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Telecommunication Innovations and Human-Technology Interface: A Review

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Abstract:

Innovations in production system, engineering, business, information and communication have catalysed into technologies set to achieve improvements in quality of human life through faster, smarter and better services. Telecommunication has achieved so much in this new area of smarter services moving from analogue to digital systems and transforming the world into a global village. The industry is a multi-billion dollar (USD) spinning business straddled by giant global players with great influence and powers over product and market systems, governance, trade and services, and global economy. This paper is premised on the dynamic nature and impact of telecom innovations, and human interface. Emerging technologies in the industry have however presented new challenges now described as disruptive innovations (more commonly known as the new normal) in the workplace and market, and essentially in the human - technology interface. The use of high telecom and other internet-based systems have introduced for example Working from Home (WFH) as one among the new normal. There is the challenge of a healthy balance between telecom innovations and impacts on human health and environment. Light speed product and market changes due to rapidly changing telecom innovations have poised a challenge to user (human) adaptation worsened by perturbations and mergers that affect stabilisations. Emerging technologies in robotics engineering, Artificial intelligence (AI), internet of things and people etc. have contributed and will still play significant roles in teletechno and human interface. This work adopted the qualitative conceptual approach in the review of literature, applying underpinning theories of sociology of technology to explain the interface and consequent ideology shift from product to consumer prominence. Paper recommends an integrated global regulation and compliance, a unified codification and standardisation, guarantee for safety and security concerns; and measures to ensure industry collaboration, product and service quality, robust market and consumer protection.

Keywords: Telecommunication technology, innovations, human interface, impacts

1. Introduction

This paper seeks to contribute to existing knowledge on the interface and crossfire between telecommunication technology innovations and human engagements. It modestly reviews the transient nature of human-technology engagement especially by looking at the impacts of changing technology innovations and human social interactions (Wajcman, 2008). In his views, Bakhit (2016), held that telecoms industry has continuously provided end users with new tech innovations and disruptive technologies. Grubber (2003) held that technology and human society are fast changing variables that can be better understood within the field of a concept. As a concept, technology is relative to time and space and so is human society. This early extrapolation is predicated on the idea that what counts as socio-technological change in one society could be perceived differently in another, may be non-existent and perhaps not even envisioned in another society or clime. Antonucci, *et al* (2017), argued that socio-technological changes and the effects on human-technology engagement is becoming fast and increasingly complicated. Therefore, our working definition and understanding of the word 'technology' is derived from an adaptive conceptual approach (Jaakkola, 2020), due to the identified relativity and nature of the crossfire between modern telecommunication innovations and human societal interface.

Study examined alongside the issues of industry regulation, speed and degree of impact of technology innovations identifying notable nuances resulting from this crossroad, such as an increase in smart engineering, internet speed, cloud technology, remote sensing, robotics and drone technology, emerging artificial intelligence (AI) etc. which have produced dislocations from what is already known and practised to what is today known and practised, resulting in the term the 'new normal' even at family level (Walsh, 2012). According to Marsh *et al* (2016), these socio-technological changes have fast separated individuals from the traditional tightly knitted community life resulting to a growing human user apathy and growing user knowledge gap in the development and deployment processes in modern telecommunication innovations. The power to manage these socio-technological changes and the increasing level of human-technology engagement has rested more in the hands of transnational corporations and national governments (Christopherson & Clark, 2007). However, Akaka & Stephen (2014), are of the view that technology is the operant (chief driver) in the innovation value chain and creation process when compared to the human factor. Thus, they have opined that technology drives the interface.

1.1. *Adopted Methodology*

The intervening variables in this investigation are more of social system (human) outcomes and the very fast changing technology innovations. The main variables do not easily correlate on mathematical (quantitative) simulations especially on the human factor hence the adoption of a concept approach to clearly distinguish, deploy and elucidate on the concepts around modern telecommunications innovations (changes) and their impact on contemporary human society. Technology and human society are therefore seen as intervening and inseparable concepts. The relationship between the two concepts in terms of business and societal impact is changing so fast that a five-year interval is enough to present a significant shift in models and impacts, in time and value. In this review, qualitative approach and use of relevant literature and theories is adopted to synthesis between the key drivers of technology and society to arrive at points of contribution.

