International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Exploring the effects of digitization and new data on labor and total factor productivity growth in the US economy

Ayesha Khan [1,*], Shabir Ali [2] and Tayyab Khan [1]

[1] *School of Economics, Wuhan University of Technology, Wuhan, Hubei, 430070, China.*
[2] *Institute of Business & Management Sciences (IBMS), The University of Agriculture, Peshawar, Pakistan.*

International Journal of Science and Research Archive, 2024, 11(02), 081–092

Publication history: Received on 15 January 2024; revised on 25 February 2024; accepted on 28 February 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.11.2.0350

Abstract

A "new economy" has been developing for almost a decade, with various indicators suggesting a shift in the American economy. The significant growth of labor and total factor productivity in the latter part of the 1990s was remarkable, leading many to interpret it as an essential development. Some indicators are less cyclical and seem to be more enduring. We argue that the advancements in digital information and the Internet represent a new form of technology that, when integrated, forms a highly innovative system known as the new economy. Actors and concepts are increasingly intertwined. We can only start to measure the complete impact of its influence at this early phase. The new or digital economy emphasizes dynamic efficiency over static efficiency. New and innovative activities and products are more important than producing more. The Internet's growing popularity has significantly increased diverse ideas and participants and enhanced connectivity. This has initiated a genuine economic revolution. While there are noticeable impacts on efficiency and output, the more significant long-term effects are incalculable.

Keywords: Total factor productivity; Digitization; Technology; U.S economy

1. Introduction

Many changes have occurred in the American economy over the past decade. The significant rise in total factor and labor productivity in the late 1990s may either be a temporary phenomenon or the beginning of a sustained productivity trend. Nevertheless, other indicators are less cyclical and more likely to persist for an extended period. A wave of new ideas is spreading rapidly. Government expenditure on research and development increased by over 100% from 1980 to 2001 (Khan, Long, & Khan, 2022). According to the Census Bureau, the number of patents granted by U.S. companies more than doubled between 1990 and 2001. Tobin's first-quarter profits in the '90s increased more than four times due to a significant rise in intangible assets compared to physical capital. With intense international competition, a deregulated economy, advanced research and development investments by small enterprises, growing technology partnerships and acquisitions, and diverse funding options, there has been a significant surge in IT output (Baily & Lawrence, 2001). Irrespective of one's interpretation of these figures - whether as evidence of the modern economy or as hints to innovative and possibly new models - the fundamental question persists: why did the US economy exhibit distinct behavior in the late '90s versus the early 2000s? What is the reason for these changes? This paper asserts that the observed changes are indicative, if not definitive, that the emergence of the new economy is a consequence of a combination of factors facilitated by the Internet and the digitization of information. Actors and ideas are increasingly interconnected at an unprecedented pace. The effects are beginning to manifest and are currently only partially measurable. In other words, the new or digital economy emphasizes dynamic efficiency over static efficiency. Novel activities and products hold greater significance than heightened productivity. While discussing economic growth broadly, more is needed to address the issue. Individual participation in developing and implementing new technologies

* Corresponding author: Ayesha Khan

contributes to economic expansion. Innovative ideas combined result in technological progress. The number of possible new combinations increases directly with the number of connections.

Below is the paper's outline. Next, we will discuss the theoretical underpinnings. It then briefly summarizes previous examples of general technology and their financial success. Secondly, digitization and the Internet have increased productivity in traditional sectors, reorganization of economic activities within industries, enhanced market efficiency, and the opportunity to present new goods and sectors.

