

Review Paper

The Impact of Digital Transformation on the Economy: Technological Innovation and Efficiency

Liudmyla Shostak^{1*}, Vasyl Goi², Olha Timchenko³, Lesya Yastrubetska⁴ and Marta Derhaliuk⁵

¹Department of Economics and Trade, Faculty of Economics and Management, Lesya Ukrainka Volyn National University, Lutsk, Ukraine

²Department of Economics and Marketing, O.M. Beketov National University of Urban Economy in Kharkiv, Kharkiv, Ukraine

³Department of Global Economics, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine

⁴Department of Finance, Money Circulation and Credit, Ivan Franko National University of Lviv, Lviv, Ukraine

⁵Department of Economics and Entrepreneurship, Faculty of Management and Marketing, National Technica University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine

*Corresponding author: lshostak14@gmail.com (ORCID ID: 0000-0001-8786-9582)

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ABSTRACT

The investigation into the evolution of the digital economy has yielded profound insights into its fundamental nature, the pivotal drivers guiding its advancement, and the trajectories characterizing the metamorphosis of economic operations within organizations. The outcomes of this inquiry are primed to underpin the effectiveness, calibre, and dependability of information-driven and analytical underpinnings, indispensable for informed managerial judgments geared towards nurturing the inventive potential inherent in the digital economy. Furthermore, these findings address the impediments that curtail seamless digital transformation. Among the preeminent findings engendering novelty in this research, the subsequent elements stand out: the formulation of a comprehensive framework for the delineation and taxonomy of economic activities within the digital economy domain, encompassing both a classification schema for economic pursuits intrinsic to the digital sector and another for economic endeavours facilitated by the integration of digital technologies. A comprehensive array of metrics has been systematically devised to assess the evolution of the digital economy. This framework encompasses indicators derived from information and communication technology (ICT) statistics, national economic accounts, fixed asset investments, and foreign trade, as well as indicators custom-developed in consonance with the proposed taxonomy of economic pursuits within the digital economy. This classification system comprises five distinct blocks, each comprising discrete sets of indicators: those about the ICT sector, the digital sector, organizational outlays on digital technologies, digital proficiency of the workforce, and a holistic gauge of the digital economy. An intricate methodology has been formulated to quantitatively evaluate the ICT sector's state, progression, and competitive standing. This methodological construct encompasses algorithms for the computation of physical quantities of gross value added and fixed capital investment segregated by the nature of economic undertakings associated with the production of ICT goods and provisioning ICT services. Also included are computations for the index of fixed capital formation rate, alongside indicators appraising the extent of the economy's engagement with international trade concerning diverse digital products.

HIGHLIGHTS

- The study underscores the transformative impact of digital technologies on the global economic landscape and their pivotal role in advancing progress towards the United Nations' Sustainable Development Goals (SDGs) by 2030.

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It emphasizes the potential of digital technologies to amplify economic development, improve the quality of goods and services, enhance energy efficiency, and create new employment opportunities.

- ① The research aims to comprehensively investigate the drivers shaping the evolution of the digital economy, focusing on technological innovation and evaluating their effectiveness. It articulates objectives such as providing clarity to the conceptual realm of the digital economy, formulating a comprehensive classification framework, identifying influential factors, and conducting a meticulous analysis of the ICT sector.

Keywords: Capital expenditures, digital economy, digital platforms, digital technologies, electronic services, technological improvements, ICT infrastructure

In recent timeframes, the enhancement of societal welfare has become inextricably linked with profound shifts within the global economic landscape and the reconfiguration of economic interactions, catalyzed by the unparalleled velocity of scientific and technological advancement, with a pronounced emphasis on digital technologies. Within the realm of these transformative dynamics, digital technologies have been accorded a paramount role by the international community, catalyzing expediting progress towards each of the seventeen Sustainable Development Goals (SDGs) outlined by the United Nations (UN) for attainment by the year 2030. It is envisaged that these technologies hold the potential to amplify nations' capacities for pioneering economic development, manifesting through the amelioration of goods and services quality, the enhancement of energy efficiency in production processes, and the concomitant creation of novel employment opportunities. The imperative to tackle global imperatives and capitalize on prospects for enhancing the well-being of nations within the digital epoch has propelled a heightened international discourse regarding the statistical underpinning of digital economy progress. A coalition of dedicated United Nations (UN) specialized agencies, diverse international bodies, and national statistical entities are ardently engaged in crafting a robust evidentiary foundation to facilitate the scrutiny and formulation of policies encompassing pivotal facets of the digital economy. This collective endeavour acknowledges the salience of refining statistical instruments. In tandem with this, an exigent undertaking emerges: the examination of factors shaping the evolution of the digital economy, underpinned by the assessment of the magnitude and trajectories of digital transformation through the analysis of dynamism and the projection of economic digitalization patterns.

