Future of Business and Finance

Abeba N. Turi
Pooja Lekhi *Editors*

Innovation, Sustainability, and Technological Megatrends in the Face of Uncertainties

Core Developments and Solutions

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Future of Business and Finance

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Editors
Abeba N. Turi
Northeastern University,
University Canada West
Vancouver, BC, Canada

Pooja Lekhi
University Canada West
Vancouver, BC, Canada

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In loving memory of my father, ***Mr. Anoop Kumar Lekhi****, whose guiding presence lives on, illuminating every step of my journey.*

—Pooja Lekhi (Ph.D.)

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We also want to express our deepest gratitude to all the individuals (close family members and friends) who supported us throughout our journey. Your unwavering support fueled our determination, and we are immensely grateful for your unconditional presence.

With profound thanks and appreciation,

Editors of the book.

Executive Summary

This edited book focuses on the multidimensional aspects of the technological megatrends shaping our global economic system's social, economic, and geopolitical order in the face of uncertainties. With continued shocks, economic downturns, socio-political crises, climate change, and waves of pandemics that pose an existential threat, technological forces have significant effects in defining our path. In this book, by focusing on recent innovations and technological megatrends, the book navigates the sustainability of such developments in the face of uncertainties. The content structure follows a multidisciplinary approach with experts across various fields of study sharing collective insight toward sustainable innovation and technological catalysts that shape the next-gen socio-economic and political sphere. More specifically, in this work, we will flesh out the core developments and trending tech solutions that pose challenges and bring opportunities for businesses and the economies at large as global economies emerge from the devastating economic downturn caused by the COVID-19 pandemic and beyond.

The core theme of the book revolves around three drivers of the tech wheel (geopolitics, environmental change, and economic forces) with a focus on tech democratization, polarization, deglobalization, decentralization, and technological risks at the heart of recent human innovations (see Fig. 1, the next-gen tech steering wheel available in the first chapter of this book). The discussions in this book cover (1) emerging tech trends, opportunities, and threats: cybersecurity and cybercrime: preparedness and resilience to cyber threats, regulation of tech forces and technological backlash, and revolutionary technologies to curb the tension beyond the tech war; (2) geopolitics-technological convergence and catchup amidst bi-polar global order and environmental change; and (3) economic forces—income disparities, financial instability, global health and waves of pandemic threats, well-being, and social welfare.

Book Organization

The book is developed to communicate up-to-date data and illustrative examples across various domains and disciplines in relation to the core theme, innovation, sustainability, and technological megatrends in the face of uncertainties. Below, we will present the organization of the book in sequential order highlighting each chapter's coverage.

The book comprises three principal parts focusing on the (1) *Technological Breakthrough and Revolutionary Technologies Shaping the Future*, (2) *Technological Convergence*, and (3) *Technological Threats: Policy and Regulatory Insights*.

Part I focuses on technological breakthroughs and revolutionary technologies that are shaping our future. Topics of coverage under this part include data explosion and algorithm economy, Industry 5.0 and the future of workforce beyond efficiency and productivity, digital assets, Fintech 4.0 and financial systems, and sustainability in technology and revolutionary technologies.

The first chapter starts with analyzing the algorithm economy in the light of data explosion and artificial intelligence (AI) fervidness in this chapter. The chapter presents a high-level abstraction and analysis of major AI tech trends and advancements, focusing on sectoral innovation diffusion and country-level AI readiness.

The second chapter navigates through Industry 5.0, the future of the workforce beyond efficiency and productivity, with a focus on the implications of the industry through the lenses of integrated technologies, practices of customer-centric production, sustainable business approach, open-source manufacturing, and the role of COVID-19 pandemic in the paradigm shift. It further analyzes the impact it has on the future of the workforce. The chapter concludes with a qualitative prediction of these developments in the near and far future.

The third chapter presents the megatrends and innovations shaping the future of finance, navigating through distributed ledger technologies, artificial intelligence, machine learning solutions, consumer protection, financial stability, and risk management. By identifying the driving forces, including technological advancements, regulatory reforms, the rise of fintech companies, and change in demographic patterns and consumer preferences, the chapter provides readers with a concrete review of the panorama of technology-enabled financial systems.

The fourth chapter analyzes Fintech 4.0 and financial systems navigating through the latest developments in the industry, starting with a high-level introduction to the fourth-gen technologies and financial principles in this sphere. It further explores the factors that affect the development of fintech, the integration of technologies with finance principles, the transformation of fintech from product focus to scenario focus, and the discussions on the future of fintech toward control-oriented vs. credibility-oriented direction.

The fifth chapter explores some technological breakthroughs in financial services since the 2008 credit crunch. The discussion under this chapter focuses on payment services, including mobile payment, mobile wallets, online payment, debit/credit cards, and cross-border payment. Besides, the chapter briefly examines buy-now-pay-later (BNPL) services offered by retail giants and the central bank digital currency (CBDC), a low-cost payment digital currency backed by central banks.

The sixth chapter covers technological megatrends for sustainable business with a focus on the notion of sustainability and trending technologies for energy efficiency, waste management, supply chain management and operations, sustainable manufacturing, and predictive maintenance. The chapter further navigates through the benefits and challenges in relation to these developments and further explores the human factor in Fintech 4.0 through the lens of Industry 5.0.

The seventh chapter presents sustainable development that drives green tech and cleantech innovations through the lenses of selected United Nations (UN) Sustainable Goals: affordable and clean energy; industry, innovation, and infrastructure; sustainable cities and communication; responsible consumption and production; and climate action. The study under this chapter elucidates the importance of sustainability, green tech, and clean tech to achieve the sustainability goals of the UN.

The eighth chapter navigates through the origins, evolution, and future of sustainable accounting by focusing on the history of sustainability accounting, from its emergence in the 1970s to the modern-day adoption of a global set of industry-specific sustainability accounting standards. The chapter discusses the impact of sustainability accounting on businesses, hiring practices, and sales strategies. It further analyzes the limitations of sustainability accounting when left in the hands of businesses.

Part II presents technological convergence covering technological shocks, innovation diffusion and evolution, the new generation of societal and economic orders, technologies, and the platform economy considering the increasing income disparities, sustainable tech solutions together with the developments in the field, and tech democratization. Under this part:

The ninth chapter analyzes the real business cycle (RBC) theory to draw a context of the theory with a focus on the implications for employment in light of technological advancements. The chapter explores the shift in focus from monetary shocks to real shocks in explaining business cycles, highlighting the contributions of economists such as Kydland, Prescott, Nelson, and Plasser, and examining criticism of the theory regarding the impact of technological advancements on recessions, and presents the responses put forth by RBC proponents.

The tenth chapter considers how financial systems are converging with respect to financial service players, big data, and regulations. It navigates through the dynamics of these three forces shaping the global financial industry. It further explores the challenges in attaining and sustaining a coordinated uniform global financial system, including regulatory standards to achieve financial inclusion and a sustainable financial environment.

The eleventh chapter presents the advancements in Industry 5.0 considering sustainable innovations and industrial progress with the paradigm shift in the face of uncertainties with the looming environmental and social challenges. More specifically, the chapter addresses sustainable innovation and the significance of the business models underlying Industry 5.0. It further examines the difficulties associated with implementing sustainable innovation and provides examples of sustainable business practices as it applies to various industries.

Part III presents technological threats—policy and regulatory insights *addressing the issues of technological risks and the looming technological threats in the face of uncertainty by focusing on the threats posed by technological advancements in terms of economic uncertainties and political instability, policy challenges, and geopolitical tensions*. Topics of coverage here include tech trends and the looming threats to businesses and economies, digital finance risks, security, regulation of tech forces—technological backlash and programmable money hype, and the implications for financial instability*, automation, and cobots (collaborative robots). The principal coverage of each of these chapters is highlighted as follows.*

The twelfth chapter provides a high-level analysis of the regulation of tech forces investigating technological backlash through the Luddite perspective. By focusing on the emerging artificial intelligence, machine learning, and robotics technologies that have societal ramification effects, including labor market disruptions and job replacement effects, the chapter fleshes out the potential threats these developments bring with policy and regulatory insights for a smooth techno-economic landing. It further explores the implications of autonomous production models by taking the cases of autonomous weapon systems and self-driving cars.

The thirteenth chapter examines financial services innovation and looks into the socio-economic and regulatory concerns in relation to this, including consumer privacy and protection, cybersecurity, financial stability, and safety. Additionally, the chapter discusses effective management of regulation concerns by balancing the need for financial services innovation and the desire for the financial systems' safety and stability. The chapter concludes by exploring possible collaboration mechanisms for regulators and financial services stakeholders for the common good.

The fourteenth chapter presents a novel approach to open innovation (OI) as it applies to small-and-medium-scale companies (SMSCs) suffering from multilayer constraints to benefit from such a collective tech value creation model. Based on a refined proof of concept, the chapter develops an OI model for SMSCs with multiple layers of stakeholder involvement. The proposed model observes a semi-centralized framework with the leading role of government in open innovation initiatives for SMSCs.

Contents

About the Editors

Abeba N. Turi, Ph.D., is a published author and scholar with expertise in digital economy. She has extensive experience in academia and various research domains across different regions in Africa, Europe, and Canada. Her research works have been presented at international indexed conferences in China, Canada, Germany, Italy, Spain, and the United Kingdom. Her research interest areas include algorithm economy and data science, applied economics, digital economy, fintech applications and e-commerce, business model design and engineering, DLTs and cryptonomics, tech policy, and emerging tech analysis. Dr. Turi identifies herself as a disruptive tech and decentralization enthusiast.

Pooja Lekhi, Ph.D., is a proficient professional with over nine years of experience in teaching and research within the business administration field, specializing in finance. She currently holds the positions of Vice Chair in the Department of Quantitative Studies and finance professor at the University Canada West. Backed by a solid academic foundation and a comprehensive grasp of effective pedagogical and assessment methodologies, she adeptly communicates intricate technical and financial concepts with clarity. Her instructional responsibilities embrace both management and finance courses. She possesses a Ph.D. in business administration (finance) and a master's in business administration (finance) from Punjab Technical University in India. Her contributions include numerous published research articles, magazine pieces, and book reviews. Moreover, she is frequently cited in various international media outlets, including Express.co.uk, capital.com, and currency.com. Her research interests span analyzing asset quality management practices in banks, evaluating banks' loan and investment portfolios, and exploring cryptocurrencies and financial technologies.

Part I
Technological Breakthrough and Revolutionary Technologies Shaping the Future

Data Explosion, Algorithm Economy, and the AI Fervidness

Abeba N. Turi

Abstract The recent surge in artificial intelligence (AI) technologies and applications across domains has brought the algorithm economy into the spotlight like never before. The chapter explored major AI-tech trends and advancements in this context, focusing on sectoral innovation diffusion and country-level AI readiness. The analysis depicts a high intensity of adoption, mainly in risk management and products and service development domains across different sectors. Here, we identified government, the economic value embedded within the tech, and the proliferation of data combined with tech advancements in the field as the core drivers of the AI hype. In the AI readiness sphere, we have observed regional and country-level disparities between the USA and Singapore from the Americas and Asia, respectively, depicting higher average readiness levels. African countries remained the laggards (except for Mauritius and South Africa, which performed relatively better in their data and infrastructural readiness), while Western European countries like the UK, Finland, and Germany, along with others, depict better preparedness. In this regard, the economic capacity with data availability and AI infrastructure of the countries showed a positive association with the countries' AI readiness. We have also observed higher carbon footprints for countries with significant government AI readiness index (greater than 60), mainly China and the USA.

Introduction

Artificial Intelligence (AI) has recently become one of the driving forces and transformative tech with opportunities and challenges across different application domains. Artificial Intelligence refers to machine intelligence built through computer systems that sense their environment, learn the pattern, and analyze to respond

A. N. Turi (✉)
Northeastern University, University Canada West, Vancouver, BC, Canada
e-mail: abeba.nigussie@ucanwest.ca

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to the target task under consideration. With years of evolution, AI technologies have brought significant transformative implications across industries. An AI-enabled economic system targeted at the algorithm economy is built on the exploding sea of data, algorithms, and data-driven insights and the computational power of machines to drive economic value.

