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Managerial Economics: The Significance of the Internet of Things (IoT)

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Abstract

The progress of the models of managerial economics, comprising mostly of the models of digital circular economy, are being made at a rapid pace. The researchers solely concentrate on the significance as well as the influence of the principles of managerial economics that are circular in nature, and the technologies of the Internet of Things (IoT) in the present environment. The present environment has been identified as the prime mover of every circular approach, as well as making the first initiative in the direction of the future solutions of the industry, at the time of generating the new possibilities of development. In order to have a comprehensive view of the digital circular economy, every field needs to be scrutinized. If we make a systematic review with an exhaustive investigation of the digital circular economy, the Internet of Things (IoT), and the cooperative partnership separately, we are able to make a research on the applications, models of business, respective features and architectures. The focus of the research has always been the Internet of things (IoT), for quite some time, through different innovations, publications as well as projects. The industry on the past has had the maximum focus among the fields of application, in view of the association of the scientific as well as technical leaps forward. The Cyber Physical Production Systems (CPPS) effected the smart transfer of data real-time and the cooperation between the manufacturing processes. With the existence of such technological features, the concepts for the future industry targeted the growth of Artificial Intelligence and a digitalized industry to a tougher and more humane approach.

Keywords : digital circular economy, Internet of Things (IoT), innovations, architectures and Artificial Intelligence.

Introduction

The academia had proved through inputs to the ideas and services, the vast scope of the fields of application, features as well as models of architecture. Simultaneously, it was considered that circular economy is a dynamic as well as state-of-the-art theory, highlighting the reduction of the waste products, reprocessing as well as reclaiming the materials rather than going for the usual process of disposal. The significance is scrutinized by a range of scientific viewpoints as well as possibilities, that also includes global initiatives. The union of the Information and Communication Technology (ICT) systems along with their auxiliaries as Cloud Computing, Internet of Things (IoT) as well as Big Data, impact the execution of the circular economy, as well as the introduction of its automation in the industry, while affecting the environment comprising of the structures of technology and the models of business. The generation of the new technological architectures, designs as well as the Internet of Things (IoT) circular strategies, were accelerated due to the possibilities of circular economy and their auxiliaries, as well as the potentialities of the Internet of Things (IoT). The augmented methods of the remanufacturing, recycling as well as the reprocessing, that are reinforced by the technologies of the Internet of Things (IoT), along with their auxiliary risks, are matters of research. The present and the future industries, highlight the electronic conversion of manufacturing, and encourage the innovative possibilities, in terms of generation as well as the utilization by inducting the circular principles. The union of the two conceptions constitute the key facilitator for the systems as well as the models in the augmented efficiency of tracing resources, preserving the enhanced quality during the maturity of the services and the products. As far as the technological aspects are concerned, the technologies of the Internet of Things (IoT) have the capacity for the usage of the platforms as well as the algorithms, that are begun for the process as well as the scrutiny of the created circular data, along with the generating upgraded processes of decision-making for optimal circularity.

Objective of Study

The objective of the study is to conduct a detailed review through a systematic analysis of the digital circular economy, the Internet of Things (IoT) and their combined functional relationship separately, by the analysis of the architectures, models of business and the specialized features respectively.

Methodology

The research pursued the methodology of methodical analysis in this work. Various platforms were utilized for making access to the latest publications of the work, and a detailed study was made. This enabled the conducting of analyses of the earlier research carried out in the subject. It was observed that the recorded definition of the Internet of Things (IoT) was that it was a global infrastructure for the systems of information, that conducted advanced services linking the digital and physical elements, that are built on compatible growing and existing information and technologies of transmission. It was further observed that circular economy was considered to be a model for generation and utilization, that included recycle, reuse, rental, repair, sharing and renovating the existing elements as well as products. This resulted in the maturation of the product, that signified that the waste is reduced to a minimum. On the maturity of a product, its elements are retained in the economy. These elements could be recycled again and again and recreate further value. The foundation of the Internet of Things (IoT) is based on the linkage of the electronic and physical constituents, that use the Internet and the Information and Communication Technologies. So the Internet of Things (IoT) are utilized globally in diverse areas, considering the requirements, application and system. The diverse approaches and phases of the systems of the Internet of things (IoT), enable the benefit of one section over the other, as well as encourage the requirement and the acceptance of the consumers and the businesses.

