is a contentious requirement to achieve sustainable supply chain management. GHG and carbon emission counts have been a challenging topic in the past century. More so, recent technological innovations are making it possible for companies to track and report carbon footprint in segments, across the different supply chain stages, thereby increase assurance of the decision outcome (Khan, 2015). The willingness of suppliers to develop and utilize alternative durable materials during production, or exploitation of biodegradable oils and fuels in the transport operation will contribute to the reduction of carbon footprints by a considerable percentage. Strategic models and regulatory policies by companies and joint collaborative initiatives developed by participating stakeholders toward the actualization of the GSCM target should capture

economic, environmental and social best practices that will attract entrepreneurial interest and framed around advanced information technology. The future of GSCM premised on sustainability in the general industry perspective, must explore alternative methods/material/utilize zero environmentally harmful concept tracked and assessed through portable sophisticated monitoring devices that can self-coordinate and simultaneously keep track of changes while diagnosing the situation and considering both social presence (workers safety) and environmental impacts.

3.5 Lean Manufacturing and Recycling

Wastes take many forms and are found at different times in different places, consuming recourses without adding any value to the product or process. According to Chen et al. (Chen et al., 2013), an integrated system of synergetic combined advanced technologies will decrease industrial waste, therefore lead to GSCM. The integration of factory operation mechanisms with IT presents one dimension towards the technological transformation of the GSCM, its applicability in manufacturing could reduce lead time in operation, minimize material waiting time and improve quality (Abdu et al., 2016). As such, industrial manufacturing processes will retrogress to real-time performance tracking of products digitally and retain the information in a cloud system (software), assessable at all times. Through RFID support systems at the A, B and C tier (Figure 1), operation and production throughput will become optimum. As a result, for every data shared and information received, specific actions are executed. Such level of digitization and information sharing will indirectly lead to the elimination of wastes and cost saving on storage spaces. A lot of opinions about going digital, as a measure of sustainability is linked to the argument that more can be saved if less anomaly is measured, such as, the not likely to be needed papers, desk, and other auxiliaries. Hence, reducing pressure on the ecosystem for wood sourcing in paper manufacturing, and the carbon emitted during its production process.

Unfortunately, more than 1.3 billion tonnes of solid waste is collected globally on a yearly basis and continues to rise according to research (Mahajan and Vakharia, 2016). The recycling of materials for re-use to eliminate waste is a sustainable practice that cannot be undermined; it is a proven way of reducing carbon footprint. A lean method, therefore, is a potential tool, as well, the practice of monitoring production and service creation is essential to decide and plan the dimensions, as to elimination of excesses. The technological integration that will access quality and integrity in manufacturing operations process and other service companies will ensure optimal monitoring of technics and checks-and-balances within the tiers of the supply chain in the context of economic and environmental objectives. Development of business strategies and information sharing, linking customers to operational processes and exchanging ideas and information of resources management and service requirement is also possible on the cloud platform (figure 1) where industry managements monitor operation and customers give feedback in real-time. Resource waste will tend to zero as excellent service delivery is met leading to more energy conservation and resourcefulness. GSCM must also integrate a reverse supply chain model where recycling, forms part of the remanufacturing process. Feedbacks to consumers is essential for recovery and intended for implementation of new advancements. For example, customers receive advice about the waste disposal and after-use products, which in the long run, enable manufacturers to manage recycling operations. Fortunately, customers nowadays have become increasingly aware and sort purchases based on resource utilization (green procurement). Hence, consideration and advocacy are given to companies that prioritize environmental decadence and engage in eco-designs, ensuring lesser energy consumption, efficient materials utilization, and effective emission control.