2. Theoretical framework

Innovation is the primary driver of economic growth. This encompasses novel products and services, innovative approaches, and diverse market segments (Dekker, 2018; Schumpeter, 1912). There are nearly limitless possibilities for potential innovations. Few technical possibilities are considered, and even fewer are implemented for profit. Experiments were carried out to uncover the new combination. More effort and experimentation are required to explore additional technical capabilities. Economic elements are technological capabilities that are converted into economic prospects. As a system of interconnected components, the economy is straightforward to analyze. Identifying existing opportunities increases consensus among participants and ideas, leading to a broader range of combinations and understandings. The system's structure can change whenever the link is modified. Modifications to the structure impact the system's dynamic properties. Potts states that this changes the connection's current state, potentially resulting in new opportunities, the breakdown of current ones, or the reinforcement of existing ones. Technical changes occur when existing connections between elements are altered, or new connections are established. More connections lead to a higher probability of discovering a new combination. Sparse systems produce limited technical possibilities compared to dense systems, which offer numerous technical possibilities due to their large state spaces. Within broader frameworks of social change theories, Jason Potts argues that the key characteristic of the contemporary economy is the significant transformations in technology, organizations, and institutions (Jason Potts, 2000). Eliasson's experimental organizational economics considers vast technological options, cognitive constraints, and the rationality of all actors, leading to an understanding of the modern economy. Due to the synergy of these factors, optimization becomes challenging, leading to frequent errors and increased technical opportunities with more experiments (Eliasson & Eliasson, 1996). Experimental settings vary in prevalence across different locations. The corporate world can be best described as an innovative system. Various experiments with innovation systems have been conducted in the literature, but the technical innovation conceptual systems are considered the most beneficial (Bo Carlsson, 1984, 1997, 2012a, 2012b; Benny Carlsson & Stankiewicz, 1991). It focuses on a particular technology or set of technologies. It involves all stakeholders (beyond just those in the market), the networks they use to communicate, and the foundational institutional structure. Technical innovation systems lay the foundation for innovation and introduce new commercial opportunities. The technological innovation system plays a role in implementing various contact systems (Khan, Khan, Wei, Khan, & Ayub, 2022). A technology innovation system comprises three components: A cognitive element that organizes sets of interconnected technologies and creates new opportunities for technological progress. As discussed later, the relevant knowledge base, or "design space" of the system is situated: 2. Document the network's interactions encompassing its institutional and organizational intricacies; 3. Individuals engaged in the development of these technologies; and 3. Financial factors Comprises players who can turn a technical opportunity into a commercial one. It is a compilation of composite design areas devised by skilled groups of individuals (Stankiewicz, 2002). The design space represents only a small portion of the numerous technological opportunities available. It could be considered a pragmatic method for incorporating essential technical expertise. Specific types of commercial activities. The design space is constantly changing. The design space is expanded by incorporating new features, built through gradual integration and the co-evolution of different elements, and application-specific knowledge is gathered regarding the evolutionary paths of a specific artifact, such as an airplane. Academic and industrial research and development can influence design through ideas, theories, research methodologies, tools, and improved system-absconding capabilities. The design space concept is well-suited for economic activities that involve digitalization and the Internet because the Internet enables a seamless connection between the human body, cognition, and information. Consequently, previously unrelated tasks will be connected, combined, and reorganized, leading to the emergence of new features. People have acquired additional knowledge through actively seeking out more information. Clarity will improve as we progress with this piece. Changes in design space lead to corresponding changes in organizational components and system dimensions. This encompasses networks, individual actors, public and private institutions, and educational institutions. Since the emergence of biotechnology, the pharmaceutical industry has shifted its knowledge focus from chemistry and chemical engineering to biotechnology. Neither the organization nor the individual sharing this information has any connections to the traditional medicine industry. Technology innovation is more likely to lead to commercial opportunities when the design space is highly interconnected at cognitive and organizational levels. Entrepreneurs should seek out promising technological advancements and transform them into profitable business ventures. Entrepreneurs require entrepreneurship capital, such as venture capital and the necessary business expertise, to

develop a viable strategy, acquire crucial resources, and execute the plan effectively. Robust exit markets, like an initial public offering market and an acquisition-friendly corporate climate, are essential for facilitating resource reallocation and transfer of ownership. Considering all factors, A capacity group comprising skilled consumers, innovators, entrepreneurs, venture capitalists, and industrialists can be identified. They exited the market successfully and introduced innovations for mass production (Eliasson & Eliasson, 1996). The system's technical advancement is defined by the capability group's composition and technology's presence.

In conclusion, the increase in internet connectivity has resulted in significant growth in the range of new technological setups that are now possible. Expanding your social network leads to a greater diversity of ideas and a higher number of potential combinations. There is no assurance that a business opportunity will inevitably evolve from a unique possibility into a profitable one. Participants in cutting-edge systems and skill groups need to maintain frequent and close communication to foster the emergence of new technological opportunities, which is crucial for economic advancement. A more diverse cast with more actors of various faiths can lead to increased economic growth if people have high expectations of them due to the introduction of new ideas. Building robust connections can decrease specific transactions within institutions such as technology innovation systems and markets (Loasby, 2001). Densely connected systems are more effective at assimilating and leveraging new ideas than sparser systems. The New York Stock Exchange (NYSE) is more inclined to support innovative ideas than a small, unstable stock market. This article mainly discusses scope economies, although a closely interconnected system can produce both types of economies. A larger market is more crucial than introducing a brand-new product.

3. Historical examples showcasing the application of adaptable technologies

Is there historical evidence that new connections have led to economic growth? This section will examine three recent instances where new technologies have emerged, providing opportunities for entrepreneurs to leverage and stimulate economic growth. GPT is accessible to all individuals. Novel opportunities exist instead of more specialized technology. The economic growth potential of a technology is directly related to how widely it can be applied. The potential of GPT to generate cost savings is significant, but it is just one element contributing to economic growth; other components are equally crucial, if not more so. We believe employing a strategy focused on comparing costs and the related methodology is optimal. Cost-benefit analyses overlook nuanced factors, but his research demonstrates that the expansion of generic technologies primarily operates through innovation complementarities and the positive cycles they create rather than just cost advantage. New technologies must promote innovation at lower levels and investment in complementary areas across various user segments to be considered for GPT, regardless of potential cost savings. Only after meeting these criteria can, they be evaluated for sustained expansion. However, a universally innovative and complementarity-oriented technology may not result in significant cost reductions, but this should not prevent it from being considered a General-Purpose Technology (GPT). Rosenberg and Traitenberg stated that although GPT can generate new combinations, the notable delays it sometimes encounters complicate the ability to determine and measure the precise influence of these combinations. Economic growth, as demonstrated in the following reference (Rosenberg & Trajtenberg, 2001).

3.1. 1440 saw the invention of the printing press

Johannes Gutenberg's creation of the printing press in the mid-15th century greatly influenced the spread of information. Before the printing press was invented, books were copied by hand, making them scarcer and more expensive. The invention of the printing press enabled the mass production of books, thus enhancing information accessibility. Elizabeth Eisenstein argues in her influential book, The Printing Revolution in Early Modern Europe, that the printing press played a crucial role in making information more readily available to the general public. The democratization process was the main factor that led to the Renaissance and the Reformation by enabling the quick and extensive spread of ideas and information (Eisenstein et al., 1979).