Analyses and Findings

For the Internet of Things (IoT), solutions are developed for the real-time and detailed assessment of the soil, biomass as well as the environmental conditions, for the continuous requirement of the tracking and controlling of vast areas, for the applications of Smart Agriculture. The variables of tracking for the applications of environment include humidity, vibration, temperature, shock, etc. The statistics of the environment are normally collected through cloud and sensing components that are combined through wireless technologies, rapid deployment, high quality as well as longer lifespan. The application fields of environment include smart water supply, that highlight the adequate supply for the residents and the buildings of the city, and reduction of loss through leakage. This advantage is achieved by the installation of a wireless network system within a pipeline, that indicated the data of the measurement of the flow and the alerts when the supply of water was not within the range that was already predefined. The wireless sensor network tracks and calculates the variables of temperature, humidity, utilizing a wider scale of the wireless sensor network.

The technologies of the Internet of Things (IoT) are also capable of being customized for the present-day healthcare systems. The healthcare systems have three separate environments, that included small clinical environment, non-clinical environment and hospitals. The advanced Internet of Things (IoT) technologies, utilize the biosensors, as well as microfluidic biochips for the generation of an augmented clinical diagnostics of chronic diseases. The healthcare systems, supported by the Internet of Things (IoT) provided several innovative solutions during the recent global pandemic Covid-19.

The growth of the Internet of Things (IoT), due to the seamless trading of the statistics and the particulars, resulted in the generation of social applications that help to conceptualize the Smart Cities. The applications that improve the daily social life, include smart surveillance with on-time tracking of danger zones and garnering data through cameras, smart homes with linked sensors for controlling lighting, air-conditioning and temperature, as well as smart parking systems for drivers. Energy management drew more attention due to the state-of-the-art solutions of the Internet of Things (IoT). When the regulations and the technologies of the Internet of Things (IoT) combine for management of energy, the concept of Smart Grid is established. Due to the special features of Smart Grid, these are capable of being utilized in different types of sectors and application zones of the Internet of Things (IoT).

The significance and the implications of the prevailing industry require a short discussion about the Industrial Internet of Things (IIoT). This technology is extensively utilized on the equipment of manufacturing and the industrial machinery. The highlight on the industry causes the chains of manufacturing to yield augmented values for the consumers, along with advancement of the service lines and predictive maintenance of machinery. The prevailing industry used the techniques of computing with the applications of Industrial Internet of Things (IIoT) and generated a smart environment for manufacturing by way of automating the processes of the industry, on completion of the analyses of the on-time data through the matrix of the linked machinery. The variety of the data analytics, smart sensors and Artificial Intelligence were united to generate the principles of the present industry. There is also the introduction of the supportive technologies, like Blockchain, that were implanted into the overall infrastructure, for the augmentation of the stability as well as the security of the wide range of applications of the industries, and simultaneously providing the supportive functionalities for different aspects, like, technological upgrades, infrastructure management, and solutions of supply chain. The future industry is expected to be based on thriving synergy and the transmission between automated machines and human beings, that tracked the human actions through the techniques of Deep Learning, for arriving at a supporting state. The researchers believed that the application of advanced technology required digital platforms that permitted the sharing of information between networks that were part of a more huge network with several links. A detailed study of the future industry outcomes, revealed some salient features, like Predictive Maintenance, Cyber Physical Cognitive Systems, Smart Additive Manufacturing, and Hyper Customization. These regenerate some innovative technologies, that could be supported, like, Digital Twins, Big Data, 6G, Edge Computing, Blockchain, Cobots and the Internet of Things (IoT). There is an air of uncertainty about the results of the future industry, without being oblivious of the fact that there is an effect of the linkage between the digital and the physical assets.

