Expert Journal of Business and Management, Volume 10, Issue 2, pp.102-114, 2022
© 2022 The Authors. Published by Sprint Investify. ISSN 2344-6781
http://Business.ExpertJournals.com

Leveraging the Internet of Things to Enhance Employee Productivity in Operations: A Conceptualization

Zama GAMEDE and Matolwandile MTOTYWA*

Tshwane University of Technology, South Africa

Technological advancements and environmental turbulences require firms to continuously reconfigure their operational models by rapidly transforming the workplace. This study explores how the Internet of Things (IoT) can improve employees' productivity in operations. This conceptualization paper highlights five determinants of employee productivity: learning orientation, problem-solving, acquisition of knowledge, and monitoring and evaluation. The developed conceptual model has a three-phased approach to optimizing the impact of the internet of things with Bayesian classification. This is critical to effectively leverage improvement in employee productivity, profile deviation analysis and to predict the effectiveness of interventions. This study provides vital insights into leveraging the IoT during the fourth industrial revolution, offering the needed continuous development of employee productivity to help with the survival and stability of firms. This will assist the management of a firm by providing practical insights and an actionable approach towards fostering increased employee productivity during challenging times.

Keywords*: Internet of Things, business efficiency, employee productivity*

JEL Classification: *L60, M11, O33*

1. Introduction

Productivity of employees is one of the essential management subjects that has garnered considerable research attention from researchers and is regarded as a crucial mechanism for enhancing success within a firm (Hanaysha 2016; Attygalle and Abhayawardana, 2021; Olasanm et al., 2021). Nowadays, this attention is driven by multiple facets such as the high levels of uncertainty and impact caused by pandemic turbulence (Koffman et al., 2020; Chatterjee and Chaudhuri, 2021), generational mix, and changes in the workplace and required skills for future work (Husic et al., 2017). This requires the firms to revisit and optimize their approaches to improve employee productivity. In confirming this thinking, Chigada and Madzinga (2021)

*Corresponding Author:
Matolwandile Mtotywa, Tshwane School for Business and Society, Tshwane University of Technology, Pretoria, 0001, South Africa

Article History:
Received 28 September 2022 | Accepted 14 November 2022 | Available online 15 December 2022

Cite Reference:
Mtotywa, M. and Gamede, Z., 2022. Leveraging the Internet of Things to Enhance Employee Productivity in Operations: A Conceptualization. *Expert Journal of Business and Management,* 10(2), pp.102-114.

argue that these challenges require firms to continuously reconfigure their operational models by adopting technologies, thereby rapidly transforming the workplace. The pace of technology adoption is accelerated by the desire to remain relevant and functional to survive. The 4IR encompasses a range of technologies, such as the internet of things (IoT), cloud manufacturing, RF technology, and mobile apps (Sony and Naik, 2020). The fourth industrial revolution (4IR) technologies are progressing when leveraged to improve employees' baseline skills and improve the skills scale-up. This is critical because a firm's sustained growth, substantial profits, and improved social advancement are all results of increased productivity, which also tend to optimize the firm's competitive advantage through reduced costs and higher quality production (Sharma and Sharma, 2014).

Training and capability development could be aided by using technologies such as machine learning, artificial intelligence, and virtual reality. Firms that adopt these technologies will be better prepared for the future and save money in the process. To construct Cyber-Physical Systems (CPS), the 4IR facilitates the connection between manufacturing operations systems and ICT, particularly the IoT (Dalenogare et al., 2018). In all these technological applications, the human being is at the center of monitoring and controlling the operations to ensure synergies. The remainder of the paper synthesizes the literature focusing on the capabilities of IoT and changes in firms that can result from IoT. This is followed by the proposition and approach of the conceptual paper, the model development and the relationship between the model's focal constructs. The paper closes with the conclusion, theoretical contribution, managerial implications and limitations, and the proposed directions for future research.

2. Literature Review

2.1. Capabilities of the Internet of Things

The Internet of Things (IoT) is the interconnection of computing devices embedded in everyday objects through the internet. These devices send and receive data. The IoT connects physical objects and intelligent entities to the internet, resulting in context-aware autonomous behavior. It is a network in which objects are wirelessly linked via smart sensors (Guan et al., 2022). The Internet of Things can interact without human interaction (Li et al., 2015). The IoT is needed in general firm and human resource management to transparently manage efficiency, security and objectivity without bias (Mohanty and Mishra, 2020). Its applications demonstrate how people could provide superior services. The IoT is a unique technology platform that is essential for capturing real-time and other relevant data (Singh et al., 2020) and it may face substantial obstacles in various turbulent environmental circumstances.

Kaur, Raina and Sharma (2020) argue that IoT is a broad notion for which no standardized architecture has been developed; as such scholars, researchers and practitioners present multiple IoT architectures. These architectures generally range from three to five layers (Mahmoud et al., 2015; Ray, 2018; Mekki et al., 2019; Kaur, et al., 2020; Parto et al., 2020). The first layer is the physical layer, which is the perception layer (Kaur et al., 2020) or sensors, IoT devices and actuators (Mekki et al., 2019). The sensors in this layer can detect and collect data from many sources to allow actuators to use this data to carry out targeted actions. These IoT devices and actuators are attached to "things" through a network or gateways. These "things" may be machines, a building or even a person. The three-layer architecture integrates some of the stages (Parto et al., 2020) while the five-layer architecture may also break them down. In the five-layer architecture, there is a transport stage where the information gathered at the perception layer is sent on to the processing layer. The transport layer makes use of a variety of technologies, including local area networks, wireless networks, generation networks (3G-5G), other radio frequencies and long-term evolution (LTE) (Kaur et al., 2020).