3.2. Steam power and the Industrial Revolution of the 18th and 19th centuries

The rapid technological advancements during the Industrial Revolution led to the widespread adoption of steam engines, particularly the Watt steam engine. Steam power evolved into a versatile and reliable energy source, enabling the operation of machinery in factories and the propulsion of locomotives and ships. Donald N. McCloskey's 2010 book "Bourgeois Dignity: Why Economics Cannot Explain the Modern World" discusses how steam engines significantly increased productivity, leading to the mechanization of various industries. This transformation shifted from agrarian economies to technologically advanced societies, causing a profound change in the economic and social fabric (McCloskey, 2010). Most American steam engines in 1870 were relatively small, with power ranging from 5 to 25 horsepower (Rosenberg & Trajtenberg, 2004). George W. Bush from Providence, Rhode Island, collaborated with Collis to create an innovative series of steam engines in the early 1850s. The engines were equipped with an automatic

variable cut-off mechanism and had a significantly greater capacity than the previous models. Corliss engines enhance steam engines' performance and fuel efficiency to match that of hydraulics. Analyzed data indicates that the deployment of the Collis engine led to a significant industrial migration from rural to urban areas, especially in the northeastern United States (Rosenberg & Trajtenberg, 2001).

3.3. The Internet from the 1960s to the Contemporary

An instance of a contemporary and continuous technological upheaval is the creation and extensive use of the Internet. Initially designed for military communication, the Internet evolved into a global network linking people and data. Manuel Castells' book "The Internet Galaxy: Reflections on the Internet, Business, and Society" explores how the Internet is more than just a technological system; it is a powerful influence changing social interactions and business environments. Castells asserts this in his book. It showcases its adaptability in real-world applications as a communication platform, information repository, and driver of innovations like e-commerce and social media (Castells, 2004).

3.4. Advancements in communication and transportation over the past century

The article "Scale and Scope" argues that implementing ships, cables, telegraphs, and railways has improved speed and reliability, significantly reducing transportation and communication costs. This has led to a substantial domestic market in the United States, allowing capital-intensive industries that depend on intricate production techniques to take advantage of innovative and improved manufacturing processes (Alfred Dupont Chandler, Hikino, & Chandler, 2009). This development signifies a significant and varied economy, a phenomenon never seen before. Extensive manufacturing facilities that use cutting-edge technologies typically have much lower costs per unit than smaller facilities. Converting new opportunities into economic growth is not always guaranteed. Insignificant or trivial: Entrepreneurs must invest in three related areas to take advantage of the cost efficiencies provided by new high-volume production technologies. Investing solely in production facilities can expand technology's potential scale or scope. The second strategy involves dedicating resources to developing an extensive marketing and distribution network nationally and globally. This network will streamline the sale of products to ensure that sales can efficiently align with the expanded production capacity. Both types of investment should be fully optimized in the end. Entrepreneurs need to assign resources to hire and train managers capable of efficiently supervising the growth of facilities and the expansion of production and distribution teams. Furthermore, they must oversee and synchronize these crucial operational tasks while strategizing and assigning resources for upcoming production and distribution. Modern industrial enterprises have seen growth due to their focus on investing in production, distribution, and management, creating a comprehensive strategy (Alfred D Chandler, 1990). The rise of large industrial projects in the United States, United Kingdom, Germany, and other countries signaled the beginning of the industrial era, leading to more than a century of economic growth. Chandler concentrates on large, capital-intensive companies that operate in a process-oriented manner. These companies excel in production and marketing by effectively leveraging economies of scale and scope through adapting to changes in production technology. These companies are the primary recipients of advancements in transportation and communication technologies, although they are not the only ones who benefit. Railways, ships, cables, and telegrams substantially impact the features and spatial arrangement of almost all economic activities. Advancements in transportation and communication depend on standard technologies that enable the entire economy, particularly industries with high capital investment, to create new combinations. Advanced transport and communications technologies have helped combine fragmented regional markets into a unified national market. The United States rapidly became the world's largest civilian economy. The significant population growth, partially due to immigration, has led to substantial investments in infrastructure and manufacturing. American companies have been able to adopt new technologies faster than European companies in industries that demand large-scale operations and substantial capital investment. These factors have created a more favorable environment for economic growth in the United States compared to other countries. The United States has benefited more from these advancements than Britain and Germany, even though it had more technological progress and a larger market before the end of the 19th century. New technologies have a more significant impact in the United States than in densely populated Europe. Pioneers expand markets by combining reliable transportation with large-scale production of goods. As their operations expanded, they created new combinations by introducing additional products. Chandler hinted at potential by-products and associated products that could arise as production increased, even though he did not directly address the issue. For example, aluminum and synthetic ammonia manufacturing companies are driven by cost advantages from economies of scale to find alternative products to use their highly efficient plants' excess production capacity. The increase in meat packaging facilities has produced by-products like fertilizers, soaps, and glues. Moreover, the refining process has produced new petrochemicals. Sales networks are set up nationwide when production reaches a substantial level, such as fertilizer and leather made by large meat processing companies. Managers are hired, and different departments are combined to enhance the sales of these products (Alfred D Chandler, 1990). Systematically exploring opportunities to increase production scale and diversify operations can result in significant benefits.

