Technology-enabled well-being in the era of IR4.0

marketing and public policy implications

Roy, Abhijit ; Bakpayev, Marat ; Boninsegni, Melanie Florence; Kumar, Smriti; Peronard, Jean-Paul de Cros; Reimer, Thomas

Published in:
Journal of Consumer Marketing

DOI:
10.1108/JCM-11-2021-5021

Publication date:
2023

Document version:
Accepted manuscript

Citation for pulished version (APA):
Roy, A., Bakpayev, M., Boninsegni, M. F., Kumar, S., Peronard, J.-P. D. C., & Reimer, T. (2023). Technology-enabled well-being in the era of IR4.0: marketing and public policy implications. *Journal of Consumer Marketing*, *40*(4), 431-444. https://doi.org/10.1108/JCM-11-2021-5021

Technology-Enabled Well-Being in the Era of IR4.0: Marketing and Public Policy Implications

Journal:	*Journal of Consumer Marketing*
Manuscript ID	JCM-11-2021-5021.R2
Manuscript Type:	Regular Paper
Keywords:	4th Industrial Revolution, digital, physical and biological technologies, public policy implications, technology enabled well-being

Technology-Enabled Well-Being in the Era of IR4.0: Marketing and Public Policy Implications

Throughout history, technological waves have considerably impacted consumer well-being across three major industrial revolutions. The 1st Industrial Revolution of the 18th —early 19th century brought about weaving machines, steam engines, and railroads while the 2nd Industrial Revolution of the late 19th—early 20th century introduced electricity, light bulbs, radio, telephone, television, and mass production. Finally, the 3rd Industrial Revolution of the second half of the 20th century gave rise to digital computing, automatized production, and the Internet (Bell, 1973; Rifkin, 2011; Stearns, 2018).

Today's 21st-century technological wave with artificial intelligence, machine learning, the Internet of Things, blockchain, robotics, biotechnology, neurotechnology, nanotechnology, 3D printing, virtual and augmented realities, and other cyber-physical systems is referred to as the 4th Industrial Revolution (IR 4.0) (Schwab, 2017; Schwab and Davis, 2018). Together, these technologies continue to transform present-day society drastically. However, despite the unprecedented pace, scale, and nature of the most recent technological revolution, its impact on consumers and their well-being is unclear. Similarly, questions arise concerning public policy responses toward IR 4.0.

Imagine this near-future scenario. A consumer is just getting ready to go home after a stressful day in the office. Biocompatible sensors notify her that her blood sugar level is high. They also suggest a tomato salad for dinner. On the way home, her self-driving car connects with a personal therapy bot. As the driving and the session proceed, the car connects with the fridge and learns that it is out of tomatoes. The bot intelligently suggests a brief shopping trip. The car heads out to a nearby Amazon Go, and the consumer buys tomatoes with Bitcoin. Meanwhile, at home, Alexa; Nest; and a cooking robot, Frank, adjust home settings and prepare for cooking.

Our vignette illustrates an assemblage of technologies that impact consumer well-being. A healthy diet and exercising benefit individual well-being; self-driving and retailing support societal well-being—with locally-sourced tomatoes and reduced road accidents; retailing organized around careful consideration of food waste and intelligent home settings reducing the carbon footprint helps environmental well-being. These technologies raise several public policy questions related to evaluating the societal impact of service robots, regulating data privacy, and promoting technology-enabled healthy eating.

The overarching aim of this article is to examine the transformative impact of IR 4.0 on consumer well-being across individual, societal, and environmental dimensions. Since new technologies exert a dramatic influence on healthcare, education, financial services, manufacturing, retailing, and other sectors, it is essential to examine them. We refer to these sectors as core sectors. Our primary focus is on the consumer well-being field, recognized for multiple perspectives and conceptualizations (Bahl *et al.*, 2016; Block *et al.*, 2011; Davis and Pechmann, 2013; Lee *et al.*, 2002; Mende and van Doorn, 2015; Mick *et al.*, 2012; Sirgy and Lee, 2006; Sirgy *et al.*, 2007).

We position our work as a contribution to consumer well-being and public policy literature from the lens of increasingly important in our technology-integrated society emerging technologies (Davenport *et al.*, 2020; Hoffman and Novak, 2018; Huang and Rust, 2018; Kaplan and Haenlein, 2019; Kumar *et al.*, 2020; Mende *et al.*, 2019; van Doorn *et al.*, 2017; Walker *et al.*, 2019). We highlight specific gaps in the literature. First, past studies in consumer well-being did not incorporate substantial changes that emerging IR 4.0 technologies bring, especially across increasingly blurring digital, physical, and biological domains. Second, past research focused on individual technologies and individual well-being. What is unaccounted for is the potential for a synergetic, proactive effect that emerging technologies bring on the aggregate level not only to individuals but also to society and the environment. Finally, understanding the differences between responses to different outcomes of technologies has important implications for developing public policy.

To address the gaps outlined above, in this paper, we discuss how converging novel technologies transform core sectors and affect consumer well-being. Our key focus is on technologies— also referred to as "new-age technologies" (Kumar *et al.*, 2020), "technology-enabled interactions" (Yadav and Pavlou, 2020), and "new technologies" (Grewal *et al.*, 2020). In essence, we continue to study "technological products," highlighted in the classic study by Mick and Fournier (1998). Another concept closely related to IR 4.0 and often used to refer to the same technologies is "Industry 4.0" (Erro-Garcés, 2019; Lu, 2017; Liao *et al.*, 2017). We refer to technologies such as artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), blockchain, and a multitude of others as IR 4.0 technologies.

This conceptual paper contributes to two major bodies of literature. First, our primary focus is on joining the dialogue on consumer well-being. While there is an established understanding of well-being, the available literature lacks the focus on technology-enabled changes that may be associated with it. We show how new changes in the technological environment enable a synergetic, proactive approach toward consumer well-being. More specifically, we propose a conceptual framework that incorporates principles of IR 4.0 technologies, accounts for their transformational impact on core sectors, and puts forward a technology- and policy-oriented perspective on well-being. We portray a novel technology-enabled view toward well-being. As such, this research becomes an essential development in Transformative Consumer Research (TCR) literature that focuses on well-being. Second, we provide a novel theoretical contribution to the literature on IR 4.0 as well as diverse technology-specific research that investigates sub-fields within it such as AI, ML, the IoT, robotics, and many others. We show a more comprehensive perspective toward the assemblage of technologies. Finally, we outline public policy implications.

We begin by proposing our theoretical framework followed by a comprehensive review of literature on consumer well-being, consumer well-being and technology, and technology-enabled well-being. We then look at the digital, physical, and biological domains of IR 4.0 and examine the intersectional ties of newer technologies across these three domains. In conclusion, we discuss the implications for policymakers and outline directions for future research.

Conceptualizing IR 4.0 Framework for Technology-Enabled Well-Being

We begin with a conceptual overview of consumer well-being and technology. We then progress toward the conceptualization of technology-enabled well-being (TEW). We provide an overview of key domains and various sectors, grounding our paper in some specific illustrative IR 4.0 technologies. Our conceptual framework, shown in Figure 1, highlights principles of IR 4.0 technologies; blurring of digital, physical, and biological domains; transformation of core sectors, and the public policy response continuum in the progression toward TEW.

Insert Figure 1 about here

Our central claim is that (1) data-driven, (2) intelligent, and (3) connected IR 4.0 technologies are blurring traditional boundaries between digital, physical, and biological domains. Our approach is different from the earlier investigations on consumer well-being because it is based on a technological perspective not just from a single technology but rather from a synergetic view toward multiple agentic technologies across different domains and sectors. We also connect IR 4.0 technologies to a continuum of public policy reactions. The traditional context of IR 4.0 is in the manufacturing and supply chain domain (Corsi *et al.*, 2020). However, we argue that novel capacities of IR 4.0 technologies need to be examined on the consumer side, too. Our work is broadening the context of IR 4.0 toward consumers and, most importantly, expanding the concept of consumer well-being impacted by technologies—both negatively and positively. With IR 4.0 development, consumers are not interacting with a single technology; instead, they interact with a multitude of technologies in an unprecedented way—with a potential synergy of combined technologies that can proactively shape consumer well-being.