Data move from sensors through the network to the clouds for processing, analysis and storage. Therefore, IoT, Big Data, and Cloud computing are inseparable. For instance, when a connected Internet of Things device performs activities such as turning on a light or turning on a sensor to detect motion, such actions are logged as data and sent to the cloud or a data center so that they may be recorded and analyzed. As a result, if there are data involved, there must be an IoT architecture to inform the data where to go, what format to use and how to get there, and what actions should be made depending on these data (Mekki et al., 2019). In the architecture of the internet of things, data can also be transferred in the opposite direction, in the form of instructions or commands intended to tell an actuator or linked device to perform some action to regulate a physical process. A data acquisition system, often known as a DAS, is responsible for collecting raw data from sensors and converting that data from an analogue format to a digital version. In the final layer, either the cloud or a data center will carry out an in-depth study of the data. The information gathered from several field sites and sensors is consolidated to present a more comprehensive picture of the IoT system and provide IT and business management with insights that can be put into action. Thus, IoT allows everyone, processes, data and diverse items to establish a relevant network and have value to translate information into tangible actions (Abazi, 2016). Kaur et al. (2020) posit this final layer as the business layer as it governs the operation of the overall IoT system.

2.2. Changes in Firms Caused by Implementing the Internet of Things

Elijah, Rahman, Orikumhi, Leow and Hindia (2018) highlight that IoT allows firms to recruit, select and hire employees with the right skills for specific jobs. Thus, IoT applications facilitate human resources management processes by appointing employees to roles commensurate with their job function, skills, and reporting lines. Given the complexities in virtual reality technology, most employees do not have the requisite skills and competencies to use IoT. However, continuous training and development decreases the skills gap in firms. Firms use IoT for collaboration - especially when people are working remotely. Harbers, Bargh, Pool, van Berkel, van den Braak and Choenni (2018) state that IoT enhances knowledge sharing, collaboration, and cross-pollination of team skills. For example, people in different geographic locations use IoT to communicate and work on a project. Thus, implementing IoT may provide a variety of benefits for businesses, and the data acquired by it allow for substantial insights for firms and employees to experience a considerable productivity boost (Dwivedi et al., 2017). Sony and Naik (2020), supported by Ejsmont (2021), posit that the employee's role in the smart factory, and changes in qualifications and professional competencies are critical, especially in the era of digital skills and professional development to enhance productivity within the firm.

As the 4IR progresses, factory workers will have to perform different tasks and meet different needs. Industrial firms are finding it harder and harder to successfully implement Internet of Things (IoT) networks. This is because IoT connectivity appears to make it possible for all goods and activities to have more accurate and real-time information (Sievers et al., 2021). Using an interconnected network, a system that is connected to the Internet of Things (IoT) can be used to supervise things. Javaid, Haleem, Singh and Suman (2021) report that IoT makes it less likely for mistakes to happen in manual processes. In addition, automated processes can be controlled, which can lead to good results. Digital technologies are being used by businesses to offer new digital services to customers, such as internet-based services built into products (Ayala, Paslauski, Ghezzi and Frank 2017; Coreynen et al., 2017). From an operational point of view, digital technologies such as CPS are thought to cut down on set-up times, labor and material costs, as well as processing times, making production processes more efficient (Jeschke et al., 2017).

2.3. Employee Productivity Dimensions

Firms can improve employee productivity through learning orientation, problem-solving, knowledge acquisition, and monitoring and evaluation. Such firms that leverage the capabilities of digital technologies to provide their clients with novel digital solutions, such as internet-based services incorporated in their goods, are called "digital natives" (Ayala et al., 2017). Digital technologies, such as CPS, are offered from an operational standpoint to decrease set-up periods, labor, material costs and processing times, hence increasing the productivity of production operations (Brettel et al., 2014; Jeschke et al., 2017).

2.3.1 Learning Orientation

A firm that fosters learning helps its employees develop the skills they need to produce the kinds of results they care about. It creates a space where individuals can learn to learn together incessantly and where a shared dream can be realized (Chigada, 2014). The literature on learning within firms lacks conceptual tools that enable researchers to comprehend and assess the common good at the ecosystem level as the aim of the learning. Employees' foundational abilities and the scalability of those abilities are both enhanced through the application of 4IR technology. Technology such as social media, ML/AI, mashup apps, wearables, VR and AR can be used to make training and capacity building more accessible and effective (Javaid et al., 2021). In a study conducted by Ejsmont (2021) in Australia to determine the impact of 4IR on employees, it was established that the 4IR meant changes to both technology and employees. Given the widespread assumption that the industrial revolution would lead to a dramatic improvement in business efficiency, the Fourth Industrial Revolution had far-reaching effects on workers and their occupations. It is in the best interest of businesses to ensure that their staff members have access to relevant operational expertise. Human capital is a firm's most valuable asset because it can be used to accomplish strategic goals, adapt to changing market conditions and acquire a competitive edge. Thus, there is a major shift in the way that firms train their future workforce and define the competencies and abilities they need to succeed in the 4IR era (Ejsmont, 2021). Technology innovation, in which incremental upgrades are made to provide ever-increasing value to clients, is identical to a "learning attitude" and because of the inextricable relationship between knowledge and the process of learning, new information is constantly being generated and disseminated inside the firms (Chigada, 2014).

2.3.2 Knowledge Management

The field of knowledge management (KM) has proliferated in the last 20 years, making firms realize that knowledge and information are important strategic tools that are needed to make good decisions (Chigada and Ngulube, 2015). When KM became popular and well-known in the early 1990s, many firms started to realize it's importance (Grant and Grant, 2008). Knowledge management is a strategic way for a firm to handle its knowledge so as to gain a competitive edge (Chigada, 2014). Thus, KM is now at the center of discussions about how to make a firm more competitive in a competitive market. Top management should be involved and committed to adopting and implementing 4IR and its technologies, such as IoT, to create and preserve knowledge assets over more traditional ones. This entails making resources available and ensuring that project implementation of new technologies receives support. Adegbite and Adeosun (2021) highlight that employees should be adaptable to 4IR especially as resistance to change can make other employees resist new technology. Training and development are pertinent to ensure 4IR is embraced in the firm. Each firm has to focus on its product/services design strategy to create customer value-through quality, cost-effectiveness, speed, flexibility and reliable products and services (Heizer and Bender, 2020). In a knowledge-based economy, economic progress, the supply of exceptional and distinctive services, highly skilled and educated individuals together with expertise are dependent on knowledge (Drucker, 1999; Muzam, 2022). Knowledge work and knowledge worker roles will continue to expand in the workplace of the future (Kudyba et al., 2020). As a result of global market issues, firms will continuously need to create new capabilities and alter their existing approaches to remain relevant and sustainable.

