NEW FUTURE FOR SUSTAINABILITY AND INDUSTRIAL DEVELOPMENT: SUCCESS IN BLOCKCHAIN, INTERNET OF PRODUCTION, AND CLOUD COMPUTING TECHNOLOGY

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ABSTRACT

The industrial operation, as we know, is transitioning. Newly emerging innovations and digitization techniques now play a vital role in transforming manufacturing activities beyond the natural materials selection requirement, energy savings, and waste reduction. Here, we explore new concepts and review technological drivers, including big data, Cyber-Physical Systems (CPS), high-speed internet, and the Internet of Things (IoT) application to promote SMEs' operational performance. The purpose of this study is to support the improvement of competitiveness in production and sustainability in the industrial sector, citing nascent technological approaches. We aim to understand the applicability and awareness level of selected techno-innovation strategies: Internet of Production, cloud computing, and blockchain technology to bolster productivity in the manufacturing and service sector. A survey is conducted, comprising of experts; University faculties, reputable IT-savvy specialists, and managers of innovation-minded corporations to draw inference on outlooks for techno-innovation success in the near future. The results proffer strategies to ameliorate the limitation of new technological initiatives to transform industrial operations and sustainably promote productivity. More so, the article is a contribution to the body of knowledge on the subject matter, giving insight to technicalities, challenges, and a series of recommendations for future industry development.

Keywords: Internet of production, cloud computing, blockchain, techno-innovation

1. INTRODUCTION

The world industrial world is diversifying, and as technology becomes more viable and accessible, it brings along a change in traditional methods of improving organizational development. The industrial manufacturing sector, which is a massive global resource and energy consumption sector, is under pressure to transform their operational activities and become more productive. The adoption of a newly emerging approach to transforming manufacturing operations explores models that are executable in a circular system and drives innovation in manufacturing (Frazier, 2014; Gao et al., 2015). The transformation process has attracted robust information communication technology, blockchain application, internet of production, cloud computing, and other associated smart technologies, such as Cyber-Physical Systems-CSP (Networking, sensor technology, and wireless communications), big data, Internet of Things (IoT), etcetera. Four advanced manufacturing models have been highlighted by Fisher et al., (2018), and three in more recent times by Peng et al. (Peng, Fang, & Tang, 2015), that establishes a solid background which discusses operational performance within the scope of supply chain network. However, the pace of development as per manufacturing SMEs' operations on techniques of resource maximization for sustainable production still lacks a reliable financial strategy (Onu & Mbohwa, 2019; Peter & Mbohwa, 2019; Shokri, Waring, & Nabhani, 2016).

The emergence of IoT means an increase in connectivity and information sharing and therefore, a need for increasing trust and efficiency in transactions, which may impact the supply chain and its resilience to recover from all kinds of disruptions (Mondragon, Mondragon, & Coronado, 2018). Blockchain is a distributed data structure that is replicated and shared among the members of a network (Witte, 2017), it keeps a chronologically-growing list (chain) of records (blocks) secure from tampering and revision. The use of Blockchain technology allows for a more transparent supply chain of goods or services. Each block in the chain cans enables each stakeholder to control information through secure, auditable, and immutable records (Muzammal, Qu, & Nasrulin, 2019; Wood, 2014). The most crucial area where the Blockchain helps in is the guarantee of validity and accountability of a transaction, such that it gives businesses the ability to view the entire supply chain. Two objectives align to industrial sustainability, i.e., the number 8 and 9 sustainable development goals (SDGs). Whereas SDGs-8 relates to sustained economic growth, SDGs-9 refers to social progress, both of which may be achieved through technological innovation to develop industries and admonish resilient infrastructures. Hence, both goals contribute to endogenous sustainability but have an exogenous effect on the SDGs-15 and the remaining SDGs. Therefore, industrialization must align techno-innovation to advance sustainability into the unfolding future effectively. The paper provides insight into the adaptability of emerging technology in the near future for the smart industrial solution. The body of the article is as follows: the subsequent section highlights essential theories, followed by the methodology for the investigative study, then, the result, and ends with the concluding chapter.