The study endeavors to undertake an exhaustive investigation into the pivotal drivers underpinning the evolution of the digital economy, alongside discerning the forces that shape the impact of digital transformation on domains of technological innovation, emphasizing evaluating their efficacy.

Aligned with this overarching goal, the study articulates and endeavors to resolve the ensuing objectives: to provide clarity to the conceptual realm of the digital economy, unravel its essence and economic underpinnings, and formulate a comprehensive classification framework for constituent elements of the digital economy; to pinpoint the nuances of its formation and to devise a robust set of indicators to facilitate the identification and assessment of influential factors within the digital economy; and to conduct a meticulous analysis of the prevailing status, trajectory of growth, and competitive landscape characterizing the ICT sector.

LITERATURE REVIEW

Several scholars (Guellec *et al.* 2017; Loebbecke *et al.* 2015; Makedon *et al.* 2022) cogently establish a connection between medium-term trajectories of global societal and economic progression and the concurrent processes of digitalization. Presently, novel digital technologies and pioneering business models are permeating every facet of economic activity, thereby exerting a transformative influence on the fundamental fabric of the economy and instigating substantial qualitative shifts within it. We concur with the viewpoints articulated by Martínez-Caro, E., Cegarra-Navarro, J. G., Alfonso-Ruiz, F. J. (2020) and Westerman, Bonnet, and McAfee (2014), positing that humanity has ushered into a new epoch of global transformation due to the interplay of digitalization and other technological shifts.

In contemporary discourse, the digital economy is characterized by the scholarly contributions of Sghari and Mezghani (2021) and Vial (2019) as a potential panacea, with its rapid expansion touted to address an array of extant challenges. This sentiment is also mirrored in the exponential surge in attention devoted to digital themes within socioeconomic and humanitarian research.

The advancement of the digital economy, following Bai *et al.* (2021), Janicki, Goździewska-Nowicka (2018), and Hess, Matt, Benlian, Wiesböck (2016), necessitates a holistic contemplation within the broader framework of concurrent changes experienced by contemporary society and economy. This entails thoroughly examining its systemic attributes and exploring the pragmatic applications of its tools within business operations.

The theoretical underpinnings of the digital economy, encompassing investigations into its conceptual evolution, elucidation of its fundamental nature, and the scrutiny of interrelated categories, have been expounded upon in the scholarly contributions of Ater and Rigbi (2023), along with Ertz and Boily (2019). Furthermore, an exploration into the theoretical and pragmatic facets of the quantitative realm of the digital economy draws from the seminal works of prominent economists such as Goldfarb and Tucker (2019) and Nose and Mengistu (2023).

The delineation and analysis of trends in business advancement within the digital economy, the appraisal of digital technology utilization across economic and societal realms, and the evaluation of nations' standings within global indices tracking digital development constitute the focal pursuits of scholars, including Masoud and Basahel (2023), Murat, Saida, and Timurlan (2023), and Wieland (2022). These scholars and experts have significantly enriched the scholarly discourse encompassing theoretical and practical dimensions of digital economy progression. However, it is pertinent to acknowledge that the published works do not constitute an exhaustive examination of the digital economy but rather illuminate distinct phenomena and processes manifesting within the domain of digital technologies.

METHODS

The study employs the subsequent methodological tools and approaches:

1. Strategic Aspect of Digital Economy

Development: Within the purview of this approach, the study underscores the assertion that the long-term transformation of economic activities predicated on the utilization of digital information necessitates strategic decision-making integral to strategic management. It is imperative to highlight that digitalization serves as the bedrock for creating novel competitive advantages and fostering competitiveness. Digital transformation entails a comprehensive overhaul of the business, entailing a successful shift toward fresh business models, novel communication channels with stakeholders, innovative products, business and production processes, and a corporate culture predicated on novel paradigms for data management underpinned by digital technologies. This transformation is undertaken to significantly enhance efficiency and ensure sustained viability over the long term.