2.3.3 Interoperability and Synergies

Firms use IoT for collaboration, especially when people are working remotely. Harbers et al. (2018) posit that IoT enhances knowledge sharing, collaboration and cross-pollination of team skills. People in different geographic locations use IoT to communicate, work on project assignments/tasks without worrying about time differences, boundaries or distance. People anywhere across the globe can collaborate with their peers in other parts of the world and still accomplish the same productivity irrespective of not physically being present or seeing each other – they are ubiquitous (Laudon and Laudon, 2020). Ansari, Ali, and Alam (2020) state that IoT and Cloud computing has changed the course of technological development because they use a synergistic approach to amalgamate their benefits into a single package. The IoT provides network infrastructure with interoperable communication protocols and software that facilitate connection and incorporation. This is facilitated by the IoT comprising Internet-based physical devices embedded with operating systems (OS), devices, sensors, actuators and other electronic components and wireless connectivity to collect and exchange data via these objects (Ansari et al., 2020). At the same time, cloud computing possesses infinite storage and system capabilities designed to resolve most of the IoT issues. This creates a novel IT paradigm that incorporates both Cloud and IoT technologies known as Cloud of Things (CoT). The CoT enhances the present and future of IoT systems and efficiently manages IoT devices and resources. Thus, the CoT is becoming popular and widely used by industries and manufacturers to enhance productivity and make their systems more efficient (Azam et al., 2014). The increasing number of IoT devices generates a massive volume of data in a wide variety of formats, kinds and granularities. It is possible to analyse these (big) data and link them to other data sets in order to give richer information about people and both the physical and virtual surroundings in which they live. This information frequently includes personally identifiable data that are newly collected (Rose et al., 2015; Parto et al., 2020).

2.3.4 Problem-Solving

An aging global population and the impact of turbulence such as COVID-19 (Rachidi, 2020) created a strain on firms and there is, thus, an urgent need for an improved younger generational mix within firms, but this, in turn, leaves the firm with less experienced employees who need enhanced skills, especially in problem-solving. The IoT will make it possible for younger, inexperienced employees to improve their skills from IoT capabilities and other technologies, such as simulation. This is made possible by the capability of the IoT to bring together machine-to-machine (M2M) communication and big data, among others, making the connection between cyber space and humans (physical systems) more pervasive and thereby giving rise to cyber-physical systems (Farhan et al., 2018). These interconnected nodes and intelligent products can carry on conversations with one another, for the most part, without any direct human involvement and can help with problem-solving even in complex operations. Sensor-enabled, wirelessly connected devices can help predict a firms' patterns and requirements, such as air pollution levels (Al-Turjman and Abujubbeh, 2019).

2.3.5 Monitoring and Evaluation

Monitoring and evaluation (M & E) is a method for ensuring that objectives are met. It involves systematic and routine data collection to evaluate the project's performance relative to its stated objectives. It is an effective tool for enhancing the quality of a project through continuous performance evaluation (Ile et al., 2019). In addition, M & E provides early warning, is central to control during problem-solving to overall improve and strengthen governance, accountability and transparency (Markiewicz and Patrick, 2016). These requirements are within the IoT capabilities and can be exploited to increase the effectiveness of M & E. Hizam and Ahmed (2019) explain that operations, especially quality management, can benefit from technology. This resulted in the development of Quality 4.0 as a reference for the future of quality and firm excellence within the context of 4IR (Mtotywa, 2022). Aldag and Eker (2018) argue that quality is the most significant and necessary part of the firm because it eliminates errors that slow down flow speed and it improves reliability dependability. Effective quality management minimizes errors that cause time-, effort- and money-wastage. Quality monitoring and analysis can improve a firm's product or service, make firms more proactive and reduce customer complaints. Additionally, monitoring the process can assist in minimizing stoppages and deviations in planned production. The advent of digital technology has created new chances for sustainable practices, such as encouraging staff to collaborate closely so that the firms' sustainability goals are met and that workers can deliver on their assigned tasks efficiently and fairly. According to Azam et al., (2014), sensor-enabled gadgets help to monitor performance and movement patterns and alert the appropriate authorities if anything seems out of the ordinary. Deploying IoT technology, thus, can enable more precise environmental monitoring through data, along with predictive capabilities. Integrating IoT devices with artificial intelligence could enhance these capabilities.

2.4. Linking of Capabilities of IoT with Employee Productivity Enhancement Factors

Martinez-Caro, Cegarra-Navarro and Alfonso-Ruiz (2020) assert that the 4IR compels firms to train and re-skill their employees to develop skills and knowledge pertinent to generating new ideas that will impact their firms' performance. The employees' ability to drive internal progress ultimately influence the type of technological developments (Pavitt, 1991). Employee performance and technological progress are closely related elements of the firm and as such should be treated with care (Song et al., 2019). Table 1 presents the linkage of IoT characteristics and capabilities with employee productivity enhancement factors.

Technological implementation can lead to productivity as well as enhanced performance if it is driven by competent and capable employees. Human resources-related operations management practices such as quality management are critical in the firm as they improve learning orientation, knowledge integration and strategic flexibility (Gutierrez-Gutierrez et al., 2018). Therefore, IoT contributes a huge impact factor on productivity and quality products and services. Employees using production technologies achieve high quality through prevention rather than inspection. To this end, the proposition of the research is:

P1: The internet of things (IoT) technologies can help improve the productivity of people in operations

This conceptual paper aims to build the conceptual model that predicts the links between concepts associated with IoT technologies and employee productivity improvement (Jaakkola, 2020). A conceptual model characterises and identifies concerns that should be explored in a study. The model aims to describe contingencies associated with the focus constructs. This entailed theorizing and adopting a formal analytical method to explore relationships and their related mechanisms (Delbridge and Fiss, 2013; Mtotywa, 2022).

