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Review Article

Technological innovation and public value creation: A multidisciplinary evaluation

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ABSTRACT: Innovation (e.g., technological, sustainable, social, etc.) should be able to create value. The key objective of this paper is to evaluate public value creation and improvement via technological innovations and present a general position. This paper adopts a simple evaluation strategy by exploring viewpoints/positions, dimensions, realities, and pieces of evidence in some selected relevant literature, documents, and reports. The multidisciplinary evaluation of how technological innovations help to create or improve public value shows a relatively similar outlook from the dimensions of objectives, strategies, limitations, and outcomes/successes. One of the key discoveries from this paper relating to the objective dimension in the disciplines of social sciences is that tech innovation mainly focuses on enhancing well-being, dignity, human rights, and prosperity for all (individuals, societies, the environment, and the world). Concerning the objective dimension in the disciplines of the humanities, tech innovation focuses on promoting cultural diversity, inclusion, and responsible communication. Regarding the objective dimension in disciplines of physical and natural sciences, tech innovation focuses on reducing/eradicating dehumanization, social, economic, psychological, and environmental challenges (e.g., climate change and biodiversity depletion). The originality of this paper is premised on the fact that presently very little attention is given to this kind of topic, especially from a multidisciplinary perspective. Therefore, this paper attempts to contribute to the multidisciplinary evaluation gap that exists between technological innovation and public value creation. The general position of this multidisciplinary evaluation is that public value creation is the key goal of tech innovation across many disciplines.

***KEYWORDS*:** technology; innovation; public value; Industry 4.0; sustainability; multidisciplinary

1. Introduction

Innovation is concerned with a new way, pattern, or idea. Intellectual, ideological, and cultural views differ significantly across space, time, and place when the concept of innovation is brought into context. Innovation in general is primarily meant to create value[1]. The major question then becomes: what kind of value and level of impact is innovation meant to inform/achieve? OECD[1] further argues that personal/individual, business/entrepreneurial, public/societal, and national and global aspects are some of the areas in which innovations must try to create value and good.

Within the technological innovation context, some advocacies relating to the need for and importance of innovations can be traced to the 'design and development school of thought', while other

advocacies relating to the need for, and importance of innovations can be traced to the 'adoption and usage school of thought'[2]. Within the 'design and development school of thought', arguments or advocacies relating to innovations are mainly about the need for and importance of conceptualizing/idealizing, designing, and developing new technologies such as Artificial Intelligence (AI), Robotics, and other Smart, Green, and Sustainable Technologies[3]. Within the 'adoption and usage school of thought', arguments or advocacies relating to innovations are mainly about the need for and importance of adopting and using technological ideas, tools, and infrastructures such as digitalization, the internet, space technologies, etc.[4].

The 'design and development' and 'adoption and usage' schools aim to create value, especially public values from different dimensions/standpoints[2]. Hence, the need to explore the nature of public values created and being created by technological innovations becomes imperative. In addition, exploring the objectives, strategies, limitations, and successes associated with some disciplines in the creation of public values via technological innovations is also crucial. Innovations (e.g., technological, sustainable, social, etc.) should be able to create value. However, the nature of value that innovations should create/improve is often complex or difficult to identify, study, or understand. Papers, studies, or research dealing with the evaluation of how technological innovations help to create public value are often missing or rare. Therefore, it is viable to argue that a great gap exists in this aspect.

The main objective of this paper is to evaluate the nature of public value creation through technological innovation from some selected disciplines' perspectives. In addition, this paper tries to examine the key objectives, strategies, limitations, and outcomes/successes relating to technological innovations and public value creation from the dimensions of the selected disciplines and offers a general position from the multidisciplinary evaluation. This paper adopts a simple evaluation strategy by exploring viewpoints/perspectives, positions, realities, and pieces of evidence in some selected relevant literature, documents, and reports.

1.1. Innovation and change management

The concept of innovation as earlier described is related to a new way, pattern, or idea. Therefore, it is meaningful to interlink the concepts of innovation and change. Most emerging global, national, social, economic, environmental, technological, and political events and developments are influenced by the 'change mantra'[5]. 'Change is often described to be the only constant in life', and individuals, groups, institutions, societies, and nations that refuse to change with times and situations often encounter the survival challenge(s) or lose their competitive advantage(s). The integration of the global economy and cross-border sharing of ideas/intelligence in relation to science, education, administration, and security have led experts to identify "place" as one endangered species of reformation because one reform idea can now be applied at the local, regional/state, federal/national and global levels simultaneously. Change management in most disciplines has a strong background in contemporary global issues such as technological innovations and their safety. Change management is often referred to as the general strategy adopted in teaching and helping institutions, governments, administrations, groups, societies, and individuals to pursue and realize change. It is through the adoption of change management, that innovations relating to products and service designs/outlooks are achieved and Sustainable Development Goals (SDGs) by the United Nations are supported/promoted[6,7].