1.2. *An Adaptive Approach to the Concepts of Technology and Human Society*

According to Berente et al (2014), the concept of technology is known by common sense yet unconsciously presumed and applied. This brings technology to the domain of common sense, a generally accepted opinion with feelings and biases. Brey (2009), posited that a concise definition of technology is a difficult task partly because technology is relative to time and context, and secondly because people ordinarily know what technology is and does. Others such as Grubber (2003), and Surry & Baker (2016), see technology as an inherently abstract concept that is equally difficult to relate across time and context. Surry & Baker (2016), further posited that technology and human society affect each other but that technology is the defining factor (i.e., the greater influencer) in the relationship. Al-Thani et al (2018), pointed out the need for common grounds in terms of green technology (human friendly technologies) as regards human health and safety as a result of deployment of telecommunication technologies. Hughes (2004), described technology as effort in organising the world for problem solving and the provision of basic needs of man through production and provision of goods and services. Merriam - Webster dictionary (2016), offered what can be called a classical definition of technology: 'application of knowledge to the practical aims of human life or to changing and manipulating the human environment'.

This definition is critical of technology from the point of view of a manipulation, as it posits more on the aspect of a negative and manipulative science especially on human life and environment. Further definitions shall be related to given technology concepts. Five contiguous areas have been identified for conceptualisation of 'technology' from where some definition can be drawn. Firstly, technology has been seen from the standpoint of innovation, creativity and intelligence (Dusek, 2006), denominating technology to set of rules or processes, hardware (materials and tools), and software (the systems and programs) for achieving a product. The basic need here is product achievement and delivery. The second concept area of technology is the historical perspective as seen by McNeil (2002), who saw technology from the use and formation of stone tools in the nomadic (hunter, gatherer) stage of man that grew into the metal age through conversion of processes into art forms, handcrafts and tools. The third is the philosophical concept, where Verkerk et al (2015), identified three core areas of philosophy function in technology which are the technology analytical function (function upon which technology can be studied and evaluated), critical technology function (a query on its usefulness), and the directional technology function (what is the future of technology development). Carroll (2017), corroborated the above view of philosophy in technology positing a three-core concern dealing essentially with the purpose, function and benefit of technology to man. The fourth concept area is the entrepreneurial (business) concept, wherein technology is seen as business for profit through the offering of goods (products) and services. This fourth concept has been the generally adopted concept of technology innovations whether it be in the telecom or other areas, especially in its ability to offer and deliver better, faster and smarter services e.g., the use of contact lens to enhance the utility and comfort of the human eye, the application of wired information and communications to reduce message time and cost etc. The telecom industry comprises of companies in the business of information and communication transmission through data means of words, voice, audio and video. Global giants and operators in this sector include Vodafone, AT & T, Orange, Verizon, Deutsche Telekom, T-Mobile, Nokia, Huawei, Amazon, Samsung, Microsoft, Apple, Google, Facebook among others. The fifth concept which is the sociological concept of technology is fast assuming prominence as it has to do with human - technology interface and its impact on the society. It is seen as the ultimate purpose of application of knowledge and tools to improve human life and the environment (Volti, 2009). It is about the impact of technology innovations on human society.

Earlier attempts at definition of technology had rested on the duet of science and technology with science concerned more with why and how things are done, and technology with getting it done. The International Technology Education Association (ITEA, 2000) had this to say about science and technology:

'Science is a study of the natural world and technology extends people's abilities to modify that world. Science and technology are different, yet symbiotic. Technology is much more than applied science and science is quite different from applied technology. When people use technology to alter the natural world, they make an impact on science. Science is dependent upon technology to develop, test, experiment, verify, and apply many of its natural laws, theories, and principles. Likewise, technology is dependent upon science for its understanding of how the natural world is structured and how its functions'

In his views, Wonacott (2001), saw technology as the result of modifications made by man to his natural environment. The migration or rather evolution from the age of science and technology to sociology and technology is emerging with inquisition on technology impact on human social systems taking as in our case, telecommunication innovation impact with a view to collaboration between innovations and product user effects. This understanding gave birth to advocacy for a discipline on the sociology of technology, a constructivist view and humanist approach to technology, with emphasis on consumer effects and engagement. Douglas (2012), advocated the integration of human

social factors into techno-innovations, research and development essentially to achieve a balance between technology deployment, its impacts and management.