Consumer Well-Being

Well-being is defined as a "state of flourishing that involves health, happiness, and prosperity" (Mick *et al.*, 2012, p. 6) or an individual's "perceived satisfaction with all or component aspects of their lives" (Hoffman, 2012, p. 193). In a recent review of well-being literature and the various definitions of the construct, Dodge *et al.* (2012) defined well-being as "the balance point between an individual's resources pool and the challenges faced" (p. 230). This construct is closely related to the quality of life, life satisfaction, or consumer welfare and can be operationalized by subjective or objective measures (Mende and van Doorn, 2015). The concept of consumer well-being implicitly assumes the presence of positive aspects such as life satisfaction and happiness and simultaneously the absence of negative conditions such as illness or poverty (Sirgy *et al.*, 1982). Consumer well-being relates to a positive psychological (i.e., self-acceptance or personal growth), physical (i.e., health), emotional (i.e., life satisfaction), and social (i.e., social acceptance or integration) state at both individual and societal levels (Block *et al.*, 2011). The perspective refers to the micro- and macro-level customer benefits (Agarwal *et al.*, 2020).

Overall, current research on well-being has different perspectives. For instance, Burr, Taddeo, and Floridi (2020) investigate the ethics of digital well-being at the individual and societal levels, while McGregor and Goldsmith (1998) identified the economic, physical, social, emotional, spiritual, political, and environmental aspects of well-being. Likewise, Bahl *et al.* (2016) identified the following domains of well-being: individual, societal, and environmental. Acknowledging the multidimensional nature of the construct of well-being and in line with Bahl *et al.* (2016), we build off the latter dimensions in the present paper. These three aspects are well supported in the Transformative Consumer Research (TCR) literature (e.g., Bahl *et al.*, 2016; Mick *et al.*, 2012). Illustrative well-being outcomes include improved health, financial situation, literacy, and overall access to needed resources as well as reduced discrimination and marginalization (Ganju *et al.*, 2016). We look beyond the individual consumer level and account for broader entities by examining the linkages between communities (cities, society) and their environment because consumer well-being is linked to long-term macroeconomic stability and cannot exist without collective well-being (Anderson and Ostrom, 2015).

Consumer Well-Being and Technology

We continue our literature review with a broader focus on the relationship between consumer well-being and technology. Methodologically, we searched multiple databases (EBSCO Business Source Premier, ProQuest (ABI/Info), Web of Science, Google Scholar) for studies containing the terms well-being*, consumer well-being*, and transformative* in combination with "fourth industrial revolution," "IR 4.0," and technology* or any discrete technology such as IoT*, blockchain*, artificial intelligence*, machine learning* and many more. Second, we checked identified studies for potentially relevant cross-references. We excluded studies that mainly focused on technical aspects. We provide the outcomes of the review in Table 1. We also emphasize the key findings below.

The primary focus of the current research is on the use of the Internet. Only recently have studies in consumer well-being and technology begun shifting toward other emerging technologies (Çikrıkci, 2016). Hoffman (2012) identified online social connections with other people as being positively related to mental and physical well-being. Ganju *et al.* (2016) showed that access to information and communication technology enhances well-being on the societal level, including welfare, health, education, and living standards. Furthermore, information and communication technology represents an essential resource for social inclusion, thus increasing mental and social well-being by being socially connected with society (Andrade and Doolin, 2016).

Service robots can play an essential role in senior care services by enhancing older adults' physical, psychosocial, and cognitive well-being (Čaić *et al.*, 2018). Assistive robots can alleviate loneliness by engaging in human-like social interactions and monitoring health and safety. Mende *et al.* (2019) have shown that using humanoid robots in food services can lead to compensatory consumption responses and thus possibly impact health-related and financial individual well-being by causing consumers to overspend on status products and increase unhealthy food consumption.

New technologies increasingly enter people's private spaces, making their homes smarter. Consumers use technologies to automate and personalize tasks in their domestic environment to raise convenience for utilitarian services and create hedonic value to meet their needs (Harvey *et al.*, 2020). This technical inclusion in the private environment can also have a transformative impact on consumers' individual and social well-being on different levels of service intentions (e.g., supportive, advisory, and persuasive). These are mostly related to physical and mental health, such as simulating natural sunlight to ease a person's wake-up or a fitness tracker trying to change someone's sports habits. Health analytics is becoming progressively important.

Consumers are equipping their homes with new technologies and increasinglymaking use of self-tracking technologies (STT). Thus, smart wearables enable consumers to monitor, analyze, and interpret personal performance data on health and physical or financial well-being (Wittkowski *et al.*, 2020). Users of smart devices are expected to monitor their performance more actively and increase advice compliance as consumers develop into more competent coproducers of professional services such as physicians or tax accountants.

However, this advice compliance depends on the self-efficacy of consumers. Self-efficacy is strengthening the effect of STT use on advice compliance and, finally, the impact on consumer well-being.

Selected papers show the impact of new technologies on well-being. One key emphasis from Table 1 is that most of the literature focuses on the individual level (and some on the societal level) of well-being. Meanwhile, a discussion of the environmental level is very sparse. Furthermore, to a large extent, the interaction between consumers and new technologies is looked at from a dyadic, individual perspective. As such, the potential of the interaction between technologies within the technological ecosystem is widely neglected. Finally, the interaction between the consumer and technology is treated as mostly as reactive. Technology's proactive impact on consumer well-being still needs to be examined.

Insert Table 1 about here

Toward Technology-Enabled Well-Being

As observed above, previous studies began assessing the impact of technology on well-being. In Table 1, we describe the studies with critical findings and well-being implications. Despite previous efforts to identify different types of technologies linked to well-being, further theorization is needed about how emerging IR 4.0 technologies change various sectors and influence consumer well-being. We argue that society is progressing toward technology-enabled well-being (TEW), which we define as a state of balance between individual, societal, and environmental needs and available resources provided by data-driven, intelligent, and connected IR 4.0 technologies. TEW is a multidimensional, holistic construct that incorporates how IR 4.0 technologies influence individuals, societal interrelationships, and ecosystems.

First, we make a note of a data-driven principle. One specific element that we see across multiple examples of IR 4.0 technologies is that they are built on data. Data availability has increased dramatically—with all kinds of information available, be it genetic, administrative, visual, olfactory, sensory, and auditory (Balmer and Yen, 2017). The digitization and sensor-based technologies such as wearables to continuously monitor various human activities have dramatically increased the number of data sources leading to the emergence of Big Data (Khakurel *et al.*, 2018).

Second, we note one of the most critical aspects of IR 4.0 technologies—intelligent principle. IR 4.0 technologies are simulating human intelligence—like a person, technology can "cognitively" recognize patterns of information and do so without human input (Armentano and Amandi, 2007). The intelligent principle is connected to data—digitization is progressing and expanding the availability of data IR 4.0 technologies, learning from it, and moving toward intelligence. We would argue that intelligence is different from smartness as decisions could be made without human input, something that is not accentuated in smart technologies. It incorporates autonomous learning and decision-making capabilities to solve complex problems and act in a complex dynamic environment on behalf of a person (Xu and Wang, 2006). McAfee and Brynjolfsson (2017) asserted that many decisions would be fully turned over to algorithms. We emphasize that IR 4.0 technologies are proactive rather than reactive. Digital agents aim to influence human behavior to improve well-being or prevent damage. They are driving intelligent actions from data and giving humans advice about how they should behave, set priorities, or even start actions for them (Harvey *et al.*, 2020). Intelligent use of big data is an opportunity to make better and faster decisions or save resources during routine tasks and thus increase the well-being on various levels.

The third fundamental principle is that IR 4.0 technologies are connected. So far, the interaction between technology and humans was mainly considered a dyad between humans and technology, such as conversations with a service robot (e.g., Mende *et al.*, 2019). However, in the era of IR 4.0, people and a multitude of technologies are connected into a wide-ranging network. Devices can directly communicate with each other. Objects or technologies are gaining new capacities due to their connectedness. Sensors, devices, agents, technologies are mostly seen individually, not related to each other. However, they can work together and build a network-potential that the devices alone could not deliver, enabling what we refer to as a synergetic, proactive effect on consumer well-being. This ecosystem of intelligent objects and technologies will have capacities to influence consumer well-being in a way that digital information, physical devices, or biological processes by themselves could not. Thus, digital or biological information connected with physical devices can have a more substantial impact on well-being than individually. The connections of these capacities are ongoing, in real-time, and can be very heterogeneous.

Blurring of Digital, Physical, and Biological Domains

In line with “bodies of technologies” (Arthur, 2009), we group technologies into digital, physical, and biological domains. As noted previously, the boundaries between these domains are blurring (Roy and Roy, 2021), which complicates assigning any new emerging technology to only one area (Huang and Rust, 2018; Schwab, 2017). For instance, the physical domain is often mixed with digital, and human interactions are combined with the non-human. Artificial intelligence coexists with natural intelligence, and human labor is mixed in collaboration with artificial autonomous systems. Physical, biological, and digital domains continue to converge, and contemporary societies become more and more hybrid environments where technologies increasingly intertwine with humans, and the degree of the control over them is changing (Aldinhas Ferreira, 2019). Unlike only seeing technology as “tools,” IR 4.0 technologies can act proactively in an intelligent way, which can be seen with both admiration and fear (Chatila and Havens, 2019).