Accountability, integrity, openness, and inclusiveness for examples within the interlink of innovation and change is to create better public value in public service provision to citizens and societies, improve technological safety, reduce dehumanization, exploitation, addictions, privacy

challenges/issues, human rights violations, etc. The advocacies of relevant ethical values within the innovation and change interlink are to improve institutional (e.g., public, private, and voluntary/humanitarian) performances and to find answers and solutions to different questions, issues, and challenges that emerged and still emerging via the change and innovation processes and procedures. The innovation ecosystem as an integral concept, idea/theory is often presented as a representation of a great number and different types of participants and resources that help in the realization of innovation objectives. Included in the broader framework are researchers, technicians, entrepreneurs, academic institutions, investors, manufacturers, developmental professionals, students, etc. The quadruplex helix development as another integral concept, idea, or theory on the other hand concerns the aspect of innovative development that focuses on enhancing interactions and development via industry, academia, government, and citizens[6,8].

1.2. Technology governance and sustainable development

From a contemporary standpoint, advocacies, and arguments for the creation of public value through technological innovations are embedded and traceable to the theories/ideas of Technology Governance and Sustainable Development. Via these theories issues relating to emancipation, prosperity, and sustainability are problematized and operationalized. The key goal of these theories/ideas is mainly to enhance humanity, the environment, societies, and the globe in general from different perspectives.

Technology governance offers great opportunities for examining the positive and negative sides of technological innovation because for example data is the new oil, and tech-racism is a reality. Technology governance is an essential framework for creating balance and fairness, enhancing sustainable development goals, studying, and enhancing partnership building, collaboration, coordination, accountability, and transparency between relevant stakeholders on matters relating to technology and its innovation. In addition, via the framework of technology governance, examining and improving/reforming outcomes (e.g., social and environmental outcomes) and requirements (e.g., minimum and extra requirements) can be addressed. Technology governance is a broad concept. Technology governance is a public policy concept. Technology governance focuses on the relationships that exist between sectors such as public, private, and non-profit in enhancing the development and application of technology. Technology governance shares many similar contents, ideas, and components with theories such as Innovation Ecosystems, Quadruplex Helix Development, Triple Helix Models, and Cooperate Social Responsibilities (CSR). The key idea is premised and guided by techno-economic paradigm shifts (the theory that focuses on the economic and social impacts of technology and the need for modifications) and innovation emphasis and analysis. Technology governance focuses on numerous global issues relating to strategies, policies, and methods for guaranteeing effective and efficient technologies. Technology governance offers opportunities for multiple stakeholders to share knowledge and information in enhancing decisions that affect public policy on technology topics. The interactions of these relevant stakeholders (organizations, experts, non-governmental organizations, international organizations, citizens, etc.) help to initiate the necessary steps and reforms that bring about the desired and sustainable outcomes. Technology governance emphasizes the participation of many stakeholders (e.g., organizations, experts, and citizens) globally for the purpose of guaranteeing sustainable results and success of technologies[9].

Examples of technology that requires governance are artificial intelligence and ICT. Artificial Intelligence (AI) governance, for example, according to Tauli[10], is about evaluating and monitoring algorithms for effectiveness, risk, bias, and return on investment (ROI), but this aspect is often neglected

in the AI process. Different technology models can be identified via the technology governance framework. Key examples of these models include AI governance, Smart City governance, Internet governance, ICT governance, and FINTECH governance models. The AI governance model helps to understand the transformative roles, societal and environmental impacts, and the ethical and legal challenges associated with AI technology[9]. The smart city governance model focuses on the debate about whether a smart city is a pragmatic solution for modern challenges or just a technology-led urban utopia; and the steps and strategies to adopt in the realization and ideal functioning[11]. The Internet governance model focuses on the different debates that emphasize the usage, benefits, challenges, functioning, and reformation of the Internet[12]. The ICT governance model focuses on the different debates that emphasize the usage, benefits and challenges, functioning, and reformation of Information Communication Technology (e.g., the model for ICT in education, the model for ICT in the public sector (e.g., hospitals), the model for ICT in the private sector). The FINTECH governance model focuses on the different debates that concern the ethical and legal responsibilities that enhance the usage and adoption of financial technology (e.g., the safety of banking software and sustainable mining of cryptocurrency).

Sustainable development relates to the development that positively affects the needs of the present generation and at the same time does not jeopardize the needs of future generations. Sustainable development aims to focus on giving solutions to universal/global issues such as climate change, inequality, dehumanization, poverty, environmental degradation (with the inclusion of biodiversity extinction), injustice, and conflict[9].

2. Value as a multidisciplinary concept

Value is a multidisciplinary concept and the strategies for creating values also differ from one discipline to another. Value is an issue of perception and necessity. Value can often be associated with ethics and interchangeably used in some situations or contexts. While ethics is connected to the guidelines for conduct, via which questions of morality are addressed, value on the other hand offers the principles and ideals upon which judgement is made on issues of relevance. It is possible to summarize, therefore, that 'Ethics' is a system of moral principles, whilst 'Value' is a thought stimulator[13].

Values are principles that guide our evaluation of what is good and acceptable. In addition, values offer the normative control that guides decision-making, because they develop grounds for action and reflect conceptions of acceptable or unacceptable actions. It is through values we understand the need for trust and the evil of dehumanization, corruption, and human rights violations. Integrity, responsibility, professionalism, caring, teamwork, and stewardship are often necessary to be included in a vision; because they tell what a nation, organization, and people represent. The quest for greatness and transformation must start with personal commitment within everyone in a society or group to pursue moral excellence. The concept of governance or management implies a value assessment and is thus value laden. Values connected to care require recognizing or providing a set of principles about responsibility for the good of others that should shape both public and private life[14]. Some ethical values are integrity, virtue, commitment, professionalism, care, justice, and responsibility.