2. LITERATURE REVIEW

The general and commonly referred definition of sustainability sufficed in 1987, purported as: “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” (Brundtland, 1987). Innovation, as it pertains to sustainability through technological outreach from the conservative perspective, focusses on environmental protection, viable materials selection, design and process development, reduced pollution activities, and energy consumption initiatives (Peter & Mbohwa, 2018b). The aspect of product quality and compatibility of the product to promote social sustainability captures health, education, culture, and housing, employee and customer satisfaction, and community security (Joung, Carrell, Sarkar, & Feng, 2013). While the economic perspective deals with optimal operations cost, over-time/profit. The advent of much newer concepts, the blockchain technology: a disruptive and foundational technology that is competitive, flexible, reliable, and innovative. It serves to provide a robust platform for manufacturing supply chain and finance management, and have been regarded as a convenient protocol for sending receiving and recording values (Olleros, Zhegu, & Pilkington, 2016). It is an electronic ledger of digital records, events, or transactions that are hashed cryptographically, authenticated, and controlled through a distributed or shared network of participants using a group consensus protocol. Blockchain proofs to be a convenient, private, and simplified mode of payment (Nakamoto, 2008); however, the technology can be diversified to smart contracts, especially in the present era of digitization (Bradshaw, Millard, & Walden, 2011; Díaz, Martín, & Rubio, 2016).

The conception of the fourth industrial revolution by Ashton (Ashton, 2009), ushered new possibilities in manufacturing operations (Peter & Mbohwa, 2018a). The gradual shift from production-centered service delivery to the service-oriented manufacturing disposition was brought about by the intervention and development of the concept of cloud computing (Li et al., 2010). Cloud computing is simply understood as internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on-demand. It is a kind of computing technique where IT services are provided by massive low-cost computing units connected by IP networks. The technology allows data to be accessed conveniently and at low cost, thereby creating the platform for collaboration and organizational effectiveness (Kalapatapu & Sarkar, 2017; Tao, Cheng, Xu, Zhang, & Li, 2014). Researchers have aligned cloud computing capabilities with sustainability (Wu, Greer, Rosen, & Schaefer, 2013; X. Xu, 2012), and operational effectiveness for large and small manufacturing enterprises. New practices and internet-based applications continue to populate the industrial sector (Peter & Mbohwa, 2019; Shahid & Aneja, 2017). The internet of production concept is a transfer of the internet of things to the world of production (RWTH Aachen University, 2019). It promotes product design, sustainable production operations, and smart manufacturing protocols with the potential to transform SMEs' operations and promises a dynamic and sustainable model for parts manufacturing.

Internet of production is a timely intervention, as organizations need to use innovation to survive, that is, apply new approaches and methods of technology application to reduce production costs while adapting to the new markets. Thus, creating differentiated products and services, that allay new business opportunities, where competition and innovative advantages may strive (Bocken, Short, Rana, & Evans, 2014; Cooper, 2014; Helfat, 2011). The context of which is known as "Intelligent Factories" is extracted from the Industry 4.0 conception and relies on physical and digital interaction (Gorecky, Schmitt, Loskyll, & Zühlke, 2014). It is possible to transfer, share and access data through a cloud infrastructure that enables smart cities to exchange data between the most diverse sectors, such as manufacturing, transportation, energy, health, and agriculture, generating optimization, and increasing efficiency in these cities. Sensors are the key point for this architecture to capture such data (Aggarwal, 2014; Aggarwal, Ashish, & Sheth, 2014; L. Xu, Jiang, Wang, Yuan, & Ren, 2014). The internet works as a network and for process control, which includes the use of cell phones, for example, that functions as the system interface (Bogatinoska, Malekian, Trengoska, & Nyako, 2016). The internet, which was conceived in the late 1960s, specifically designed to enable fast communication for the researchers and military, which made data management a prerequisite to protect intellectual propert ies. Hence, promoting data confidentiality became a significant security concern, i.e., via cloud computing and the data hiding capability