While keeping the blurring perspective in view, we propose to list illustrative IR 4.0 technologies as predominantly digital, predominantly physical, and predominantly biological.

However, we emphasize that the digital domain is often the basis for further advances in physical and biological domains. Consequently, we start with an overview of predominantly digital technologies as these are the vehicles for many cross-domain applications.

Predominantly Digital Domain

Significant advancements in the digital domain include such illustrative IR 4.0 technologies as artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), and blockchain technologies. Kumar *et al.* (2020) provide a conceptual overview of these technologies, referring to them as “new-age technologies.” Similarly, past research proposes an agenda that incorporates such technologies in various marketing-related contexts (Huang and Rust, 2018). In a predominantly digital domain, multiple examples show how IR 4.0 technologies are data-driven, intelligent, and connected (Roy and Roy, 2019).

IR 4.0 technologies show autonomous learning and decision-making capabilities. Here, the primary idea is to design technology so that it independently (i.e., without human intervention) makes decisions based on data. Intelligent information processing based on Big Data is referred to as ML and AI. Artificial intelligence incorporates automated computer programs, i.e., algorithms designed to assist users (Armentano and Amandi, 2007). AI is designed to solve complex problems effectively using Big Data and machine-learning techniques (Kumar *et al.*, 2016). ML provides systems with the ability to learn and improve from experience without being explicitly programmed (Khandani *et al.*, 2010). Therefore, AI can be viewed as a computing system designed to realize a set of goals or tasks while inhabiting, sensing, and autonomously acting in a complex dynamic environment on behalf of a person or organization that can interact with its environment and other agents (Xu and Wang, 2006). Due to the almost unlimited computer capacities, such decision-making is possible in real-time and represents the basis for predictive analytics (Green Jr *et al.*, 2017). Governments already use AI technology to improve cities. A representative example is

Pittsburgh's transportation system, where the use of sensors and cameras to recognize traffic activity has significantly reduced travel time and traffic jams in the city (Snow, 2017). In this system, AI uses the data to intelligently streamline real-time traffic. The penetration of AI, however, has raised several questions around data privacy protection, the trustworthiness of autonomous and intelligent systems, or bias in ML (Chatila and Havens, 2019; Puntoni *et. al*., 2021).

The connected principle is aptly reflected in the Internet of Things (IoT), an emergent phenomenon that vividly transcends digital, physical, and biological domains. The IoT broadly refers to uniquely identifiable objects, such as artifacts and organisms, and their interconnection in a network structure that seamlessly links the physical and virtual world (e.g., Bandyopadhyay and Sen, 2011). As such, the "Things" in the IoT are not limited to electronic digital devices but can include any physical objects, such as clothing, automobiles, and household devices as well as people, and even cities. In recent years, due to the development of low-cost sensors (e.g., RFID technology), ubiquitous wireless high-speed network (e.g., 5G) connecting the sensor devices anywhere and anytime, and cloud-based information systems that offer a virtual way to store, manage, and access data, the IoT has become more interactive and pervasive (e.g., Green Jr *et al.*, 2017; Lee and Lee, 2015). In the coming years, the IoT is predicted to open up new ways for consumers to perceive and interact with reality to benefit their well-being (e.g., Hoffman and Novak, 2018; Nobre and Tavares, 2017).

With the increase of available data, intelligent processing, and management offered by algorithms, a need for a safe and collaborative communication infrastructure for these interactions emerges (Novak and Hoffman, 2019). One relevant solution in this respect is blockchain, a technology that consists of a growing list of records, called blocks, linked using an open, distributed network ledger that can efficiently and verifiably records transactions between parties (Tapscott and Tapscott, 2016). Once registered, the data in any given block cannot be retroactively changed without altering subsequent blocks, which requires the consensus of the majority in the network. As a peer-to-peer network, blockchain is collectively managed using a protocol for inter-node communication and to validate new blocks. Therefore, by design, data in a blockchain cannot be easily modified and, due to decentralized consensus, considered secure (Iansiti and Lakhani, 2017). Essential properties of blockchain include transparency, immutability, and security, which makes it appropriate for applications such as smart contracts, financial reporting, management of private information (e.g., medical records), and even electrical grid management (Harvey *et al.*, 2018).

Predominantly Physical Domain

The predominantly physical domain includes such illustrative IR 4.0 technologies as robots, self-driving vehicles, three-dimensional (3D) printing, and wearables. Technologies here are material objects—extending digital technologies into a physical reality.

One widely recognized example of the predominantly physical domain is robotics. As an IR 4.0 technology, robotics has emerged at the crossroads of physical and digital domains. Robots are intelligent and can even be designed to look like humans. Bekey (2012, p. 18) refers to a robot as “a machine, situated in the world, that senses, thinks, and acts.” Likewise, (Duffy, 2003, p. 177) defines a robot as “a physical entity embodied in a complex, dynamic, and social environment sufficiently empowered to behave in a manner conducive to its goals and those of its community.” Belk (2016) emphasizes a broader perspective toward robots, including micro-robots, driverless vehicles, military drones, web crawlers, automatic thermostats, robotic toys, vacuum cleaners, satellites, space probes, industrial robots, “bots,” and voice-activated devices.

In our review, we propose to separate self-driving vehicles as an example on their own. Self-driving vehicles include cars as well as trucks, drones, aircraft, and boats. In several years, owing to rapid advances such as sensors and AI, these machines will be available for commercial and consumer applications. Along with passenger transport, the technologies will also allow drones to perform tasks such as checking power grid lines, delivering supplies, irrigating fields, and monitoring human masses.

The third illustrative IR 4.0 technology is 3D printing. This technology embraces a set of manufacturing techniques that can collectively create solid three-dimensional structures by building up successive layers of materials (Xu *et al.*, 2018). In today's on-demand era, consumers crave the ability to transform their digital experiences into physical ones (Hoffman and Novak, 2018). Connecting digital with physical, 3D printing is estimated to drive new consumer demand (Lee *et al.*, 2018; Skilton and Hovsepian, 2018).

Predominantly Biological Domain

Illustrative examples of IR 4.0 technologies in the biological domain involve innovations in genetic engineering, neurotechnology, synthetic food, implantable technology. We also note the development of new biotechnologies, drugs, and smart materials (Patra and Andrew, 2015). Major goals of all these technologies, which involve considerable financial investment and research effort, include curing hereditary diseases, eliminating hunger problems, providing cleaner energy sources, and addressing the issues of waste and its recycling (Patra and Andrew, 2015). Many aspects of the digital domain are expanding into the biological, bringing in data-driven, intelligent, and connected principles.

In this area, some of the innovations with the most significant potential for improving well-being are genetic engineering and neurotechnology. There are hopes that the manipulation of human genes will enable protecting people from deadly diseases. Another ambitious aspiration of genetic engineering is to eventually make it possible to "grow" organs for transplantation in a laboratory. Furthermore, with the use of genetic screening, it may be possible to cure unborn children's diseases. Neurotechnology advancements have the potential to even implant a full artificial memory in the human brain. Overall, genetic engineering and neurotechnology have a strong potential to improve well-being and enable a longer lifespan (Fischer *et al.*, 2002). In the last two decades, the costs of editing the human genome have fallen six-fold, and the technology can also be used to edit the genes of plants and animals. Importantly, along with addressing scientific issues, there have also been growing concerns about ethical issues.

Another recent technology that has emerged in the biological domain is the production of synthetic food. Produced by biochemical processes and 3D printing, synthetic food imitates natural products in appearance, taste, and smell. Synthetic food provides new possibilities to combat hunger. Nevertheless, the effects of these technologies on society and, perhaps more importantly, on the environment must be considered.

One final example of IR 4.0 technologies that has recently emerged in the biological domain is implantable technology. These days, devices are not just being worn but are increasingly implanted in human bodies to monitor people's behavior, location, and health functions. While forerunners of devices such as pacemakers and cochlear implants have been in use for quite some time, many more health devices are expected to be launched in the future. These will not only help to identify and locate their hosts but also monitor their health status and even tap into their minds to detect hidden thoughts or moods via the use of "built-in" smartphones.