The surge in algorithm economy and AI applications is here to shape the future of value creation principles through machine-amplified decision-making, more efficient personalization, and customization. This will lead to (1) enhanced operational efficiency and productivity, (2) the emergence of new and innovative business models, products, and services, (3) generation of new revenue streams, (4) Identification of growth hacking opportunities, and (5) unlock the potential for novel entrepreneurial prospects. As one of the principal developments in collaborative economic systems (Kohli et al., 2023; Lekhi, 2023), the role of open innovations, collaborations, and knowledge-sharing principles to lure the advancements and innovation diffusion of AI technologies are significant.

The paradigm shift in the means of value creation fueled by the explosion of data comes with challenges and opportunities for businesses, society, and economies at large. In this context, this chapter pinpoints the main concerns and challenges connected with adopting AI technologies and solutions. Further, to understand the dynamics of the algorithm economy and enabling AI technologies, we will analyze the sectoral and institutional AI readiness level and innovation diffusion in light of these challenges and opportunities.

The remainder of this chapter is organized as follows. Section ”Related Works” presents related works to link the study to the larger dialogue in the field and shares empirical and theoretical evidence. Section ”The Next Gen Tech Steering Wheel” navigates the driving wheels of emergent technologies and the triple pillars shaping the ride to the next generation of digital economic systems. In Sect. ”Selected AI Models and Solutions”, by concentrating on AI tech solutions, we will look at selected AI models and solutions, followed by the analysis of major players and industry trends in this tech space in Sect. ”Key Players and Industry Trends”. Section ”The AI Pulse—Tech Readiness Analysis” presents a tech readiness analysis focusing on sectoral AI Innovation diffusion and countries’ level of AI readiness. Building on these, Sect. ”AI Adoption Challenges and Major Concerns” presents AI technologies’ adoption challenges and concerns for consideration. The chapter wraps up by highlighting the critical points covered with further direction for future works and policy implications.

Related Works

To draw context from the substantial body of literature on the area, let us have a closer look into the empirical and theoretical evidence pinpointing the looming presence of algorithm economy, the significance of AI technologies, and its adoption in today’s dynamic environment.

Data explosion and the looming algorithm-driven value creation have led to the expansion of the emergent algorithm economy (Ezrachi, 2016; Joque, 2022; Furman & Seamans, 2019; Zillner et al., 2021; Turi, 2020b; Turi & Li, 2021). In this economic system, value capture is initiated or amplified through algorithms fueled by data, unlike conventional production-based value creation practices. Massive returns are expected from this paradigm shift in value creation since the inception of the information society and digital economy in general. Yet, this comes with principles and practices that challenge traditional ways of operation and production across various domains. Zuboff (2019), in his book *The Age of Surveillance Capitalism*, navigates how data-powered algorithmic economic systems shape the socio-economic power of the human future.

AI is known for its prominent features amplifying productivity and economic growth, Szczepanski, 2019. Despite its promising features and value-add (including improved decision-making, personalized services, and increased efficiency), the adoption of AI adoption solutions in some sectors is limited. The impacts of AI on the labor market, economy and the associated industry disruptions are some of the prominent topics in the field (Webb, 2019; Agrawal et al., 2019; Furman & Seamans, 2019; Zarifhonarvar, 2023; Szczepanski, 2019). The results in the area are not consistent. Studies show a significant impact of AI on wages, employment, and economies (Webb, 2019; Zarifhonarvar, 2023; Szczepanski, 2019). Here, Furman and Seamans (2019) present mixed effects on the labor market. On the other hand, Zarifhonarvar argues that, unlike software and robots, AI solutions affect high-skilled tasks, while Webb presents a neutral effect on the top 1%. Looking into the broader economic impact of artificial intelligence technologies, we see evidence of a significant role played by institutions and policies, Aghion et al. (2019).

Lately, with the evolving AI applications and solutions, including ChatGPT, the impact on the educational sector has been one of the trending topics in the field. With the potential disruption of the teaching and learning process, mainly in higher educational institutions, some scholars in the field suggest possibilities to rethinking the conventional educational sector to encompass the ever-changing tech environment, Popenici and Kerr (2017), Abdullah et al. (2022), Zhai (2022).

The Next Gen Tech Steering Wheel

Artificial intelligence as an economic catalyst has come with about 15.7 trillion dollars of value to the global economy, with an average of 26% in countries' GDP by 2030, according to PwC's Global Artificial Intelligence Study (2023). Here, data availability and institutional and national AI strategies play a vital role. In connection with this, let us look at a broader view of the emerging tech space with a spotlight on AI solutions.

There are three key driving forces behind these tech trends and developments, which we identify as (1) the possible emergence of a bipolar global order with the emergence of powerful economies like China; (2) climate change and environmental changes; and (3) economic forces and instabilities that followed the COVID-19 economic downturn and shocks. Figure 1 depicts the Next Gen Tech Steering Wheel with AI as one of the technological Megatrends of the era.

In this context, AI has emerged as one of the core technological developments with massive transformative and disruptive potential across industries. Behind the recent AI hype are the following driving forces that are shaping the algorithm economy and the tech space in general:

- The economic value brought by AI with enhanced productivity, cost savings, and competitive advantages at institutional and national levels.
- Technological advancements, including physical and digital reality using connectivity and network technologies, cloud edge computing, and immersive and visualization technologies like augmented reality (AR), virtual reality (VR), advances in computer speed, data collection and storage, and algorithms.
- Data explosion and availability- data is the currency of the algorithm economy. Massive DATA capture has revolutionized analytics and its derivative application

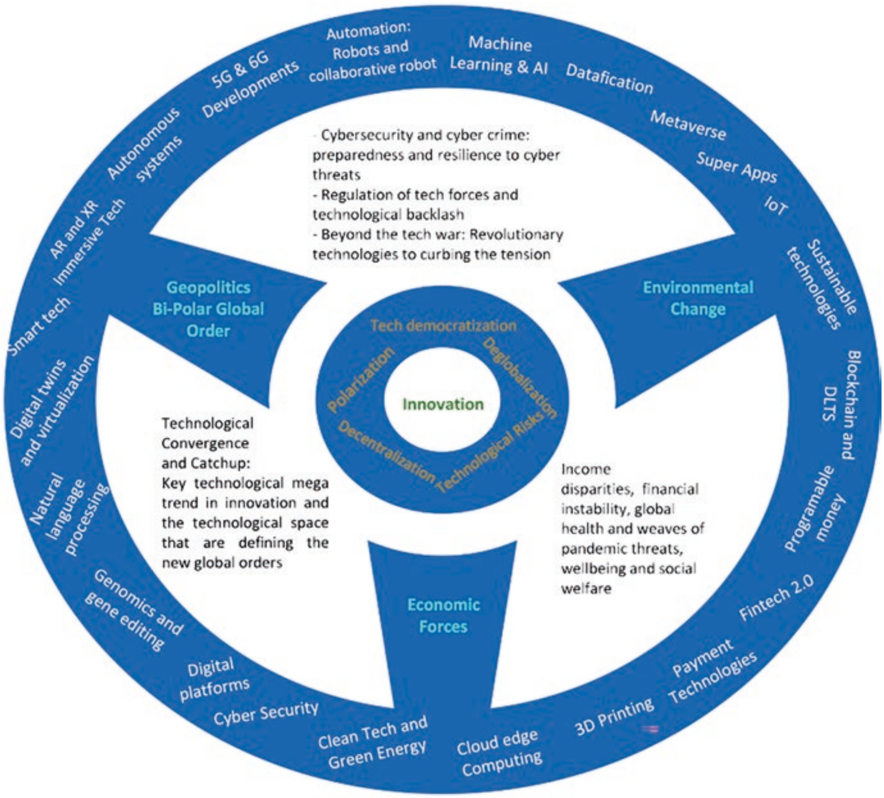

Fig. 1 The next gen tech steering wheel: technological megatrends in the face of uncertainties. Source: Author's development

domains like never before. We will discuss this in-depth in the subsequent section.

- The tech race and geopolitics with the global powers' fight to seize the steering wheel and drive "the tech truck" toward their best interest for economic and political reasons.

Selected AI Models and Solutions

Based on our observations of the developments in the field, here, I will flesh out some of the prominent AI solutions and applications that have continued to have a significant impact in their respective domains.

i) Natural Language Processing AI Solutions—GPTs.

The Generative Pre-trained Transformer is a large language model of artificial neural networks on which data-driven decisions are made to generate text that human language patterns. Currently, the solution is being developed in a series of different versions by the OpenAI.[1] The technology is being used in text-based communications, including translation, sentiment analysis, content generation, text autocompletion, and summarization, question answering, language translation, chatbots, and the design of conversational agents (Ali, 2023; Zhang & Li, 2021).

Some of the common limitations of these AI solutions are: (1) Hallucination—uncontrollable and inaccurate content generation due to lack of understanding; (2) Large computing power Consumption and data; (2) Heavy capital investment; (3) Environmental concerns with significant CO_2 emissions; (4) Accuracy and context of the generated contents are limited to the training data; (5) generating repetitive text in the earlier versions (GPT-1); and (6) Harmful content reinforcement like hate speech and disinformation issues (see Zhang & Li, 2021; Koubaa, 2023; Ali, 2023). The latest release, GPT-4, comes with innovative solutions over its earlier versions to curb some of these constraints while it still suffers from some of the aforementioned issues.

With the emerging AI solution, Natural language processing AI Solutions are one of the dominant use cases in the AI and ML space (Databricks Report, 2023).

ii) Gaming AI Solutions.

Advancements in the field have come with powerful computer programs fed with rich databases that predict complex game outcomes and even win professional game players. The functionality of such computer programs is based on (1) player (agent) modeling, which consists of facial recognition, body motion, lip-synchronized speech settings for game complexity adaptation and tricks prediction, and (2) natural language processing for text-based sentiment analysis and scoring.

[1] An American AI research lab: https://openai.com/Page accessed on May 12, 2023.

One of these is AlphaGo,[2] a program that plays a complex board game Go based on deep neural networks and reinforcement learning techniques. Its high performance has enabled it to defeat human professional players of the game (Holcomb et al., 2018; Wang et al., 2016).

iii) Facial and Image Recognition AI Solutions.

Built on face detection, feature extraction, and face recognition settings, these AI solutions allow agent identification based on key features (Kortli et al., 2020). Combined with other factors, the increase in digital footprints and training data has amplified the progress in the field (Parkhi et al., 2015).

Below are some cutting-edge AI models and solutions in the image and facial recognition sphere. (a) One of these is the facial recognition system DeepFace, an AI solution created by Facebook.[3] The technology recognizes human faces from digital images by analyzing the patterns and facial attributes. The company has faced some societal concerns in relation to the privacy and security of users, leading to some developments in the application by Facebook. A similar computer program is VGGNet, with image recognition capabilities. (b) DeepDream (from Google) is an AI solution for enhancing and visualizing images using deep neural networks to detect patterns in visual images.[4] This has enabled computers to produce dream-like visual images using data patterns just like the human brain depicting patterns from clouds, etc., aka, Pareidolia. The AI solution is used in the Arts and music industry and plays a significant role in the emergent metaverse world (Rastelli et al., 2022 and Turi, 2020a). (c) CycleGAN is a deep learning model that learns image-to-image mapping without paired data through unsupervised machine learning. The solution is used for image translation, season translation, object transfiguration, style transfer, and generating photos from paintings.[5]

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[2] Developed by DeepMind Technologies, UK, web page: https://www.deepmind.com/research/highlighted-research/alphago Accessed on June 15, 2023.

[3] See: "An Update On Our Use of Face Recognition" by Jerome Pesenti, November 2, 2021, at https://about.fb.com/news/2021/11/update-on-use-of-face-recognition/ Page accessed on April 29, 2023.