1.3. *Technology Revolutions: A Chronology*

Generally, technology revolution and industrial revolution imply change in ways of doing things. However, the industrial is seen more from the eye of machines and tools (i.e., hardware) whereas technology tends more to software base that use electronic and electromagnetic signal systems and packages. Unlike the industrial which is machine based, the technological operate on E-Systems that utilise high speed and high precision automated devices in performing operations with less human control. The world has witnessed three distinguishable industrial and equally technological revolutions.

The first industrial revolution spanned the period 1760 - 1830 and was largely originated in Great Britain. It was characterised by revolutions in machine applications and use in the farms, textiles mill and coal mines. The emergence of railroads, steam powered locomotives, factory machines; use of telegraph and telephone, electricity and incandescent lamps (light bulbs) etc. significantly transformed community (societal) life and standards to semi-urban communities. The second industrial revolution emerged about 1870 into 1914 and spread significantly in continental Europe and America and was characterised by greater exploitation of natural resources, synthetic materials, new metal alloys, coal energy etc and huge leap in innovations and standard of living. America is credited to have championed this stage of the revolutions. Production systems, trade and market services opened up in rural agricultural communities with huge impact on emerging consumer society and culture. The third industrial revolution which became pronounced late 1950s brought in its wake digital revolution and application of semiconductors, personal computing, internet systems, and aggressive innovations in machine and tool technology. The era witnessed rapid digitalisation, commercialisation and democratization of information and communication. Janicke & Jacob (2013), saw the third industrial revolution as bringing sweeping changes, conflicts and pressure on man and the environment. In what is today known as technology war, giant nations emerged in Europe, Asia and America seeking global leadership and control in emerging technology innovation and deployment especially the nations of USA, China, Russia, Germany, Japan, South & North Korea, India, France, UK and Canada. The fourth industrial revolution referred to as the 'Industry 4.0' (also known as the 4IR) is already around having come by a seamless transition and translation of the third revolution into what is known as the 'e' age and system, shifting significantly from machines and tools characteristic of industries to high tech, high precision and high speed miniaturised and digitised automated devices. Rifkin (2011), observed that 'industry 4.0' is a convergence of energy regimes and communication technologies through application of the internet e.g., emerging artificial intelligence (AI), internet of things (IOTs) and internet of people (IOP); robotics engineering and other smart technologies with great impacts (Brignal 111 & Van Valey, 2005), on global economy, trade and commerce, human sociology and health, environment and sustainability

2. **Telecommunication Systems and Human Society: Impacts and Challenges**

Dobres & Hoffman (1999), had posited that technology has an enormous impact on human society especially in shaping the dynamics of a new human social and mental order. Marsh et al (2016), held that the future of emerging smart cities is designed to replace former housing and community life, social system formations, transportation and communication systems. Generally, telecommunication is the process of information exchanges and communication through electrical and electromagnetic wave signals. What is communicated is in the form of data signals, voice (audio), and pictures (video) through devices such as telephones, microwave systems, satellites, fibre optics, radio and television frequencies, internet, computer networks among others. Basically, there is three stages to telecommunication and which are in the order of the transmitter (i.e., signal generator / the sender) stage, the transmission medium stage, and the receiver stage that converts signals into usable information. Modern telecom systems seek to eliminate distance between person to person, country to country; reduce distortions over sent messages, produce quality usable signals and then communicate. Stone (2015), held that global telecommunication industry has experienced exponential growth in methodology, innovations and market spread over the last decade.

The International Telecommunication Union (ITU) is the world body charged with responsibility for harmonisation of telecom data and development of international definitions, standards and methodologies. Through her various organs (professional units), ITU ensures that information communication and technology (ICT) applications comply with environmental protection and sustainability; safe and sustainable production, installation, consumption and disposal of ICT; and management of security concerns raised in the course of ICT deployment and usages.