To summarize, AI, ML, the IoT, blockchain, self-driving vehicles, 3D printing, wearables, genetic engineering, neurotechnology, synthetic food, and implantable technology are key illustrative IR 4.0 technologies that open up novel possibilities that historically were not possible to the same degree. Emerging technologies move beyond solely digital disembodied reality into physical and biological space. These IR 4.0 technologies demonstrate data-driven autonomous learning and decision-making, interactivity, and the possibility of transparent, secure transactions that could be happening among the technologies. Advancements lead to a merger between biological and physical, creating cyborgs, artificial enhancements, and other biologically-based materials that can now be manipulated. These IR 4.0 technologies explicitly reveal data-driven, intelligent, and connected principles. The intersectional ties of new technologies across the three domains (physical, biological, and digital) are illustrated in Figure 2.

Insert Figure 2 about here

Public Policy Implications

As outlined above, data-driven, connected, and intelligent IR 4.0 technologies—that are blurring traditional boundaries between digital, physical, and biological—affect consumer well-being across individual, societal, and environmental well-being. Public policy needs to respond to this by considering an integrative TEW framework as a guide. Policymakers could support the spreading of IR 4.0's positive effect throughout the society as well as alleviate potential exclusion or vulnerability associated with it. They use a combination of both formal legal regulation and self-regulation in achieving this balance (Doyle, 1997; Hoffmann-Riem, 1997). In the former, policymakers provide a safe environment for the consumer, and in the latter, they create a sense of urgency and responsible behavior toward IR 4.0 technologies. In our recommendations, we highlight a wider public policy continuum. Namely, policy makers could (1) evaluate IR 4.0 technologies that are emerging without a clear indication of positive and negative effects, (2) regulate and (3) restrict IR 4.0 technologies that have negative effects, and (4) guide and (5) promote IR 4.0 technologies that have positive effects. While developing a further discussion on how policymakers could respond, we provide some illustrations and specific policy recommendations—connected to implications in well-being—in Table 2.

Insert Table 2 about here

Evaluation of IR 4.0 Technologies

Policymakers could actively use various research methods to evaluate the impact. For instance, there are several advanced methods available for identifying and analyzing complex socio-technical networks. The challenge will be to apply these methods to track consumer well-being over time and to uncover processes that are self-organizing and emergent networks of consumers and things (e.g., Kuo *et al.*, 2002). Consequently, sophisticated quantitative methods are needed that go beyond simple time series to model the complexity of co-evolutionary processes. With few exceptions (e.g., Balta-Ozkan *et al.*, 2013), a more in-depth and qualitative understanding of the interplay of technologies, contexts, and consumers is also needed, which are likely to involve ethnographic approaches for making sense of how things and people are well integrated into networks but also how existing systems of relationships are challenged by new technology (e.g., Yapchaian, 2018).

Regulation/Restriction of IR 4.0 Technologies

If IR 4.0 technologies bring in potential threats, policymakers could regulate or even restrict their use. For instance, currently, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) provides consumer protection. However, much of this regulation appears to be rather old and does not safeguard consumer privacy today, such as securing consumers' genetic data from being sold to insurance businesses. As argued by Xu *et al.* (2018), the 4th Industrial Revolution has ushered the era of breakthroughs that far exceed the slow pace of implementing laws and regulations. Currently, the most far-reaching attempt to provide consumer protection is the European Union's General Data Protection Regulation (GDPR) which requires businesses to collect user consent before collecting sensitive information. This way, consumers can individually prioritize which of their personal data should be recorded (the opt-in approach).

Policymakers should consider the possibilities of creating equal access to IR 4.0 technologies. Special attention should be given to consumers of especially low-income groups who do not have the economic means to afford IR 4.0 access and/or technologies and are, therefore, discriminated against participating and taking advantage of the IR 4.0 benefits. Public policies must provide necessary sponsoring, funding, and subsidiaries for the less-favored to enter IR 4.0 by directly supporting the purchase of computers and digital devices in schools and elsewhere accompanied by support for Internet accessibility and instructor education. The urban and rural digital divide is also something that requires the attention of policymakers. Rural consumers might not get the same level of access to digital information as urban consumers (Akileswaran and Hutchinson, 2019; Peronard and Just, 2011).

Consequently, there is a need for skills and capacity building not only to cope with the adverse effects of transformative technologies but also to capture the promises of IR 4.0. Especially in rural and poor areas, it is critical for policymakers and planners to provide leadership and convince key stakeholders to participate in shaping a desirable outcome of changes that follow IR 4.0 (e.g., Akileswaran and Hutchinson, 2019). A tangible way to do this is by expanding the adoption rates of low-income groups to increase investments in continuous local educational programs and technology infrastructure so that access to IR 4.0 technologies from more remote geographic areas and households is made possible. Besides, as talent more than capital is likely to become a critical factor in the future, establishing a sustainable local business environment with jobs for the many but especially attracting those people with ideas and skills must be on the top of policymakers' agendas (e.g., Mellander and Florida, 2011). Whenever it gets to putting individuals, society, and the environment into potential danger, public policy should restrict the use of IR 4.0 technologies. For instance, the discriminatory bias in self-learning algorithms may hurt vulnerable consumers.

Finally, it is important to recognize the significance of the impact of lobbying of government officials by the technology sector. Oleshchuk (2020) identifies the various technologies for informational influence to put unidirectional pressure on public policy decision-makers. Recognizing the perception of the gap between the technology sector and the legislative branches of government, the first Technological Assessment Institute was set up in the US [Office of Technology Assessment (OTA)], followed by TA offices in the EU member states in the 1980s (Salo and Kuusi, 2001). Yet, in 1995, the Congress in the US terminated this office just as the internet was flourishing and the digital economy unfolding. Now at a time when most people are deeply concerned with privacy, security, fairness, transparency, and human safety, coupled with the stunning growth of the IR 4.0 technology innovations, it may be time to reinstitute this agency. This will allow governmental agencies to be proactive rather than reactive in enacting public policies.

Guide/Promotion of IR 4.0 Technologies

Policymakers can guide consumers regarding IR 4.0 technologies or even promote them to gain acceptance. As outlined in the previous section, consumers may only reluctantly use transformative technologies due to a lack of trust and fear. Demonstration projects may prove valuable as they create awareness-, how-to, and function-knowledge aiming at increased acceptance (Rogers, 2003). However, the demonstration of innovation may also be considered persuasive in so far that it provides convincing and compelling arguments for adoption and diffusion in a given population (Dearing, 2009).

Nevertheless, the lack of symmetrical communication between businesses/technicians and the public is bound to create mistrust and skepticism among consumers. Thus, it is a barrier to persuasion and, subsequently, the adoption of IR 4.0 technologies. Consequently, ensuring public trust becomes a pivotal communication issue where debate supported by well-documented and high-quality research is needed. Since much of the current research stems from the technical sciences, it needs to be scrutinized and reinterpreted by social scientists to critically assess the tension between the social, economic, and technical dimensions of IR 4.0. Arguably, best cases can support debates such as panels, workshops, roundtables, conferences, and build consensus among stakeholders, which will help form new and relevant policies that will be more readily accepted.

Based on this, policymakers inform consumers of the negative aspect of IR 4.0. For instance, Berthon *et al.* (2019) suggest issuing warning labeling and other types of declarations that create awareness of possible frauds and risks as well as installing transparency measures (e.g., opt-in/out) of personal data use or putting restrictions on addictive marketing programs of new technologies. Furthermore, educating consumers and not ignoring their creative potential to use new technologies may counter the challenges of decreased employment in certain sectors (e.g., An, 2019). That is, policymakers must be more attentive to help people actively participate in IR 4.0 to absorb and exploit possible changes that follow from technological development. Training programs for both consumers and employees are indeed needed.

Conclusion

We address the need for a conceptual framework at the intersection of IR 4.0 technologies and humans by analyzing TEW. The critical theoretical contributions of this study are to understand better the impact of IR 4.0 technologies on the three key facets of well-being across significant sectors of society. Specifically, by focusing on TEW, we examine in detail the mostly unexplored impact of IR 4.0 technologies on human needs and resources on an individual and collective level. By incorporating the individual, societal, and environmental perspectives, we provide a holistic view of the synergetic, proactive, and transformative impact of IR 4.0 technologies. Our study, therefore, extends prior work dealing with the role of new technologies in customer service interactions and behavioral loyalty (e.g., Mende *et al.*, 2019). These studies focused on B2B settings, company outcomes, and workplace conditions (e.g., Huang and Rust, 2018), or studies exclusively concerned with consumer well-being at an individual level (e.g., Lu *et al.*, 2019).