[4] See "DeepDream: How Alexander Mordvintsev Excavated the Computer's Hidden Layers A Google researcher looks into the mind of a computer." by Arthur I. Miller, July 1, 2020, at https://thereader.mitpress.mit.edu/deepdream-how-alexander-mordvintsev-excavated-the-computers-hidden-layers/. Page accessed on June 12, 2023.

[5] See "A Gentle Introduction to CycleGAN for Image Translation" by Jason Brownlee, August 17, 2019, at https://machinelearningmastery.com/what-is-cyclegan/ Page accessed on May 12, 2023.

iv) Object Detection AI Solutions.

Object detection is one of the complex problems in the field of computer vision. Major challenging issues involve the underlying complex and time-consuming deep models to train large amounts of data, calling for further optimal solutions, Diwan et al. (2023). While these limitations remain open, one of our state-of-the-art solutions for real-time object detection algorithms is You Only Look Once (YOLO) and its architectural successors. The application is known for its speed of detection, with detection accuracies of 63.4% which is lower than its counterpart, Fast-RCNN, with 70% accuracy, Diwan et al. (2023). Its ability to operate with minimal data makes it feasible for new object detection, classification, localization, and segmentation tasks. Some of its use cases include video surveillance, real-time object tracking for self-driving cars, and augmented reality.

Key Players and Industry Trends

Built on the science of philosophy, logic, mathematics, computation, psychology, biology, and neuroscience and fed with large data to replicate human-like decisions, AI technologies are one of the most powerful technologies of our digital economic system, Westera et al. (2020). With their significant potential across different domains through years of evolution, AI solutions have proved to be the present and future of the technological competitive advantage countries, and institutions intend to excel. Some of the values brought by the AI algorithms include enabling frictionless agent interactions, automation of repeated tasks, reducing false positives and human error, etc. (Insider Intelligence, 2023).

Lately, we have observed increased investment in AI solutions across industries while the rate of penetration differs from industry to industry. Figure 1 depicts the global number of active machine learning (ML) and artificial intelligence (AI) patent families ownership by company since 2013. According to the data, Baidu has observed a dramatic increase in its active patents, with a record of nearly 14,000 active patent families in 2022. Here, we see Baidu, the Chinese tech giant known for its algorithm development for search engines, autonomous driving, NLP, and voice recognition, along with other tech companies (primarily concentrated in the USA) that develop algorithms for operating systems, search engines, ML frameworks, productivity tools, NLP, analytics, ML, and quantum, search engines, autonomous driving, NLP, and voice recognition and other services (Fig. 2).

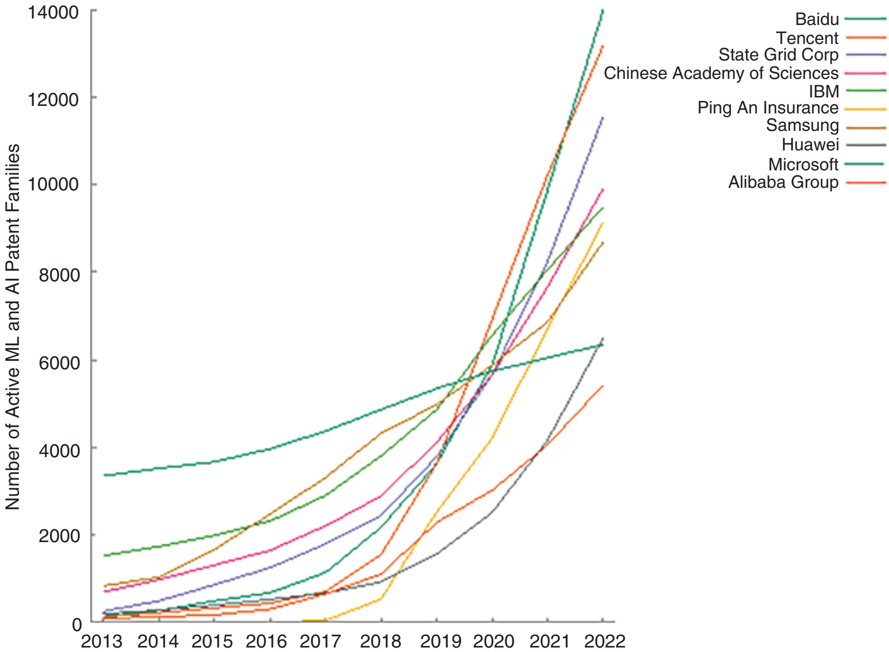

Fig. 2 The global number of active machine learning (ML) and artificial intelligence (AI) patent families ownership by company. Source: Author's composition based on data from LexisNexis PatentSight (2023) at Statista available at com.ezproxy.myucwest.ca/statistics/1032627/worldwide-machine-learning-and-ai-patent-owners-trend/ Accessed on June 10, 2023

Table 1 in the appendix summarizes the top AI companies across different industries based on different online sources. We will further investigate the innovation diffusion and rate of adoption by industry and function later in this chapter.

The AI Pulese—Tech Readiness Analysis

In this section, by taking evidence from sectoral and national level AI adoption patterns, we will look into the innovation diffusion of this technology and reflect on the level of preparedness countries show to meet the dynamic tech space.

Sectoral AI Innovation Diffusion

As the AI space is a dynamic and evolving at-speed field, new models and algorithms will continue to shape the future of socio-economic and business operations across industries. With this under consideration, in this section, we will analyze the innovation diffusion and rate of adaptation of AI solutions across different industries.

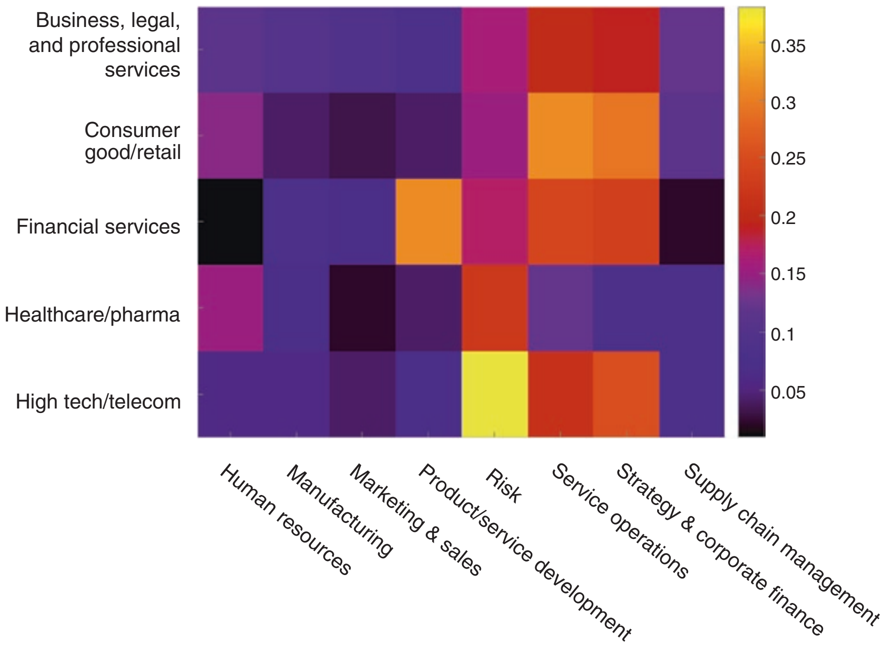

Fig. 3 Global AI adoption heatmap for the year 2022 by industry and function. Source: Author's development based on Stanford University (2023). AI adoption data https://www-statista-com.ezproxy.myucwest.ca/statistics/1112982/ai-adoption-worldwide-industry-function/ Accessed on June 2, 2023

Figure 3 depicts the intensity of the adoption of artificial intelligence solutions across five different sectors. The survey result depicts two different forms of adoption depending on the industry and functions to which the AI solutions apply.

(1) Functions with a High Propensity of Adoption

During this year, the retail, business, legal, professional, and financial services and the tech sector have an intense adoption of AI mainly in their services operations, strategy, and corporate finance functions. Risk assessment functions observed a high AI adoption, with the highest record being in the healthcare, financial services, and high-tech sectors, with a more than 20% adoption rate. The technology has observed a heavy intensity of adoption in the risk management and products and service development functions, with a record of about 38% and 31% adoption rates in the financial services and healthcare sectors, respectively. AI applications are estimated to save about 447 billion USD by 2023 for North American banks alone, adding to the attractiveness of the tech to the financial sector in the years to come (Insider Intelligence, 2023).

(2) Functions with a Low Propensity of Adoption

We see a relatively lower adoption rate for human resources, manufacturing, marketing, and sales functions. This is justified by the need for the human decision component (see also Marinc (2015), Turi (2020a), and Artificial Intelligence Index Report 2023 by Stanford University). Marinc, M. (2015), by taking the case of digital disruptions, the banking industry asserts a lower likelihood of automatized decision-making to replace human decision-making. This is on the basis of a game of incomplete information, such as a poker game, to be more challenging for machines to master than chess, resulting in the relevance of human decision-making over automatized ones when it comes to strategic decision-making, Turi (2020a).

In the financial sector, for example, soft information is contextual and qualitative, which is difficult to store and transmit impersonally. Such information plays a vital role in relaxing credit constraints in lending relationships. In addition to hard quantifiable information, soft information, which a banker gains through a front desk service, for instance, allows individual decision-making on physically observed information. However, direct interaction and transmission of soft information are not viable through automated machine-delivered decisions. Tsai and Chen, 2022, by taking the stock market forecast model of big data robo-advisors identified unstable model prediction rates, feasible relative advantages and observability, and complexity of these models, limiting them from being a reference basis for fund investment candidates. They also stressed the possibilities for such AI solutions to be heavily adopted over time with the maturity of the tech and familiarity (tech acceptance) of investors with neural network-like stock prediction models. Despite some of the constraints mentioned above, we still see virtual financial solutions (e.g., P2P lending relying on artificial intelligence and different algorithms for decision-making due to the digital nature of such business models (Turi et al., 2017; Tsai & Chen, 2022).

Nevertheless, with the advances in AI solutions and algorithm developments, there is a potential to surpass human decision-making. This has more to do with the accuracy of object recognition and detection AI solutions that enable dermatology or visual interpretations of lipreads. These and similar other solutions that address complex issues we discuss in the subsequent sections of this chapter are things we will observe as part of the advancements in the field.

Countries' AI Readiness and Data Fuel of the Algorithm Economy

In relation to AI readiness, we will investigate the infrastructural development for deploying AI applications, data access, and availability to feed the AI system and the governance layer in terms of national AI strategies and policies (Oxford Insights, 2022). Countries' tech readiness, in general, is defined by the role governments play in facilitating tech adoption and unlocking the enablers. This is reflected in the form of government policies, strategies, and government spending targeted toward AI tech. More specifically, for AI readiness, the active role played by the government in unlocking data availability, human capital, and technological capital (infrastructure and other AI enabling tools), combined with flexible policies and strategies that meet the dynamic tech space, is vital.