2. Method of Digital Technology Adoption: This method inherently encapsulates an innovation-driven process, albeit innovations precipitated by digital transformation are innovative. This assertion seamlessly aligns with the methodological approach embraced for measuring innovation through statistical means. Owing to its multifaceted nature, integrating digital technologies is not an undertaking that can be swiftly accomplished, encompassing intricate technical considerations as well as intricate organizational and economic dimensions. The execution of digitalization initiatives mandates substantial allocations of financial and human resources, while the tangible economic gains do not invariably straightforwardly present themselves. Digital innovation emerges as a protracted and strategic business initiative with far-reaching implications.

3. Methodological Approach to Process Scaling:

The methodological stance employed pertains to the scaling of processes. The magnitude and scope characterizing digital transformation endeavors warrant formulating a distinct strategic blueprint, referred to as a digital transformation strategy. This strategy encompasses delineated sections and

fundamental tenets of the enterprise's innovation-driven developmental agenda. During the strategy's formulation, due attention is accorded to the subsequent dimensions of digital transformation: the conception and nurturing of novel business models; the establishment of innovative paradigms for data governance; the embrace of digital modeling techniques; the assimilation of digital technologies and platform-based solutions; and the creation of an overarching digital ecosystem.

RESULTS

Commencing from the latter part of the 20th century, information technology has progressively assumed a more pivotal role in the economic advancement of numerous nations. The establishment of an integrated information-driven economic milieu, facilitated by scientific and technological advancements, substantially contributes to economic expansion and enhanced productivity. This milieu fosters the emergence of innovative employment opportunities and digital assets, endows citizens with more excellent agency, facilitates heightened access to global markets, bolsters the competitiveness of enterprises, and augments the quality of public services, among other benefits.

The establishment of a novel economic paradigm grounded in the profound infiltration of digital technologies into economic processes stands as an indisputable contemporaneous reality. This phenomenon is attributable to the rapid acceleration of digital technology advancement and its pervasive integration across diverse dimensions of societal and economic realms. As attested by numerous analysts, economists, governmental authorities, and senior executives (Avanesova, 2021; Burstein, Morales, Vogel, 2019), the ongoing trajectory undeniably exhibits a long-term character, with disregard for this trajectory posing the potential to precipitate the collapse of businesses and even entire economies within certain global regions. Hence, it is of paramount significance to accord specialized attention to strategic considerations encompassing the evolution of both enterprises and territories, with due cognizance of the prevailing trend toward digitalization.

It is widely acknowledged that the notion of the "digital economy," about the utilization of contemporary information technologies (digital)

within economic processes and their administration, was first propounded by N. Negroponte in 1995. Negroponte posited that the merits intrinsic to the digital economy encompass the absence of tangible product weight, supplanted by the dimension of informational content, diminished resource outlays for the manufacturing of electronic goods, a markedly reduced spatial footprint of products, and the nearly instantaneous transmission of commodities facilitated through the Internet (provided that specific digital technologies are implied). A selection of principal attributes characterizing the digital economy is delineated in Table 1.

Commencing with localized endeavours within individual enterprises and corporate initiatives, the process of business digitalization is progressively assuming a global dimension, with prominent digital business entities attaining paramount standing on the international stage. Notably, global enterprises such as Apple, Alphabet, Microsoft, Amazon, and Facebook rank among the most valuable corporations globally in terms of market capitalization. A noteworthy exception is the Chinese online retailer Alibaba Group, which occupies a notable position among non-U.S. entities on this list. Furthermore, instances of "digital ecosystems" are discernible across diverse industries and corporate entities (Abidi *et al.* 2022). The effective cultivation of markets within the digital economy is contingent upon the presence of cutting-edge technologies, mandating the focalization of incentivization efforts on two key fronts. Firstly, institutional paradigms require reconfiguration and modernization to establish an environment conducive to digital economy growth, encompassing the formulation of regulatory frameworks pertinent to digital markets and production, and the cultivation of a workforce equipped with digital competencies. Secondly, the technical underpinnings, comprising transmission networks, data centres, and software services, necessitate substantial investment and concerted efforts to actualize (Fuster *et al.* 2019; Lelyk *et al.* 2022).