Table 1. *Linkage of IoT characteristics and capabilities with employee productivity enhancement factors*

	Learning orientation	**Knowledge management**	**Interoperability and synergies**	**Problem-solving**	**Monitoring and evaluation**
Training and skill development	X	X		X	
Enhanced data collection.		X	X	X	X
Instant data access and uses real-time data		X	X	X	X
Improved data-based decision making	X	X			
Better time management	X			X	
Monitoring activities					X
Systems integration			X		X
Optimization of process	X	X	X		
Efficient resource utilization		X	X	X	X
Interconnected system for improved safety			X		X

3. Developing the Conceptual Model

This is a three-phase approach starting by optimizing the impact of IoT with Bayesian classification as this in critical to effectively leverage the IoT for improved employee productivity, profile deviation analysis and prediction effectiveness. The conceptual model is presented in Figure 1.

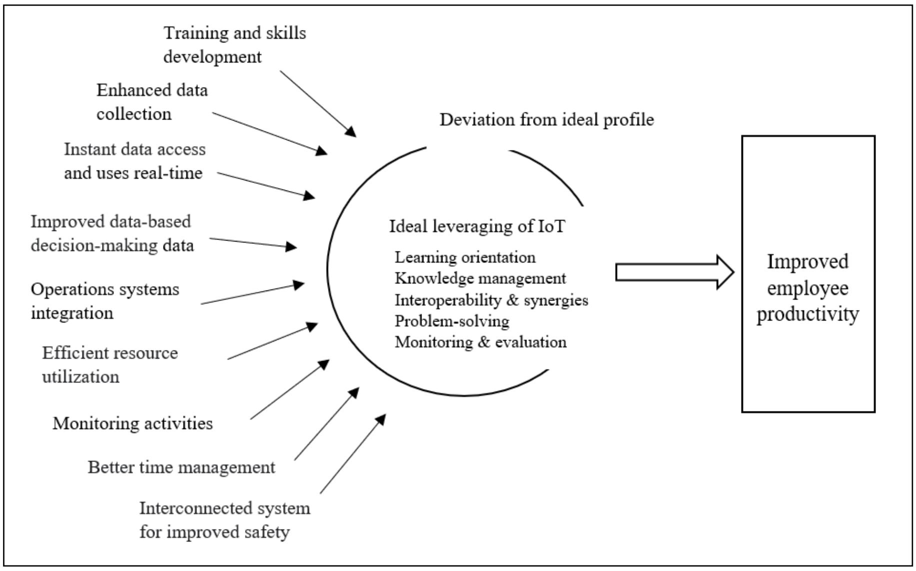

Figure 1. *Linkage of Internet of things characteristics and capabilities with employee productivity enhancement factors*

3.1. Optimizing the Impact of IoT with Bayesian Classification

Using prior knowledge of the system, Bayesian statistics may forecast the likelihood of a specific data set. Integrating joint probability and conditional probability, Bayes' theorem (Robert, 2014):

$$p\ (X|Y) = \frac{p\ (X|Y)\ p(X)}{\sum_a\ p\ (Y|X=a)\ p\ (X=a)} \tag{1}$$

$p\ (X|Y)$ is the probability of an event X occurring if and only if condition in Y holds true. While discrete datasets can be analyzed using the Bayes theorem without any modification, continuous datasets must either be discretized or have their distribution properties taken into account. It was stated by Parto et al. (2020) that autonomous operations based on detecting circumstances are a crucial step towards smart manufacturing.

For more accurate event prediction, supervised classification models can be built from data collected from sensors and sensor arrays. This ensures that the IoT is being used to the full extent of its potential in order to boost workplace efficiency.

3.2. Profile Deviation

A firm that can decipher the role of each piece of the IoT, can put those parts to work in a way that brings about wealth. This can ensure that an ideal profile for leveraging IoT is achieved which in turn will assist with employee productivity improvements. Modelling the ideal type to exploit IoT should begin with the recognition that an ideal type is a theoretical construct, i.e., a unique and discrete reality as opposed to a nominal category (Malhotra et al., 2013). To establish the ideal type, any empirical test should therefore include a rich multivariate method (Mtotywa, 2022). The IoT employee productivity determinants do not need to be categorised into nominal groups because the deviation from the ideal type is the essence of the concern. Consistent with empirical evidence and theory, the profile deviation (Euclidian distance) can therefore be utilised to forecast IoT efficacy in enhancing learning orientation, problem solving, acquisition of knowledge and monitoring and evaluation effectiveness for improved employee productivity. The calibration sample serves as the standard for the comparisons of the remainder of the sample. The degree of alignment is calculated with the weighted Euclidian distance from the ideal profile (Venkatraman, 1989) using the equation (Baker et al., 2011):

$$Alignment = 1 + \sqrt{\sum_{i=1}^{n} \{b_i \, (X_{ijt} - I_{ijt})^2\}} \qquad (2)$$

b_i is the weight of the employee productivity determinant, *i*; while X_{ijt} is the score for determinant *i* from firm *j* at time, *t*. I_{ijt} The ideal score is the degree of fit of X_{ijt} for determinant *i* from firm *j* at time, *t*. The ideal score can be determined from the top 10% most productive employees from leveraging the IoT capabilities. Low scores indicates that there is better alignment.