Samuel Morse revolutionized long-distance communication with his invention of the telegraph in 1837 (Morse, 2014)—revolutionizing communication by enabling rapid message transmission across vast distances profoundly impacted business, politics, and society. The telegraph can be seen as a precursor to modern global communication systems, as discussed by Tom Standage in his book "The Victorian Internet" (Standage, 1998). Sir Alexander Fleming's discovery of penicillin in 1928 was a pivotal moment in medical history (R. H. Fleming, 1928). Antibiotics initiated a healthcare revolution by efficiently treating bacterial infections. The article "On the Antibacterial Action of Cultures of a Penicillium, with Special Reference to Their Use in the Isolation of B. Influenzae" highlighted the groundbreaking impact of penicillin on infectious diseases (A. Fleming, 1929). In 1947, a significant event in electronic history took place when the transistor was invented by John Bardeen, Walter Brattain, and William Shockley at Bell Labs. Electronic devices decreased in size as transistors replaced bulky vacuum tubes (Bardeen, 2004). This breakthrough was essential for the development of the digital age. Crystal Fire: The Birth of the Information Age by Michael Riordan and Lillian Hoddeson explores the impact of the transistor (Riordan, Hoddeson, & Herring, 1999). The Global Positioning System (GPS) developed by the U.S. Department of Defense transformed navigation and location-based services in 1978 (McDonald Hutchins, 2007). Initially developed for military purposes, GPS is now widely accessible to the general public, leading to a significant change in industries like transportation and mapping. Richard D. Easton and Eric F. Frazier explore the history of GPS in their book "GPS Declassified: From Smart Bombs to Smartphones" (Launius, 2015).

3.5. The Historical Innovation of the Dynamo

The dynamo, a revolutionary device in electrical engineering developed in the late 19th century, played a crucial role in transforming electrification and significantly enhancing the Total Factor Productivity (TFP) growth of the United States. By the end of the nineteenth century, Thomas Edison and Werner von Siemens applied Michael Faraday's theories on electromagnetic induction by inventing the dynamo. This advancement established the foundation for the electrification movement, which extensively impacted various sectors of the economy and lifestyle. The invention of the dynamo was a critical advancement that allowed for the widespread generation of electricity in urban areas, businesses, and homes. In his work "The Dynamo and the Computer: A Historical Perspective on the Modern Productivity Paradox," Paul David explains how this transition had a cascading impact on different industries, leading to increased efficiency and productivity. The extensive utilization of electric motors in factories, enabling enhanced and automated production processes, demonstrates the impact of dynamos on Total Factor Productivity (TFP) growth (P. A. David, 1990). Werner von Siemens invented the dynamo 1867, a groundbreaking device that converted mechanical energy into electrical current. As an electrical power source, Siemens' dynamo facilitated industrial expansion, leading to heightened production and economic development. Robert J. Gordon's research on durable goods prices and other studies on total factor productivity growth emphasizes the relationship between technological progress and overall increases in productivity (Gordon, 1990). Another crucial element in establishing the Pearl Street Station in 1882, the first operational electric power station, was Thomas Edison's development of direct current (DC) dynamos. William Lazonick highlighted in his 1991 book "Business Organization and the Myth of the Market Economy" how the widespread adoption of electric power in various sectors enhanced operational efficiency in industries, resulting in continuous growth in total factor productivity (Lazonick, 1991).

The examples demonstrate the significant impact of widely applicable technologies on shaping societies' operations, communication, and progress throughout history. They emphasize the intricate connection between technological progress and societal development, underscoring these advancements' significant and enduring impacts.

3.6. Reflecting on the Economic Impact of Multipurpose Technology in the Past

According to conventional criteria, examining several popular technologies reveals their collective contribution to a more efficient and productive economy. However, that is only part of the narrative; the other part involves the impact on economic prosperity and sustained growth. The capacity of a technology to create new combinations increases with its ability to be applied broadly, its overall impact, and the range of potential applications. The printing press, steam engine, and dynamo are historical inventions that illustrate the economic impact of General Purpose Technologies (GPTs). This discussion focuses on the insights gained from these groundbreaking technologies and their enduring impact on economic development. Here are the lessons we derive from previous history:

Lesson 1 of Chandler's size and scope model focuses on building large businesses in industries requiring much money and growth. This approach also involves developing new and creative products and services. Transportation and communications are versatile technologies that have applications beyond manufacturing.

Lesson 2, Enhancing Productivity and Knowledge Accessibility Johannes Gutenberg's creation of the printing press demonstrated that knowledge could be more widely available. The transition from a system of exclusive knowledge to widespread knowledge sparked the Reformation and Renaissance. The steam engine and dynamo invention expedited

industrialization and enhanced productivity across various sectors. The positive economic impact of a GPT can lead to increased productivity in various industries, not just the ones directly targeted.

Lesson 3 discusses the effects of new technologies and systemic changes. Steam engines, dynamos, and other innovations were utilized for purposes beyond their original intentions. Conversely, they triggered technological spillovers that affected various sectors. The dynamo hastened the electrification of different sectors, while the steam engine fueled transportation, industries, and agriculture. The GPTs have inspired new industries and disrupted established economic systems, leading to significant changes in the global economy.

Lesson 4 discusses catalysts for structural transformation and economic growth. GPTs are crucial in sparking sustained economic growth and fundamental transformation. The dynamo drove the electrification movement, leading to new business models and enhanced industrial efficiency. In retrospect, GPTs played a vital role in shaping entire economies and driving sustained growth.

Lesson 5: Industries and labor forces needed to be resilient and flexible to implement General Purpose Technologies (GPTs) in the past. Several adjusting factors were involved in transitioning from mechanical book copying to the printing press or mechanical manufacturing to electrical processes. The extent to which societies were willing to adopt new technologies and address economic disruptions played a crucial role in determining their success.