The architectural design of the system of the Internet of Things (IoT) comprised of the Perception Layer, that is the base of the architecture, and highlighted the functionalities of the technology of the design. Next is the Network Layer that joined the Application and the Perception Layer by utilizing wireless as well as the wired protocols, and the technologies of transmission, for the transfer of the garnered data to the processing units of information, and supporting the operation of Management Layer. Application Layer supplied and depicted the end-user with the garnered information and service of the infrastructure of the Internet of Things (IoT). Management Layer is responsible for the total management of the infrastructure of the Internet of Things (IoT) and the model of the architecture, while tracking the functionality of the other layers that were linked in the unified system. Virtual Layer is arranged for the visualization of the physical structures into cyber ones, and stored on the base of the cloud.

The salient features of the systems of the Internet of Things (IoT), is garnering and processing various types of data. This function required solid execution of the mechanisms of privacy and security for the protection of the garnered data and shielding the user. The salient requirements of privacy and security included, Data Confidentiality, that guaranteed the protection of the garnered data from passive attacks, through the usage of data encryption during the garnering process. Next is, Data Integrity, that ensured that the garnered data were neither edited nor processed by unauthorized users. The process of Source Authentication verified that the source of the communicated data was authentic and not of any pernicious origin. The feature of Availability, made the availability of the system of linked nodes, that guaranteed of the accessing of the data and its transmission to the unified matrix, though there could be the denial-of-service attacks. Innovated encrypted solutions are required for the privacy and the security of the customers of circular chain, that are required to be promised for the monitoring of the circular data, prevention of the intrusions to generation, end services as well as supply chains.

The salient protocols of the Internet of Things (IoT) that are essential for the operations and the adjustment of the systems of the Internet of Things (IoT) included :

a) LoRaWAN : Long Range Wide Area Network is necessary for the execution of the wireless communication in long range.
b) SigFox : It initially supported the uplink transmission, but was later extended to downlink transmission as well.
c) NB-IoT : It is Narrowband Internet of Things (IoT) that is a radio access matrix protocol, created by The Third Generation Partnership Project, that kept up the deployment of a huge number of gadgets, that have reduced complexity in the design and executed operations of high coverage, at reduced price for radio chips, and a high battery life.
d) Wi-Fi : The operation is under two modes, infrastructure and Ad-hoc, The infrastructure mode joined through Access Points, and caused linkage to the stations The Ad-hoc mode is devoted to the links that were wireless, and generated a peer to peer matrix, that operated simultaneously as an Access Point and client.
e) MQTT : This is Message Queuing Telemetry Transport that is a standard and open protocol, utilizing three modes of operation, like, Publishers, Subscribers and Brokers. Publishers and Subscribers exchanged data continuously, along with communication and linkages, through the linkage channel of Broker, that conducted the verification and guaranteed reliability.

f) ZigBee : It is a wireless communication protocol, forming a part of the Internet of Things (IoT). It performed short range transmissions, and is a simpler version of Wireless Personal Area Network.

The digital circular economy and the technology of the Internet of Things (IoT), are expected to be collaborative in the following activities :

a) Smart Grid : The customers receive the generated energy and then decide how they would utilize the electric waste
b) Smart Healthcare : The decision-making algorithms are utilized for the disposal of the wastes, and utilize circular economy aspects for recovery of reusable materials
c) Smart Manufacturing : Digital technology and Blockchain are utilized for tracking wastes in manufacturing, and the generated circular data is shared with the other customers
d) Smart Agriculture : Digital technologies are utilized for crop management, while reducing the influence of agriculture on climate change
e) Smart Buildings : The sensory devices of the Internet of Things (IoT) and smart Building Management Systems are used for the sustainable consumption of resources

Circular Economy was heavily encouraged for taking on the global economic growth in the renewable approaches of the environment. A normal, non-renewable model is an undeviating approach of extrication, generation, and then usage of the physical waste. The researchers established that circular economy was the initiation of encouraging the flows of cyclical nature, that did not highlight only on reusing, but also the re-engineering of physical matters, repairing, upgrading, remanufacturing, as well as refurbishing, while minimizing the physical wastes. The study had also brought to light the impact of circular economy on diverse applications and sectors. As a result, diverse sectors have funded the solutions of circular economy, for the promotion of the future industry. The result of the study further recognized the fragility of the industries, adopting the mechanisms of circular economy, that included in general, electronics, waste management and electricity, whereas industries following a slower approach, included healthcare and mining.