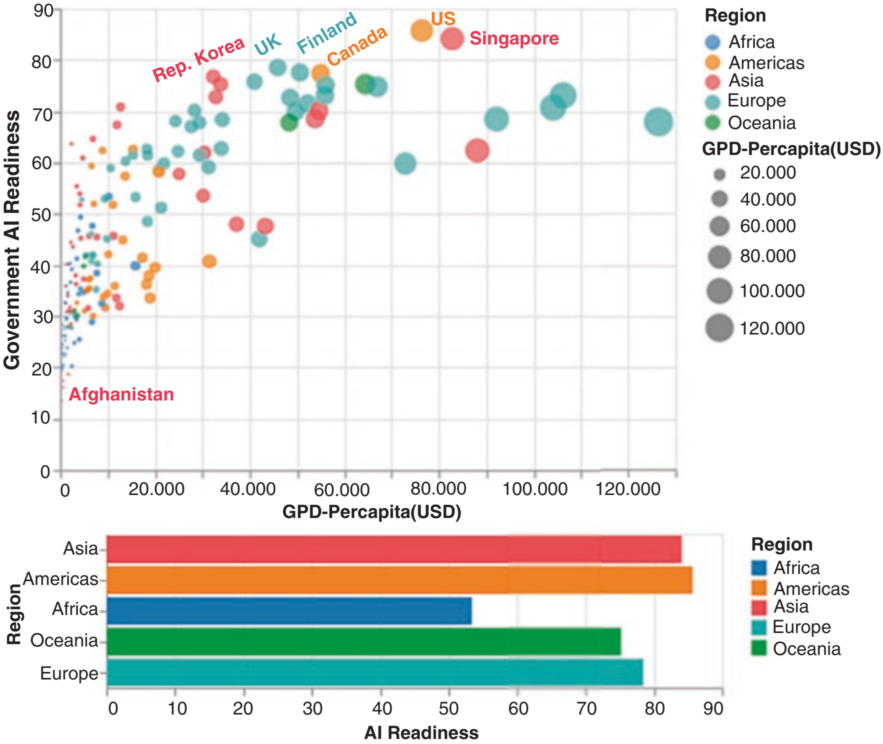

Fig. 4 Countries' AI readiness. Source: Author's development based on Oxford Insights (2022). Government AI Readiness data and World Bank Development Indicators

Figure 4 depicts countries' AI readiness across three layers of government, data, infrastructure, and technology based on the pillars defined by Oxford Insights (2022). At a regional level, we see the Americas and Asia with a relatively higher average readiness level, while Africa remains the laggard, partly reflecting the association with the economic status of the regions under consideration. Western European countries like the UK, Finland, and Germany depict better preparedness in this sphere. At a country level, the USA and Singapore, with a high per capita GDP and Government AI readiness index, are leading the global economies. Luxembourg showed relatively lower preparedness even if the country tops the global economies with its highest per capita GDP for the year under consideration. In the lower end, we see countries like Afghanistan, Yemen, Syria, South Sudan, Eritrea, and the Democratic Republic of Congo underperforming in their AI readiness coupled with their low economic performance.

Data that fuels the algorithm economy comes in different forms captured from different sources. Some of these data fountains include transaction and demographic records (in healthcare, finance, transportation, location, social media, etc.), recommendation algorithms (through digital footprints of consumers), market data feeds (real-time market data, news sentiment), user-generated contents, sensor-absorbed

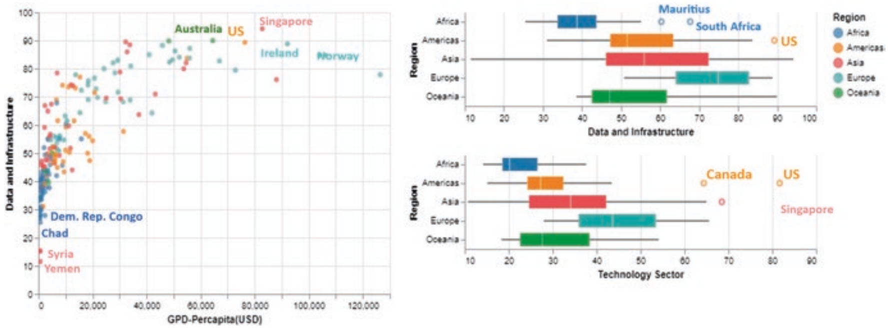

Fig. 5 Data and AI Infrastructure and economic status of countries in 2022 (left panel) and box-plots for technological and data layer readiness by region (right panel). Source: Author's analysis based on countries' GDP per capita data from the World Bank (2022), and Oxford Insights, 2022 Government AI Readiness Index

data from IoT devices, production, and supply chain data, institutional data (e.g., Government Open Data).

One of the prominent enablers of AI applications, along with others, is data availability and infrastructure to utilize these data. Accordingly, technology and data infrastructure layers play a significant role in equipping countries and institutions. Figure 2 depicts countries' AI readiness in these two layers.

Data availability and representability in capturing the reality on the ground and infrastructural developments to deliver AI tools and solutions play vital roles in the efficient adoption of the tech across sectors. The data and infrastructure pillar for the AI tech readiness index by Oxford Insights captures this aspect for about 181 global economies. Figure 5 depicts the economic capacity with data availability and AI infrastructure of the countries and traces a positive pattern for richer countries performing better. The government policies targeting data availability give these countries a competitive advantage in the tech race.

Here, we spot Mauritius and South Africa being outliers in their data and infrastructural readiness in the region, while the USA stands out in the Americas. In the technology sector, the USA and Canada outperform the region with the supply of AI tools, advancements in innovation, and human capital investment, coupled with the government's supply of AI tools—capacity for innovation, human capital investment boosted by research and development public funds. This is amplified by the ease of doing business and entrepreneurial ventures. Singapore stands out in its technological readiness for the Asian region, while China's massive emergence in the global geopolitical and tech orders remains significant. In Europe, Western European countries dominate the region, which is in line with their relative economic performance.

AI Adoption Challenges and Major Concerns

As is common to principal innovations in human history, Artificial Intelligence tools and applications are subject to multifaceted constraints that limit their at-scale adoption and create disparities in innovation diffusion. Along with the barriers, AI technologies have sparked various policy debates. As it applies to AI, let us look into some of these major barriers and concerns.

– Privacy infringement and security issues—Like most emerging tech solutions, data privacy and security concerns remain open regarding AI applications. Here, transparency and explainability with autonomous decision-making (clarity in the algorithm-based decisions) and security and privacy concerns put extra layers of complication to the ease of adoption of AI solutions. Interpretability and transparency in these decisions with the black box nature of complex algorithmic systems are yet to be addressed, along with clearly defined data governance, regulation, and ownership frameworks.
– AI Governance—In this chapter, we have seen a significant role played by a government in a country's tech readiness. Yet, due to the dynamic nature of these technologies, this also comes with regulatory challenges to the governments in flexibility in meeting the regulation gap that emerges with new waves and generations of AI tools and applications.
– Users' and businesses' Tech Acceptance—At the institutional and end-user level, weak institutional and user tech acceptance and poor technological transformation with rigid organizational settings add an extra layer of complexity for the timely adoption of the AI solution.
– Human Capital—Limit in human capital development and lack of skilled labor force (structural unemployment in the field).
– Poor tech enablers—See the details on the AI enablers and countries' readiness measures discussed under Sect. "The AI Pulse—Tech Readiness Analysis" of this chapter. Here, we have observed countries with poor technology, data, and infrastructure, and governance layer enablers underperforming on their AI preparedness.

As it applies to AI, there are diverse concerns that arise in its deployment and applications. Here, we will focus on three of the major concerns: labor market dynamics and AI, ethical concerns and algorithmic biases, and environmental issues in terms of sustainability and AI carbon footprints.

a) *Labor Market Dynamics and AI*

There are contradicting views in relation to the labor market and AI. While some scholars observe the diminishing returns effect of AI on labor market with a replacement effect, changes in job roles and skills, and job displacements (Webb, 2019;

Zarifhonarvar,2023; Szczepanski, 2019), others see the productivity boost that comes from the amplifying effect of AI solutions Agrawal et al. (2019). By concentrating on the prediction technology, Agrawal et al. (2019) identified four effects of AI in the labor market as substitution effect, automation of decision tasks with a change in relative returns to capital versus labor, increased labor productivity through automation, and an increase in relative returns to labor versus capital for tasks with automated decisions and enabling possibilities for new decision-making scheme for previously infeasible decision tasks.

Overall, while the disruption to the labor market is unarguably visible, the impact rather depends on the approach and utilization strategies we have toward enabling technologies like AI, Turi (2020b). The AI wave and advancements in the algorithm economy are inevitable. With more advancements in the algorithm economy, exploring efficient human–AI collaboration and a framework for their co-existence will unlock opportunities brought by AI technologies. This calls for responsible AI systems that enhance and augment human power while addressing major concerns around the tech. At the institutional level, this can have an approach to considering AI solutions as amplifying tools for human capital rather than a replacement. Thus, businesses should consider how to equip their labor force with such productivity unlocks as it applies to their core business line. This is to create AI-empowered people and infrastructure through intensive human capital and tech capital investment that paves the way for new employment opportunities. This will rather create more job opportunities that offset the replacement effect for human intelligence, which is non-substitutable despite machines suffering from several algorithmic constraints. So, the recommendations are to identify where the opportunity lies and connect the dots as it applies to the target business under consideration.

b) Ethical concerns and algorithmic biases

As AI solutions penetrate the economies across domains of applications, fairness, algorithmic accountability, and responsibility issues in the use of AI technologies remain open. Garbage-in-Garbage-out (data bias in the training dataset): AI technologies are fueled by the data the system is fed, thus reenforcing the socio-cultural and political bias without any filter. The impacts in this sphere include social divides and inequalities, mainly in marginalized groups, with the impact being lesser in developing countries. Social impacts and ethical concerns are the other issues in relation to AI (Hagerty & Rubinov, 2019). In this regard, Hagerty and Rubinov's synthesis of the literature in the field shows different social impacts from region to region which are affected by the local cultural and social values. Another fairness issue in AI solutions is the feedback loop with the machine–human interaction. This feature allows the system to learn user behavior and patterns to consistently perpetuate and reenforce biased outcomes based on users' temporal (digital) footprint and create a vicious circle problem of amplifying pre-existing beliefs and hypes.

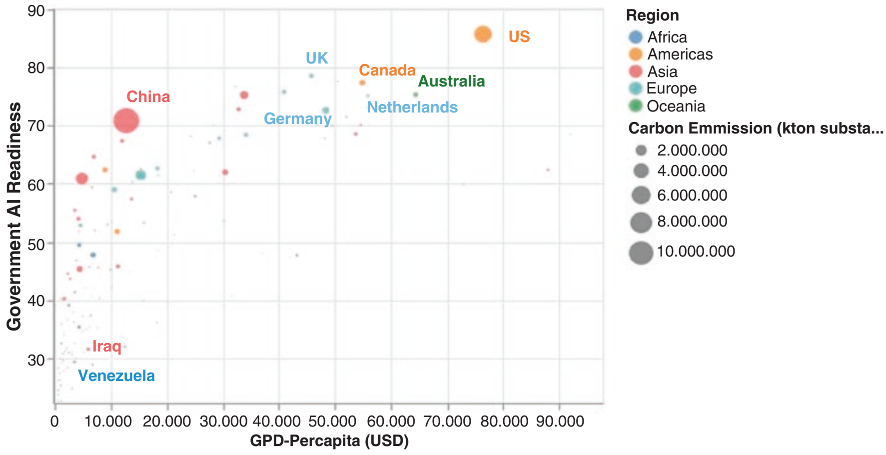

Fig. 6 Government AI readiness and Carbon Footprints (in kton substance per year) by country. Source: Author's analysis based on Carbon emission data from the Emissions Database for Global Atmospheric Research (EDGAR) (2021), countries' GDP per capita data from the World Bank (2022), and Oxford Insights, 2022 Government AI Readiness Index

These biases call for a bias control intervention system in the AI solution which requires an advanced algorithmic setting, diversity, and inclusion in AI developing team, unbiased data fuel, and key stakeholders' involvement in securing accountable, transparent, and fair system with continuous advancements in the tech solutions to incorporate social need addressing ethical concerns through regulatory and infrastructural layers.

c) Sustainability and AI Carbon Footprints

The impact of AI technologies on the environment has widely been covered in literature (Dhar, 2020; Wu et al., 2022). Figure 6 presents countries and Carbon Footprints (in kton substance per year) by country. Countries with significant government AI readiness index (greater than 60) and hence adoption reflect a higher propensity of CO_2 emission. Here we see, a significant emission of kton substance per year for countries like China and the USA, with relatively smaller emissions per year for the Western European countries like the UK, Germany, and Netherlands. On the other hand, for the countries with low AI readiness index, we see low emissions, with some exceptions. While countries' carbon footprints come from diverse industrial and production decisions, AI-related environmental impacts are not to be overlooked as one of the fountains of greenhouse gas emissions.