The matter with regards to cloud security has been explored by notable researchers (not exhausted in the present study, as this was not the authors' focus). Wang et al. (2013) proposed a system for security of storage data in cloud computing named as privacy - preserving public auditing system. The authors used the random masking, and homomorphic - linear-authenticator to ensure a third party cannot learn any information about data content that is saved in the cloud server. Yu et al. (2018) present the IRIBS (Intrusion Resilient Identity Based Signature) scheme, which based on the framework of the FSIBS (Forward- secured Identity Based Signature) scheme, hence, a binary tree framework is utilized to join periods. In their research, they proffer and indirect safe proof for the IRSBS scheme. Yu et al. (2017) proposed a new protocol for RDIC (remote data integrity checking), which is identity - based, on the utilization of key-homomorphism cryptographic primitive. The proposed protocol leak no stored knowledge to the third party verify throughout the RDIC procedure.

3. METHODOLOGY

This study uses a questionnaire survey that was electronically developed and designed using survey monkey. The questionnaires were distributed through to official/verified emails of experts in industries, consultancy firms, academia, and Government practitioners involved in quality services delivery and standardization. It consists of three sections. The first section contains multiple-choice questions related to participant characteristics such as gender, age, nationality, language, educational level, and new technology awareness/year of service. The second section contains questions about the participants' observation of new technological entries in the past eight years (2010 to 2018). The participants were asked to choose one among a list of answers made available to them. The purpose was to investigate the severity of techno-innovation assess by understanding the challenges that limit its success. The third section contains seven multiple-choice questions on the three different technology interventions, which forms the main focus of the current investigation. Each of the selected technology strategies is among the most recent, envisaged for the transformation of industrial operations in the near future. Thus, to ascertain a respondent's understanding of his/her awareness based on the applicability of the technologies. It is essential to mention that the scope of the investigation target sustainability capability and productivity improvement through nascent technology initiatives, discussed in the paper.

The study accessed demographic information of the respondents and used the mean item score technique to evaluate the identified limitations and strategies discussed. The normality test for the data was conducted, and the level of significance of the respondent's opinion was analyzed using the Shapiro-Wilk and the Kruskal-Walis H-Test, respectively. The reliability of the questionnaire was also analyzed using the Cronbach's alpha test to measure its consistency for the survey. Hence, the limitation of the advancement of new technology implementation is compared with the strategies that bring the conception to successful implementation.

4. RESULTS AND DISCUSSIONS

4.1 Demographic characteristics of the respondents'

After three months from the time, when the request was sent to participants (English format), and 38 out of 45 responses were received. Data obtained through the questionnaire has been analyzed using SPSS Statistic 25.0. The summary of the demographic characteristics of the participant who responded to the survey is shown in Table 1. More than 60.2% of the respondents were between 25 and 45 years old, while 59.8% were male. The majority of the respondents are Asians. 81.9% of the respondents who had witnessed/aware changing technological access within their field or domain was above four (4) years, which is reasonable, considering that they are experts and experienced faculties, and industrial professional. Likert scale (1 to 5) was used to evaluate respondents' perspectives regarding sustainability consideration and performance improvement of the new technology when, or if they sufficed. Number 1 represents strongly disagree, and five (5) strongly agree on the opinion questions asked. Data obtained from the operators were divided into two parts; frequency and percentage table. Descriptive analysis was used to explain the respondent's demographics. Besides that, questions involving techno-innovation consideration in term of sustainability compatibility and productivity improvement was evaluated using Paired Samples t-test. For both parts, the mean score, standard deviation, and significant difference (Sig (2-Tailed) value) were determined. Hence, an understanding of the level of penetration which the new technology initiative introduces to promote sustainability advancement and improve manufacturing SMEs operations is grasped.