From a broader background, the concept of value is connected to something highly considered useful, worthy, important, special, unique, rare, etc. If something is described in this manner, then it is possible to conclude that something like that is deserving. Value is said to be a multidisciplinary concept because different sectors are driven by different motives, goals, and management philosophies. The public sector is often driven by the key motive to provide public services to the citizens and maintain law and order in society. The private sector is often driven by the key motive to provide goods and services for the purpose

of making a profit. The third sector is driven by the key motive of providing goods and services for humanitarian and voluntary purposes[15]. If the concept of value is a multidisciplinary concept, then what is public value? It is this question we try to answer in the next section of this paper.

Technological innovation and public value creation framework or model

Public value is often defined or associated with the value that a sector, institution, organization, discipline, or activity offers to society because broader societal good is enhanced and promoted through public value. In the beginning, public value was only associated with the public sector, but as time progressed the idea of public value became a part of the private and third sectors discourses. Public value as a social-psychological-based concept, evolves within the boundaries of social structures and relationships because of lessons learned and knowledge gained from social structures and relationships. The lessons learned and knowledge gained are aimed and used as measurement standards and assets for promoting and enhancing the well-being and living standard of the people. Some experts have identified that the key objective and driving force behind the public value idea is to enhance managers' orientations on the 'common good'. In recent times, however, the public good idea has become a framework for encouraging managers to make positive impacts relating to the 'common good' through their entrepreneurial engagements, policies, procedures, and activities. The public value idea is strongly related to management concepts such as sustainability, corporate social responsibility, and stakeholder value because the common good is also promoted, enhanced, and positively impacted through these management concepts[6,15].

In relation to public value creation through technological innovation; organizations, management, and managers often promote and adopt different frameworks or models. One important dimension or perspective to study and understand useful frameworks/ models for public value creation is the Industrial Revolution perspective/dimension. From the First Industrial Revolution to the current Fifth (though still emerging and being articulated) Industrial Revolution, different frameworks/models for public value creation can be identified. In the First Industrial Revolution, public value creation was a key emphasis in this era that occurred between 1740 and 1840 in England, because it was one of the most crucial, innovative, and developmental periods in human history. One of the notable achievements in relation to the creation of public value in the First Industrial Revolution was the establishment of global human prosperity through technology. In the Second Industrial Revolution, which occurred between 1870 and 1914, public value creation was also a key emphasis. In this era, a visible and rapid rate of pathbreaking inventions (macro-inventions) and technological progress that was defined in terms of productivity increase and improvements in product quality was witnessed in areas such as energy, materials, chemicals, and medicine[16,17].

The Third Industrial Revolution started in the latter half of the 20th century and Digital Revolution was the main feature and hallmark of innovation because a radical transformation from mechanical and analog electronic technologies to digital electronics was witnessed. The key goal of technological transformation witnessed in this era was also to enhance Public Value creation; especially, in the aspect of ushering in better human communication/interaction, economic prosperity, and human living standard upliftment. For the Fourth Industrial Revolution, we are going to focus on that in the next paragraph, because that is where we will examine a technological innovation model or framework for Public Value creation in-depth. The Fifth Industrial Revolution is mostly described presently as an idea in progress, but the Fifth Industrial Revolution hopes to enhance Public Value creation by deepening the integration between humans and technology. Presently, there are numerous discussions going on in

different countries and organizations regarding the "Fifth Industrial Revolution," which follows on from the Fourth Industrial Revolution. Hopefully, the Fifth Industrial Revolution will incorporate concepts such as "sustainability," "human-centeredness," "concern for the environment", and "transformation of the industrial structure via the utilization of AI, IoT, big data, etc."[18,19].

Regarding the Fourth Industrial Revolution, conflicting arguments exist on when it really began, some supporting the very end of the 20th century and others supporting the beginning of the 21st century. Industrial 4.0 is a model or framework associated with the Fourth Industrial Revolution through which Technological Innovation is used to enhance Public Value creation. It is often argued that the Fourth Industrial Revolution, which is also known as "Industry 4.0" grew out of the 1st, 2nd, and 3rd Industrial Revolutions. The interconnectedness of industrial systems via the use of the Internet of Things (IoT), automated machinery, real-time data management, and analysis, as well as other technologies, are the key features of the Fourth Industrial Revolution[20]. To create Public Value through technological innovation, Industry 4.0 is built on a model/framework, that is made up of Nine Technology Pillars. These Technology Pillars used for Public Value creation under Industry 4.0 are presented and briefly explained in **Table 1** below:

Table 1. Industry 4.0 model for public value creation[21–24].