Academic studies have highlighted that Information Technology could be combined with the circularity principles, balancing the benefits of all the sides that could result in the generation of innovative systems and technologies. For the purpose of the integration of digitalized circular economy, there was the requirement of fundamental technologies, for successful transformation, that could be categorized as Process-Based Information Systems. These systems constituted from the union of some solutions of Information Technology that streamlined the combination of the digital technologies on the changing requirements of business. The concept of digital intelligence was utilized for the construction of a solid foundation on the circular models, by the exercising of control, optimization of resources, as well as automated monitoring. These could be found in automated optical sorting for reused materials, modelling devices, digital tracking, as well as digital sensors that supported repairing, recycling as well as remanufacturing for electrical waste monitoring. The maintaining of the data through to maturity, and storage of the information on physical footprint and composition were done by cyber-physical systems. The information that was garnered, could be divided among businesses, for methodical and systematic results on use and management. The Internet of Things (IoT) could be used for platforms that projected the availability of the facilities of the reuse of the products, that led to the recycling of the materials.

The authors suggested the circular architectural model that unified the technology of the Internet of Things (IoT) and Blockchain, having the assistance of the mechanisms of edge computing. The outline consisted of the nodes of the Internet of Things (IoT), that were installed in the digital circular atmosphere, and aided by the programs of Blockchain, that authenticated the storage and the garnering of the data, and dividing the forms of proceedings. The high requirement of Blockchain for memory, and the nodes fully devoted to the processes off circular data, the technology of edge computing was utilized to meet the requirements of memory, by way of supplying independent nodes for the entire local storage. The protocols of interactions in this specific architecture are Long Range Wide Area Network (LoRaWAN) and SigFox (Low Power Wide area Network). Blockchain could be used as means for aiding the circulatory outlines, and these suggested the variations of the utility of Blockchain. The first variation permitted the reuse and repair, with the maturity of the garnering of Blockchain and reclaimed data, and the execution of sensor for the purpose of decision-making, of the possibility of reusing and reclaiming. The second variation comprised of the reclaiming phase, and the system was adjusted for the purpose of decision-making in the stage of maturity, where the process made the selection of the objects that could be recycled, re-engineered or re-manufactured. The third variation comprised of the participation of the customers, with the usage of devices for the garnering of data of the respective results and the objects, that made the dispatch to the main outline of the groundwork, and aiding with smart contracts, the resource economy. The study had developed an outline, that utilized a reverse and forward arrangement, by executing the principles of the Internet of Things (IoT), for attaining the features of circularity. This specified strategy lowered the generation of waste by exercising the foundational loops of the circular economy, and preventing an undeviating approach. The assumption stood as the products were executed with the technologies of the Internet of Things (IoT), as modules as well as sensors, for tracking through 5G matrix. The designs tracked the maturity and the reclaim of the products, with the segments being positioned, before the parts of the products were completely integrated. The sensory gadgets garnered the data, while the product was under the usage, and transferred the data back to the Decision Support System, that was aided by an Intelligent Material Circularity Detector.

The authors have also proposed an indicative digital application of circular economics, that could be divided into two types, depending on the concept of circularity, that are open loop and closed loop applications. The open loop applications were categorized by the accessibility of the benefits of the re-functionalities for the rest of the participants of the circular chain, when the applications of closed loop were highlighting on the utilities used by the manufacturers. Each application was classified as a multiple or single sector circular economy, in accordance with their capability of being utilized in fields, other than their initial purpose. An example of open loop application was when a retailer provided grocery, executed with a product service business model. The features of circularity could be attained through subscriptions by pay-per-use facilities, while lowering the consumption of the supplies. The subscription provided the potential to make entry to the performance of the appliance, utilizing a kit of the Internet of Things (IoT), offered by the retailer, linking the devices, and controlling as well as tracking them. An example of closed loop application, required the combination of the technologies of the Internet of Things (IoT), as well as data-driven circular economy, through an Indoor Space Usage Monitoring System, that furnished an eco-friendly surrounding. The model used a system of the Internet of Things (IoT) that supplied the complete data at specified rates using the protocol of Low Power Wide Area Network. The data could be utilized for eco-friendly executions of actions in versatile management of space as well as smart circular buildings.