Ultimately, versatile technologies significantly demonstrate their ability to influence societies and economies through their lasting economic effects. Studying historical lessons can guide us in adapting to new technology, recognizing systemic impacts, and leveraging GPTs for sustained economic development in the evolving technological landscape.

4. Exploring the growing digital economy

It is crucial to distinguish between information and knowledge when delving into the realm of the growing digital economy. Information consists of raw facts, while knowledge is a well-organized framework, whether theoretical or hypothetical, that helps organize and explain information. In the traditional economy, information was shared using physical methods like cash, checks, invoices, bills of lading, reports, face-to-face meetings, analog or radio and television transmissions, blueprints, maps, photos, music scores, and direct mail advertisements. All types of information are converted into digital form, stored as bits in computers, and quickly transmitted through networks at the speed of light in the modern digital economy. Tapscott described this shift in 1995 as a significant change on par with the invention of language. It indicates a shift from the previous model centered on physical interactions (TapSCOtt, 1996).

While the idea of information is not novel, the methods for collecting, manipulating, storing, and transmitting it have progressed. In his book "Post-Capitalist Society" (1993), Peter Drucker argues that knowledge has been essential in economic activities since the Industrial Revolution. Drucker stated that economic activity between 1700 and 1850 involved transforming practical experience into organized, standardized knowledge. Between 1850 and 1950, a notable productivity revolution was marked by the crucial importance of applications. Drucker introduced the term "management revolution" to refer to the 1950s when he stressed the significance of applying knowledge effectively. He stressed that knowledge is now the most vital resource in the contemporary world. Drucker determined that in this specific scenario, the conventional elements of production, such as land (natural resources), labor, and capital, have not disappeared but have taken on a less critical role. The increased availability of knowledge has caused a change in focus towards considering knowledge as a means to achieve social and economic results (P. Drucker, 2012). The updated concept of knowledge, initially introduced by Drucker in 1993 and subsequently supported by Neff in 1998, highlights the significant value of knowledge work (P. F. Drucker, 1993; Neef, 1998). Engaging in complex problem identification, advanced problem-solving, innovative design, introducing revolutionary products or services, and creating new markets have rapidly become the primary catalysts for economic growth at both individual and organizational scales (Neef, 1998).

4.1. Impact of Digitization and the Internet on Productivity in the Oil Industry

Since the first finding of oil in Pennsylvania's Oil Creek in 1859, approximately 820 billion barrels of oil have been used globally, nearly 75% consumed since 1973. The proven oil reserves are only half of what they were in the 1970s, even though they are more than ten times larger than in 1950. The average cost of discovering new oil has significantly decreased from $12–16 per barrel in the 1970s and 1980s to $4–8 (Rauch, 2001).

Several significant developments have contributed to this change:

4.1.1. Computing power

Between 1970 and 2000, the performance of microprocessors increased by a remarkable 7,000-fold. The computational speed significantly increased, leading to a decrease in the time required for complex tasks. The cost of storing one megabit of data decreased significantly, from over $5,000 in 1975 to just 17 cents in 1999. Seismic imaging is the method of utilizing seismic waves to generate images of underground formations.

Geologists underwent a significant advancement in seismic imaging, a technique they use. Computers currently use 3D imaging to create a detailed representation of rock formations. Integrating 3D imaging into commercial applications in 1975 marked a significant advancement that necessitated substantial computational power.

4.1.2. Combining computing with 3D seismic imaging

The fusion of computing and 3D seismic imaging led to a notable reduction in processing times and expenses. From 1985 to 1995, processing one square kilometer of data decreased from 800 minutes to 10 minutes. The expense of surveying a 50-square-mile area dropped substantially from $8 million to around $90,000.

4.1.3. Directional drilling

A revolutionized the industry by allowing wells to reach reservoirs from the most favorable angles. This technology facilitated the extraction of previously hard-to-reach reserves or economically impractical, making them readily available. By the late 1980s, the adoption of 3D seismic imaging enabled accurate target identification, leading to the economic viability of directional drilling.

4.1.4. Measurement-While-Drilling (MWD) technology

Before 1980, drilling operations often stopped for measurement purposes. MWD technology has revolutionized the process by continuously monitoring the drill bit's location in real time, thus reducing the need for frequent interruptions and improving efficiency.

4.1.5. The Internet integration

The internet has played a crucial role in driving the evolution of the oil industry. Geologists and managers can remotely access current data from drilling sites worldwide, enabling prompt decision-making. Connectivity has facilitated cost reduction and operational optimization. Significant advancements in the oil industry are the digitalization of data and the integration of evolving technologies in line with the increasing use of the Internet. Using high-resolution 3D imaging, advanced sensors, and powerful computing has transformed the precision drilling process, where knowledge plays a vital role. The digitization of information and Internet connectivity have fundamentally changed decision-making in oil business management. This transformation has led to decreased costs and improved efficiency. Digitalization and the Internet have converted knowledge into an abundant resource, surpassing the significance of oil in propelling progress in different industries (Rauch, 2001).

4.2. Enhancing Productivity Through Collaboration

Digital technology, the Internet, and innovative software solutions allow companies to change how they work with suppliers and customers, resulting in increased productivity. 38% of participants in a survey conducted by the National Association's online newsletter in March 2002 indicated that collaborating with supply chain partners would significantly influence their business in the subsequent three years. Subsequently, 26% of the participants opted for new information technology, while 5% selected network reorganization. Additionally, 28% of people recognized the combined effect of all three strategies (Tuttle, 2002).