Concluding Remarks

The golden era of algorithm economy, data, and AI is here. With the advancements in the field, the full integration of algorithms into everyday life is becoming a reality. Along with data explosion and the emergence of complex analytical tools, there is a rising innovation diffusion and adoption of AI tools to shape our near future. In this regard, institutions and countries that prove better readiness will lead the next-gen tech space.

The analyses in this work are principally based on Stanford University AI adoption data, the World Bank development indices for countries' average income, Oxford Insights Government AI Readiness Index, and carbon emission data from the Emissions Database for Global Atmospheric Research (EDGAR). The analysis of this tech space and the algorithm economy conducted here reenforces prior findings on the tilted tech power and value generation by institutions and countries with established economic power. Based on the analysis, we have observed discrepancies in the value capture through AI solutions due to factors like (1) poor tech enablers—technology, data, and governance; (2) poor human capital investment; (3) sluggish users and businesses' tech acceptance; (4) AI governance and regulatory challenges; (5) privacy infringement and security issues; (6) growing environmental concerns and AI Carbon footprints; and (7) ethical concerns and algorithmic biases. In addition, the labor market dynamics in relation to AI technologies and as a replacement tool vis-a-vis efficiency and productivity boost opportunities brought by the AI solutions were under the spotlight of the chapter.

The chapter discussed the innovation diffusion of AI across industries, its key drivers, and barriers to adoption. The analysis revolves around the major advancements in AI tech applications and solutions, including machine learning, natural language processing, computer vision, and robotics. Besides, it fleshes out the potential impacts of the technology in different layers and draws implications and policy recommendations for optimal socio-political and economic target hit and ethical considerations in relation to its adoptions. In the AI technologies management sphere, policies and strategies that (1) prevent discriminatory AI outcomes, (2) promote inclusive algorithmic systems, and (3) measures to bridge the digital divide with equal access to data and algorithms, and (4) address digital literacy at institutional, national and global levels are required. Lastly, we recommend international cooperation, collaboration, and standardization in the governance, efficient utilization, and exploitation of opportunities brought by AI technologies for the common good despite the looming bipolar global order and deglobalization.

Appendix

Table 1 The landscape of the AI industry and top companies under each category. Source: Composed by the author based on different online sources

Industry	Top companies	Applications
Cloud AI	Google Cloud, IBM Cloud, Alibaba Cloud, Amazon Web Services (AWS), DataRobot, Baidu AI Cloud, Microsoft Azure, and Salesforce	Contract Management, Fraud detection, and prevention, AML, claims management through claims management, recommendation systems for online platforms, Omni-channel end-to-end order management, personalized customer interaction using customer interaction data and product purchase history
Health care AI	Tempus, Suki.Ai, Nanox, Freenome, Neurala, ICarbonX, Flatiron Health, Deep 6, Butterfly Network, K Health, and Insitro	Disease diagnosis, medical imaging analysis, drug discovery using historical data and medical intelligence, patient monitoring, personalized medicine, building sophisticated machines for diagnosing diseases and identifying cancer cells, etc.
Transportation AI	Anduril Industries, AEye, Pony.Ai, Nauto, Nuro, Zoox, DJI, Orbital Insight	Autonomous vehicles, heavy goods transportation (e.g., Truck platooning that connects heavy goods vehicles),), traffic management, ride-Sharing, route planning, etc.
Security AI	CrowdStrike, BlackBerry, DataVisor, Sherpa.Ai, BigPanda, Symphony AyasdiAI, Dataminr, Darktrace, Darktrace	Data security by identifying unknown threats/ anomalies, flaw Identification, threat prevention and response, detect anomalies, pattern identification, and security risk mitigation (intrusion detection systems, behavior analysis, and threat intelligence platforms), etc.
E-Commerce AI	Algorithmia, The Trade Desk, Swim.Ai, Phrasee, Pymetrics, People.Ai, AlphaSense, Icertis, Bizzabo, One Model, CopyAI, C3.Ai, Accubits, SS&C Blue Prism, DocuSign, Tetra Tech, Nvidia, ViSenze, ServiceNow, Pointr, Directly, Rulai, Tamr, Aurea Software	Personalized Shopping through recommendation systems for online platforms, Virtual shopping assistants, and chatbots for real-time engagement
Marketing and Financial Services AI	HighRadius, Signifyd, Numberai, Cleo, Fount, Upstart, Brighterion	Predict and assess loan risks in corporate finance, personal finance (e.g., Capital One's Eno), consumer finance (e.g., JPMorgan Chase), task automation, advanced fraud detection, targeted and personalized ads through behavioral analysis, pattern recognition, reporting, and AI-powered chatbots

(continued)

Table 1 (continued)

Education AI	Riiid, Iris.Ai, Rev.Com, Clarifai, HyperScience, Narrative Science	Automated admin tasks, smart content creation, animations, personalized learning
Manufacturing/ Engineering AI	CognitiveScale, Lobster Media, SenseTime, Bright Machines, Graphcore, Deepmind, Domino Data Lab, OpenAI	Smarter factories with AI-powered assembly, supply chain, robot workers, Inspection, quality control, improving production performance using sensors, product designing, etc.
Energy/ Environment AI	SenSat, Blue River Technology, Stem, Xanadu, Ambyint, VIA, Siemens, Zymergen	Analytics, optimizing equipment development and management, efficient waste storage and disposal, detecting energy emission reductions, CO_2 removal, monitoring deforestation, and predicting extreme weather conditions. AI-aided production and operations optimization leading to reduced emissions, etc.
Robotics AI	Bossa Nova Robotics, CloudMinds, Vicarious, HiSilicon, UiPath, Smart Eye, Qualcomm	Real-time updates in labor-intensive tasks for robots, including carrying and moving around, cleaning, and inventory management tasks
Web, entertainment, and social media AI	Discord, Facebook, Tencent, SoundHound, AIBrain	Facial recognition, digital maps, personalized content recommendations and text translation of posts (DeepText at Facebook), content filtering like hate speech and fraud detection

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Industry 5.0, Future of Workforce Beyond Efficiency and Productivity

Manbo He and Badr-un-nisa Chand

Abstract Industry 5.0 is revolutionary in the sense that it proposes a very different approach for industries and economies to succeed in a sustainable manner. Industry 5.0 emphasizes the need for an eco-friendly and human-centric production system that promotes workforce well-being and empowerment using flexible and adaptable technologies. The technologies in Industry 5.0 are agile and resilient and offer sustainable development while respecting planetary boundaries. In short, Industry 5.0 is based on the integration of the four Ps principle, people, planet, profit, and processes. The key elements/drivers of Industry 5.0 are (1) Reduced cost due to resource efficiency, (2) Improved safety and well-being, (3) Empowered workers remaining in control, (4) Competitive edge in new markets, (5) Adapted training for evolving skills, and (6) Competitive industry by attracting the best talent.

Although Industry 5.0 is still a new concept, and the technologies used in it are still being developed and refined, it holds great value for both businesses and society as a whole. From the introduction of a range of environmentally friendly technologies to offering flexibility through customization and personalization, from addressing workplace safety concerns to increasing the efficiency of manufacturing processes, Industry 5.0 promises a significant impact on the future of mankind and the planet.

Introduction

Since the Great Industrial Revolution occurred 300 years ago, the continuous improvement of efficiency and productivity has always been the focal point of innovations that drive the advancement of society and the well-being of humankind. While massive inventions have been implemented in the manufacturing process to

M. He (✉) · Badr-un-nisa Chand
University Canada West, Vancouver, BC, Canada
e-mail: manbo.he@ucanwest.ca; nisa.chand@ucanwest.ca

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facilitate the production function and maintain high-performance levels seemingly effortlessly.

The human factor, however, had been long overlooked or even ignored. Throughout the history of industrial revolutions, we have witnessed the same consequences: every time there was a great invention that drastically improved efficiency and productivity, it was always accompanied by a large number of workers losing their jobs. Global corporations have long been using machines and technology to pursue their profitability goals. These technological advancements, despite having great potential to uplift the economic standards of societies and the people, have been noticed to adversely impact the workforce, their job prospects, and the planet. One thing common in the industrial revolution from Industry 1.0 to Industry 4.0 has been the constant innovation and creation of newer machines, technologies, and agile production processes while intentionally or unintentionally overlooking how these developments were gradually eliminating the workforce from the organizational landscape and damaging our planet.

For instance, the First Industrial Revolution, which began in the late eighteenth century with the introduction of water and steam power, saw the transition from manual labor to machines. This resulted in job loss for many skilled artisans and craftspeople who could not compete with the efficiency of the new machines. Later, in the late nineteenth century, when electricity and mass production techniques were widely used, lots of skilled craftsmen, as well as workers in agriculture and textiles, had all lost their jobs, as machines could do the work more efficiently. Then not so long ago, the advent of computers and automation resulted in job loss in a wide range of industries, from manufacturing to finance. Many low-skilled jobs were automated, and some higher-skilled jobs, such as those in accounting and data entry, were also affected. The latest example is the debut of Chat GPT and GPT-5—the most advanced AI technology that has made so many things so easy, yet again, at the cost of people losing their jobs.

Humans have worked so hard to invent technologies and processes to continuously improve efficiency and productivity. The end result, however, is that humans are replaced by machines and have lost their jobs—which is contradictory to the notion that technological advancements improve the well-being of society as a whole. For centuries, organizations have relentlessly pursued the highest standards of efficiency and productivity in the name of improving human well-being. However, in the process, corporations have forgotten the genuine purpose of all the inventions and innovations in the first place.

It is argued that a balanced societal and economic structure requires the long-term prosperity of human society beyond efficiency and productivity. There needs to be serious consideration for fairness, equality, inclusivity, resilience, and sustainability. In response to this realization, we have seen the start of a global movement from the European Union, Japan, and China, promoting Society 5.0, which incorporates Industry 5.0, and aims to strike a balance between the advancement of technologies and the well-being of humans, or a balance between efficiency, productivity, prosperity of mankind, and care for the planet. The term Industry 5.0 was first populated by the EU (European Union) in 2021 in their published report "Industry 5.0:

Towards a Sustainable, Human-centric, and Resilient European Industry." The document highlighted a shift in the European economic players' mindset from a product-first to a human-first approach. EC's report develops the concept of Industry 5.0 based on initial discussions by Germany in 2011 under "Industry 4.0″ about the ever-changing role of workers. However, the primary focus of Industry 4.0 was the acceleration of production processes through digitalization.

The focus of Industry 5.0, in comparison, is quite different. In addition to Industry 4.0 from Germany, EC's 2021 report also acknowledged that the concept of Industry 5.0 was influenced by Society 5.0—The concept of Society 5.0 was first presented by Keidanren of Japan in 2016 and has subsequently been promoted by the Japanese government. In the "Societies" concept, the way in which people ensure their livelihood is directly related to the way they build their society. By introducing Society 5.0, Japan essentially takes the digitalization and transformation dimensions to update the national strategy, policy, and philosophy.

Global corporations have long been using machines and technology to pursue their profitability goals. These technological advancements, despite having great potential to uplift the economic standards of societies and the people, have been noticed to adversely impact the workforce, their job prospects, and the planet. One thing common in the industrial revolution from Industry 1.0 to Industry 4.0 has been the constant innovation and creation of newer machines, technologies, and agile production processes while intentionally or unintentionally overlooking how these developments were gradually eliminating the workforce from the organizational landscape and damaging our planet. To this end, Industry 5.0 is revolutionary in the sense that it proposes a very different approach for industries and economies to succeed in a sustainable manner.

The concept of Industry 5.0 emerged as a response to the growing concern that automation and digitization, which were the main focus of Industry 4.0, would lead to the replacement of human workers by machines. Some experts believed that this would have a negative impact on society, leading to increased unemployment and inequality.