Nature of technology used for public value creation	**A brief explanation and linkage to public value creation**
Internet of Things (IoT)	This aspect of Industry 4.0 concerns communication systems that are effective and reliable in enabling companies to create effective communication platforms and infrastructure so that connectivity can be maintained: especially, in logistics. Through IoT networks, different smart devices can be linked, monitored, communicated, and controlled so that business issues and data access-related problems can be settled. Public value is created from this perspective in multiple ways (e.g., IoT technology helps individuals and companies to track products and provides remote access controls, real-time updates, and resolve queries related to the products and data tracking).
Big data and AI analytics	This aspect of Industry 4.0 is the adoption of processes and technologies, including AI and machine learning in combination to analyse large datasets with the aim of identifying patterns and developing actionable insights for faster, better, data-driven decisions that can improve efficiency, revenue, and profits. Public value is created from this perspective in multiple ways (e.g., the realization of better products and services and quality and improved income for the individuals and society).
Cloud computing	This aspect of Industry 4.0 helps in logistics operations and activities via cloud-based servers and programs by which it is easy to access services and deal with data storage and management-related issues. Public value is also created from this perspective in multiple ways (e.g., helps in enabling consumers to receive real-time updates and track data in less time via which operational efficiency and productivity can be improved).
Cybersecurity	This aspect of Industry 4.0 helps guarantee security via the application of technologies (e.g., blockchains and machine learning), processes, and controls to protect systems, networks, programs, devices, and data from cyber-attacks or other threats. Public value is also created from this perspective in multiple ways (e.g., helps individuals and societies to reduce the risks relating to cyber-attacks and ensures protection relating to unauthorized exploitation of systems, networks, and technologies).
Augmented reality	This aspect of Industry 4.0 helps to place computer-generated images on users' views of the real world, thus offering or revealing composite views. Public value is also created from this perspective in multiple ways (e.g., helps to boost individuals' and societies' intellect and analytical skills).
Autonomous robots	This aspect of Industry 4.0 helps to perform tasks and function in an environment independently, free of human control or intervention through programmed and inserted information during design and engineering. Public value is also created from this perspective in multiple ways (e.g., helps individuals and societies to execute complex and heavy tasks and responsibilities speedily and easily).

Table 1. (*Continued*).

Nature of technology used for public value creation	A brief explanation and linkage to public value creation
Additive manufacturing 3D	This aspect of Industry 4.0 helps in the act or process of merging materials to produce objects from 3D model data, which is often executed via layer-upon-layer manufacturing methodologies, as opposed to traditionally subtractive manufacturing methodologies or digital fabrication technique that produces physical items from a geometrical model via the addition of materials. Public value is also created from this perspective in multiple ways (e.g., helps individuals and societies to avoid material waste and reduces start-up costs).
Simulation	This aspect of Industry 4.0 helps in producing a computer model of something to assist and enhance study or imitation. Public value is also created from this perspective in multiple ways (e.g., helps to develop and enhance the intellectual capacity of individuals and societies).
Horizontal and vertical integration	Finally, this aspect of Industry 4.0 helps in realizing unprecedented amounts of synergy or alignment across entire organizational ecosystems, from the factory floor to enterprise-level systems, across the supply chain, and in every process, business department, and third-party partner. Finally, public value is also created from this perspective in many ways (e.g., helps individuals and societies to easily comprehend the processes of producing goods and services and quickly detect relevant complaint channels for proposing improvement).

In summary, Industry 4.0 is the rise of digital industrial technology, because these technological innovations or transformations allow us to work alongside machines in new, highly efficient, effective, and productive patterns[20]. In **Table 1** above, we can observe the uses of the different technologies under Industry 4.0 and some ways they help in creating public value for individuals and societies.

3. Technological innovation and public value creation from a social sciences perspective

Social science is a group of academic disciplines that focus on the study, which deals with human behaviour from its social and cultural perspectives. Some examples of disciplines in social sciences are Criminology, Psychology, Anthropology, Political Science, Sociology, Public Management and Administration, Geography, Economics, Business Studies, etc. Advocacies and orientations relating to technological innovation are of many outlooks. The adoption or use of technology in the conduct of activities relating to this discipline is often advocated, but advocacy relating to development, design, modernization, and updating/upgrading of technology in the conduct of activities is also common to come across.

In most recent discourses and advocacies from many disciplines in social sciences, the potential of the recent innovative technologies and strategies to transform governance and relevant activities in meeting citizens' expectations and finding solutions to societal problems have been identified. These positions are so because creating and improving public value require technology to shape current and future public organizations and management. The process of change in public value generation over time requires various types of technologies (from mainframes to websites and social media and beyond), because of different public management paradigms (from traditional public administration to new public management). This can effectively and efficiently occur via open and collaborative innovation processes that are developed under this emergent technological wave in encouraging transformative practices in the public sector, societies, and globally[4].

Economic, environmental, social, political, health, and cultural challenges that affect humans, societies, the environment, and the world often inform the need to explore the possibilities of innovative technologies in finding solutions to these challenges by creating and improving public value. These

challenges and others are key foci under social sciences as issues that demand attention and solutions. According to many innovation scholars, to think about finding solutions to challenges related/embedded in social sciences is to think about improving or creating public value, because public value offers innovative ways to plan, design, and implement transformative initiatives (e.g., digital government). Creating public value through technological innovation is a key goal of every discipline in the social sciences in their daily business/activities. In the growing field of smart government and smart cities, which focuses on IT-enabled innovations in the social, economic, political, administrative, criminal, psychological, business, anthropological, geographical, or public sphere, different challenges have been witnessed within the framework of innovations due to complex technologies, high investments, and the numerous stakeholders involved. To find solutions to this issue, some branches of governments in continental Europe have turned to collaborative innovation approaches, partnering with (semi-)public utility companies in the hope that their additional innovation assets will enhance innovativeness and public value creation[7,25].