Table 1. Demographic characteristics of survey participants (n=38)

Variable	Frequency	% of participants
Gender		
Male	23	60.5
Female	15	39.5
Age		
18-25	4	10.5
25-35	6	15.7
35-45	16	42.1
45-65	9	23.7
Other	3	8.0
Continent		
Africa Europe Asia	10	26.3
North America South America	11	28.9
	14	36.8
	2	5.3
	3	2.7
Educational Level		
Graduate	9	21.5
Graduate and University faculty member	15	39.0
Graduate and Industrial Professional	14	39.5
Year of Service		
Less than 4 years Between 4-8 years	7	18.4
Up to 8 years	9	23.7
	22	57.9

4.2 Limitation of the advancement of new technologies

To access the limitations of new technology implementation on sustainability and industrial development, some constructs were identified from the review of related pieces of literature. Respondent's opinions were collected from their feedback by rating the level significance of the question asked. As such, a normality test was carried out to learn about the parametric or non-parametric nature of the data received. As a rule of thumb, and since the sample size of the study is less than 2000, the researcher attempted the Shapiro-Wilk normality test (Ghasemi & Zahediasl, 2012). Results of the analysis present the significant value for limitations of new technology implementation appear below the required criteria for normality (0.05). Because of this reason, a non-parametric investigation was carried out. The Kruskal-Walis H-Test for the non-parametric test was conducted. This helped to ascertain the significant difference in the respondent's perception and opinions, shown in table 4. The Kruskal-Walis Test displays the significant limitations as rated by respondents on the challenges of new technology implementation for sustainable industry development. The annotation, which forms the problems accessed in the table 4, provides evidence of the tendency of the accessed limitations to affect future industry productivity performance and sustainable advancement. The mean value, points above the average (3.0), with the most significant being.

Table 2. Limitations of new technology implementation (Shapiro-Wilk, normality test)

Limitations	Statistic	df	Sig.
Level of understanding of sustainability and techno-innovation	0.712	37	0.000
Techno-innovation access and awareness	0.976	37	0.000
Satisfaction with existing techniques	0.801	37	0.002
Economic of the new technologies	0.803	37	0.000
The complexity of the technologies	0.860	37	0.000
Lack of training/skill-set	0.911	37	0.001
Taking necessary action	0.742	37	0.000
Applicability of the technology	0.814	37	0.000
Consideration to meet sustainable performance improvement	0.901	37	0.000
Standardizations and Government regularization	0.884	37	0.000

Table 3. Limitation of new technology implementation success (Kruskal-Walis Test, normality test)

Limitations	Mean	Rank	Chi-Sq	Sig.
Lack of training/skill-set	4.34	1	5.821	0.194
Level of understanding of sustainability and techno-innovation criteria	4.11	2	5.705	0.254
Economic of the new technologies	4.04	3	10.503	0.030**
Standardizations and Government regularization	3.74	3	5.102	0.349
The complexity of the technologies	3.73	5	3.344	0.573
Techno-innovation access and awareness	3.71	6	2.105	0.696
Taking necessary action	3.68	7	1.980	0.784
Consideration to meet sustainable performance improvement	3.60	8	1.595	0.801
Applicability of the technology	3.49	9	11.172	0.019**
Satisfaction with existing techniques	3.44	10	1.324	0.894

** Significant at $p < 0.05$

Lack of training/skill-set, level of understanding of sustainability and techno-innovation criteria, and economics of new technologies with had mean values of 4.34, 4.12, and 4.4, respectively. Eight out of the ten assessed limitations in the Kruskal-Walis Test reveals a p-value higher than 0.05 and poofs no bias (significant statistical difference) in the opinion of the respondents. However, the respondents have a divergent view on the economy of the new technologies and the diverse nature of the technological systems. These responses are justified, as there is no clear indication that the entry of new technologies has been thoroughly demystified of its cost implication or operability. The juxtaposition is that nascent innovation is birthed daily, and new invention naturally outlives tradition design. Respondents express concern about the expensiveness. They may not guarantee the level of impact these technologies: Blockchain, Internet of Production, and Cloud Computing may have on business, health, and safety in the near future.