Among several positive telecommunication impacts on human society is the breaking down of boundary walls caused by distance and geographic (logistics) obstacles between persons and countries. The entire world has become a global village in terms of online (real time) activities through use of internet powered Facebook, YouTube, Instagram, Twitter etc. Earlier, Hagan (1996), had described this as information super highway where distance, time and quality of message passed is becoming faster, smarter and better managed. Modern telecom systems have digitised global trade and marketing, engendering compartmentation and computerisation of the market place and business, and eliminating challenges of national currency differences and modes of payment across borders (Mohapatra, 2013). Another key positive impact of telecom innovations and revolution is the overtime reduction in the final cost of product due to cost benefit achievements and process optimisation. The telecom industry has also made a great impact in the way people meet, relate and conduct business ranging from the corporate, public governance and personal (family relations and contacts) through social media network systems. The use of modern telephony and virtual systems like zoom, google meet, skype etc has enabled effective virtual relationships and conferencing which has made the cost and risks of such meetings significantly

low and online (real-time). Emerging innovations in telecom industry has revolutionised communication for social media mobilisation, political and public governance information and uses, security system and infrastructure management (Oginni&Moitui, 2015). The use of modern telecommunication devices has made learning, education and entertainment much easier, quicker and at reduced costs through use of smart phones, the Google and other educational tools thus reducing cost, enhancing comfort and efficiency. Modern telecom systems have enabled the application of online geographic information system (GIS), climate change surveillance and reporting, for effective preparedness and contingency response on natural and non-natural emergencies. Telecom innovations have also brought about standardisation in global market language systems in what is now known as 'unified codification and communication'. Cowan & Foray (1997), have held that standardisation has brought about economy of scale of business and diffusion of knowledge in the industry. Apavaloaie (2014), also posited that the internet has contributed greatly in expanding consumer base, created new business ventures, generated employment (new jobs) and raised incomes. Jagunet al (2008), have also posited that the use of telephony systems has greatly improved micro- economic enterprises in the Nigerian case. Further, Salehan et al (2018), averred that telecom technology has significantly impacted and changed the way human society operates and concluded that the stage of technology of any society determines the structure and level of economic, social and cultural development.

The negative impacts of telecommunication systems on human society have however become the mirage of contemporary challenges confronting emerging innovations and development in the sector (Bergek et al, 2013). Prominent among them is the increasing loss of jobs through redundancy occasioned by increased application of internet-based services. Working from Home (WFH) is fast emerging as a result of successes in internet applications offering fast and effective remote services enabling staffers to work from home or anywhere outside of the work place leading to eventual redundancy and job loss as the sector continues to optimise on time, cost and tools. Further, the application of packages such as internet of things, internet of people, artificial intelligence etc. will significantly replace human labour services in the near future. The social disconnect caused by the use of modern telecom gadgets has impacted negatively on human sociology especially among teenagers and youth. Kim et al (2009), observed that loneliness, depression, drug addiction, alcoholism, violence, criminality, acts of fraud and rape etc have emerged as consequences of this dislocation with serious cost on public health, safety and social responsibility.