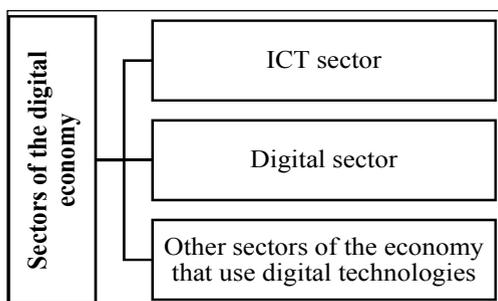
The absence of a universally acknowledged taxonomy for the constituents of the digital economy curtails the avenues available for practical investigation within this domain. The framework guiding the classification and grouping of economic pursuits, upon which the digital economy definition

Table 1: The key characteristics of the digital economy

Characteristics	Impact on the overall economic development
Economic endeavours centre around digital economy platforms.	These platforms foster interactions among economic entities, engender cost reductions (particularly in transaction-related expenditures), furnish supplementary capabilities for both suppliers and consumers and enhance their collaboration. This, in turn, curtails the duration required for the conception and introduction of novel products to the market, while also expediting the process of generating and disseminating innovative products and solutions.
Personalized service models are being formed	Precise online marketing strategies, coupled with technologies like 3D printing and other digital innovations, facilitate the customization of goods and services production and distribution. This entails tailoring offerings to align with the distinctive requirements and preferences of individual customers. Such customization not only optimizes resource utilization by aligning supply and demand structures and volumes but also augments the quality of goods and services, thereby enhancing the overall quality of life within the community.
Direct interaction between producers and consumers is carried out	Prerequisites are being established to truncate the intermediary chain linking producers and end consumers, while concurrently fostering efficacious collaboration between production entities and consumers.
The “sharing economy” is spreading	The overarching process of comprehensive digitalization, coupled with the expedited pace of communication, engenders the foundational conditions for the gradual dissolution of conventional property arrangements. This paradigm shift is paralleled by the evolution of legal frameworks underpinned by the theoretical institutional construct of a “bundle of property rights.” Consequently, the emergence of shared ownership of commodities, particularly those of a technically intricate and high-cost nature like automobiles, is underway. This trajectory holds the potential to substantially curtail expenses incurred by end users.
The role of contribution to economic activity by individual participants is growing	The progression of small and medium-sized enterprises assumes a pronounced role within business operations, owing to their heightened adaptability and mobility. This sector serves as an incubator for innovative startups, bolstering the expansion of the “individual economy” segment. Moreover, there is a discernible inclination toward augmenting the “atomization” of the economic framework.

Source: (Banalieva and Dhanaraj, 2019; E-commerce and Digital Economy Programme Year, 2023; McAfee and Brynjolfsson, 2017).

is grounded, affords the identification of three distinct elements intrinsic to the digital economy (as depicted in Fig. 1).



Source: Compiled by the authors.

Fig. 1: Elements of the digital economy

The domain encompassing the fabrication of goods and provision of services within the realm of digital technologies is encapsulated by the information and communication technologies sector (ICT sector).

Serving as a fundamental constituent of the digital economy, this sector assumes a pivotal role, its innovative capacities radiating into disparate sectors of the economy, thereby fostering their digital transformation.

The explication and consolidation of economic pursuits and commodities within the Information and Communication Technologies (ICT) sector have been formulated by the Organization for Economic Co-operation and Development (OECD) Working Party on Information Society Indicators. As per its directives, the ICT sector is delineated as a collection of entities whose economic endeavours pertain to the creation of goods and services intended for the facilitation or execution of functions related to information processing and communication through electronic modalities, encompassing the transmission and visual replication of data

(Digitalization in Europe 2022-2023: Evidence from the EIB Investment Survey, 2023).

A noteworthy phenomenon within the ambit of the digital economy has been the advent of inventive business models associated with the dispensation of online intermediation services. These digital intermediation services encompass the provisioning of information and the adept alignment of two autonomous transactional entities via a digital platform, all done in exchange for a transparent fee structure (comprising commissions and other user charges applicable to digital platform usage). This domain of operation encompasses what is commonly referred to as the platform economy. The platform economy denotes a constellation of bilateral online markets wherein consumers and producers of commodities and services interact within the digital realm of a platform environment.

In the year 2019, the OECD introduced the subsequent articulation of an online platform. An online platform is an electronic service that facilitates the interaction of two or more distinct yet interconnected groups of users, comprising both entities and individuals, who engage with said service through the Internet (Digital Transformation enters a new phase - here's what comes next, 2023).

This definition, subject to marginal adaptations, has been operationalized within the framework of monitoring endeavours within the ICT sector. As outlined in the guidelines on the completion of the 3-*Inform* form, a digital platform is conceptualized as an information system that assembles a notable assembly of autonomous participants. Within this ecosystem, an innovative business model takes shape, yielding a reduction in transactional costs while concurrently expediting interactions among the participants.

While certain conceptual frameworks for quantifying digital platforms have been incorporated into the methodologies employed by national statistical agencies, a consensus regarding a universally endorsed method for their classification and grouping in the context of accounting remains elusive (Acemoglu, 2021). Reflecting the prevailing consensus discernible within these investigations, the functional approach emerges as one of the most pragmatic and conceptually robust strategies. It is this functional approach that forms the bedrock

upon which the classification schema for digital platforms, as expounded in Table 2, is predicated.