To tackle this problem, a variety of participants, including governments, industry associations, and academic institutions, are collectively raising awareness about the concept of Industry 5.0. Industry 5.0 aims to combine the strengths of human workers with those of machines to create a more efficient and productive manufacturing process. The idea is to focus on tasks that require human intuition, creativity, and problem-solving skills while leaving the more routine and repetitive tasks to machines. While Industry 4.0 focused on the integration of digital technologies such as automation, robotics, and the Internet of Things into the manufacturing process, Industry 5.0 takes this a step further by emphasizing the importance of human skills and collaboration.

The key idea behind Industry 5.0 is that humans and machines should work together in a more integrated and collaborative way to achieve better results. This involves using advanced technologies to enhance human skills and capabilities rather than simply replacing human workers with machines. For example, instead of using robots to perform all tasks on a production line, humans could work alongside robots to perform more complex or creative tasks, while robots handle repetitive or dangerous tasks. Industry 5.0 also emphasizes the importance of customization and personalization in manufacturing. Rather than mass-producing standardized products, manufacturers are increasingly turning to digital technologies to create more personalized and customized products that better meet the needs of individual consumers. This involves using technologies such as 3D printing, artificial intelligence, and advanced materials to create products that are tailored to individual preferences and needs.

This chapter attempts to highlight the gradual transition toward Industry 5.0, with an emphasis on the relationship between the human workforce and corporations' goals for efficiency and productivity. At the outset of the chapter, we will provide an overview of related work from the field. This will be followed by a review of the evolution of the industry from the First Industrial Revolution in the late 1700s–early 1800s, or Industry 1.0, to its most recent development, Industry 5.0. The chapter engages with the discussion of how different Industry 5.0 is from previous industrial evolutions (from Industry 1.0 to Industry 4.0), what initiatives and movements we can expect from Industry 5.0, and ultimately, what impact Industry 5.0 will have on the human factor in the industry, namely the workforce, while efficiency and productivity are no longer, at the center of innovation. The authors will outline the factors that have impacted the relationship between productivity, efficiency, and workforce well-being at different periods of the industrial revolution. The chapter will examine different interpretations, initiatives, and practices of Industry 5.0 and different economic systems around the globe. We will conclude our chapter with a forward-looking view into the future of the workforce under Industry 5.0.

Related Works

Dmitry Ivanov (2023) propose a framework for Industry 5.0, which includes the integration of humans, machines, and data to achieve a human-centric and sustainable manufacturing system (The Industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives). Morandini and Fraboni et al. (2023 The Impact of Artificial Intelligence on Workers' Skills: Upskilling and Reskilling in Organisations) discuss the impact of Industry 5.0 on the workforce, focusing on the need for upskilling and reskilling to meet the demands of the changing manufacturing landscape.

Kagermann et al. (2013) discuss the evolution from Industry 4.0 to Industry 5.0, highlighting the importance of a human-centered approach and the integration of new technologies such as AI, IoT, and blockchain. Zhihan Lv (2023, Digital Twins in Industry 5.0) examine the role of digital twins in Industry 5.0, which can facilitate the integration of the physical and digital worlds and enable predictive maintenance and optimization.

Wang et al. (2021) discuss the role of digital transformation in Industry 5.0, emphasizing the importance of data-driven decision-making and the integration of new technologies such as 5G and edge computing. Wang et al. (2021) examine the challenges and opportunities of Industry 5.0 in the context of global supply chains, proposing a framework for supply chain digital transformation that includes real-time monitoring, data sharing, and automation. Almada-Lobo et al. (2015) discuss the impact of Industry 5.0 on the manufacturing ecosystem, emphasizing the need for collaboration and knowledge sharing among stakeholders to enable innovation and value creation. Garau and Vanino (2020) examine the opportunities and challenges of Industry 5.0 for small and medium-sized enterprises, highlighting the importance of a human-centered approach and the integration of new technologies such as AI and robotics.

Zhang and Bai (2020) propose a human-centric development model for Industry 5.0, which includes the integration of humans, machines, and data to enable personalized and adaptive manufacturing. Examine the impact of Industry 5.0 on the digital transformation of the manufacturing industry, proposing a framework for intelligent manufacturing that includes the integration of new technologies such as AI, IoT, and blockchain. Sahlab et al. (2021) discuss the challenges and opportunities of Industry 5.0 in the context of smart factories, emphasizing the need for a human-centric approach and the integration of new technologies such as 5G and cloud computing. Adel (2022) examine the future of Industry 5.0, discussing the potential for new business models, value creation, and societal impact, and emphasizing the need for a human-centered and sustainable approach.

Overall, these works highlight the importance of a human-centered approach in Industry 5.0, as well as the integration of new technologies such as AI, IoT, and blockchain. They also discuss the implications for workforce development and management, digital transformation, sustainability, and collaboration among stakeholders in the manufacturing ecosystem.

From Industry 1.0 to Industry 4.0

The evolution of Industry 5.0 represents a significant progression from the early days of manufacturing during Industry 1.0. From the invention of simple machines and processes such as the sewing machine and the combustion engine, to more sophisticated technologies, including computers, and robots, the industrial revolution is responsible for shaping the world in its existing form. Here's a brief overview of the key stages in the evolution of the manufacturing industry.

Industry 1.0: The first industrial revolution began in the late eighteenth century and continued halfway through the nineteenth century. Industry 1.0 represented a visible transition from manual/labor-intensive production approaches to mechanization processes that transformed the ways goods were produced and consumed. Steam power was used to drive machines, and this enabled production on a previously unseen scale and marked the beginning of the modern era of manufacturing.

The establishment of large-scale factories resulted in the mass production of goods and fueled economic growth globally. Some of the milestones of Industry 1.0 include:

- Mechanization of the textile industry that boosted productivity and significantly reduced costs.
- Steam-powered engine invention by James Watt, provided a new means of goods transportation. Transportation was further supported by using coal as fuel.
- Infrastructural development of canals, roads, and railway networks facilitated the easy movement of goods and workforce across national and international borders.
- Introduction of smelting processes caused a surge in iron production, leading to the drastic expansion of the iron and steel industry.
- Establishment of factories centralized the human and capital resources and streamlined the production activity leading to economies of scale.

Industry 2.0: The second industrial revolution took place in the late nineteenth and early twentieth centuries and was characterized by the widespread adoption of electricity generated by fossil power and the introduction of the production line. The use of electricity allowed machines to be powered more efficiently, and this led to the development of faster and more reliable production processes. During this phase, industries made significant progress on the transportation front that ensured faster and more efficient delivery of goods. The invention of the telegraph further supported the evolution by enabling long-distance communication, allowing for efficient message transfer within business and social settings. Some of the major inventions of this phase include:

- Electricity generation and distribution meant the invention of new tools and machinery that were used to improve both means of production and transportation.
- The introduction of the assembly line technique, pioneered by Henry Ford in the early twentieth century, facilitated the mass production of complex goods while maintaining quality via the standardization of products and processes.
- The mechanical harvesting tools greatly benefited the agricultural industry production.
- Advanced methods of transportation, such as automobiles and airplanes, increased the outreach of produced goods.

Industry 3.0: The third industrial revolution, also known as the Digital Revolution, began in the 1970s and continued to the twenty-first century. This phase was characterized by the widespread use of computers and automation in the manufacturing process. The introduction of computer-aided design (CAD) and computer-aided manufacturing (CAM) allowed for more precise and efficient production processes. The invention of the internet in the late nineteenth and early twentieth century further supported the industrial revolution by supporting the integration and expansion of production processes and supply chain processes locally as well as globally. Although the invention of computers and the internet opened new avenues for growth and expansion, it also caused job loss as industries started replacing manual labor with computers. The focus quickly shifted from human well-being and support to mass production and efficiency at the expense of cutting jobs from the economy.

Industry 4.0: The fourth industrial revolution began in the late twentieth century and is currently at the center of industry development. It is characterized by the integration of digital technologies such as automation, robotics, and the Internet of Things (IoT) into the manufacturing process. This has led to the development of "smart factory" that includes flexible production systems that are capable of responding to changing demands in real time. Despite the adoption of cutting-edge technologies, this era widened the job security issues first rendered visible in Industry 3.0. Robots could easily replace humans and work longer hours with more efficiency. Industrialists started viewing the workforce as a liability and hired people only in more specialized roles that required critical thinking and creativity. Some of the main technological innovations during this phase include:

- Artificial Intelligence (AI): AI technology is unique as it has the ability to improvise its function by reflecting on the experience. The use of AI technology has enhanced human–machine collaboration to optimize manufacturing processes using predictive maintenance. AI algorithms can analyze large amounts of data to identify patterns and trends to predict future needs and can be used to optimize production processes and improve product quality. AI can also be used to monitor machines and predict when maintenance of production units is needed, reducing downtime and increasing productivity.
- Robotics: Robotics is another key technology in Industry 4.0. Robots can be used to perform repetitive and dangerous tasks, freeing up human workers to focus on more complex and creative tasks. Robots can also work collaboratively with humans, enhancing their capabilities and increasing productivity. In addition, robots can be used for quality control and inspection, reducing defects, and improving product quality.
- Internet of Things (IOT): The IOT technology connects technological devices with each other and with humans and facilitates information sharing in real time. IoT monitors and supports production processes remotely, allowing for flexibility and efficiency in the industrial landscape.
- Big Data Analytics: This technology can digitally store, utilize, and interpret large data sets collected from a variety of sources. Big companies use this analysis to understand customers' needs and wants and address these expectations by modifying their products and manufacturing processes.
- Cloud Computing: Cloud computing is a step forward in the industrial revolution as it facilitates remote access to data by making it centrally available. This enables companies and their employees to process data and collaborate with team members virtually. Cloud computing has helped industries in reducing costs and improve information security.

Overall, the evolution of the manufacturing industry from Industry 1.0 to Industry 5.0 represents a long and continuous process of innovation and improvement that has transformed how we produce goods and services. Each stage has brought new technologies and new ways of working that have increased productivity, efficiency, and flexibility, and we can expect this trend to continue as we move into the future.

Industry 5.0—Forward Thinking Approach

In their quest for maximizing production, efficiency, and profits—manufacturers in the previous industrial revolution phases largely ignored issues pertaining to human rights and the impacts of mass production on the ecosystem. This neglect was evident from the multinational companies' strategies, be it Nike's 1990s case of operating sweatshops and child labor exploitation In East Asia, Joe Fresh's ignorance of poor working conditions in their Bangladesh garment factory that eventually resulted in the building collapse killing thousands of workers, Zara's nonpayment of factory workers in Turkey, or Volkswagen's scandal of faking the emission results to boost sales while ignoring the severe environmental damage. Although Industry 5.0 is built around the technologies introduced in Industry 4.0, it is different as it focuses on human-centric and value-based production. Industry 5.0 is striving to find a balance between the drive for production, workers' safety and well-being, and environmental sustainability.

In our previous discussion of Industry 3.0 and Industry 4.0, we highlighted how the modernization of production processes and digitalization of work resulted in undermining the value of human capital. Industry 5.0 was characterized by a deliberate attempt to put humans back in the picture. Still in its infancy, Industry 5.0 aims to foster collaboration between humans and machines rather than using machines to facilitate human ouster from the industries and production process. This was followed by a perceptive shift from viewing employees as mere operators of the machines and digital tools to valuable partners who will work alongside machines, robots, and advanced applications such as Augmented Reality (AR) and Virtual Reality (VR) in critical roles to ensure equality, respect, and efficiency in the production process.

Industry 5.0 also marks a departure from intense productivity focus to a sustainability focus. This view promotes the notion of balancing the need for production and cost efficiency with the creation of technologies that are socially and environmentally friendly. This collaborative approach has a dual focus; addressing the climate change challenges and the concerns for inequality. To achieve this, Industry 5.0 places emphasis on sustainable manufacturing practices that aim to minimize waste, conserve resources, and reduce the environmental impact of production processes. This involves the incorporation of cutting-edge technologies such as smart sensors and data analytics to optimize energy use, reduce waste, and minimize the carbon footprint of manufacturing activities.