Discussion

The highlight of the study is the evaluation of the relationship between the principles of digital circular economy and the technologies of the Internet of Things (IoT) into united systems, by reviewing the details available with the academic communities. With reference to the technologies of the Internet of Things (IoT), it was needed to investigate the available features and models of architecture, as well as the application fields that were available for a better understanding of the proposals and solutions of a circular system of the Internet of Things (IoT). As far as the fields of application were concerned, most of the studies on industrial applications and energy management, considering the future industry, relied more on the form of hypothesis, and less on practical applications, for the necessities of extensive research and resources. Inspite of the availability of the diverse types of models of architecture, most of the models relied on the layers of foundation of the models of the Internet of Things (IoT), and resorted to the usage of the protocols, as Long Range Wide Area Network (LoRaWAN) and Sigfox Low Power Wide Area Network (SigFox). There was a combination of opinions regarding the integration of the digital form of circular economy, into smaller infrastructures. There were positive indications, that encourage the growth and the regeneration, using technologies that were combinations of Machine Language, Artificial Intelligence and the Internet of Things (IoT), while deploying Big Data for a huge amount of analytics, due to the principles of circularity. The reverse view was assisted by the rising of costs for new infrastructure, need for innovative equipment, and the duration of the adjustment to the latest circular operations. A greater number of solutions could be utilized by the re-engineering of the hidden data and the existing data beyond their primary functions. These operations had the potential of generating an all-round efficiency with reduction of maintenance costs, and diverting the existing assets for minor operations and acquiring the latest outlooks of business for data-driven outcomes. When the two ideas were united, the connections between the Internet of Things (IoT) and digital circular economy were completely based on the technology of the present industry. The involvement of the future technology was limited due to the dearth of the appropriate results as a self-sustaining field. The association of customers and stakeholders allowed the models of business the usage of the Blockchain for secure conducting of business of the circular services. Digital circular economy is driven by data, and there are also suggested innovative resolutions for a loop of turning tangible materials into information store and then reprocess and reclaim the primary products. It was also observed that there was considerable dearth of applications that united the technologies of the Internet of Things (IoT) and circular economy, but there were abundant industrial models of business.

Limitation and Further Scope of Research

It is clear from the study that further research was necessary as far as the strategies of applicable integration and the models of digital circular economy were concerned for the generation of an integrated framework of circular economy, that could be utilized in diverse scenarios. In accordance with the requirements of the cases, the designs and the technologies of the architecture were included for the assistance of the processing as well as collection, and organization of the circular data.

Conclusion

The research made the evaluation of the linkage between the principles of digital circular principles, the trends of the present industry and the technologies of the Internet of Things (IoT). The study was divided into the three segments of digital circular economy, the Internet of Things (IoT), and the correlation between the two. The analysis brought to light that digital circular economy was completely reliant on the existing technology, for its operation, while highlighting the positive results for the tracking of the maturity and recycling. Most of the applications and architectural models were particularly designed according to the traditional principles of circular economy, as in reuse, reassembly, remanufacturing and recycling. The applications of the modern age joined hands with the customers in their models of business for result-oriented circular transitions. In the end, the research could record that the most ordinary technologies, that were used in applications, were the tracking sensory devices of the Internet of Things (IoT), Blockchains for transactions as well as security, Artificial Intelligence for the purposes of automation, as well as Big Data for the purpose of analytics. The research was concluded on a positive note that a large number of theory-based propositions were being converted to practical applications.

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