Thus, the critical contribution is in identifying the future abrupt and radical change primarily propelled by core drivers of IR 4.0, blurring domains, and impact on well-being at varied levels (i.e., the individual consumer, society, and environmental) across various sectors of society (Boninsegni *et al*., 2022). We propose a conceptual framework that incorporates critical principles of IR 4.0 technologies and their transformational impact on core sectors and puts forward technology-enabled views on the essential aspects of well-being.

Admittedly, these boundaries domains' are now blurred (Huang and Rust, 2018; Schwab, 2017). Data-driven, intelligent, and connected IR 4.0 technologies is the force that is actively contributing to the blurring of the domain. However, we want to theorize on this more specifically. What are these boundaries? Should they be stable? What are the outcomes of such blurring? We are building off a comprehensive evaluation of the nature of technology by Arthur (2009), who notes that domains ("bodies of technologies") re-domain, and that is how technology progresses. Moreover, looking at technologies and the blurring of mechanical and biological, Arthur (2009) argues that with the sophistication of tech, it becomes more biological.

The blurring of digital, physical, and biological boundaries is also creating something that Krafft *et al.* (2020) refer to as a "boundary object." The authors note acceleration in blurring of domains based on AI and 5G and introduce a "boundary object," referring to IR 4.0 technologies. As such, novel IR 4.0 technologies cross the traditional borders across domains. Emerging technologies also have "power and capabilities of creating connections and overcoming discontinuities between disciplines. In doing so, they help further collaborations across disciplinary boundaries and hence contribute to advancing and accelerating knowledge creation" (p. 2). We argue that blurring of the domains is the progression of technology, enabling novel approaches to well-being. However, it should be approached from the public policy perspective, as the technologies also come with a set of threats.

References

Agarwal, R., Dugas, M., Gao, G. and Kannan, P.K. (2020), "Emerging technologies and analytics for a new era of value-centered marketing in healthcare", *Journal of the Academy of Marketing Science*, Vol. 48 No. 1, pp. 9–23.

Akileswaran, K. and Hutchinson, G. (2019), *Adapting to the 4IR: Africa's Development in the Age of Automation*, Tony Blair Institute for Global Change, London, UK.

Aldinhas Ferreira, M.I. (2019), "Technological Development and Well-Being", in Aldinhas Ferreira, M.I., Silva Sequeira, J., Singh Virk, G., Tokhi, M.O. and E. Kadar, E. (Eds.), *Robotics and Well-Being*, *Intelligent Systems, Control and Automation: Science and Engineering*, Springer International Publishing, Cham, pp. 1–9.

An, N.Q. (2019), "How will demographic transformation and 4.0 industry innovation affect the labor market?", *Proceedings of the 10th Neu-Kku International Conference on Socio-Economic and Environmental Issues in Development*, Vol. 5, pp. 555–566.

Anderson, L. and Ostrom, A.L. (2015), "Transformative service research: advancing Our knowledge about service and well-being", *Journal of Service Research*, Vol. 18 No. 3, pp. 243–249.

Anderson, L., Spanjol, J., Jefferies, J.G., Ostrom, A.L., Nations Baker, C., Bone, S.A., Downey, H., Mende, M. and Rapp, J.M. (2016), "Responsibility and well-being: resource integration under responsibilization in expert services", *Journal of Public Policy & Marketing*, Vol. 35 No. 2, pp. 262–279.

Andrade, A.D. and Doolin, B. (2016), "Information and communication technology and the social inclusion of refugees", *MIS Quarterly*, Vol. 40 No. 2, pp. 405–416.

Armentano, M.G. and Amandi, A. (2007), "Plan recognition for interface agents", *Artificial Intelligence Review*, Vol. 28 No. 2, pp. 131–162.

Arthur, W.B. (2009), *The Nature of Technology: What it is and How it Evolves*, Free Press, New York.

Bahl, S., Milne, G.R., Ross, S.M., Mick, D.G., Grier, S.A., Chugani, S.K., Chan, S.S., Gould, S., Cho, Y.-N. and Dorsey, J.D. (2016), "Mindfulness: its transformative potential for consumer, societal, and environmental well-being", *Journal of Public Policy & Marketing*, Vol. 35 No. 2, pp. 198–210.

Balmer, J.M.T. and Yen, D.A. (2017), "The Internet of total corporate communications, quaternary corporate communications and the corporate marketing Internet revolution", *Journal of Marketing Management*, Vol. 33 1/2, pp. 131–144.

Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013), "Social barriers to the adoption of smart homes", *Energy Policy*, Vol. 63, pp. 363–374.

Bandyopadhyay, D. and Sen, J. (2011), "Internet of things: applications and challenges in technology and standardization", *Wireless Personal Communications*, Vol. 58 No. 1, pp. 49–69.

Banker, S. and Khetani, S. (2019), "Algorithm overdependence: how the use of algorithmic recommendation systems can increase risks to consumer well-being", *Journal of Public Policy & Marketing*, Vol. 38 No. 4, pp. 500–515.

Bekey, G.A. (2012), "Current trends in robotics: technology and ethics", in Lin, P., Abney, K. and Bekey, G.A. (Eds.), *Robot Ethics: The Ethical and Social Implications of Robotics*, The MIT Press, Cambridge, MA, USA, London, UK, pp. 17–34.

Belk, R. (2016), "Understanding the robot: comments on Goudey and Bonnin (2016)", *Recherche et Applications en Marketing (English Edition)*, Vol. 31 No. 4, pp. 83–90.

Bell, D. (1973), *The Coming of the Post-Industrial Society: A Venture in Social Forecasting*, Basic Books, New York.

Berthon, P., Pitt, L. and Campbell, C. (2019), "Addictive de-vices: a public policy analysis of sources and solutions to digital addiction", *Journal of Public Policy & Marketing*, Vol. 38 No. 4, pp. 451–468.

Block, L.G., Grier, S.A., Childers, T.L., Davis, B., Ebert, J.E., Kumanyika, S., Laczniak, R.N., Machin, J.E., Motley, C.M., Peracchio, L., Pettigrew, S., Scott, M. and Bieshaar, M.N.G. (2011), "From nutrients to nurturance: a conceptual introduction to food well-being", *Journal of Public Policy & Marketing*, Vol. 30 No. 1, pp. 5–13.

Boninsegni, M.F., Roy, A., Bakpayev, M., Kumar, S., Peronanrd, J.P. and Reimer, T. (2022), "Opportunities of and threats to consumer well-being in the age of Fourth Industrial Revolution (IR 4.0) technologies", *Digital Policy, Regulation and Governance*, Vol. 24 No. 1, pp. 93-105.

Burr, C., Taddeo, M., & Floridi, L. (2020). The ethics of digital well-being: A thematic review. *Science and engineering ethics*, *26*(4), 2313-2343.

Čaić, M., Odekerken-Schröder, G. and Mahr, D. (2018), "Service robots: value co-creation and co-destruction in elderly care networks", *Journal of Service Management*, Vol. 29 No. 2, pp. 178–205.

Chatila, R. and Havens, J.C. (2019), "The IEEE global initiative on ethics of autonomous and intelligent systems", in *Robotics and Well-Being*, Springer, Cham, CH, pp. 11–16.

Çikrıkci, Ö. (2016), "The effect of internet use on well-being: meta-analysis", *Computers in Human Behavior*, Vol. 65, pp. 560–566.

Corsi, A., Pagani, R.N., Kovaleski, J.L. and Luiz da Silva, V. (2020), "Technology transfer for sustainable development: Social impacts depicted and some other answers to a few questions", *Journal of Cleaner Production*, Vol. 245 No. 2, pp. 1–22.

Davenport, T., Guha, A., Grewal, D. and Bressgott, T. (2020), "How artificial intelligence will change the future of marketing", *Journal of the Academy of Marketing Science*, Vol. 48 No. 1, pp. 24–42.

Davis, B. and Pechmann, C. (2013), "Introduction to the Special Issue on transformative consumer research: developing theory to mobilize efforts that improve consumer and societal well-being", *Journal of Business Research*, Vol. 66 No. 8, pp. 1168–1170.

Dearing, J.W. (2009), "Applying diffusion of innovation theory to intervention development", *Research on Social Work Practice*, Vol. 19 No. 5, pp. 503–518.

Dodge, R., Daly, A.P., Huyton, J. and Sanders, L.D. (2012), "The challenge of defining wellbeing", *International Journal of Wellbeing*, Vol. 2 No. 3, pp. 222–235.

Doyle, C. (1997), "Self regulation and statutory regulation", *Business Strategy Review*, Vol. 8 No. 3, pp. 35–42.