3.3. Prediction of Effectiveness

Prediction of effectiveness involves assessing the relationship between the characteristics and capabilities of IoT and five productivity-enhancing factors. Once the IoT devices are online and set up, they will gather data from the real world, share it online and offline, and store in the cloud (Kaur et al., 2020). Sensory and status data are two common sorts of data generated by IoT devices. Such information is regularly updated in real-time and stored in a structured manner for straightforward, later retrieval. The information generated by private and public IoT gadgets is immediately available to anyone who wants to see it. Suppose there are internet-connected smart devices, such as a smartphone or tablet. In that case, it is possible to access data and information from an Internet-connected IoT device at any time, irrespective of the location. Better choices can be made with more data at hand. Having more data at employees' disposal, aids in making educated choices. Knowledge is power, and more knowledge is better, whether making a routine or complex decision (Brous et al., 2019). Improved decision-making is possible with the help of IoT devices since it is data driven (Neagu et al., 2019). Those tasked with keeping the infrastructure running smoothly have found the IoT to be a tremendous boon. To prevent unexpected breakdowns, preventative maintenance can be scheduled in advance because of notifications sent out by IoT devices about their current process health. When IoT is part of a broader system, it can help eliminate inefficiencies and save money by preventing or fixing problems before they impact productivity. The IoT increases firm output by providing just-in-time training for workers, boosting labour efficiency, and decreasing the skill gap. It keeps an eye on how things are and provides alerts that can assist in problem solving. This can ensure that employees fix problems before they get worse, thus saving time and money for the firm. With IoT, machines are more reliable and error-free, leading to more output for firms. Many advantages of the IoT cannot be realised without automation, which is facilitated and made possible by so-called machine-to-machine communication (Farhan et al., 2018). Using the IoT, a variety of tasks can be automated to free up time to devote to other crucial tasks. To determine the effect of the IoT on employee productivity the ordinary least square regression model will be as follows:

$$EP_i = \alpha_o + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots \beta_n X_{ni} + \varepsilon_i \qquad (3)$$

where EE is employee productivity, while $X_1 \dots . X_n$ are the explanatory variables, learning orientation, knowledge management, interoperability and synergies, problem-solving as well as monitoring and evaluation. α_0 is the constant, $\beta_1 \dots . \beta_n$ are coefficients and ε_i is the error term. It is recommended that the control variable be included to eliminate omitted variable bias. These controls should be the firm's variables. In the presence of the control variables, the regression model will be:

$$EP_i = \alpha_o + \beta_1 X_1 + \beta_2 X_{2i} + \cdots \beta_n X_{ni} + C_i' + \varepsilon_i \quad (4)$$

However, the most important assumption that must hold is the conditional means independence:

$$\epsilon \left(u_i \mid X_{1i}, X_{2i}, X_{3i}, X_{4i}, X_{5i} \right) = \epsilon \left(u_i \mid X_{2i}, X_{3i}, X_{4i}, X_{5i} \right) \quad (5)$$

This indicates that the expected value of the error term is conditional to all regressor variables, is equal to the error term, conditional to all the regressor variables for X_1. This means that the causal variable $X_1$and the error term are uncorrelated when we control for the firm's variables and $X_2 \dots . X_n$. The key multicollinearity assumption needs validation using the variance inflation factor (VIF), confirming the model specification. This is because a linear connection between two explanatory variables can cause the standard errors of the coefficients to be inflated needlessly when multicollinearity is present (Akinwande et al., 2015; Salmerón et al., 2018).

The equation for multicollinearity is:

$$VIF = \frac{1}{1-R_j^2} \quad (6)$$

where R_j^2 is the proportion of the variance from the regressions of the explanatory variables, j = 1, 2,... p. The other assumption critical to ensure the accuracy of the model that needs assessment is homoscedasticity with the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity. To put it another way, if the standard deviation of the error term does not change then there is homoskedasticity:

$$Var\left(\varepsilon \middle| \underline{X}\right) = \delta^2 \quad (7)$$

where the var ε given the vector for all explanatory variables is equal to a constant δ^2. It is argued that the error terms are heteroskedastic if the variance of the errors does not remain constant. Assessment of the other assumption, serial correlation, is then done with Durbin-Watson d-statistic and normality of the residuals with the Jarque-Bera normality test. If the assumptions are violated, we calculate the variances of OLS estimators (along with their standard errors) by employing White-Huber standard errors or heteroscedasticity robust standard errors by utilizing $\hat{E}$:

$$\mathrm{VAR}\left(\hat{\beta}\right) = (X'X)^{-1} X'EX(X'X)^{-1} \quad (8)$$

Oke, Arowoiya and Akomolafe (2020) also found that the adoption of the IoT has a significant impact on worker security, privacy, safety, productivity and performance.

4. Conclusion

This objective of this conceptualization paper was to develop a conceptual model to leverage the internet of things to enhance employee operational productivity. This is critical given the rapid changes brought about by turbulences such as high levels of uncertainty, generational mix and changes in the workplace, as well as required skills for future work. This is critical for short-term and medium-term interventions. Short-term measures include business continuity, protection of employees and ensuring that they are productive and that there are minimal disruptions across production processes. For medium-term interventions, firms have established new local supply ecosystem networks and diversified their supply bases (Jacob 2017). Using big data in conjunction with IoT can provide insights into the effectiveness of employees and help firms determine effectiveness within the workplace. A productive employee can help create a domino effect that will ensure customer service improvement and profitability in the firm. For this to be successful, the firms must revisit and optimize the approaches to improve employee productivity. Donepudi (2020) concluded that 83% of the firms that used IoT systems have efficiency gains, and these technologies, when correctly leveraged, improve firm's performance and sustainability. The developed conceptual model has a three-phased approach to optimizing the impact of IoT with Bayesian classification. This is critical to effectively leverage and improve employee productivity, profile deviation analysis, and prediction effectiveness. This confirms the proposition of the research that the technologies of the IoT can help improve the productivity of people in employment operations.