Within the discourses of technological innovations creating and improving public value in social sciences disciplines, different strategies are propagated, promoted, proposed, or adopted. In an attempt to create or improve public value through improved, efficient, and effective public service delivery; enhancing productivity and profit; improving the well-being, dignity, human rights, skills, and positive impacts of individuals, communities, and societies; promoting greener and sustainable environment; enhancing ethical standards and values; improving organizational efficiency and effectiveness; realizing effective and efficient technologies and tools; etc., it is common to come across therefore, topics such as smart city, smart aviation, smart agriculture, artificial intelligence (AI), digitalization (e.g., digital government and digital economy), green transformation, green deal, robotics, and smart specialization, green and smart aviation, green and smart marine and transportation, etc.[25,26]. However, Osifo[27] has identified some of the following as challenges of technological innovations to creating public value: Autonomy and Independence; Financial Limitations; Lack of Awareness and Issues of Participation and Trust; Rules and Regulations (e.g., GDPR); Addiction and Monotony; Ethical Issues; Social and Cultural Biases; Security (e.g., hacking, virus and malware) and Privacy Issue; Orientation towards Gains (profit) and Competition; Developmental Inequalities; Illiteracy and Non-Acceptance; Big Data or Data Deluge; Ambiguity and Complexity; Poor Policy Planning and Approval; Language and Beliefs; etc. Since these challenges are of mixed outlook, careful steps must be taken in order to not spoil or eradicate the gains made already in technological innovations creating public value.

4. Technological innovation and public value creation from a physical and natural sciences perspective

In many instances, natural science and physical science are often used interchangeably, because they are similar in most aspects. Natural science is a group of disciplines that focus on the study of all living organisms; examples of such disciplines are Medicine, Biochemistry, Agriculture, Optometry, Dentistry, Psychiatry, etc. Physical science on the other hand is a group of disciplines that focus on the study of non-living natural objects, through experiment, observation, analysis, and deduction. Examples of such disciplines are Engineering, Mathematics and Statistics, Computer Science, etc.

In most discourses in many disciplines in physical and natural sciences, the impact and willingness to innovate is often measured with specific indicators, because this is how public value is created. For example, Tartaruga et al.[28] used sociocultural indicators to study propensities to innovate in specific social groups. According to them, the confluence of investigations in the field of Public Understanding

of Science and Innovation Studies, the key indicators of the propensity to innovate were identified and they are efficiency, creativity, trust in science and technology, uncertainty tolerance, and cooperation. Models to create and improve public value in the various disciplines of physical and natural sciences often differ from one discipline to another. According to the University of Twente[29], one good model in this regard must start and include relevant stakeholders, a timeframe for the desired impact (with the inclusion of core values, core competencies, ethics and responsibilities, and core activities), vision to create public value and shape societal and individual outlooks by focusing on honest and technological innovations.

Within the discourses of technological innovation creating and improving public value in natural and physical sciences disciplines, different strategies are also propagated, promoted, proposed, or adopted. In an attempt to create or improve public value via the improvement of product safety, standard, and design; realizing efficient and effective public service delivery; enhancing productivity and profit; improving the well-being, dignity, human rights, skills, and positive impacts of individuals, communities, and societies; promoting greener and sustainable environment; enhancing ethical standards and values; improving organizational efficiency and effectiveness; realizing effective and efficient technologies and tools, and many others, it is common to come across therefore, topics such as waste management, environmental protection and conservation, smart city, smart aviation, smart agriculture, artificial intelligence (AI), digitalization (e.g., education, digital government and digital economy), green transformation, green deal, robotics, and smart specialization, green and smart aviation, green and smart marine and transportation, co-creation, ethics and responsibility, space commercialization, e-medicine (etc., e-prescription), data science and management, cybersecurity, etc.[5,30]. According to Bozeman[8], commitments to highly invest in science and technology bring about innovation and the key outcomes and benefits of innovation are advances in productivity, economic development, and wealth creation; these improvements in economic conditions lead to better life and standard of living for individuals and communities.

Scientific, natural, economic, social, political, health, and cultural challenges that affect humans, societies, the environment, and the world often inform the need to explore the possibilities of innovative technologies in finding solutions to these challenges by creating and improving public value. These challenges and others are also key foci under physical and natural sciences as issues that require actions. Also, according to numerous innovation scholars, to think about finding solutions to challenges related/embedded in natural and physical sciences is to think about improving or creating public value, because public value offers innovative ways to plan, design, and implement transformative ideas (e.g., data management and security). Creating public value via technological innovation is a key goal of every discipline in the natural and physical sciences both in their daily business or activities. In the growing field of data science and management, which focuses on the digital revolution, nurturing data scientists who excel in both technical-scientific (STEM) and business domains. This area also focuses on an inquiry-based educational model, where students and other individuals take active roles in all the various pillars of their learning experiences (e.g., project works with companies, hackathons, competitions, and interactions with top academics and industry leaders on hot topics such as artificial intelligence, machine learning, and big data analytics, and their implications for businesses at both the national and international levels). In summary, technological innovations relating to data science and management create and improve public value by boosting cybersecurity, e-medicine, e-government, e-commerce, space exploration, environmental protection, biodiversity management, conservation of wildlife and marine, etc.[5,30].