Duffy, B.R. (2003), "Anthropomorphism and the social robot", *Robotics and Autonomous Systems*, Vol. 42 3/4, pp. 177–190.

Erro-Garcés, A. (2019), "Industry 4.0: defining the research agenda", *Benchmarking: An International Journal*, In press.

Fischer, A., Hacein-Bey, S. and Cavazzana-Calvo, M. (2002), "Gene therapy of severe combined immunodeficiencies", *Nature Reviews Immunology*, Vol. 2 No. 8, pp. 615–621.

Ganju, K.K., Pavlou, P.A. and Banker, R.D. (2016), "Does information and communication technology lead to the well-being of nations? A country-level empirical investigation", *MIS Quarterly*, Vol. 40 No. 2, pp. 417–430.

Green Jr, K.W., Zelbst, P.J., Sower, V.E. and Bellah, J.C. (2017), "Impact of radio frequency identification technology on environmental sustainability", *Journal of Computer Information Systems*, Vol. 57 No. 3, pp. 269–277.

Grewal, D., Hulland, J., Kopalle, P.K. and Karahanna, E. (2020), "The future of technology and marketing: a multidisciplinary perspective", *Journal of the Academy of Marketing Science*, Vol. 48 No. 1, pp. 1–8.

Harvey, C.R., Moorman, C. and Toledo, M. (2018), "How Blockchain can help marketers build better relationships with their customers", *Harvard Business Review*, Vol. 9, pp. 6–13.

Harvey, J., Poorrezaei, M., Woodall, T., Nica-Avram, G., Smith, G., Ajiboye, T., Kholodova, K. and Zhu, K. (2020), "The smart home: how consumers craft new service networks by combining heterogeneous smart domestic products", *Journal of Service Research*, Vol. 23 No. 4, 504-526.

Hoffman, D.L. (2012), "Internet indispensability, online social capital, and consumer well-being", in Mick, D.G., Pettigrew, S., Pechmann, C.C. and Ozanne, J.L. (Eds.), *Transformative Consumer Research for Personal and Collective Well-being*, Routledge, London, pp. 193–204.

Hoffman, D.L. and Novak, T.P. (2018), "Consumer and object experience in the internet of things: An assemblage theory approach", *Journal of Consumer Research*, Vol. 44 No. 6, pp. 1178–1204.

Hoffmann-Riem, W. (1997), "Regulating media-the licensing and supervision of broadcasting in six countries", *Journalism and Mass Communication Quarterly*, Vol. 74 No. 2, pp. 447–448.

Huang, M.-H. and Rust, R.T. (2018), "Artificial intelligence in service", *Journal of Service Research*, Vol. 21 No. 2, pp. 155–172.

Iansiti, M. and Lakhani, K.R. (2017), "The truth about Blockchain", *Harvard Business Review*, Vol. 95 No. 1, pp. 118–127.

Kaplan, A. and Haenlein, M. (2019), "Siri, Siri, in my hand: who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence", *Business Horizons*, Vol. 62 No. 1, pp. 15–25.

Khakurel, J., Melkas, H. and Porras, J. (2018), "Tapping into the wearable device revolution in the work environment: a systematic review", *Information Technology & People*, Vol. 31 No. 3, pp. 791–818.

Khandani, A.E., Kim, A.J. and Lo, A.W. (2010), "Consumer credit-risk models via machine-learning algorithms", *Journal of Banking & Finance*, Vol. 34 No. 11, pp. 2767–2787.

Krafft, M., Sajtos, L. and Haenlein, M. (2020), "Challenges and opportunities for marketing scholars in times of the Fourth Industrial Revolution", *Journal of Interactive Marketing*, Vol. 51, pp. 1–8.

Kumar, V., Dixit, A., Javalgi, R. and Dass, M. (2016), "Research framework, strategies, and applications of intelligent agent technologies (IATs) in marketing", *Journal of the Academy of Marketing Science*, Vol. 44, pp. 24–45.

Kumar, V., Ramachandran, D. and Kumar, B. (2020), "Influence of new-age technologies on marketing: a research agenda", *Journal of Business Research*, In press.

Kuo, R.J., Ho, L.M. and Hu, C.M. (2002), "Integration of self-organizing feature map and K-means algorithm for market segmentation", *Computers & Operations Research*, Vol. 29 No. 11, pp. 1475–1493.

Lee, D.-J., Sirgy, M.J., Larsen, V. and Wright, N.D. (2002), "Developing a subjective measure of consumer well-being", *Journal of Macromarketing*, Vol. 22 No. 2, pp. 158–169.

Lee, I. and Lee, K. (2015), "The Internet of Things (IoT): applications, investments, and challenges for enterprises", *Business Horizons*, Vol. 58 No. 4, pp. 431–440.

Lee, M., Yun, J., Pyka, A., Won, D., Kodama, F., Schiuma, G., Park, H., Jeon, J., Park, K. and Jung, K. (2018), "How to respond to the Fourth Industrial Revolution, or the Second Information Technology Revolution? Dynamic new combinations between technology, market, and society through open innovation", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 4 No. 3, pp. 21–45.

Liao, Y., Deschamps, F., Loures, Eduardo de Freitas Rocha and Ramos, L.F.P. (2017), "Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal", *International Journal of Production Research*, Vol. 55 No. 12, pp. 3609–3629.

Lu, Y. (2017), "Industry 4.0: a survey on technologies, applications and open research issues", *Journal of Industrial Information Integration*, Vol. 6 No. 6, pp. 1–10.

Lu, Y., Papagiannidis, S. and Alamanos, E. (2019), "Exploring the emotional antecedents and outcomes of technology acceptance", *Computers in Human Behavior*, Vol. 90, pp. 153–169.

McAfee, A. and Brynjolfsson, E. (2017), *Machine, Platform, Crowd: Harnessing our Digital Future*, WW Norton & Company.

McGregor, S.L.T. and Goldsmith, E.B. (1998), "Expanding our understanding of quality of life, standard of living, and well-being", *Journal of Family and Consumer Sciences*, Vol. 90 No. 2, pp. 2–6.

Mellander, C. and Florida, R. (2011), "Creativity, talent, and regional wages in Sweden", *The Annals of Regional Science*, Vol. 46 No. 3, pp. 637–660.

Mende, M., Scott, M.L., van Doorn, J., Grewal, D. and Shanks, I. (2019), "Service robots rising: how humanoid robots influence service experiences and elicit compensatory consumer responses", *Journal of Marketing Research*, Vol. 56 No. 4, pp. 535–556.

Mende, M. and van Doorn, J. (2015), "Coproduction of transformative services as a pathway to improved consumer well-being", *Journal of Service Research*, Vol. 18 No. 3, pp. 351–368.

Mick, D.G. and Fournier, S. (1998), "Paradoxes of technology: consumer cognizance, emotions, and coping strategies", *Journal of Consumer Research*, Vol. 25 No. 2, pp. 123–143.

Mick, D.G., Pettigrew, S., Pechmann, C. and Ozanne, J.L. (2012), "Origins, qualities, and envisionments of transformative consumer research", in Mick, D.G., Pettigrew, S., Pechmann, C.C. and Ozanne, J.L. (Eds.), *Transformative Consumer Research for Personal and Collective Well-being*, Routledge, London, pp. 3–24.

Nobre, G.C. and Tavares, E. (2017), "Scientific literature analysis on big data and internet of things applications on circular economy: a bibliometric study", *Scientometrics*, Vol. 111 No. 1, pp. 463–492.

Novak, T.P. and Hoffman, D.L. (2019), "Relationship journeys in the internet of things: a new framework for understanding interactions between consumers and smart objects", *Journal of the Academy of Marketing Science*, Vol. 47 No. 2, pp. 216–237.

Oleshchuk, P. (2020). The Instruments of modern media lobbying. *Future Human Image*, *14*(14), 48-55.

Patra, S. and Andrew, A.A. (2015), “Effects of genetic engineering - the ethical and social implications”, *Annals of Clinical and Laboratory Research*, Vol. 3 No. 1, p. 5.

Peronard, J.-P. and Just, F. (2011), “User motivation for broadband: a rural Danish study”, *Telecommunications Policy*, Vol. 35 No. 8, pp. 691–701.

Popiel, P. (2018). The tech lobby: Tracing the contours of new media elite lobbying power. *Communication Culture & Critique*, *11*(4), 566-585.

Puntoni, S., Reczek, R. W., Giesler, M., & Botti, S. (2021). Consumers and artificial intelligence: An experiential perspective. *Journal of Marketing*, *85*(1), 131-151.