The massive deployment and use of telecom gadgets in nearly every aspect of human life coupled with the present cyberspace anonymity regime has created the problem of loss of privacy and associated security challenges (Chawki, 2010). This fact is supported by the number and increasing sophistication in globalised internet frauds and criminalities ranging from virus attacks, hacking, malware releases, financial frauds, money laundering, fake news, and loss of data privacy, among others. The net effect of these frauds run into billions of dollars for corporate and private businesses resulting in business failures, bankruptcy and insolvencies occasioned by 'Yahoo Yahoo' activities. Further, some modern telecom technologies have been specifically developed and deployed for warfare and terror activities in the area of space satellites, espionage, terrorism and other warfare monitoring and launching platforms made possible by telecommunication technology innovations (Sechrer et al, 2019). There is the critical aspect of health challenge occasioned by telecom system innovations and deployments e.g., the use of microwave bands by telecom masts that emit radio frequency electromagnetic waves and radiations into surrounding space. Once beyond acceptable assimilation threshold these radiations are harmful to human health (West, 2012) with consequences leading to carcinogenic diseases, skin infections, respiratory disorders, neurophysiological effects etc. There is presently a disagreement over the degree of harmfulness of telecom radiations between industry providers, regulators, consumers and consumer promoters (Zamanian&Hardiman, 2005). This disagreement or rather argument on specificity and intensity of harm has today raised a conspiracy theory that has enmeshed the installation and use of the 5th generation of cellular telecommunications (aka 5G) with respect to harmful impacts on human health. Antagonists of 5G installations and migration have alluded to the presently ravaging Covid 19 deaths to radiations from the 5G cellular telecom systems. The controversy rages on as there is yet to be seen an agreement as to the truth or falsehood of this accusations between the principal duets of ICT providers and consumers. Levitt & Lai (2010), have however expressed concern and worry over radiation effects of telecom systems on human epidemiology over time. Earlier, Barak (1999), advocated for impact threshold definition and regulation of telecom systems and installations through research and development harmonisation with consumer effects, raising concerns for effective global regulation and standardisation. Iversen (2000), posited that the issue of motley intellectual property (patency) rights in the industry and its administration has challenged effective and adequate global regulation, standardisation, harmonisation, quality and assurance control. There is intense competition for brand prominence (market share) among industry giants, and sometimes through some unfair practices and strategies. Added to this is the high product turn - over in speed and forms, on the consumer, that has challenged effective human assimilation, adaptation, stability and response.

2.1. The Nigeria Telecommunication Industry: A Background

The Nigerian telecommunication industry has grown by leaps and bounds since its formal debut in the year 1992 when the Nigeria Communications Commission (NCC) was established by the then Military government. Between 1999 and 2012 at the behest of democratic governance, the industry expanded astronomically in the mobile telephony subsector that gave birth to MTN, Globacom, Mtel, Etisalat, Econet Wireless etc. licensed as service providers. According to Ayo et al (2007), Nigeria grew from 0.49% of country population in 2000 to 25.22% in 2007 in telecommunication infrastructure thus opening up a big consumer market in that subsector of telecommunication industry. This improvement has however come with some challenges in basic infrastructural, manpower, technical capacity and connectivity

development issues. Most challenges have been on safety and human factor concerns (Kukoyi&Aigbavboa, 2019) that have brought palpable fears and apprehensions about health risks and hazards due to radioactive emissions from telecom installations mostly from base stations. There was the initial challenge of indiscriminate and uncontrolled installation of masts and telecom equipment by service providers without respect to the built and spatial environment, public health and critical economic considerations. These challenges have consequently raised people apathy and apprehensions on safety of telecom installations despite World Health Organisation (WHO) and International Commission on Non-Ionizing Radiation Protection (ICNIRP) attestation that Nigeria as a nation is within safety threshold on discharged Electro-Magnetic Radiation (EMR) values (Kazaure& Matthew, 2021). Further, Okereke & Chukwujindu (2019), commented of need for effective code of conduct and practice, industry regulation and control especially within built environment in terms of locational installation of radio frequency (RF) emitting equipment. One of the greatest challenges to telecommunication development in Nigeria has been the issue of overrun costs due largely to the importation of telecommunication equipment, fast changing technologies and requisite manpower costs (Ameh et al, 2010). Digitalisation of the information and communication (telecom) industry has emerged in the last two decades with great impacts on global economies and economic models (Tebepah, 2010), affecting nations worldwide, Nigeria inclusive, at various points of technology innovation and development.