Some of the identified challenges relating to technological innovations in creating or improving public value in natural and physical sciences are Ambiguity and Complexity in Tech Procedures and Processes; Autonomy and Independence; Inadequate Expertise and Personnel Shortages; Financial Limitations; Social and Cultural Biases; Lack of Awareness and Issues of Participation and Trust; Rules and Regulations (e.g., GDPR); Addiction and Monotony; Ethical Issues; Addiction and Monotony; Security (e.g., hacking, virus and malware) and Privacy Issue; Orientation towards Gains (profit) and Competition; Developmental Inequalities; Illiteracy and Non-Acceptance; Big Data or Data Deluge; Poor Policy Planning and Approval; Language and Beliefs; etc. Since these challenges are also of mixed outlook, careful steps must be taken to not spoil or eradicate the gains made already in technological innovations improving or creating public value[8,27].

5. Technological innovation and public value creation from a humanities perspective

Humanities as a field is made up of a group of academic disciplines that focus on interpretation of culture and humanity; in addition is the teaching of valuable skills. Some of the disciplines that make up humanities are Philosophy, Arts, Linguistics, Communication, and Arts. In many recent discourses and advocacies from many disciplines in humanities, the potential of recent innovative ideas (e.g., Biosemiotics, Cybernetics, and Cybersemiotics) and strategies to boost transdisciplinarity have been identified. Boosting transdisciplinary approaches in most disciplines of humanities is to create and improve public value through a deeper consciousness, interpretation, and understanding of cultures (e.g., intercultural studies), languages, communication, administrations, arts, and philosophies[31]. Within the discourses of technological innovations creating and improving public value in disciplines of humanities, different strategies are also propagated, promoted, proposed, or adopted. In an attempt to create or improve public value via the improvement and understanding of technological tools; decolonization of the internet (e.g., minority representation in metaverse); realizing efficient and effective public service delivery; enhancing productivity and profit; improving the well-being, dignity, human rights, skills, and positive impacts of individuals, communities, and societies; promoting greener and sustainable environment; enhancing ethical standards and values; improving organizational efficiency and effectiveness; realizing effective and efficient technologies and tools, and many others it is common to come across topics such as Social Media, Augmented Reality (AR), Virtual Machine Environment (VME), Digitalization (e.g., e-government and digital economy), AI and Generative AI, Metaverse, etc.

Technological innovation creating and improving public values in humanities mainly aims to influence human consciousness, because of the transformation it offers. In the current stage of the institutionalization of the digital economy, for example, technological innovation aims at assisting people to adapt to the new environment and play the most important role. The interaction between key types of innovative technologies has made it possible to characterize the process of institutionalization of a new type of economy that is known as the digital economy. In the preliminary stage, technological innovations trigger organizational changes needed for making a transition to new business models and mechanisms of institutional change at the upper stage. In the intermediate stage, technological innovations in humanities become a priority, because they make it possible to influence and direct options made by consumers and businesses via the institutional market toward digital solutions and models of behaviour. In the advanced stage, a full-scale launch of the institutional market mechanism and institutionalization of the digital economy will assist in identifying a set of key technologies and making a holistic prediction about evolving and future technologies. The holistic interactions that occur via

technological innovation processes and procedures help to enhance the competitiveness of companies in corresponding markets as well as to improve national policy in this area. When all these are realized public value is created and improved from different dimensions[32,33].

Cultural, communicative, economic, social, political, administrative, and health challenges that affect humans, societies, communities, nations, the environment, and the world often inform the necessity to examine the possibilities of innovative technologies in finding solutions to these challenges by creating and improving public value. These challenges and others are also key foci under humanities as issues that require actions. Also, according to numerous innovation scholars, to think about finding solutions to challenges relating to the field of humanities is to think about improving or creating public value, because public value offers innovative ways to study and understand humans and the composites of societies (e.g., intercultural communication). Creating public value via technological innovation is also a key goal of every discipline in the humanities both in their daily business or activities. In the growing area of social media and its impacts from different dimensions. Social media as an interactive technology enhances the creation and sharing of ideas, perspectives, information, data, interests, and content via networks and virtual communities. Technological innovations in humanities create public value by examining the successful exploitation of new ideas by adding value to products (e.g., artworks) and services (e.g., language translation or interpretation), because of the need to create and maintain high-value products and services that are prized within global markets. Technological innovations from the perspectives of many disciplines in humanities also focus on creating public value via the commitment to trying to find solutions to social and natural issues. Solutions to social and natural problems such as terrorism, climate change, public health issues, and aging populations will need new thinking and the collective use of technological, cultural, social, and economic innovations and adjustments[34,35].

Some of the identified challenges relating to technological innovations in creating or improving public value in humanities are Social and Cultural Biases; Ambiguity and Complexity in Tech Procedures and Processes; Autonomy and Independence; Inadequate Expertise and Personnel Shortages; Financial Limitations; Lack of Awareness and Issues of Participation and Trust; Rules and Regulations (e.g., GDPR); Addiction and Monotony; Ethical Issues; Addiction and Monotony; Security (e.g., hacking, virus and malware) and Privacy Issue; Orientation towards Gains (profit) and Competition; Developmental Inequalities; Illiteracy and Non-Acceptance; Big Data or Data Deluge; Poor Policy Planning and Approval; Language and Beliefs; etc. Since these challenges are also of mixed outlook, careful steps must be taken in order not to spoil or eradicate the gains made already in technological innovations improving or creating public value in humanities[8,27,34].