Swiftly accessing information and promptly addressing customer needs is vital in distribution. Distributors can engage in product design and development by utilizing collaborative web technology. Communicating directly with vendors allows for quick verification of product availability and rapid order fulfillment, leading to a substantial decrease in order processing time from days to minutes. Additionally, the software can store transaction data for future use, enhancing efficiency in the distribution process (Tuttle, 2002).

The Daimler Chrysler fast-track car project demonstrates how web technology facilitates effective collaboration among design engineers. The company aims to accelerate the new car development process by 40% by utilizing an online system instead of traditional communication methods like phone, fax, and email. The implementation of this efficient method enables quicker design modifications and substantial cost reductions in vehicle development (Moozakis, 2000).

General Motors (GM) has notably reduced its production timelines from 42 months in the mid-1990s to 18 months, showcasing the substantial impact of digital collaboration (Keenan, Ante, Elgin, & Hamm, 2002).

The digitization of information and the extensive utilization of the Internet decrease costs and improve productivity, enabling manufacturers to adjust to evolving consumer needs promptly. Improved connectivity expands the scope of design options, making it easier to develop more ideas and quickly implement or discard new concepts. The interaction between supply-side mechanisms and demand-side reactions propels economic growth in this innovative market environment. The competence group's skilled choice and support of viable new products are crucial elements in this process.

4.3. Restructuring of economic activities is occurring within industries, particularly in the banking sector

An increasing trend in the banking sector involves the growth of providers offering online self-service technologies. The introduction of automated online channels has dramatically changed how banks and their customers interact, especially for customer service representatives like call center agents. The focus remains on maintaining a high standard of customer service despite the change. This provides the opportunity to lower expenses and improve productivity, potentially leading to better customer service. Banks can focus their employees on more valuable and personalized customer queries, potentially enhancing customer satisfaction (Profile, 2007). The banking sector has experienced substantial reorganization due to technological advancements and the digitalization of economic activities.

4.3.1. Online banking platforms

Online banking platforms have supplanted traditional brick-and-mortar banking. Customers can now conduct various transactions through user-friendly mobile applications and online platforms, such as transferring funds and managing their accounts. This shift has reduced reliance on physical branches and transformed the customer experience.

4.3.2. Integration of financial technology

Financial technology integration has encouraged collaboration and merging in the banking industry. Financial institutions are increasingly collaborating with fintech companies to incorporate advanced solutions like electronic wallets, peer-to-peer lending platforms, and automated investment advisors. This is done to enhance their services and meet evolving customer demands.

4.3.3. Automating repetitive transactions

Automated systems now more frequently manage routine and repetitive transactions like deposits, withdrawals, and balance inquiries. Banks have adopted self-service kiosks, online banking, and ATMs as standard tools, allowing them to reallocate human resources to more complex and advantageous tasks.

4.3.4. Using Big Data Analytics for Customized Services

The banking industry utilizes big data analytics to gather data on customer behavior, preferences, and financial patterns. Banks can enhance customer satisfaction and promote loyalty by using a data-driven approach to offer personalized services, targeted marketing campaigns, and customized financial products.

4.3.5. Blockchain technology and smart contracts

Blockchain technology is transforming how financial transactions are carried out. Blockchain technology facilitates smart contracts, enabling automated, transparent, and secure agreement execution. This reduces the need for intermediaries and enhances the speed and security of financial transactions.

4.3.6. Security protocols

With the increasing digitalization of financial activities, there is a heightened focus on cybersecurity. Financial institutions have enhanced security protocols to strengthen the safeguarding of customer data, financial transactions, and sensitive information from cyber threats. This includes the implementation of advanced encryption, multi-factor authentication, and continuous monitoring systems.

4.3.7. Transition to Digital Lending

Digital lending platforms have caused significant changes in the lending industry. These platforms use algorithms and artificial intelligence to assess creditworthiness, streamline loan approval processes, and provide quick access to funds. This restructuring has significantly improved the efficiency of lending operations.

4.3.8. The utilization of virtual and augmented reality in the banking industry

Banks are exploring virtual and augmented reality to enhance customer engagement. Virtual banking environments and augmented reality apps provide immersive and interactive experiences, like virtual tours of bank branches or personalized financial advice.

4.3.9. Enhanced adherence to regulations and standards

The utilization of digital technology has streamlined and simplified the process of regulatory compliance. Banks utilize digital tools and software solutions to ensure compliance with ever-evolving regulations, reducing the burden of manual compliance procedures. The effect of implementing cheque image processing technology on the work dynamics in two different divisions of a significant bank facilitates instant communication, observation, and information sharing(H. David, Levy, & Murnane, 2000; Thinakal, 2001).

The restructuring of economic activities in the banking industry indicates a shift towards digitalization, automation, and enhanced customer-centric services. The modifications improve operational efficiency and pave the way for a more adaptable and technologically advanced banking system.