4.3 Strategies for the proliferation of Techno-innovation to advance productivity and sustainable industry development

In determining the strategy for improved product performance and sustainable industrial development, we repeat the approach used to determine the limitations of the advancement of new technology initiatives, as in the previous section. The focus is on the Strategies for the proliferation of Techno-innovation to advance productivity and sustainable industry development. The normality test was carried out to discern the nature of the data (parametric/non-parametric), whence the Shapiro-Wilk normality test conditions have been considered, is shown in Table 5. The Kruskal-Walis H-Test for the non-parametric test was also conducted (Table 6).

Table 5. Strategies for the proliferation of Techno-innovation (Shapiro-Wilk, normality test)

Limitations	Statistic	df	Sig.
Level of understanding of sustainability and techno-innovation	0.712	37	0.000
Techno-innovation access and awareness	0.976	37	0.000
Satisfaction with existing techniques	0.801	37	0.002
Economic of the new technologies	0.803	37	0.000
The complexity of the technologies	0.860	37	0.000
Lack of training/skill-set	0.911	37	0.001
Taking necessary action	0.742	37	0.000
Applicability of the technology	0.814	37	0.000
Consideration to meet sustainable performance improvement	0.901	37	0.000
Standardizations and Government regularization	0.884	37	0.000

Table 6. Strategies for the proliferation of Techno-innovation (Kruskal-Walis Test, normality test)

Strategies	Mean	Rank	Chi-Sq	Sig.
Review Higher Education Institution (HEI) curriculum, and artisan program	4.67	1	3.205	0.784
Increase Research Development Demonstration, and Deployment – RDD&D of the technology	4.53	2	3.988	0.651
Align Techno-innovation with sustainable industry development	4.19	3	4.478	0.354
Policy and regularization	4.19	3	5.444	0.210
Promote industrial and University's collaboration on techno-innovation solution	4.19	3	8.001	0.195
International cooperation on digitization framework	4.09	6	3.150	0.384
Encourage staff training and development	3.96	7	4.011	0.386
Ensure viable and equitable access to finance techno-innovation	3.74	8	1.384	0.643

Table 6 summarizes the respondents' (within the educational, IT, and manufacturing industry), where all the assessed strategies have the tendency of enhancing the techno-innovation proliferation within the industry. This is supported by their mean values, which fall above the average of 3.0. The same holds for the 'success of new technology implementation.' However, in the current case, the most agreed strategy concerns the opinion, 1) HEI curriculum and a robust program that prepares artisan for the retrospective future of digitization envisaged. 2) Encouraging RDD&D of the emerging technologies to integrate current practice with future excellence, and transform operation to become more cost-effective in a high-performance process that is sustainable in every manner. 3) The techno-innovation initiatives (Internet of Production, cloud computing, and blockchain) are eco-friendly, cost-effective, and conveniently secure, and is capable of driving productivity and sustainable industry development. Moreover, the mean values of 4.67, 4.53, and 4.19, respectively, were registered to support the points from the Kruskal-Walis Test. Also, while it has been noticed that none of the mean value appears below 3.0 and the all the significant p-value is above 0.05, the opinion of the different innovation professionals is valid for enhancing techno-innovation strategies to promote sustainability and industrial development.

4.4 Reliability and validity

The study has adopted the Cronbach's alpha reliability test to measure the consistency of the questionnaire. Previous literature has iterated 0.7 as an acceptable reliability coefficient, depending on the scoring parameters (Pallant, 2016). However, in this study, there was no need to conduct a reverse-score on the data since the number of items did not exceed 10. Thus, the reliability statistics and the Cronbach's Alpha for sustainability capability and productivity improvement tendency of the three techno-innovation strategies are presented in Table 6 and Table 7. According to the rule of thumb for Cronbach's Alpha value and internal consistency, individual Cronbach's Alpha for productivity improvement tendency obtained 0.784 and 0.744 for sustainability capability. Based on the reliability statistics, the questionnaire used was well-articulated, and the data herein is reliable since the values are higher than the earlier recommended 0.7 – acceptable level for small-sized data-set.