Rifkin, J. (2011), *The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World*, Palgrave Macmillan, New York.

Rogers, E.M. (2003), *Diffusion of Innovations,* 5th ed., Free Press, New York.

Roy, M. and Roy, A. (2019),"Nexus of Internet of Things (IoT) and Big Data: Roadmap for Smart Management Systems (SMgS)," in *IEEE Engineering Management Review*, vol. 47, no. 2 (June), pp. 53-65.

Roy, M. and Roy, A. (2021). "The rise of interdisciplinarity in engineering education in the era of Industry 4.0: Implications for management practice," in *IEEE Engineering Management Review*, vol. 49, no. 3 (September), pp. 56-70.

Salo, A. and, Kuusi O. (2001) Developments in parliamentary technology assessment in Finland *Science Public Policy* 28, 453–464.

Schwab, K. (2017), *The Fourth Industrial Revolution*, Crown Business, New York.

Schwab, K. and Davis, N. (2018), *Shaping the Future of the Fourth Industrial Revolution*, Currency, New York.

Sirgy, M.J. and Lee, D.-J. (2006), “Macro measures of consumer well-being (CWB): a critical analysis and a research agenda”, *Journal of Macromarketing*, Vol. 26 No. 1, pp. 27–44.

Sirgy, M.J., Lee, D.-J. and Rahtz, D. (2007), “Research on consumer well-being (CWB): overview of the field and introduction to the Special Issue”, *Journal of Macromarketing*, Vol. 27 No. 4, pp. 341–349.

Sirgy, M.J., Samli, A.C. and Meadow, H.L. (1982), “The interface between quality of life and marketing: a theoretical framework”, *Journal of Marketing & Public Policy*, Vol. 1 No. 1, pp. 69–84.

Skilton, M. and Hovsepian, F. (2018), *The 4th Industrial Revolution: Responding to the Impact of Artificial Intelligence on Business*, Springer, Cham, CH.

Snow, J. (2017), “This AI traffic system in Pittsburgh has reduced travel time by 25%”, available at: https://www.smartcitiesdive.com/news/this-ai-traffic-system-in-pittsburgh-has-reduced-travel-time-by-25/447494/ (accessed 3 October 2019).

Stearns, P.N. (2018), *The Industrial Revolution in World History,* 4th ed., Routledge, New York.

Tapscott, D. and Tapscott, A. (2016), *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World*, Penguin, London.

van Doorn, J., Mende, M., Noble, S.M., Hulland, J., Ostrom, A.L., Grewal, D. and Petersen, J.A. (2017), “Domo arigato Mr. Roboto: emergence of automated social presence in organizational frontlines and customers’ service experiences”, *Journal of Service Research*, Vol. 20 No. 1, pp. 43–58.

Walker, K.L., Milne, G.R. and Weinberg, B.D. (2019), “Optimizing the future of innovative technologies and infinite data”, *Journal of Public Policy & Marketing*, Vol. 38 No. 4, pp. 403–413.

Wittkowski, K., Klein, J.F., Falk, T., Schepers, J.J.L., Aspara, J. and Bergner, K.N. (2020), "What gets measured gets done: can self-tracking technologies enhance advice compliance?", *Journal of Service Research*, Vol. 23 No. 3, pp. 281–298.

Xu, D. and Wang, H. (2006), "Intelligent agent supported personalization for virtual learning environments", *Decision Support Systems*, Vol. 42 No. 2, pp. 825–843.

Xu, M., David, J.M. and Kim, S.H. (2018), "The Fourth Industrial Revolution: opportunities and challenges", *International Journal of Financial Research*, Vol. 9 No. 2, pp. 90–95.

Yadav, M.S. and Pavlou, P.A. (2020), "Technology-enabled interactions in digital environments: a conceptual foundation for current and future research", *Journal of the Academy of Marketing Science*, Vol. 48 No. 1, pp. 132–136.

Yapchaian, M. (2018), "Human-centered data science: a new paradigm for industrial IoT", *Ethnographic Praxis in Industry Conference Proceedings*, Vol. 1 No. 10, pp. 53–61.

.

Figure 1: IR 4.0 Framework for Technology-Enabled Well-Being

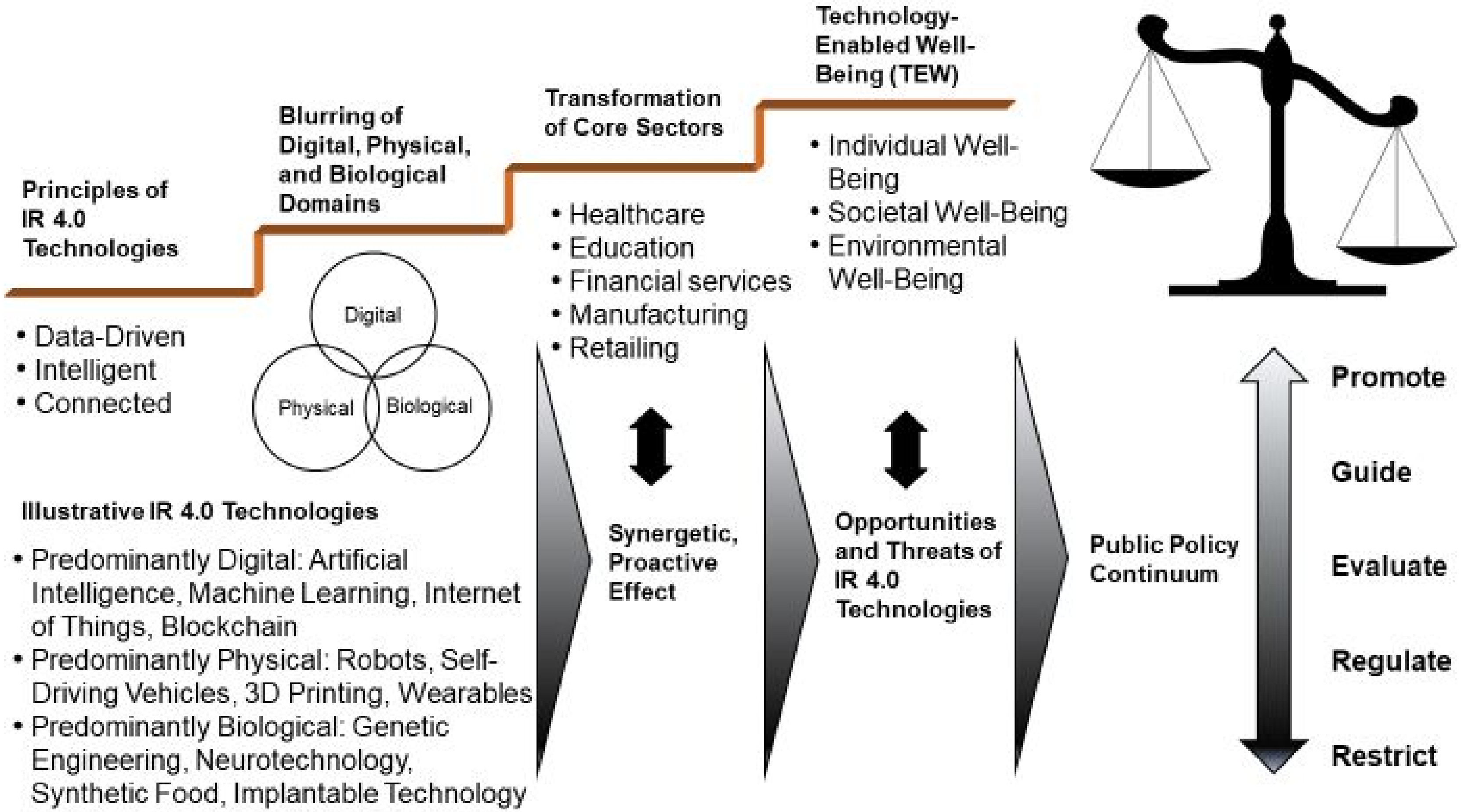

Figure 2: Intersectional Ties of Newer Technologies Across the Three Domains of IR 4.0

IR 4.0 Technologies		Key Domains of IR 4.0		
		Predominantly Digital	Predominantly Physical	Predominantly Biological
Predominantly Digital	Artificial Intelligence	●	◒	◒
	Machine Learning	●	◒	◒
	Internet of Things	●	◒	○
	Blockchain	●	◒	○
Predominantly Physical	Social Robotics	◒	●	○
	Self-Driving Vehicles	◒	●	○
	3D Printing	◒	●	◒
	Wearables	◒	●	◒
Predominantly Biological	Genetic Engineering	◒	◒	●
	Neurotechnology	◒	◒	●
	Synthetic Food	◒	◒	●
	Implantable Technology	◒	◒	●