4.4. Internet's Influence on Market Efficiency

Research involves analyzing how Internet usage impacts market efficiency. Various studies, such as those conducted by Smith et al., demonstrate that the primary impact of the Internet on the market is its ability to facilitate price comparisons for buyers and sellers. This is achieved by removing intermediaries, reducing transaction costs, and removing barriers to participation. The Internet has heightened competition, enhancing the efficiency of the price mechanism. The primary and measurable effects of the 'new' economy focus on improving the effectiveness of the 'old' economy (Smith, Bailey, & Brynjolfsson, 1999). There is evidence backing these assertions, including recorded reductions in expenses for banking transactions and ticket issuance when conducted online (Grant, 1996). Litan and Rivlin attempted to measure the collective influence of the Internet on the evaluations conducted by industry-level analysts concerning individual companies (Litan & Rivlin, 2001). Their research suggested possible yearly cost reductions between $100 billion and $230 billion. Over five years, these savings could potentially lead to an annual productivity increase of 0.2-0.4% if converted. The primary source of these savings is reduced transaction costs, improved management efficiency, increased competition, transparent pricing, and expanded market access.

Reducing transaction costs positively impacts management efficiency, supply chain management, and overall business performance. The Internet's impact extends beyond e-commerce to include traditional sectors like healthcare and government, transforming how information is shared. The main benefits are expected to focus on enhancing consumer convenience and expanding choices rather than just boosting productivity and lowering prices.

4.5. Innovative Combinations in the Form of New Products and Industries

Digitalization and the Internet have significant effects beyond enhancing production and market efficiency. They serve as catalysts for the development of entirely novel products and services. While the specific details of these innovations remain undisclosed, various examples illustrate the development of current products and activities:

4.5.1. Communication Transformation

Email has transformed interpersonal communication, exceeding traditional mail and, to some degree, voice communication.

4.5.2. Progression of Financial Services

The emergence of online financial services has revolutionized how people handle their accounts, pay bills, and carry out financial transactions.

4.5.3. Academic and managerial procedures

Academic and managerial procedures involve university applications, electronic tax return submissions, utilizing online travel agencies, and showcasing shifts in educational and administrative processes.

4.5.4. Advancements in consumer products

Video games, e-cards, downloadable music, and e-tickets are innovative or altered consumer goods.

4.5.5. Research methodologies and strategies for obtaining information

Online searchable databases and e-journals have drastically changed research and study methods.

The examples demonstrate changes in existing product distribution, emphasizing the importance of digitization. Uncovering entirely new products that did not exist before the Internet remains a challenging endeavor. Examples of innovative services based on the Internet include open innovation, specialized product procurement assistance, and customized advertising solutions for local markets. These services often involve a brokerage role that relies on immediate connectivity and information collection, use, and sharing. The concept of "new combinations" highlights integrating innovative elements into projects, leading to cumulative effects. A new economic theory has emerged, emphasizing that market development and innovation are the main drivers of growth, replacing the traditional focus on productivity and cost-cutting. In advanced economies, adopting state-of-the-art technologies and problem-solving services are critical drivers of economic growth, leading to new markets (Neef, 1998).

5. Conclusion

The main progress in the developing digital economy stems from integrating digitalization and the Internet. Just as generic product technologies (GPTs) had a significant impact in the past, true innovation lies in combining them. The Internet speeds up the blending of various ideas and people, encouraging a variety of creative combinations, similar to how advancements in transportation and communication technologies in the 19th century helped expand a large national market. The Internet's distinct impact lies in information processing, unlike previous GPTs, which mainly affected the production of costly goods. Earlier versions of GPT, like the Corliss steam engines, had substantial effects on crucial industrial procedures. The Internet excels in gathering, organizing, and disseminating information efficiently. Assessing the influence of these technologies on productivity and economic activity is challenging because of their extensive effects on various activities and their enduring presence.

Throughout history, groundbreaking technologies like electrification, automotive progress, commercial aviation, and television have significantly altered daily life, showcasing the profound impact of General Purpose Technologies (GPTs). The process of transforming data into a digital form and utilizing the Internet has implications beyond mere enhancements in efficiency. This phenomenon significantly impacts the service sector, encompassing healthcare, government, and financial services, contributing over 75% to the gross domestic product (GDP). Efficiency and productivity gains can be measured, but their real significance lies in the profound and enduring changes they bring about, which are challenging to quantify but unquestionably transformative.

Compliance with ethical standards

Acknowledgments

The team of authors would like to thank all those who have helped to complete this work.

Disclosure of conflict of interest

There are no conflicts of interest.

References

[1] Baily, M. N., & Lawrence, R. Z. (2001). Do we have a new economy? *American Economic Review, 91*(2), 308-312.

[2] Bardeen, J. (2004). LILLIAN HODDESON. *No Boundaries: University of Illinois Vignettes*, 241.

[3] Carlsson, B. (1984). The development and use of machine tools in historical perspective. *Journal of Economic Behavior & Organization, 5*(1), 91-114.

[4] Carlsson, B. (1997). *Technological systems and industrial dynamics* (Vol. 10): Springer Science & Business Media.

[5] Carlsson, B. (2012a). *Technological systems and economic performance: the case of factory automation* (Vol. 5): Springer Science & Business Media.

[6] Carlsson, B. (2012b). *Technological systems in the bio industries: An international study* (Vol. 26): Springer Science & Business Media.

[7] Carlsson, B., & Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal of Evolutionary Economics, 1*, 93-118.

[8] Castells, M. (2004). *The network society: A cross-cultural perspective*: Edward Elgar Publishing, Incorporated.

[9] Chandler, A. D. (1990). The enduring logic of industrial success. *Harvard business review, 68*(2), 130-140.

[10] Chandler, A. D., Hikino, T., & Chandler, A. D. (2009). *Scale and scope: The dynamics of industrial capitalism*: Harvard University Press.

[11] David, H., Levy, F. S., & Murnane, R. J. (2000). Upstairs, downstairs: computer-skill complementarity and computer-labor substitution on two floors of a large Bank. *NBER Working Paper*(w7890).