4.1. Theoretical Contribution

The theoretical implication of the study is that 4IR is changing the workplace, and IoT drives operations to improve efficiency and productivity. Therefore, the findings from this study confirm the importance of technology. It has been established that IoT facilitates knowledge management, where knowledge has been identified as a key firm's strategic asset. Thus, the findings are important for practice, where traditional bricks and mortar approaches should be revisited and replaced with more efficient processes to generate knowledge and establish a learning culture within a firm. Thus, IoT has and will continue to change how businesses operate regarding business models and so practitioners should be motivated to adopt IoT.

4.2. Managerial Implications

The research provides firm management with practical insights and an actionable approach towards fostering high employee productivity resulting from leveraging IoT, a key fourth industrial revolution technology. Firms must align quality management with the era of digitization (Quality 4.0) technologies that facilitate creativity, fresh insights, and connectedness between humans and machines. The challenge that awaits firms is the lack of skilled human capital with the requisite skills to use 4IR technologies. Firms must invest in their human resources, retain them and ensure sustained continuity. The findings from this study create opportunities for management to be introspective as to the benefits of IoT on employee productivity and firm performance. Ejsmont (2021) determined the impact of 4IR on employees and established that the 4IR meant changes to technology and employees. This assumption that the fourth industrial revolution substantially impacted employees and their jobs stems from the belief that the industrial age has led to an exponential development in efficiency within a firm.

4.3. Limitations and Directions for Future Research

The study showed how businesses are moving towards 4IR to improve efficiency. The strength of the research is the development of a comprehensive conceptual framework for leveraging the IoT to improve employee productivity. The limitation of the study is that this framework is not yet validated and, post-validation, might vary slightly. Despite this, initial reports are very encouraging as to the link between the IoT and improvement in employee productivity (Donepudi, 2020; Oke et al., 2020). Our model provides a direction for execution and a necessary flexibility. Technology development is an evolving process; therefore, the firm must not adopt every new technology because of its immediate appeal. Rather, it should complement existing tools and strategies to improve employee productivity and firm competitiveness. The Fourth Industrial Revolution is becoming a central component in the formation and reformation of global collaborative networks to bring unique value propositions to global markets and customers and improve firm performance. This netocracy incorporates virtual reality technologies which use sophisticated manufacturing models and enterprises' information technologies with the assistance of the Internet of Things. As a network focus, a firm should prioritize leading networks, individuals with various networks, and networks of networks to assist employees in improving productivity. Future studies should concentrate on validating the study's conceptual model, linking the IoT to employee productivity determinants, customizing the Bayesian classification for the firms' IoT, and creating an ideal profile that can be used to assess the IoT's and prediction effectiveness. To achieve this, the directions for future study should focus on operationalizing a practical approach for strategic alignment of 4IR technologies with firm strategies geared towards ensuring that the firm is sustainable during this time of operational turbulence and uncertainty.

Author Contributions: Zama Gamede and Matolwandile Mtotywa: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Writing - Original Draft, Writing - Review & Editing, Visualization. Matolwandile Mtotywa: Supervision.

Acknowledgements: We wish to recognise the support from Tshwane School for Business and Society.

Funding: This research received no external funding.

Conflicts of Interest: The authors state that they have no conflicts of interest.

References

Abazi, B., 2016. An approach to the impact of transformation from the traditional use of ICT to the Internet of Things: How smart solutions can transform SMEs. *IFAC-PapersOnLine*, *49*(29), pp.148–151.

Adegbite, W.M. and Adeosun, O.T., 2021. Fourth industrial revolution skillsets and employability readiness for future job. *Global Journal of Social Sciences Studies. 7*(1), pp. 35-49.

Aldag, M.C. and Eker, B., 2018. What is Quality 4.0 in the era of industry 4.0?. In Proceedings of the 3rd *International Conference on Quality of Life, Kopaonik, Serbia,* 28–30 November 2018, Kopaonik, Serbia, pp. 31–3.

Akinwande, M.O., Dikko, H.G. and Samson, A., 2015. Variance inflation factor: As a condition for the inclusion of suppressor variable(s) in regression analysis. *Open Journal of Statistics, 5*, pp.754-767. http://doi.org/10.4236/ojs.2015.57075

Al-Turjman, F. and Abujubbeh, M., 2019. IoT-enabled smart grid via SM: An overview. *Future Generation Computer Systems*, 96, pp.579–90.

Ansari, M., Ali, S.A. and Alam, M., 2020. *A synergistic approach for Internet of Things (IoT) and cloud integration: Current research and future direction*. [online] Available at: https://arxiv.org/pdf/1912.00750.pdf [Accessed 28 July 2022].

Attygalle, D. and Abhayawardana, G., 2021. Employee productivity modelling on a work from home scenario during the Covid-19 pandemic: A case study using classification trees. *Journal of Business and Management Sciences*, 9(3), pp.92-100. https://doi.org/10.12691/jbms-9-3-1

Ayala, N.F., Paslauski, C.A., Ghezzi, A. and Frank, A.G., 2017. Knowledge sharing dynamics in service suppliers' involvement for servitization of manufacturing companies. *International Journal of Production Economics*, 193, pp.538-553.

Azam, M., Khan, I., Alsaffar, A.A and Huh, E.N., 2014. Cloud of Things: Integrating Internet of Things and cloud computing and the issues involved. *Applied Sciences and Technology (IBCAST)*, pp.414–419.

Baker, J., Jones, R.D., Cao, R.Q. and Song, J., 2011. Conceptualizing the dynamic strategic alignment competency. *Journal of the Association for Information Systems*, *12*(4), pp.299-322.

Brettel M., Friederischen, N., Keller, M. and Rosenberg, M., 2014. How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 perspective. *International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering*, *8*(1), pp.37-44.

Brous, P., Janssen, M. and Herder, P., 2019. Internet of Things adoption for reconfiguring decision-making processes in asset management. *Business Process Management Journal*, *25*(3), pp.495-511. https://doi.org/10.1108/BPMJ-11-2017-0328

Chatterjee, S. and Chaudhuri, R., 2021. Supply chain sustainability during turbulent environment: Examining the role of firm capabilities and government regulation. *Operations Management Research.* https://doi.org/10.1007/s12063-021-00203-1.