Table 1: Literature Overview of the Relationship Between Consumer Well-Being and Technology

Author(s)	Definition of Well-Being	Key Objective	Industry Sectors	Intersection of Technological Domains	Type of Interaction (Individual vs. Assemblage)	Proactive Impact of Technology	Level of Well-Being
Çikrıkci (2016)	Positive psychology which focuses on wellness of the individual physically, mentally, and socially (life satisfaction, psychological well-being, self-esteem).	Meta-analysis study to investigate the effect of internet use on well-being.	N.A.	No (Digital)	Individual Technology	No	Individual
Ganju *et al.* (2016)	Subjective well-being as overall happiness or life satisfaction (implicitly including welfare, health, education, living standards).	Exploring the role of information and communication technology (ICT) in enhancing well-being of nations.	N.A.	No (Digital)	Individual Technology	No	Societal
Hoffman (2012)	N.A.	Examine several key factors that may contribute to whether Internet use will lead to increased consumer well-being.	Online Contact	No (Digital)	Individual Technology	No	Individual, Societal
Andrade and Doolin (2016)	Ability to achieve valuable functioning. Achieved well-being or freedom to achieve well-being according to capability approach.	Use of information and communication technologies (ICTs) for inclusion of newly resettled refugees. ICTs as resource for refugees to exercise their agency and enhance their well-being.	Settlement service	No (Digital)	Individual Technology	No	Individual, Societal
Banker and Khetani (2019)	N.A.	Show overdependence of consumer regarding algorithm-generated recommendations.	Online Purchase; Healthcare	Yes (Digital; Physical)	Individual Technology	No	Individual
Čaić *et al.* (2018)	Physical, psychosocial, and cognitive health.	Investigate the potential roles for service robots (i.e., socially assistive robots) in value networks of elderly care.	Elderly Care	Yes (Digital; Physical)	Individual Technology	No	Individual

Author(s)	Definition of Well-Being	Key Objective	Industry Sectors	Intersection of Technological Domains	Type of Interaction (Individual vs. Assemblage)	Proactive Impact of Technology	Level of Well-Being
Mende *et al.* (2019)	N.A.	Examine whether these humanoid robots (compared with human employees) will trigger positive or negative consequences for consumers and companies.	Food service	Yes (Digital; Physical)	Individual Technology	No	Individual
Anderson *et al.* (2016)	Personal and societal well-being (including e.g., health, environmental sustainability, poverty).	Develop a conceptualization of resource integration under responsibilities with different actors and identification of different resource-integration practices to negotiate responsibilities.	Healthcare	Yes (Digital; Physical)	Individual Technology	No	Individual, Societal
Wittkowski *et al.* (2020)	Consumers' overall perceptions of their quality of life and health status.	Investigate if self-tracking technologies enhance advice compliance and whether it depends on consumers' self-efficacy.	Healthcare	Yes (Digital; Physical)	Individual Technology	Yes	Individual
Harvey *et al.* (2020)	Personal and social well-being.	Examine how and why consumers automate smart domestic products.	Home appliances	Yes (Digital; Physical)	Individual Technology	Yes	Individual
Agarwal *et al.* (2020)	Perceived benefits on micro- and macro-level as customer value in healthcare ecosystem.	Developed framework of value-centered marketing in healthcare. Described how emerging technologies can be used in healthcare system.	Healthcare	Yes (Digital; Biological)	Individual Technology	Yes	Individual, Societal
Our Article	*State of balance between individual, societal, and environmental needs and available resources provided by data-driven, intelligent, and connected IR 4.0 technologies.*	*Theorize technology-enabled well-being, examine opportunities and threats associated with IR 4.0 technologies and discuss public policy implications.*	*Healthcare; Education; Financial services; Manufacturing; Retailing*	*Yes (Digital; Physical; Biological)*	*Assemblage of Technologies*	*Yes*	*Individual, Societal, Environmental*

Table 2: Public Policy Implications in the Context of IR 4.0 Technologies and Technology-Enabled Well-Being

Key Domains of IR 4.0		Example	Public Policy Action	Well-Being Implications
Predominantly Digital	Emerging Issue: **Regulate or Restrict Data Misuse**	Individuals lose control of their private data that can be exploited for commercial and criminal ends. Institutions (financial & insurance companies) may take advantage of personal data by offering a lower price to premium consumers if personal data are not concealed.	To mitigate the threat institutions should Provide data control (GDPR) and set standards for application in case of security breach or hacking. Furthermore, to mitigate the threat institutions should increase transparency in product production and tracking.	People are regaining confidence in the use of new technologies. The openness to share data for meaningful and safe generation of synergistic benefits for individuals and society such as data-based investigation of diseases.
	Emerging Opportunity: **Guide or Promote Education Access**	Lifelong learning of the population through online education and access to open-source-based platforms contributes to education of all ages as well as provide education to disadvantaged segments of the society.	To promote this opportunity institutions should ensure worldwide access by ensuring free and fast online access. They also should provide a smart societal infrastructure through the public use of IR 4.0 to develop population skills and digital capabilities.	Give people knowledge and competencies to succeed in life, promote their mental health and financial well-being. Thus, creating human potential to make the world a better place.
Predominantly Physical	Emerging Issue: **Evaluate Legal Responsibility**	Automation and AI decision-making can lead to legal and ethical issues (traffic accidents, misdiagnoses, fatalities) which raises the question regarding responsibility and liability.	To mitigate the threat institutions should identify dilemmas of accountability and interrelatedness and prepare protection for affected persons according to legal and ethical standards.	When people are fully informed about the potential dangers but also the possible responsibilities, mental and financial security is provided, which increases well-being.
	Emerging Opportunity: **Promote Assistance to Fragile Population**	Robotic can provide supportive needs to fragile population regardless of mobility and physical impairments.	To promote this opportunity technology could supplements the care provided by humans (especially in healthcare).	Social interaction and providing companionship are improving health and psychological well-being.
Predominantly Biological	Emerging Issue: **Evaluate Adoption Barriers**	Lack of trust and knowledge in advanced biological technologies creates barriers for adoption from a part of the population, especially manipulation of genes and organ reproduction raise societal concerns.	To mitigate the threat, institutions should set-up panels, workshops, roundtables, conferences and support bottom-up processes with key stakeholders to inform about potential societal benefits.	Education in all social classes would increase the openness to novel biotechnological technologies and thus create a new potential for health-related well-being.
	Emerging Opportunity: **Guide on Medical Advancement**	Synergetic use of IR 4.0 technologies such as 3D printing, genetic engineering, and neuroscience to improve early diagnosis, prevention and especially treatment of diseases.	To promote this opportunity institutions should communicate about quality-of-life improvements and at the same time develop ethical protocols.	The population's quality of life and life expectancy can be drastically improved and thus increase health-related well-being.

Technology-Enabled Well-Being in the Era of the 4th Industrial Revolution: Marketing and Public Policy Implications

Abhijit Roy
Professor of Marketing
Kania School of Management
University of Scranton
320 Madison Avenue, Scranton, PA 18510
Phone : 570-941-7715
Email: roya2@scranton.edu

Marat Bakpayev
Assistant Professor of Marketing
Labovitz School of Business and Economics
University of Minnesota Duluth
1318 Kirby Drive, Duluth, MN, 55812
Phone: 218-726-8483
Email: mbakpaye@umn.edu

Melanie Florence Boninsegni
Assistant Professor in Marketing
Department of Marketing and Communication
IPAG Business School
184 Blvd Saint-Germain
75006 Paris, France
Phone : +33 1 5363 3600
Email : m.boninsegni@ipag.fr

Smriti Kumar
Visiting Assistant Professor,
Northeastern University
360 Huntington Avenue
Boston, Massachusetts 02115
Phone: 413-545-5663
Email : sm.kumar@northeastern.edu

Jean-Paul Peronard
Associate Professor
Department of Business Development and Technology
Aarhus University
Birk Centerpark 15
DK-7400 Herning, Denmark
Phone: +45 87164700
Email: jeanpaul@btech.au.dk

Thomas Reimer
Assistant Professor in Consumer Behavior
Department of Sociology, Environmental and Business Economics
University of Southern Denmark
Degnevej 14, DK-6705 Esbjerg Ø, Denmark
Phone: +45 65 50 12 60
Email: thore@sam.sdu.dk

Submitted to:

Journal of Consumer Marketing

November 2021/ Revised August 2022/ January 2023 [Final]