The quantitative assessment of phenomena and processes associated with shifts in economic activities stemming from the incorporation of digital technologies can be conducted through the utilization of a statistical indicator system, which comprises a more focused selection of indicators. Within the context of our investigation, predicated upon the delineation and taxonomy of digital economy constituents, we have devised a comprehensive set of indicators that encapsulate the determinants and outcomes characterizing the evolution of the digital economy (as exemplified in Table 3).

Indicators specific to the ICT sector serve to portray the evolution of ICT production and the international trade of ICT goods and services. These indicators serve to encapsulate the progress of the domestic ICT market and foreign trade in ICT, structured following the diverse categories of economic pursuits encompassed within the ICT sector, as well as the array of ICT products. The indicators pertinent to the digital sector bear a resemblance to those deployed for delineating the advancement of the ICT sector. Notably, the key distinction lies in the fact that these indicators are formulated by amalgamating the gamut of economic activities characteristic of the digital sector, in conjunction with the classifications of digital goods and digital services (Zhao *et al.* 2021).

Indicators associated with organizations' outlays on digital technologies serve to portray the financial disbursements incurred by a company due to the procurement and utilization of digital technologies. These indicators encompass the proportion of such expenditures within the overall organizational expenses and their relationship to the magnitude of products sold. Metrics on the costs incurred from digital technology can be configured based on various cost categories, while indicators denoting cost intensity and profitability can be configured based on distinct product categories. This approach facilitates the assessment of the extent and orientations of investments directed towards technological enhancements in the corporate ICT infrastructure, executed within the context of business digital transformation endeavours (Heidi, 2022).

Table 2: Classifications of digital platforms based on a functional approach

Classification feature	Types of digital platforms
By type of assets	Capital entails the intermediation in transactions involving capital assets, and labour, encompassing the intermediation in transactions involving human resources.
By type of intermediary services	Search and advertising platforms.
By main types of income	Transaction and innovation platforms.
By reach	Super platforms, constellation platforms, autonomous platforms.
By functional purpose	Messengers, mobile application platforms, peer-to-peer platforms, freelance and crowdsourcing platforms, long-term car rental platforms (carpooling), mobile payment platforms, search platforms, short-term residential real estate rental platforms, social networks, super apps, and trading platforms.
By source of income	Platforms that provide services for a fee. Platforms that provide free services.
By type of interaction between buyers and sellers	B2B, B2C, C2C platforms.
In the country of the supplier's participation	Platforms whose suppliers are located in developed, developing, or least developed countries.

Source: (Makedon et al. 2022; Ross et al. 2021).

Table 3: System of Indicators for the Development of the Digital Economy

Blocks of indicators	Indicators
ICT sector indicators	<p>Quantity of establishments within the Information and Communication Technologies (ICT) sector.</p> <p>Workforce headcount engaged within the ICT sector.</p> <p>Gross value added generated by the ICT sector.</p> <p>The proportion of gross value added attributed to the ICT sector in the overall gross domestic product.</p> <p>The magnitude of investments directed toward fixed assets within ICT organizations.</p> <p>Fraction of investments channelled into fixed assets within ICT organizations relative to the total investments in fixed assets.</p> <p>Revenues accrued by entities within the ICT sector.</p> <p>The volume of products dispatched by ICT organizations of in-house fabrication (total, encompassing both ICT products and others).</p> <p>International trade activity associated with ICT products.</p> <p>The aggregate volume of exports and imports of ICT products.</p>
Indicators of the digital sector	<p>Quantity of establishments operating within the digital sector.</p> <p>Workforce counts engaged within the digital sector.</p> <p>Aggregate gross value added attributed to the digital sector.</p> <p>Fraction of gross value added of the digital sector within the broader gross domestic product.</p> <p>The magnitude of investments allocated to fixed assets within organizations within the digital sector.</p> <p>The proportion of investments targeted towards fixed assets within digital sector organizations concerning the overall investments in fixed assets.</p> <p>Revenues amassed by entities functioning within the digital sector.</p> <p>The volume of products dispatched by digital sector organizations with internal fabrication (total, encompassing both digital products and others).</p> <p>The extent of international trade involving digital products.</p> <p>Exports attributed to digital products.</p> <p>Imports associated with digital products.</p>