Overall, Industry 5.0 represents an exciting new era in manufacturing that is characterized by greater collaboration, customization, and sustainability. As this trend continues to evolve, we can expect to see even more innovative and transformative technologies being developed that will help to reshape the manufacturing industry for the twenty-first century and beyond. The new agile technologies are capable of producing more at a lower cost in less time. It will be possible for companies to increase their production while using fewer resources and selling the products for less. However, this will not be possible without a trained and highly skilled workforce.

Although Industry 5.0 emphasizes multiple ways in which human–machine collaboration can occur, it also raises concerns regarding the implications of automation on the existing and future workforce. Since human–computer collaboration requires a constant investment in human reskilling and upskilling to enable them to work with dynamic technologies, it also means that humans have to be flexible and ready to adapt to their ever-changing roles. To this end, Industry 5.0, needs to establish a supportive work environment that focuses on employee well-being and job safety.

Future Implications of Industry 5.0

Central tenets of Industry 5.0 are people (workforce and customers), sustainable practices, and safe technologies. Although it has already laid a solid foundation for a collaborative approach to achieving efficiency and productivity, there is still room for improvement. Going forward, we believe Industry 5.0 will focus on the following areas for its growth.

1) Integrated Technologies: Industry 5.0 revolves around automation and digitization (carried forward from Industry 4.0) and its interaction with humans to improve workforce experiences. These technologies are designed to work in collaboration with the workforce and facilitate the completion of hazardous aspects of production and ensure workers' safety. As a result, workers can focus on more complex and creative jobs. Cobots, Augmented Reality, Internet Of Things, Additive Manufacturing, Artificial Intelligence, Machine Learning, and Blockchain technologies are some of the modern integrated technologies. These collaborative technologies, although smart enough to make complex decisions based on algorithms, still rely on human interaction to provide huge data sets for decision accuracies. The integrated technologies are also human-dependent for understanding the specific business or customers' needs. For instance, Chat GPT and other AI tools are capable of generating a waste amount of information within seconds; however, they can't do so without getting efficient/intelligent prompts from humans using them.
2) Customer-centric Production: Following Industry 4.0 s blueprints, Industry 5.0 facilitates a more agile, flexible, efficient, and customized production approach. The notion of a customer-centric approach enables the industry to understand customers' expectations and needs and modify the production processes accordingly. Such initiatives will foster strong human collaboration between the

workforce, customers, manufacturers, suppliers, management, and technology such as data analytics.

3) Sustainable Business Approach: According to the "World Economic Forum" 54% of Earth's power is used for supporting production and manufacturing activities across the globe and causes 20% of emissions. Gradually moving away from mass manufacturing is not only a cost-effective approach but also environmentally beneficial, as it reduces the wastage of resources, controls pollution, and encourages the use of renewable energy sources. A future trend will be rethinking the impacts of mass manufacturing on the environment and promoting biodegradable, recyclable, and reusable products. The use of sustainable technologies and their impact is covered in detail in the "Technology Megatrend" chapters in this book.
4) Open-source Manufacturing: Industry-wide collaborations to share ideas, creativity, and technology-based approaches will be the new norm. Companies will be open to sharing their design and process ideas to achieve cost efficiency. Another milestone for Industry 5.0 will be to include Small and Medium Enterprises (SMEs) in this exchange of resources and promote equal access to sophisticated technologies to bridge the gap between giant manufacturers and SMEs.
5) Post-pandemic world: COVID has helped businesses recognize the need for adaptability and shifting traditional work from designated office spaces to flexible working patterns such as remote working, working from home, and telecommuting. It is important to note that none of these work arrangements would be possible without robust technological systems in place. However, the adoption of these technologies is aimed at facilitating the workforce and reducing environmental damage rather than threatening the job security of workers. To this end, organizations are implementing technologies to support alternative work arrangements, reduce the carbon footprint from the daily commute to the offices, offer flexibility, promote employee well-being, and increase efficiency. During COVID, the healthcare sector also relied on Industry 4.0 technologies to track and treat patients affected by the virus while practicing social distancing.

Impacts of Industry 5.0 on the Future of the Workforce

Industry 5.0 offers multiple benefits that bypass the typical organizational concerns of job creation, expansion of business activity, and profit maximization. The fifth industrial revolution is based on the planet and society's first approach. The core values driving Industry 5.0 are respect, trust, and well-being of the planet and the workforce. Rather than focusing aggressively on technological advancements, this era attempts to highlight the value of soft skills such as emotional intelligence, communication, and collaboration. The projected impacts of human–technology interaction on the future of the workforce include:

Human–Machine Interfaces: It is expected that future technologies will be more human centric. Industry 5.0 emphasizes a collaborative approach that combines human intelligence and advanced technologies for value creation. Some of the noticeable human–technology collaborations include machine learning used to analyze exceptionally large data sets, and BMIs (Brain–Machine Interfaces) to operate technologies using brain waves to improve decision-making processes. With the help of technology, workers will be able to implement their most creative ideas and solutions, not previously possible. The capabilities offered by the technologies will also aid the workforce in thinking out of the box to propose solutions to complex business situations and issues that machines cannot.

Technical Skills Upgradation: While humans will be able to utilize the new technologies to their advantage, however, uncovering their full potential will also require constant upskilling of the workforce to engage meaningfully with the collaborative technologies. Humans will be expected to demonstrate proficiency in technical and problem-solving skills to keep pace with technological evolution. For instance, the introduction of the concept of "intelligent healthcare" is revolutionary as it helps doctors diagnose the disease with precision and make quick decisions on effective treatments. However, doctors need to have skills to work with Machine Learning systems and to use and interpret the results generated by smart wearable technologies such as smartwatches and intelligent sensors that monitor patients' ongoing health conditions. Humans also need to learn how to best use the cobots and robots to achieve desired goals. Although humans possessing the updated skills and knowledge will be able to thrive in these new job roles, it might also cause displacement of the workforce lacking the required technical skills or failure to update the skills in a timely manner.

Soft Skills: Although the human–machine interrelationship is supposed to create many new job opportunities, these ventures are largely contingent upon the demonstration of high level of skill both technical and soft. Especially soft skills, including communication and emotional intelligence, will guarantee human presence in the workplace in the long run due to technologies' inability to demonstrate these skills. Despite their wide range of functionality, machines cannot take into account differences of opinion, collaborate with teams, sense emotional issues faced by the team members, and think logically and creatively. Industry 5.0 stresses that for all these competencies and skills, the workforce will continue to play an important role in the industries. A 2021 study by Chin also asserts that the emotional stability of the workforce has a significant impact on organizational performance and productivity.

Health and Safety of Workforce: One of the key aspects of Industry 5.0 is to promote the concept of a safe workplace. To this end, machines, robots, and other technologies will be used to perform riskier jobs in unsafe conditions, thus taking off the burden of physically challenging jobs and controlling workers' fatigue. This will supposedly reduce workplace accidents and injuries significantly. In fact, robots are already being used to perform jobs "such as welding and painting in car factories and loading and unloading heavy consignments in warehouses" (Yli-Ojanper et al., 2019 as cited in Maddikunta et al., 2022, p. 12).

To enhance the safety of workforce wearable devices such as smart glasses have been introduced. These intelligent devices provide real-time data on health and safety risks involved in the manufacturing process.

Global Viewpoint on Industry 5.0: Germany, Japan, the USA, China (MH)

As we discussed previously, Industry 5.0 is a concept that builds upon the Industry 4.0 paradigm, which focuses on the digitalization of manufacturing and production processes. Industry 5.0 envisions a future where humans and machines work together to achieve more sustainable and customized production, with a focus on human-centered design and creativity.

From the global viewpoint, although the consensus is that Industry 5.0 is to transform the industry from an efficiency and productivity-oriented approach toward a more balanced ecosystem that emphasizes people, planet, resilience, and sustainability, different steps are taken by different nations in achieving this seemingly similar goal. Among them, Germany, Japan, the USA, and China are the ones playing leading roles in this transformation.

Germany: Germany has been a leader in Industry 4.0 and is now pushing ahead with Industry 5.0. The country has a well-established manufacturing sector and is home to many innovative companies, such as Siemens and Bosch. Germany has also been investing heavily in research and development in areas such as AI, robotics, and 3D printing. Some of Germany's key accomplishments in Industry 5.0 include the development of the Industry 4.0 platform, which aims to create a standardized approach to the integration of IT and manufacturing, and the establishment of the Smart Factory KL research facility, which is focused on developing smart manufacturing solutions.

Japan: Japan has a long history of manufacturing excellence and is now at the forefront of the development of smart factories and advanced robotics. The country has been investing heavily in research and development in areas such as industrial IoT, AI, and robotics, and has launched several initiatives to promote the adoption of these technologies in manufacturing. Some of Japan's key accomplishments in Industry 5.0 include the development of advanced humanoid robots, such as Pepper and ASIMO, and the establishment of the Connected Industries Forum, which aims to promote collaboration and innovation in manufacturing.

China: China has emerged as a major player in Industry 5.0 in recent years, thanks to its massive manufacturing sector and ambitious plans for technological development. The country has been investing heavily in areas such as 5G, AI, and robotics, and has launched several initiatives to promote the adoption of these technologies in manufacturing. Some of China's key accomplishments in Industry 5.0 include the development of the Made in China 2025 plan, which aims to transform China into a world leader in advanced manufacturing, and the establishment of the

China Industrial Internet Consortium, which is focused on promoting the development and adoption of industrial IoT technologies.

The USA: The USA has a long history of innovation and technological development, and is now at the forefront of the development of Industry 5.0 technologies such as AI and robotics. The country is home to many innovative companies, such as Tesla and Google, and has been investing heavily in research and development in these areas. Some of the USA's key accomplishments in Industry 5.0 include the development of the Advanced Manufacturing Partnership, which is focused on promoting innovation in manufacturing, and the establishment of the Manufacturing USA initiative, which is focused on accelerating the adoption of advanced manufacturing technologies.

Overall, there is a growing interest in Industry 5.0 as a way to drive innovation and productivity, and to create more sustainable, efficient, and human-centric manufacturing systems around the world. While each country may have its own unique approach, they are all working toward the same goal of using technology to enhance the capabilities of humans and machines in manufacturing and production and to achieve the ultimate people-planet-prosperity.

Cyber-Physical Systems Versus Human-Cyber-Physical Systems and Human in the Loop Versus Human on the Loop

While many technologies are common in both Industry 4.0 and Industry 5.0, for instance, Artificial Intelligence (AI), Internet of Things (IoT), Robotics, Augmented Reality (AR) and Virtual Reality (VR), 5G Networks, Advanced Materials, Digital Twins, and more, the main dividing line that separates Industry 5.0 from Industry 4.0 lays in the application and promotion of CPS vs. HCPS, and of HITL vs. HOTL.

CPS stands for Cyber-Physical Systems, which are systems that combine physical components, such as machines and sensors, with digital components, such as software and algorithms, to create a more efficient and automated manufacturing process. CPS are designed to be autonomous and can be controlled and monitored remotely, which can lead to improved quality control, better resource utilization, and increased productivity. In terms of applications, CPS are used in a wide range of industries such as manufacturing, transportation, energy, healthcare, and smart cities. They are used to monitor and control physical systems, such as machines or power grids, in real time. CPS can detect anomalies or faults and take corrective actions to prevent or mitigate potential problems.

Industry 4.0 relies on CPS to transform manufacturing into digitalization and intelligence.

On the other hand, HCPS stands for Human-Cyber-Physical Systems. HCPS are similar to CPS in that they integrate physical components with computational and communication components. HCPS are used in applications where the human element is critical, such as healthcare, rehabilitation, and education. For example, HCPS can be used in the field of medical robotics to provide assistance to surgeons during complex procedures, or in physical therapy to help patients recover from injuries or disabilities. HCPS can also be used in education to provide personalized learning experiences to students based on their individual needs and abilities.

Industry 5.0 emphasizes more on a HCPS-based approach.

The main difference between CPS and HCPS is the level of interaction with humans. CPS are designed to operate autonomously in industries such as manufacturing and transportation, while HCPS are designed to work collaboratively with humans in areas such as healthcare and education. In HCPS, the human is an integral part of the system and is involved in decision-making and control, whereas in CPS, the system is largely automated and operates without human intervention.