3. The Human-Technology Interface: Creating a Balance

Naturally, human society and technology have been in a struggle for balance ever since. Each have acted as a check or booster to the other at one time of their evolution or the other. The concept of sociology of technology is a study in the marriage and relationship between technology application and human society. Every technology innovation revolves around man, whether of space technology, nanotechnology, biotechnology or telecom technology, with significant impact on human life and social systems. Sassen (2002), and Orlikowski (2010), in addition to holding that social and cultural values strongly mediate in technology and societal relationship, have also advocated that organisational management should incorporate socio-material configurations in their research and development. Both scholars are proponents of inclusion of societal needs and tastes in technology innovations. Williams & Edge (1996), in what both have called 'the social shaping of technology' aka 'SST', advocated the deepening of the concept of sociology of technology in the technology innovation process and agenda with a view to minimising technology negative impacts on human health, environment and society. Jorgensen & Jorgensen (2009), applying what they termed 'green technology foresight', and working with the Danish Environmental Protection Agency, observed and advocated for a working relationship between societal demands, human health, technology options and environmental impact. Fulk & Yuan (2017), in their views, posited the need for a social construction of the telecommunication industry in order to respect the technology-human interface balance. Han-Lin (2010), argued that the social construction theories should be applied in contrast with technology determinism theories. The determinist theorists are of the views that technology defines and drives the development of social and cultural systems and changes. Thorsten Veblen (1857-1929) and Joseph Schumpeter (1883-1950) were early proponents of the technology determinist theory of innovation. Papageorgiou & Michaelides (2016), have extolled and advanced the positions of J. Schumpeter and T. Veblen, in canvassing the theory of technology determinism highlighting the role of entrepreneurship, profit making, corporate institutions, and market capitalism in the quest of technology innovation. Relying on social shaping of technology (SST) ideology, Wajcman (2008), posited that social constructs should be connected (relative) with empirical technology imperatives.

3.1. Outcomes

In the spheres of technology impact on social (human) systems, the technology determinism theory (TDT) and the social shaping technology (SST) schools each hold strong views and supports. In the coming years, there will be the need to define technology product by the market or the social (impact) shaping as technology becomes more borderless caused by overlapping boundaries and rapid asymmetries. Tasey (2000), canvassed for effective standardisation of products and the market in the face of fast changing and complex telecom technology industry. According to Kristensson et al (2008), there is need for the involvement of the user (consumer) in co-creation with new technology-based services. Further the years, there will be the challenge of rapid mergers occasioned by rapid innovations, dislodgements and disruptions in product and market space. It is from the background of the 'social shaping' ideology that advocates have canvassed for effective regulation and integrated control of the super highway of technology and society, with a view to ameliorating the negative impacts of the crossfire between technology and human interface. Apparently, such measures will look at affordability (pricing policy), usability (product services and safety); system upgrades e.g., 4G to 5G, human utilisation (employment generation), revenue generation both to investors and government, and overall impact on human life and sustainability. This will be the new face of sociology of technology in the telecom sector, in line with what Gabrosky (2013), described as 'responsive regulation'.

3.2. Recommendations

The challenge of telecommunication industry weighs more on speed of change and innovations with concomitant human costs and efforts at adaptation. To effectively manage this high-speed change element, it is recommended that an integrated approach be adopted in the alignment of innovation to organisational structure, industry, the marketplace and society (Ortt & van der Duin, 2008) especially in the telecommunication industry. Also, in efforts to enrich internal strength and knowledge, upgrade the system and effectively manage product development, the open innovation system (Bigliardi et al, 2012) is advised to be adopted as a business model. This system draws strength from the collaboration of internal

abilities and sharing of research and ideas among related industry players to gain market share, profitability and innovation. To better manage the motley organisations involved in the industry from product to service chains and ancillary outlets, internationally recognised professional bodies need to be established and the number narrowing on agreement in specifications, and standards adoption, to ensure universal product design, codification, testing, evaluation, and monitoring. Market in the telecom industry is more of an oligopoly, a market system that permits and is favourable to few giant operators who wield considerable control over prices (Rahman et al, 2015). There is need to introduce competition informed (base) pricing to guarantee some level of competition and ensure that the few market giants do not graduate into monopoly through innovations and price control. The spate and frequency of mergers is a serious subject issue in the telecom industry. Therefore, to check the ugly effects of market disruptions due to mergers, there is need to create standards and buffer effect zones, funding supports and policies that will checkmate huge market disruptions and enhance quick stabilisation. There is the challenge of effective international regulation, enforcement and compliance especially among top giants in the industry consequent on the introduction of market unfair competition practices and strategies. The wireless and wired telecommunication business each require appropriate and specific regulations as each present different operational challenge. Appropriate access, effective monitoring and evaluation are key in the achievement of a universally compliant and consumer protected market. All of these require international standards (procedures) and enforcement at company and industry levels, and the application of a society (human) friendly technology in the production and deployment of innovations, to enhance product and service quality; respect safety, health and environment; and address security concerns associated with the use of telecom technologies.

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