Indicators of organizations' spending on digital technologies	<p>The magnitude of outlays on digital technologies.</p> <p>The proportion of outlays allocated to digital technologies relative to the overall organizational expenditure.</p> <p>The magnitude of expenses attributed to digital technology per unit of products sold (across all products, ICT products, and digital products).</p> <p>The ratio of profits derived from products (inclusive of all products, ICT products, and digital products) per unit of digital technology costs.</p>
Indicators of digital competencies of the employed workforce	<p>Count of employed Information and Communication Technology (ICT) specialists.</p> <p>Fraction of employed ICT specialists to the overall employed population.</p> <p>Quantity of employed individuals possessing ICT skills.</p> <p>The weighted mean level of ICT competencies prevalent within the employed populace.</p>
Indicators of digital transformation of organizations	<p>Fraction of organizations that engaged with digital technologies (comprising fundamental, specialized, and end-to-end digital technologies) relative to the total number of organizations.</p> <p>The proportion of organizations that initiated (or received) procurement orders for commodities, services, and tasks via the Internet.</p> <p>Share of organizations functioning as operators of digital platforms.</p> <p>The ratio of organizations that acquired (or vented) digital products (embracing content and electronically provided services, except for digital intermediation).</p> <p>Percentage of orders conducted (or received) through the Internet in the total bulk of orders undertaken (or received) by the organization (encompassing diverse product categories, ICT products, and digital products).</p> <p>The magnitude of electronic trade encompassing goods and services (on "digital" goods and services).</p>

Source: Developed by the authors.

Expenditures within the realm of Information and Communication Technologies (ICT) encompass both ongoing and capital outlays of organizations directed toward digital technologies. These financial outlays encompass tangible costs quantified in monetary terms, including but not limited to computer and software procurements, disbursements for telecommunications services, workforce training about the development and utilization of ICT, payments to third-party entities and specialized professionals, along with sundry other expenses associated with ICT, which may incorporate autonomous software development initiatives. Indicators pertaining to the digital competencies of the employed workforce can epitomize the calibre of human capital vis-à-vis the digital transformation of the economy. These indicators serve to illuminate the proficiencies and skills embedded within the employed population concerning the manipulation of digital technologies.

Two distinct categories delineate ICT skills: professional and user skills. The realm of professional skills encompasses the proficiencies inherent to ICT specialists, essential for ensuring the seamless operation, upkeep, and evolution of an enterprise's

information and communication infrastructure. On the other hand, user skills encompass proficiencies requisite for effective engagement with digital technologies. This encompasses adeptness in manoeuvring ICT hardware, navigating the Internet, employing communication tools, interacting with information systems, as well as utilizing standard and specialized software (Guo *et al.* 2021). Indicators aligned with the digital transformation of organizations are purposefully formulated to reflect the extent to which technological innovations have permeated the accounting, management, and production processes of said organizations.

Our investigation entailed an analysis of a comprehensive set of indicators pertaining to the utilization of end-to-end digital technologies within organizations. Upon meticulous examination, it emerged that these technologies, subject to statistical scrutiny, can be tentatively classified into distinct groups as elucidated by Hanelt, Bohnsack, Marz, and Antunes Marante (2021) as well as Zhang, Zhao, Wanand Yao (2021):

Basic Digital Technologies: This category encompasses foundational digital technologies including personal computers, servers, local area

networks, Internet connectivity, extranet and intranet networks, websites, social media accounts, digital platforms, and open-source software.

Specialized Digital Technologies: This group encompasses specialized digital technologies comprising systems such as electronic document management, Electronic Data Interchange (EDI), Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Business Process Management (BPM), Human Resource Information Systems (HRIS), along with procurement and sales management systems, warehouse management systems, and other forms of specialized software.

“End-to-End” Digital Technologies: This category encompasses advanced digital technologies inclusive of big data technologies such as cloud services and geographic information systems, emerging production technologies like additive manufacturing, industrial robots, automated assembly lines, “digital twin” models, Product Lifecycle Management (PLM) and Product Data Management (PDM) systems, Computer-Aided Design (CAD), Computer-Aided Engineering (CAE), Computer-Aided Manufacturing (CAM), and Computer-Aided Optimization (CAO) systems, in addition to industrial Internet technologies such as the Internet of Things (IoT) and artificial intelligence technologies.