4. Conclusions

Integration of modern technological advances in GSCM for sustainable development is suggested from the software-hardware standpoint. While suppliers are faced with the challenges of constantly changing consumer preference, uncertainty in the cost of adopting new work environment and the cumbersome process involved in developing a new collaborative model for the green supply chain process, the long-term benefit of starting now, far outweighs the loss. Different scenarios within the industrial structure which can accommodate advanced, and technical initiatives ranging from RFID, drones and camera sensor technologies to mention a few exist. Monitoring of products in manufacturing and the execution of real-time reports on distributions and sales or the issue of feedbacks, has become demanding in todays business. This is achievable through a realistic strategy which manages operational risks to safe cost upon effective implementation of the technological initiatives to meet customers satisfaction. The technological advances

when clearly understood, and implemented will facilitate management and workers interrelationships due to constant monitoring of the same information, foster integrated business and promote overall industrial throughput. Information management and inventory control will become simple, fast and more accurate as 'Autobots,' and 'software-bots' gradually find their way into companies and entrepreneurial operations (technology-based innovation). The future indeed will embrace energy efficient solution and environmentally sustainable compliant processes. Organizational decisions to integrate information technology into the supply chain and through the use of cyber-physical systems will effectively contribute to greening the supply chain processes; increase cost savings on resources, lower long-term operational cost, toxic consumption, and unnecessary waste. Artificial intelligence application will shortly proliferate the industrial space and lead to explosive sustainable accomplishment as the anticipated technological concepts will become seamless to monitor operations, while concurrently establishing measures to perfect the general operations process at every level of the business value chain.

While cogent issues have been discussed about the holistic transformation and the abundant capabilities of techno-innovation to support the GSCM processes and sustainability development tendencies, it is pertinent to overview the general idea again and re-cap barriers. Naturally, managers are stifled to change. These are commonly due to the wide gap between the unanswered question of uncertainty (Return on Investments, Operability, Technology Life-Cycle, etc); lack of information and deficit in the know-how of managing emerging technological initiative on local and international scale presents a challenge for new techniques waiting to be integrated in the supply chain management. Company Executive Manager's concerned about risk assessment in these areas, which is yet to register proven approach/methods and professionals in the field beckons even more unrest. Regardless, most companies boycott sustainable development implementation requirement, also consumers' participation and willingness towards the utilization of available measures of exercising their capabilities to influence sustainability through monitoring of different company's operating performance. The reality of the organizing process and the implementation strategy of sustainability and GSCM will require considerable informative deposition to relate the entirety of the wholly new and unique concept. In other to determine implementation levels, a construct of systematic policies which will intensify sustainable assessment, reporting and evaluation/comparing of compliance reports must find bearing within the general industrial sense, to catapult social and environmental security. A more critical concern for the future will be on the role of different categories of technological incentive and capability to change operational mechanisms to support sustainable development and GSCM.

References

Abdu, Y.A., Peter, O., Gupta, U.K., 2016. Lean Concepts and Methods : 3P. Int. J. Sci. Res. Comput. Sci. Eng. Inf. Technol. 1, 20–24.

Ahi, P., Searcy, C., 2013. A comparative literature analysis of definitions for green and sustainable supply chain management. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2013.02.018

Chen, J.C., Cheng, C.-H., Huang, P.B., 2013. Supply chain management with lean production and RFID application: A case study. Expert Syst. Appl. 40, 3389–3397. https://doi.org/10.1016/j.eswa.2012.12.047

Geng, R., Mansouri, S.A., Aktas, E., 2017. The relationship between green supply chain management and performance: A meta-analysis of empirical evidences in Asian emerging economies. Int. J. Prod. Econ. https://doi.org/10.1016/j.ijpe.2016.10.008

Gilchrist, A., 2016. Industry 4.0: The Industrial Internet of Things, Library of Congress Control Number. https://doi.org/10.1007/978-1-4842-2047-4

Gružauskas, V., Vilkas, M., 2017. Managing Capabilities for Supply Chain Resilience Through it Integration. Econ. Bus. 31, 30–43. https://doi.org/10.1515/eb-2017-0016

IEA, 2016. Energy Statistics. IEA - Int. Energy Agency 1. https://doi.org/10.1787/key_energ_stat-2014-en

Khan, R.J.Z., 2015. World Journal of Entrepreneurship , Management and Sustainable Development Article information : Green supply Chain Manag. vol 11, 37–47. https://doi.org/10.1108/WJEMSD-05-2014-0012

Koppius, O., Özdemir-Akyildirim, Ö., van der Laan, E., 2014. Business value from closed-loop supply chains. Int. J. Supply Chain Manag. 3, 107–120.