Table 7. Reliability statistic on productivity improvement tendency

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
0.784	0.824	5

Table 7. Reliability statistic on sustainability capability

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
0.744	0.794	8

The finding of the study is in line with the necessity for future manufacturing and service operations to integrate advanced physical and digital perspectives with traditional strategies to develop intelligent ways of doing business. Manufacturing practices are gradually adopting the smart technology mechanism to operate. Corporate firms are at the verge of familiarizing with the use of wireless/sensor technologies for optimal decision throughout a product's lifecycle (Kusiak, 2017). More so, the result of our investigation allay that information technology industry has a huge role to play in industry development, it confirms that there is a gap of knowledge on the lack of understanding of the type/selection, and operability of the emerging technologies (Förster, 2015). The challenges due to technological diversity and business financing hav e become very significant and leave more to be desired. The penetration of techno -innovation strategies as in; internet of production, cloud computing, and blockchain technology is encouraged to become part of the mainstream manufacturing psyche. As per sustainability compliance, which looks at cost savings and environmental protection, this must be captured in the manufacturing life cycle. It is timeous for corporations/conglomerates to reach -out in a scientific collaboration that will improve productivity and business performance in a sustainable manner. These concepts must be introduced early and in the HEI to prepare future innovators and professionals in the industrial environ. The finding is also in line with the ascensions of Sosinsky (2013), government backing on technological operatives through its funding, implementation, and enforcement policies.

5. CONCLUSION

The threat to future organizational performance, amidst nascent technological innovations, corporate management, and new manufacturing approaches, is imminent. Furthermore, the promise of optimal SME operations, which aims to advances manufacturing activities, must overcome the under-listed criteria. (1) Lack of expertise to translate heterogeneous technological protocols. (2) Lack of sophisticated equipment desired to coordinate operations. (3) Simplicity challenge due to operational software component and end-user interface. (4) Data protection and recovery. (5) Management capability, and (6) Regulations and compliance. The alignment of blockchain with the cloud computing concept and the internet of production proposition is envisioned to facilitate a sustainable corporate strategy that will lead to a robust manufacturing supply chain. The centralized manufacturing-related activities will seize to exist in the near future. There will be no need to invest too many for a lesser result, without close interaction and collaborative networks to proffer enterprise manufacturing solutions (Onu & Mbohwa, 2018). More so, the internet of production, which showcases potential strategies that better utilize the cloud computing capabilities linked to the cyber-physical system's possibilities, will address issues such as; research development, demonstration, and deployment to accelerate commercialization of the concept.

As part of a sustainable operations strategy to transform product designs, energy concerns, and environmental protection activities, the resolve is hugely dependent on governmental policies, standardization, and financial models designed for business execution. It forms the basis for decision-making in future industrial operations excellence. Moreover, they are already equipped to drive the industrial process and invent new protocols for sustainable industry development.

This study set out to investigate the possible impact of new technology entry and the possible strategies for enhancing the use of selected techno-innovation strategies within the manufacturing-built environment. Using a survey approach, by administering questionnaires to professionals, the study identified essential limitations to techno-innovation advancement that hinders sustainability and industrial development. Possible strategies for enhancing the use of Blockchain, Internet of Production, and Cloud Computing technologies have received insight into the present article. The study, therefore, highly recommends the teaching of digital technology-linked courses in tertiary institutions, with the focus to produce new breeds of innovative inclined graduates. By so doing, the cost of training of graduates incurred by respective companies can be minimized. The authors are confident that the findings of this study will assist innovation-minded companies in understanding the major obstacles which may hinder them from achieving great success in delivering optimal output. It also brings to light the areas that need to be improved upon based on technological intervention. An in-depth study is recommended to be carried on the performance of any selected techno-innovation strategy in a case study research to measure the level of success.

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