For a more comprehensive characterization of organizations’ digital transformation, it is imperative to develop indicators that encompass a range of utilization facets, as outlined by Liu, Yan, Zhang, and Lin (2021), Makedon, Mykhailenko, and Vazov (2021), Pan, Xie, Wang, and Ma (2022):

- ♦ *Wireless Communication Technologies:* This category encompasses wireless communication technologies such as 5G, Near Field Communication (NFC), Bluetooth, Wi-Fi Direct, WiGig, Wi-Fi Miracast, and wireless charging technologies.
- ♦ *Distributed Ledger Technologies:* Encompassing hash functions, public key encryption, peer-to-peer networks, smart contracts, and cryptocurrencies, this category encapsulates distributed ledger technologies.
- ♦ *Virtual and Augmented Reality Technologies:* This category comprises virtual and augmented

reality technologies, including tracking devices, controllers, voice input devices, modelling technologies, and Virtual Reality (VR) / Augmented Reality (AR) development tools.

- ♦ *Robotics and Sensing Components:* This category encompasses technologies essential for robotics and sensing, including power source creation, actuation mechanisms, manipulation techniques, movement dynamics, and navigation technologies.
- ♦ *Quantum Technologies:* This category comprises quantum technologies like quantum simulators, quantum communications, quantum computing, and quantum cryptography.

This segment additionally encompasses e-commerce indicators, devised to quantitatively gauge the involvement of organizations in transactions conducted electronically over global communication networks (Goolsbee and Klenow, 2018). Renowned experts from both the OECD Advisory Group on Measuring GDP in the Digital Economy and the OECD-WTO Task Force on International Trade Statistics posit that the ramifications of the economy’s digital transformation can be mirrored in statistical measures predicated on the inherent “digital nature” characterizing transactions between producers and consumers of goods and services.

The revised conception of e-commerce, as delineated in a collaborative 2019 report by the OECD and UNCTAD, delineates three distinct transaction types (Chief Economists Outlook: May 2023):

1. *Digital Ordering Transactions:* These transactions involve the placement of orders through the Internet. This classification represents an e-commerce transaction, which has been integral to ICT statistics for a substantial duration. Subsequently, the ensuing discussion expands upon two transaction categories that further extend the concept of e-commerce to encompass the notion of e-trade.
2. *Digital Delivery Transactions:* These transactions are characterized as remote transactions conducted via information and communication networks, encompassing voice and data networks, including the Internet. These transactions manifest in the form of electronic downloads. Notably,

digital delivery pertains solely to services offered electronically, or content and data download services, as tangible goods cannot be electronically delivered. Illustrative instances of such transactions encompass the downloading of audio and video content, e-books, and subscription services like streaming TV and software (Makedon and Ilchenko, 2021).

3. *Transactions via Digital Intermediary Platforms:* This category pertains to transactions executed by users of digital intermediary platforms utilizing the electronic services furnished by these platforms. The conduction of such transactions necessitates the involvement of a “digital intermediary,” denoting a digital platform. The pivotal role of a digital platform as an intermediary resides in offering an electronic milieu conducive to trading interactions between buyers and sellers.

It is pertinent to observe that the revised notion of e-commerce transactions has, to a certain extent, been implemented in practical applications. Commencing in 2020, the statistical observation of digital technology utilization within organizations, as e-commerce channels, has expanded to encompass social networks, mobile applications, and marketplaces (which are digital platforms offering an electronic environment for the exchange of goods and services), alongside websites, extranets, and EDI systems (Strasser *et al.* 2023).

In conjunction with e-commerce indicators encompassing order placement and receipt, the proposed system of indicators for digital economy development introduces several novel indicators intended to capture digital delivery transactions and transactions via digital platforms.

The metric denoting the proportion of organizations operating digital platforms entails the ratio of organizations effectively managing digital platforms to the overall count of organizations. This measure is devised to assess the pervasiveness of platform-based business models. Meanwhile, the indicator quantifying the share of organizations that procured (or sold) digital products comprises the ratio of entities placing (or receiving) electronic orders for content or services to the entire pool of organizations.

This indicator serves the purpose of gauging the diffusion of digital business models, excluding those based on platforms, while evaluating the extent of organizational engagement in digital delivery transactions (Bazaluk *et al.* 2020).

The metric of the proportion of orders conducted (or received) through the Internet within the complete array of orders placed (or received) by the organization is computed by dividing the count of orders placed (or received) through digital platforms, the organization’s official website, mobile application, and EDI system Extranet by the total count of orders placed (or received) for goods, services, and works. This measure aims to ascertain the extent to which the Internet is utilized in both a comprehensive and individual capacity across e-commerce channels for placing and receiving orders concerning goods and services (Levytska *et al.* 2022).