6. A multidisciplinary synthesis of technological innovation and public value creation

To make the arguments in this paper clearer, a synthesis of perspectives from the various disciplines relating to how technological innovations create or improve public value is needed. According to Bakhshi et al.[34], multi-disciplinary research concerns the coming together of two or more different disciplines or fields of study to conduct joint research and make new discoveries. In **Table 2** below, a multidisciplinary synthesis is presented from the dimensions of objectives, identified strategies, identified limitations, and identified success/outcomes.

Table 2. A multidisciplinary view on technological innovation[1,3,4,8,9,19,20,26,27,35–43].

Technological innovation and disciplines	**Outlook on public value creation**			
	Some identified objectives	**Some identified strategies**	**Some identified limitations**	**Some identified successes/outcomes**
Social sciences	To enhance well-being, dignity, human rights, and prosperity for all; To reduce or eradicate dehumanization, social, economic, psychological, and environmental challenges; To reduce or eradicate safety, ethical, moral, security, standardization issues/problems (e.g., child exploitation, human trafficking, and online addiction) To increase outputs, productivities, efficiency and effectiveness of individuals, organizations, communities (e.g., competitive advantage).	Advocacies for design, adoption, and use of good technology and its tools (e.g., e-education and co-creation) Digitalization (e.g., digital government and digital economy); Technological training and education (e.g., hackathons); Investments in all-round technological innovations (e.g., space commercialization) Financial and other relevant benefits and support to encourage realization and maintenance of excellence (e.g., academic scholarship); Formulation, implementation, and evaluation of policies, procedures, and practices that would enhance ethical and products standards, collaborative innovation (e.g., cross-regional and inter-governmental collaborations), etc.	Financial limitations; Ethical and standardization issues; Autonomy and independence; Lack of awareness and issues of participation and trust; Rules and regulations (e.g., GDPR); Addiction and monotony; Security (e.g., hacking, virus, and malware) and privacy issues; Orientation towards gains (profit) and competition; Developmental inequalities; Illiteracy and non -acceptance; Big data or data deluge; Ambiguity and complexity; Poor policy planning and approval; Language and beliefs; etc.	Public service and business digitalization; Smart city development; E-commerce acceleration and adoption; Realization and enhancement of some SDGs goals; Global market integration; Cross-border security cooperation and coordination; Global wealth multiplication, accessibility, and sharing; Policies and procedural transparency and accountability; Human and global equality and equity advancement; Human rights and dignity advancement; Combating of global crimes; Intellectual and knowledge sharing between individuals, organizations, communities, and nations; etc.
Humanities	To enhance cultural diversity, inclusion, and responsible communication; To enhance well-being, dignity, human rights, and prosperity for all (individuals, societies, environment, and world); To reduce or eradicate dehumanization, social, economic, psychological, and environmental challenges (e.g., racism and corruption); To reduce or eradicate safety, ethical, moral, security, standardization issues/problems (e.g., drug trafficking); To increase outputs, productivities, efficiency and effectiveness of individuals,	Promoting transdisciplinary approaches (e.g., Cybernetics, Cybersemiotics, Biosemiotics); Digitalization (e.g., digital government and digital economy); Technological training and education (e.g., exchange programs and internships); Investments in all-round technological innovations (e.g., marine decarbonization); Financial and other relevant benefits and support to encourage realization and maintenance of excellence (e.g., academic and organization	Language and cultural barriers; Financial limitations; Ethical and standardization issues; Autonomy and independence; Lack of awareness and issues of participation and trust; Rules and regulations (e.g., GDPR); Addiction and monotony; Security (e.g., hacking, virus and malware) and privacy issues; Orientation towards gains (profit) and competition; Developmental inequalities; Illiteracy and non -acceptance; Big data or data deluge; Ambiguity and complexity; Poor policy planning and approval; Language and beliefs; etc.	Increase in transdisciplinary study and awareness (VME, AR, Metaverse, Social media); Smart city development; Realization and enhancement of some SDGs goals; Public service and business digitalization; E-commerce acceleration and adoption; Global market integration; Cross-border security cooperation and coordination; Global wealth multiplication, accessibility, and sharing; Policies and procedural transparency and accountability; Human and global equality and equity advancement; Human rights and dignity

Table 2. (*Continued*).