Chigada, J., 2014. *The role of knowledge management in enhancing organisational performance in selected banks in South Africa*. PhD Thesis, University of South Africa.

Chigada, J. and Madzinga, R., 2021. Cyberattacks and threats during COVID-19: A systematic literature review. *South African Journal of Information Management*, *23*(1), a1277.

Chigada, J. and Ngulube, P., 2015. Knowledge management practices at selected banks in South Africa. *South African Journal of Information Management*, *17*(1), p.634.

Coreynen, W., Matthyssens, P., and van Bockhaven, W., 2017. Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Industrial Marketing Management*, *60*, pp.42–53. https://doi.org/10.1016/j.indmarman.2016.04.012.

Dalenogare, L.S., Benitez, G.B., Ayala, N.F. and Frank, A.G., 2018. The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics, 204*, pp.383-394.

Delbridge, R. and Fiss, P. C., 2013. Editors' comments: Styles of theorizing and the social organization of *knowledge. Academy of Management Review, 38*(3), pp.325–331.

Donepudi, P.K., 2020. Leveraging cloud computing and high-performance computing (HPC) advances for next generation projects and technologies. *American Journal of Trade and Policy, 7*(3), pp.73-8.

Dwivedi, Y.K., Janssen, M., Slade, E.L. Rana, N., Weerakkody, V., Millard, J., Hidders, J. and Snijders, H. 2017. Driving innovation through big open linked data (BOLD): Exploring antecedents using interpretive structural modelling. *Information Systems Frontiers, 19*, pp.197–212. https://doi.org/10.1007/s10796-016-9675-5

Drucker, P., 1999. Knowledge-worker productivity: The biggest challenge. *California Management Review,* 41(2), pp.79-94.

Ejsmont, K., 2021. The Impact of Industry 4.0 on Employees - Insights from Australia. *Sustainability, 13*(6), 3095.

Elijah, O., Rahman, T.O., Orikumhi, I., Leow, C.Y. and Hindia, M., 2018. An overview of internet of things (IoT) and data analytics in agriculture: Benefits and challenges. *IEEE Internet of Things Journal, 5*(5), pp.3758-3773.

Farhan, L., Kharel, R., Kaiwartya, O., Abdulsalam, M, Essa, A.E. and Abdulsalam, M., 2018. A concise review on internet of things (IoT) - problems, challenges and opportunities. *11th International Symposium on Communication Systems, Networks, and Digital Signal Processing* (CSNDSP 2018), Hungary. https://doi.org/10.1109/CSNDSP.2018.8471762

Grant, K.A. and Grant, C.T., 2008. Developing a model of next generation knowledge management. *Issues in Informing Science and Information Technology, 5*.

Guan, A.L.C., Manavalan, M., Ahmed, A., Azad, M. and Miah, S., 2022. Role of internet of things (IoT) in enabling productive work from home (wfh) for environmental volatiles. *Academy of Marketing Studies Journal, 26*(1), pp.1-11.

Gutiérrez-Gutiérrez, L.J., Barrales-Molina, V. and Kaynak, H., 2018. The role of human resource-related quality management practices in new product development: A dynamic capability perspective. *International Journal of Operations and Production Management, 38*(1), pp.43-66. https://doi.org/10.1108/IJOPM-07-2016-0387

Harbers, M., Bargh, M., Pool, R., Van Berkel, J., Van den Braak, S. and Choenni, S., 2018, January. A conceptual framework for addressing IoT threats: challenges in meeting challenges. In *Proceedings of the 51st Hawaii International Conference on System Sciences*.

Hanaysha, J., 2016. Improving employee productivity through work engagement: Empirical evidence from higher education sector. *Management Science Letters, 6*, pp.61–70.

Heizer, J. and Render, B., 2020. *Operations management sustainability and supply chain management.* 11th ed. New York, USA: Pearson Education.

Hizam, S.H. and Ahmed, W., 2019. A conceptual paper on SERVQUAL-framework for assessing quality of Internet of Things (IoT) services. *International Journal of Financial Research, 10*(5), pp.387-397.

Husic, J.B., Melero, F.J., Barakovic, S., Lameski, P., Zdravevski, E., Maresova, P., Krejcar, O., Chorbev, I., Garcia, N.M. and Trajkovik, V., 2017. Aging at work: A review of recent trends and future directions. *International Journal of Environmental Research and Public Health, 17,* pp.1-15. https://doi.org/10.3390/ijerph17207659.

Ile, I., Eresia-Eke, C. and Allen-Elle, C., 2019. *Monitoring and evaluation of policies, programmes and projects.* Pretoria: Van Schaik Publishers.

Jaakkola, E., 2020. Designing conceptual articles: four approaches. *Academy of Marketing Science Review, 10,* pp.18–26. https://doi.org/10.1007/s13162-020-00161-0

Jacob, D., 2017. Quality 4.0 impact and strategy handbook: getting digitally connected to transform quality management. *LNS Research.* [online] Available at: https://www.sas.com/content/dam/SAS/en_us/doc/whitepaper2/quality-4-0-impact-strategy-109087.pdf [Accessed 28 July 2022].

Javaid, M., Haleem, A., Singh, R.P. and Suman, R., 2021. Significance of Quality 4.0 towards comprehensive enhancement in manufacturing sector. *Sensors International, 2*, 100109.

Jeschke, S., Brecher, C., Meisen, T., Oezdemir, D. and Eschert, T., 2017. Industrial Internet of Things and cyber manufacturing systems. *Industrial Internet of Things, 3*(9).

Koffman, J., Gross, J., Etkind, S.N. and Selman, L., 2020. Uncertainty and COVID-19: How are we to respond?. *Journal of the Royal Society of Medicine*, *113*(6), pp.211–216. https://doi.org/10.1177/0141076820930665

Kudyba, S., Fjermestad, J. and Davenport, T., 2020. A research model for identifying factors that drive effective decision-making and the future of work. *Journal of Intellectual Capital*, *21*(6), pp.835–51. https://doi.org/10.1108/JIC-05-2019-0130

Laudon, K.C. and Laudon, J.P., 2020. *Management information systems: Managing the digital firm*. 16th ed. Upper Saddle River, New Jersey, USA: Pearson Education.