The magnitude of electronic commerce encompassing goods and services denotes the monetary worth of products and services sold in response to orders received via the worldwide network. This metric encapsulates the scope of electronic trade involving goods and services, thus serving as an evaluative gauge for digitally orchestrated transactions categorized by groups of goods and services.

Likewise, the magnitude of electronic commerce associated with digital goods and services signifies the value of electronically transmitted content and services across a global network, independent of the mechanism employed to initiate orders for such commodities and services. This indicator mirrors the extent of e-commerce concerning digital products, providing an evaluative value assessment for digital delivery transactions classified according to groups and units of digital goods and services (Shelukhin *et al.* 2021).

Consequently, through a comprehensive analysis of global practices in formulating statistical indicator systems for the digital economy, it is evident that metrics from the realm of ICT, science, and innovation are harnessed to quantify the spectrum of phenomena and processes intricately interwoven with the economy’s digital transformation. This practice encapsulates a diverse array of effects catalyzed by digital technologies within society.

The framework of indicators delineated within this study aligns with the author's distinct definition and classification of the components constituting the digital economy. This system encompasses a more focused array of absolute and relative metrics, yet its comprehensive nature effectively captures and encapsulates the factors and outcomes underlying the evolution of the digital economy (Sumets *et al.* 2022).

The system encompasses a series of novel indicators that aptly portray the utilization of digital technologies within organizations, the progression of the digital sector, and the realm of e-commerce. Implementing these indicators in practical scenarios necessitates enhancements in statistical bookkeeping methodologies. This entails the refinement of industry and product classification frameworks to accommodate the formulation of indicators for "digital" activities, incorporation of presently unaccounted "cross-cutting" technology categories into the list of statistically observed technologies, and establishment of mechanisms for monitoring digital delivery transactions and transactions facilitated through digital e-commerce platforms.

DISCUSSION

The digital economy represents a novel form of economic interaction that has already permeated all sectors of the global market, experiencing active advancement. It stands poised to potentially emerge as a foremost segment, catalyzing the growth and progression of the entire economic system. This possibility stems from the distinct advantages inherent to the digital economy in contrast to tangible commodity and monetary transactions. These advantages encompass attributes such as swift goods delivery and nearly instantaneous service provision. Additionally, the digital economy offers the benefit of reduced production costs and transactional overheads. A pivotal edge of the digital economy over its conventional counterpart lies in the virtually limitless nature of electronic goods, existing in virtual dimensions, whereas tangible goods typically exhibit finite quantities and are relatively harder to access.

Presently, the digital economy is transcending its confines within purely economic spheres. The assimilation of digitalization into social processes has commenced, with the well-being of individuals

becoming progressively intertwined with it. Furthermore, governmental entities and structures are extensively integrating digital technologies into their operations. Nevertheless, amidst this landscape, the realm of interest remains fiercely competitive, underscoring the necessity to remain vigilant and proactive. Collaboration between government bodies and businesses becomes imperative to continue the progression of the digital economy. Such endeavours should be attuned to the challenges, risks, and threats underscored in this article, channelling resources and efforts toward their mitigation.

CONCLUSION

The study facilitates the formulation of the following scientific and practical insights:

Despite the extensive application of the "digital economy" concept, a universally acknowledged definition remains absent. A pivotal constraint contributing to this situation is the absence of a precise comprehension of the distinctive attributes that set the digital economy apart from other economic domains. Consequently, definitions that elucidate the constituent elements of the digital economy hold specific significance in the context of statistical research objectives.

Through an examination of these definitions from scholarly references, assessments, and guidance from international entities, the author discerns shared aspects and distinctions, while also elucidating the underlying principles governing their construction. The substance of the components of the digital economy can be elucidated by considering the outcomes stemming from the digital transformation of organizational economic activities. Built upon this principle, a definition has been formulated, portraying the digital economy as a realm of economic endeavours encompassing the production of ICT goods, the delivery of ICT services, the creation of digital content, the provision of services in electronic format, and the utilization of digital technologies.

Following the provided definition, three distinct constituents of the digital economy have been discerned: the ICT sector, the digital sector, and other sectors of the economy employing digital technologies. This approach aligns harmoniously with established global conventions for constructing

comprehensive classifications of economic activities intertwined with ICT, a framework that is instrumental for statistical assessments.

The research formulated a sectoral categorization of the constituents within the digital economy and examined the pragmatic viability of the prevailing sectoral classification framework for encoding data based on the types of economic activities within the digital economy. The study deduced that the provided classification holds the potential for guiding the formulation of statistical observation methodologies in this domain.

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