[12] David, P. A. (1990). The dynamo and the computer: an historical perspective on the modern productivity paradox. *The American economic review, 80*(2), 355-361.

[13] Dekker, E. (2018). Schumpeter: Theorist of the avant-garde: The embrace of the new in Schumpeter's original theory of economic development. *The Review of Austrian Economics, 31*(2), 177-194.

[14] Drucker, P. (2012). *Post-capitalist society*: Routledge.

[15] Drucker, P. F. (1993). The rise of the knowledge society. *The Wilson Quarterly, 17*(2), 52-72.

[16] Eisenstein, E. L., Lewis, R. H., Lindsay, J., Weyr, T., Osburn, C. B., & Egan, R. (1979). Print Media.

[17] Eliasson, G., & Eliasson, A. (1996). The biotechnological competence bloc. *Revue d'economie industrielle, 78*(1), 7-26.

[18] Fleming, A. (1929). On the antibacterial action of cultures of a penicillium, with special reference to their use in the isolation of B. influenzae. *British journal of experimental pathology, 10*(3), 226.

[19] Fleming, R. H. (1928). The Origin of "Sir Alexander Mackenzie and Company". *Canadian Historical Review, 9*(4), 137-161.

[20] Gordon, R. J. (1990). What is new-Keynesian economics? *Journal of economic literature, 28*(3), 1115-1171.

[21] Grant, B. J. (1996). Trends in US airline ticket distribution. *The McKinsey Quarterly*(4), 179.

[22] Jason Potts, M. (2000). *The new evolutionary microeconomics*: Edward Elgar Publishing Limited.

[23] Keenan, F., Ante, S. E., Elgin, B., & Hamm, S. (2002). The new teamwork. *Business Week*(3770), 12-12.

[24] Khan, T., Khan, A., Wei, L., Khan, T., & Ayub, S. (2022). Industrial Innovation on the Green Transformation of Manufacturing Commerce. *Journal of Marketing Strategies, 4*(2), 283-304.

[25] Khan, T., Long, W., & Khan, A. (2022). THE INFLUENCE OF INNOVATION TOWARDS ECONOMIC GROWTH IN CHINA: EVIDENCE FROM THE ARDL MODEL. *Management and Human Resource Research Journal, 11*(9), 77-86.

[26] Launius, R. D. (2015). GPS Declassified: From Smart Bombs to Smartphones, by Richard D. Easton and Eric F. Frazier. *Quest: The History of Spaceflight Quarterly*.

[27] Lazonick, W. (1991). Business History and Economics. *Business and Economic History*, 1-13.

[28] Litan, R. E., & Rivlin, A. M. (2001). Projecting the economic impact of the Internet. *American Economic Review, 91*(2), 313-317.

[29] Loasby, B. J. (2001). Time, knowledge and evolutionary dynamics: why connections matter. *Journal of Evolutionary Economics, 11*, 393-412.

[30] McCloskey, D. N. (2010). *Bourgeois dignity: Why economics can't explain the modern world*: University of Chicago Press.

[31] McDonald Hutchins, R. (2007). Tied Up in Knotts? GPS and the Fourth Amendment.

[32] Moozakis, C. (2000). Manufacturers preach teamwork—producers of customized components use web to design by committee. Internet Week. *October, 30*, 83.

[33] Morse, S. F. B. (2014). *Samuel FB Morse* (Vol. 2): Cambridge University Press.

[34] Neef, D. (1998). The Knowledge Economy Butterworth-Heeinemann Boston.

[35] Profile, C. (2007). www. datamonitor. com. *available at: Marketline database*, 1-46.

[36] Rauch, J. (2001). The new old economy: oil, computers, and the reinvention of the earth. *Atlantic Monthly, 287*(1), 35-49.

[37] Riordan, M., Hoddeson, L., & Herring, C. (1999). The invention of the transistor. *Reviews of Modern Physics, 71*(2), S336.

[38] Rosenberg, N., & Trajtenberg, M. (2001). A General purpose technology at work: the Corliss steam engine in the late 19th Century US: National Bureau of Economic Research Cambridge, Mass., USA.

[39] Rosenberg, N., & Trajtenberg, M. (2004). A general-purpose technology at work: The Corliss steam engine in the late-nineteenth-century United States. *The Journal of Economic History, 64*(1), 61-99.

[40] Schumpeter, J. A. (1912). The Theory of Economic Development, Leipzig: Dicker and Humblot: Translated by Redvers Opie, Harvard University Press, Cambridge, MA.

[41] Smith, M. D., Bailey, J., & Brynjolfsson, E. (1999). *Understanding digital markets: review and assessment*: MIT press.

[42] Standage, T. (1998). *The Victorian Internet: The remarkable story of the telegraph and the nineteenth century's online pioneers*: Phoenix London.

[43] Stankiewicz, R. (2002). The cognitive dynamics of biotechnology and the evolution of its technological systems *Technological Systems in the Bio Industries: An International Study* (pp. 35-52): Springer.

[44] TapSCOtt, D. (1996). The Digital Economy: Promise and Peril in the Age of Networked Intelligence. McGraw-Hill, New York, NY.

[45] Thinakal, S. (2001). Web-centric servicing creates mortgage industry value. *ABA Banking Journal, 93*(10), 70.

[46] Tuttle, A. (2002). E-collaboration: Build trust and success. *Industrial Distribution, 91*(6), 59.