Lakshmi Meera, B.L., Chitramani, P., 2014. Environmental Sustainability through Green Supply chain management practices among Indian Manufacturing Firms with special reference to Tamilnadu. Int. J. Sci. Res. Publ. 4, 2250–3153.

Li, X., 2014. Operations Management of Logistics and Supply Chain : Discret. Dyn. Nat. Soc. 2014. https://doi.org//10.1155/2014/701938

Luthra, S., Garg, D., Haleem, A., 2015. An analysis of interactions among critical success factors to implement green supply chain management towards sustainability: An Indian perspective. Resour. Policy. https://doi.org/10.1016/j.resourpol.2014.12.006

Luthra, S., Garg, D., Haleem, A., 2014. Green supply chain management. J. Adv. Manag. Res. 11, 20–46. https://doi.org/10.1108/JAMR-07-2012-0027

Mahajan, J., Vakharia, A.J., 2016. Waste Management: A Reverse Supply Chain Perspective. Vikalpa 41, 197–208. https://doi.org/10.1177/0256090916659029

Meera, L., 2016. Causal Effect of Between Lean and Green Supply Chain Management Practices on Environmental Performance of Manufacturing Firms 9519, 29–35.

Mudgal, R.K., Shankar, R., Talib, P., Raj, T., 2010. Modelling the barriers of green supply chain practices: An Indian perspective. Int. J. Logist. Syst. Manag. 7. https://doi.org/10.1504/IJLSM.2010.033891

Qadri, M.A., Haleem, A., Arif, M., 2011. IDENTIFICATION OF DRIVERS FOR GREENING OF SUPPLY CHAIN IN INDIA. Int. J. Constr. Proj. Manag. 3, 213–229.

Rajeev, A., Pati, R.K., Padhi, S.S., Govindan, K., 2017. Evolution of sustainability in supply chain management: A literature review. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2017.05.026

Tseng, M.-L., 2011. Green supply chain management with linguistic preferences and incomplete information. Appl. Soft Comput. https://doi.org/10.1016/j.asoc.2011.06.010

United Nations, 2016. Sustainable Development GOALS - 17 Goals to transform our world. Sustain. Dev. goals - United Nations. https://doi.org/United Nations Development Program (UNDP)

Wognum, P.M., Bremmers, H., Trienekens, J.H., Van Der Vorst, J.G.A.J., Bloemhof, J.M., 2011. Systems for sustainability and transparency of food supply chains - Current status and challenges. Adv. Eng. Informatics. https://doi.org/10.1016/j.aei.2010.06.001

Worrell, E., Bernstein, L., Roy, J., Price, L., Harnisch, J., 2009. Industrial energy efficiency and climate change mitigation. Energy Effic. 2, 109–123. https://doi.org/10.1007/s12053-008-9032-8

Wu, Y., Ranasinghe, D.C., Sheng, Q.Z., Zeadally, S., Yu, J., 2011. RFID enabled traceability networks: A survey. Distrib. Parallel Databases. https://doi.org/10.1007/s10619-011-7084-9

Wu, Z., Pagell, M., 2011. Balancing priorities: Decision-making in sustainable supply chain management. J. Oper. Manag. 29, 577–590. https://doi.org/10.1016/j.jom.2010.10.001

Yu, W., Chavez, R., Feng, M., Wiengarten, F., 2014. Integrated green supply chain management and operational performance. Supply Chain Manag. An Int. J. https://doi.org/10.1108/SCM-07-2013-0225

Biographies

Peter Onu is a Ph.D. candidate in Operations Management at the University of Johannesburg. He earned his Masters of Science degree in Mechanical Engineering from Ahmadu Bello University-Zaria, Nigeria. He is fascinated by the application of the fourth industrial revolutionary approach to drive productivity, reviewing quality assurance and risk factors linked to operations. However, his focus is drawn to Operations Management studies, about Energy and Sustainability (E&S).

Charles Mbohwa is currently a Full Professor of Sustainability Engineering and Engineering Management at the University of Johannesburg, South Africa. Contacted at cmbohwa@uj.ac.za.