Li, S., Xu, L. and Zhao, S., 2015. The internet of things: a survey. *Information Systems Frontiers*, *17*, pp.243–59. https://doi.org/10.1007/s10796-014-9492-7.

Mahmoud, R., Yousuf, T., Aloul, F. and Zualkernan, I., 2015, December. Internet of things (IoT) security: Current status, challenges and prospective measures. In *2015 10th international conference for internet technology and secured transactions (ICITST)* (pp. 336-341). IEEE.

Malhotra, N, Mavondo, F., Mukherjee, A. and Hooley, G., 2013. Service quality of frontline employees: A profile deviation analysis. *Journal of Business Research*, *66*, pp.1338–1344.

Markiewicz, A. and Patrick, I., 2016. *Developing Monitoring and Evaluation Frameworks*. Thousand Oaks, CA, USA: SAGE.

Martínez-Caro, E., Cegarra-Navarro, J. G. and Alfonso-Ruiz, F. J., 2020. Digital technologies and firm performance: The role of digital organisational culture. *Technological Forecasting and Social Change*. *154*, 119962. https://doi.org/10.1016/j.techfore.2020.119962

Mekki,K., Bajic, E., Chaxel,F. and Meyer, F., 2019. A comparative study of LPWAN technologies for large-scale IoT deployment. *ICT Express*, *5*(1), pp.1-7. https://doi.org/10.1016/j.icte.2017.12.005.

Mtotywa, M. M., 2022. Developing a Quality 4.0 maturity index for improved business operational efficiency and performance. *Quality Innovation Prosperity*, *26*(2), pp.101–127. https://doi.org/10.12776/qip.v26i2.1718

Mohanty, S. and Mishra, P.C., 2020. Framework for understanding Internet of Things in human resource management. *Revista ESPACIOS*, *41*(12), pp.3- 14.

Muzam, J., 2022. The challenges of modern economy on the competencies of knowledge workers. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-022-00979-y

Neagu, G., Ianculescu, M., Alexandru, A., Florian,V and Rădulescu, C.Z., 2019. Next generation IoT and its influence on decision-making. An illustrative case study. *Procedia Computer Science*,*162*, pp.555-561. https://doi.org/10.1016/j.procs.2019.12.023.

Olasanm, O.O., Olajide, O.O. and Ojubanire, O.A., 2021. Determinants of employee productivity in listed manufacturing firms in southwestern Nigeria. *International Journal of Applied Management and Technology*, *20*(1), pp.194–210. https://doi.org/10.5590/IJAMT.2021.20.1.11.

Oke, A.E., Arowoiya, V.A. and Akomolafe, O.T., 2020. Influence of the Internet of Things' application on construction project performance. *International Journal of Construction Management*. https://doi.org/10.1080/15623599.2020.1807731

Parto, M., Saldana, C. and Kurfess, T., 2020. A novel three-layer IoT architecture for shared, private, scalable, and real-time machine learning from ubiquitous cyber-physical systems. *Procedia Manufacturing*. *48*, pp.959-967. https://doi.org/10.1016/j.promfg.2020.05.135.

Pavitt, K., 1991. Key characteristics of the large innovating firm. *British Journal of management*, *2*(1), pp.41-50. https://doi.org/10.1111/j.1467-8551.1991.tb00014.x

Kaur, R., Raina, B.L. and Sharma A., 2020. Internet of Things: Architecture, applications, and security concerns. *Journal of Computational and Theoretical Nanoscience*. *17*, pp.2469–2475.

Rachidi, M.F., 2020. Implications of the COVID-19 pandemic on management of human capital. *Journal of Public Administration*, *55*(4), pp.688–700.

Ray, P.P., 2018. A survey on Internet of Things architectures. *Journal of King Saud University - Computer and Information Sciences*, *30*(3), pp.291-319. https://doi.org/10.1016/j.jksuci.2016.10.003.

Robert, C., 2014. *Machine learning, a probabilistic perspective*. United Kingdom: Taylor & Francis.

Rose, K., Eldridge, S. and Chapin, L. The IoT: an overview. Understanding the issues and challenges of a more connected world. Internet Society, October 2015.

Salmerón, R., García, C.B. and García, J., 2018. Variance inflation factor and condition number in multiple linear regression. *Journal of Statistical Computation and Simulation*, *88*(12), pp.2365-84. http://doi.org/10.1080/00949655.2018.1463376

Sharma, M.S. and Sharma, M.V., 2014. Employee engagement to enhance productivity in current scenario. *International Journal of Commerce, Business and Management*, *3*(4), pp.595-604.

Sievers, F., Reil, H., Rimbeck, M., Stumpf-Wollersheim, J. and Leyer, M., 2021. Empowering employees in industrial organizations with IoT in their daily operations. *Computers in Industry, 129*, pp.103445.

Singh, R.P., Javaid, M., Haleem, A. and Suman, R., 2020. Internet of things (IoT) applications to fight against COVID-19 pandemic. *Diabetes & Metabolic Syndrome, 14*(4), pp.521-524.

Song, Q., Wang, Y., Chen, Y., Benitez, J. and Hu, J., 2019. Impact of the usage of social media in the workplace on team and employee performance. *Information & Management, 56*(8), pp.103160.

Sony, M. and Naik, S., 2020. Critical factors for the successful implementation of Industry 4.0: A review and future research direction. *Production Planning & Control, 31*(10), pp.799-815, http://doi.org/10.1080/09537287.2019.1691278

Venkatraman, N. 1989. The Concept of fit in strategy research: toward verbal and statistical correspondence. *Academy of Management Review, 14*(3), pp.423- 444.