Technological innovation and disciplines	Outlook on public value creation			
	Some identified objectives	**Some identified strategies**	**Some identified limitations**	**Some identified successes/outcomes**
Humanities	organizations, communities (e.g., adoption of social media to promote goods, services, and content) etc.	collaborations); and Formulation, implementation, and evaluation of policies, procedures, and practices that would enhance ethical and products standards (e.g., code of conducts), etc.	-	advancement; Combating of global crimes; Intellectual and knowledge sharing between individuals, organizations, communities, and nations; etc.
Physical and natural sciences	To reduce or eradicate dehumanization, social, economic, psychological, and environmental challenges (e.g., climate change and biodiversity depletion); To enhance well-being, dignity, human rights, and prosperity for all; To reduce or eradicate safety, ethical, moral, security, standardization issues or problems; To increase outputs, productivities, efficiency and effectiveness of individuals, organizations, communities (e.g., data analysis/management); For the offering of entertainment (e.g., video games), etc.	Development of value creation model/framework (e.g., Industry 4.0 model); Advocacies for the design, adoption, and use of good technology and its tools (e.g., in the invention and maintenance of renewable/sustainable energy, e-medicine, etc.); Digitalization (e.g., digital government and digital economy); Technological training and education (e.g., updating of academic modules); Investments in all-round technological innovations (e.g., the building of new infrastructure); Financial and other relevant benefits and support to encourage realization and maintenance of excellence (e.g., research funding from companies); Formulation, implementation, and evaluation of policies, procedures, and practices that would enhance ethical and products standards (e.g., monitoring by national and international organizations and public-private sector collaboration), etc.	Limited expertise; Financial limitations; Ethical and standardization issues; Autonomy and independence; Lack of awareness and issues of participation and trust; Rules and regulations (e.g., GDPR); Addiction and monotony; Security (e.g., hacking, virus and malware) and privacy issues; Orientation towards gains (profit) and competition; Developmental inequalities; Illiteracy and non -acceptance; Big data or data deluge; Ambiguity and complexity; Poor policy planning and approval; Language and beliefs; etc.	Realization and production of green and sustainable tech (e.g., Solar energy); Advances in medical care; Space exploration and commercialization; Smart city development; Public air purification; Public service and business digitalization; Realization and enhancement of some SDGs goals; E-commerce acceleration and adoption; Global market integration; Cross-border security cooperation and coordination; Global wealth multiplication, accessibility, and sharing; Policies and procedural transparency and accountability; Human and global equality and equity advancement; Human rights and dignity advancement; Combating of global crimes; Intellectual and knowledge sharing between individuals, organizations, communities, and nations; etc.

Multidisciplinary studies and research are primarily about weaving multiple knowledge systems to discover cross-disciplinary generalizations in reaching a balanced or synthesized outlook and outcomes. From **Table 2** above, we can discover that technological innovation has different attachments to Public

Value and Its creation from a multidisciplinary evaluation perspective. One of the most important discoveries from **Table 2** above is that numerous similarities can be identified from different disciplines in social sciences, humanities, and physical and natural sciences in relation to creating or improving public value. This is especially, from the aspects of identified objectives, identified strategies, identified limitations, and identified successes and outcomes. The identified challenges are of a mixed outlook, so careful steps must be taken to not spoil or eradicate the gains made already in the creation/improvement of public value via technological innovation. Advocacy for the design, adoption, and use of technology and its tools is a common and strong strategy across many disciplines of social sciences, humanities, and physical and natural sciences. However, one of the main differentiations in the identified strategies for public value creation is in the disciplines of Physical and Natural Sciences, where the development of a real value creation model/framework such as Industry 4.0 is present. This is so because the real tasks of technological innovation are present within these disciplines.

7. Conclusion

This paper tries to evaluate public value creation or improvement through technological innovation from a multidisciplinary perspective because a huge gap exists in this area of study and research. The multidisciplinary evaluation approach adopts a simple evaluation strategy by exploring viewpoints/perspectives, positions, realities, and pieces of evidence in some selected relevant literature, documents, and reports. The multidisciplinary evaluation of how technological innovations help to create and improve public value shows a relatively similar outlook from the dimensions of objectives, strategies, limitations, and outcomes or successes. The most notable objective dimension in the disciplines of social sciences is to enhance well-being, dignity, human rights, and prosperity for all (individuals, societies, the environment, and the world). The most notable objective dimension in the disciplines of the humanities is to promote cultural diversity, responsible communication, and inclusion. The most notable objective dimension in the disciplines of physical and natural sciences is to reduce or eradicate dehumanization, social, economic, psychological, and environmental challenges (e.g., climate change, biodiversity depletion, and addiction).

Most notable from the strategy dimension in the disciplines of social sciences are advocacies for the design, adoption, and use of good technology and its tools (e.g., e-education and co-creation). Most notable from the strategy dimension in disciplines of the humanities is the promotion of transdisciplinary approaches (e.g., Cybernetics, Cybersemiotics, Biosemiotics). The most notable strategy dimension in disciplines of physical and natural sciences is the development of a value creation model/framework (e.g., Industry 4.0). Most notable from the dimension of limitations in disciplines of social sciences is financial limitations. The most notable dimension of limitations in disciplines of humanities are language and cultural barriers. The most notable dimension of limitations in disciplines of physical and natural sciences is limited expertise. The most notable dimension of outcomes/successes in disciplines of social sciences is public service and business digitalization. The most notable dimension of outcomes/successes in disciplines of humanities is the increase in transdisciplinary study/awareness (e.g., Via VME, AR, Metaverse, and Social Media). The most notable dimension of outcomes/successes in disciplines of physical and natural sciences is the realization and production of green and sustainable tech (e.g., solar energy).

In conclusion, public value creation or improvement is the key goal of technological innovations in all disciplines from the standpoint of this paper and the multidisciplinary approach adopted.

Conflict of interest

There is no conflict of interest and no sponsorship from any source.

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