Just like CPS in Industry 4.0 and HCPS in Industry 5.0 both reflect the different levels of interaction between humans and the respective virtual or physical manufacturing systems, HITL (Human-in-the-loop) and HOTL (human-on-the-loop) are two concepts related to the interaction between humans and artificial intelligence (AI) systems.

HITL refers to a scenario where humans are an integral part of the decision-making process and are responsible for making the final decision. In this scenario, the machine performs the initial processing of data and provides recommendations or suggestions to the human, who then makes the final decision based on their experience and judgment. HITL is often used in high-risk scenarios such as medical diagnosis, financial trading, and autonomous vehicles.

For example, in a chatbot system, a human operator may be involved in the conversation with the user when the chatbot is unable to answer a question. The operator provides the necessary information to the chatbot, which can then use it to respond to the user. In this scenario, the human is in the loop, and the AI system depends on the human's input to function effectively.

On the other hand, HOTL refers to a scenario where humans are involved in the decision-making process but only as overseers or supervisors. In this scenario, the machine performs the majority of the processing of data and makes recommendations to the human, who then reviews and approves the recommendation or takes corrective action if necessary. HOTL is often used in scenarios where there is a high volume of data to be processed, such as fraud detection, quality control, and customer service.

For example, in an autonomous vehicle, the AI system is responsible for driving the vehicle, but a human is monitoring the vehicle's operation to ensure that it is functioning correctly and taking appropriate action if necessary. In this scenario, the human is in the loop, overseeing the AI system's operation.

Overall, both HITL and HOTL have their advantages and disadvantages. HITL provides a high level of human oversight and control, which can be crucial in high-risk scenarios but can also be time consuming and expensive. HOTL, on the other hand, provides a high level of automation and efficiency, but can also be prone to errors and may require significant human oversight to ensure accuracy and fairness. The choice of HITL vs. HOTL depends on the specific application and the desired balance between automation and human control.

Human-Cyber-Physical-System (HCPS), Cyber-Physical-System (CPS), Human-in-the-Loop (HITL), and Human-on-the-Loop (HOTL) are all important concepts in Industry 5.0, together, these concepts can have a significant impact on Industry 5.0. CPS can help to create a more efficient and automated manufacturing process, while HCPS can ensure that the manufacturing process is more inclusive, collaborative, and safe. HITL can be used in high-risk scenarios to ensure that the final decision is made by a human expert, while HOTL can provide human oversight and decision-making in manufacturing processes. Overall, the combination of CPS, HCPS, HITL, and HOTL can help to create a more integrated, efficient, and inclusive manufacturing process that benefits both workers and manufacturers in Industry 5.0.

Predestination—What Is in it for Humans in the Next 10 Years? 50 Years?

It is difficult to predict exactly what will happen after Industry 5.0, as technological development is constantly evolving and influenced by a wide range of factors such as market demand, technological breakthroughs, and societal changes. However, there are some trends and developments that are likely to shape the future of manufacturing and technology more broadly:

1) Autonomous Systems: As artificial intelligence and machine learning technologies continue to advance, we may see the development of more autonomous systems that are able to operate and make decisions independently, without human intervention.
2) Quantum Computing: Quantum computing is an emerging technology that has the potential to revolutionize computing, enabling faster and more powerful processing of data. In the future, we may see the development of new applications and industries that are enabled by quantum computing.
3) Biotechnology: The development of biotechnology is already having a profound impact on medicine and healthcare, and in the future, we may see the continued development of new technologies and applications in areas such as genomics, synthetic biology, and biomanufacturing.
4) Sustainability: As concerns about climate change and environmental degradation continue to grow, we may see a greater emphasis on the development of sustainable technologies, such as renewable energy, clean transportation, and sustainable materials.
5) Hyper-Connected Manufacturing: As more and more machines and devices become connected to the Internet and each other, we can expect to see increasingly interconnected and automated manufacturing systems. This could enable real-time monitoring, control, and optimization of production processes, as well as more advanced forms of collaborative robotics and human–machine interaction.

6) Materials Science and Nanotechnology: Advances in materials science and nanotechnology could enable the creation of new materials with novel properties and applications, leading to new manufacturing processes and products. For example, nanomaterials could enable more efficient and sustainable energy storage and conversion, or new forms of sensing and actuation.
7) Augmented and Virtual Reality: Augmented and virtual reality technologies are already being used in manufacturing for training, design, and maintenance applications. In the future, these technologies could become more sophisticated and integrated, enabling more immersive and interactive manufacturing experiences.

The future of technological advancement in manufacturing is likely to be characterized by continued automation, interconnectivity, and innovation in materials science and biotechnology. As new technologies emerge and converge, we can expect to see new forms of collaboration and competition among manufacturers, as well as new opportunities for value creation and disruption.

With the continued development in technology advancement, the impact on the workforce will be reflected in the following areas:

(1) New Forms of Collaboration: Industry 5.0 is characterized by increased collaboration between humans and machines, rather than a replacement of humans by machines. This could lead to new forms of teamwork and collaboration, as humans and machines work together to achieve common goals.
(2) Upskilling and Reskilling: As manufacturing becomes more automated and technology driven, there will be an increasing need for workers with advanced technical skills, such as programming, data analysis, and robotics. This could lead to a greater emphasis on upskilling and reskilling programs, to ensure that workers can adapt to changing job requirements and remain employable.
(3) Greater Flexibility and Autonomy: Industry 5.0 may enable greater flexibility and autonomy for workers, as automation takes care of routine tasks and workers are freed up to focus on more creative and complex tasks. This could lead to more fulfilling and rewarding work experiences, as well as a better work-life balance.
(4) Shifts in Job Roles and Career Paths: The rise of Industry 5.0 is likely to lead to changes in job roles and career paths, as some tasks become automated and new roles emerge. This could require workers to be more adaptable and flexible, and to develop new skills and competencies over time.
(5) Ethical and Social Implications: The increasing integration of machines and humans in the manufacturing process raises a range of ethical and social issues, such as the impact on employment, the use of personal data, and the potential for bias and discrimination. It will be important to address these issues to ensure that Industry 5.0 is developed in a way that benefits society as a whole.

Industry 5.0 represents the next stage of manufacturing, where humans and machines work together in a collaborative and complementary way. This paradigm shift in manufacturing has significant implications for the future of the workforce beyond efficiency and productivity.

With Industry 5.0, there will be a greater emphasis on creativity, problem solving, and interpersonal skills. This is because humans will work alongside machines to complete complex tasks that require both technical expertise and human judgment. Workers will need to be able to communicate effectively with machines and with each other, and they will need to have a deep understanding of the technology they are working with. In addition, Industry 5.0 will create new opportunities for workers to engage in meaningful and fulfilling work. With machines handling routine and repetitive tasks, humans will be able to focus on tasks that require creativity, innovation, and emotional intelligence. Industry 5.0 also has the potential to promote greater work-life balance and employee well-being. This could lead to reduced work-related stress and improved physical and mental health. Finally, Industry 5.0 will require a more diverse and inclusive workforce. As machines become more integrated into the manufacturing process, workers from a range of backgrounds and skill levels will be needed to manage and operate them. Another potential trend is the rise of decentralized and distributed manufacturing, enabled by technologies such as 3D printing and blockchain. This could lead to new opportunities for small and medium-sized enterprises (SMEs) and a more diverse and flexible workforce, but could also require new models of governance, regulation, and coordination. Sustainability and social responsibility are also likely to be increasingly important considerations in the workforce of the future, with a greater emphasis on circular economy principles, responsible production and consumption, and ethical labor practices.

In conclusion, Industry 5.0 represents a new era of manufacturing that has the potential to revolutionize the future of the workforce beyond efficiency and productivity. Workers who can adapt to this new way of working and who possess the necessary human skills and qualities will be well positioned to thrive in this new era of manufacturing.

Overall, the future of the workforce after Industry 5.0 is likely to be characterized by greater integration of humans and machines, a shift toward more creative and strategic roles for humans, the rise of decentralized and distributed manufacturing, and a greater focus on sustainability and social responsibility.

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Megatrends and Innovations Shaping the Future of Finance

Pooja Lekhi

Abstract There are several megatrends in the finance industry that are shaping its evolution and driving significant change in the sector. This trend is being driven by a combination of factors, including technological innovation, regulatory reform, and the rise of fintech companies. The finance industry is subject to increasingly complex and stringent regulatory requirements, with a focus on consumer protection, financial stability, and risk management. Some other factors contributing to this change are shifting demographic patterns, such as an aging population, and changing consumer preferences for digital and mobile financial services. Overall, these megatrends are shaping the finance industry's future and driving significant change in how financial services are delivered, consumed, and regulated. This chapter covers the most significant innovations and recent developments in the finance industry like Mobile Banking, Digital Wallets, Cryptocurrencies, Peer-to-Peer Lending, Robo-Advisors, Open Banking, Blockchain and cloud computing, CBDC, and sustainability. The chapter explores how these developments are changing the face of finance and shape finance industry of future.

Introduction

The finance industry plays a crucial role in the overall functioning of the global economy. However, there is a constant need for development and innovation in this industry to keep up with the changing economic landscape and evolving consumer needs. With the increasing adoption of digital technologies and the rise of the millennial generation, consumer behavior in the finance industry is rapidly changing. Consumers are demanding more personalized and user-friendly financial products and services that can be accessed and managed from anywhere, at any time.

P. Lekhi (✉)
University Canada West, Vancouver, BC, Canada
e-mail: pooja.lekhi@ucanwest.ca

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According to a report by McKinsey, “customers are demanding greater speed, convenience, and simplicity in their financial interactions, and expect digital experiences that are as good as or better than those provided by technology leaders like Amazon and Google” (McKinsey & Company, 2019). Technology is transforming every aspect of the finance industry, from customer service and operations to risk management and compliance. Innovations such as blockchain, artificial intelligence, and machine learning are revolutionizing how financial transactions are processed and how risk is assessed, Turi (2020b).

According to a report by Deloitte, “The accelerating pace of technology change is driving firms to adapt and innovate at an unprecedented pace, leading to a paradigm shift in the way the financial services industry operates” (Deloitte, 2018).

The finance industry is highly regulated, and regulatory requirements are constantly evolving. Financial institutions must stay up to date with regulatory changes and implement effective compliance strategies to avoid penalties and maintain their reputation. According to a report by PwC, “Regulatory change remains a significant driver of innovation and investment in the financial services industry, with firms looking to balance the need for compliance with the desire to remain competitive and innovative” (PwC, 2021).

Therefore, the need for development in the finance industry is driven by changing consumer behavior, technological advancements, and the evolving regulatory environment. Financial institutions that can adapt to these changes and innovate their products and services will be better positioned to succeed in the long run.

Recent Developments in the Finance Industry

Some of the recent developments that are revolutionizing the financial landscape include digital assets, including cryptocurrencies, non-fungible tokens (NFTs), digital collectibles, and security tokens, and the rise of DeFi and its various applications, such as decentralized exchanges, lending and borrowing platforms, and decentralized insurance. Additionally, the growing field of sustainable finance and its integration with digital assets and DeFi is also a megatrend.

Digital assets are assets that exist in digital form and are verified and secured using cryptography and blockchain technology. Some examples of digital assets include cryptocurrencies, non-fungible tokens (NFTs), digital collectibles, and other digital tokens that represent ownership or value.

Cryptocurrencies: Cryptocurrencies are digital assets that use blockchain technology to verify transactions and maintain a secure ledger of ownership Turi (2020a); Turi and Thilakarathnei (2023). Some popular cryptocurrencies include Bitcoin, Ethereum, and Litecoin. These digital assets have gained popularity due to their decentralization, security, and potential for growth in value Lekhi (2023).

According to Fig. 1, the United States stands out as the leading country in Bitcoin trading, accounting for 22.77% of the world’s Bitcoin volume. This significant percentage translates to a value of over $1.44 billion in BTC. Alongside the United

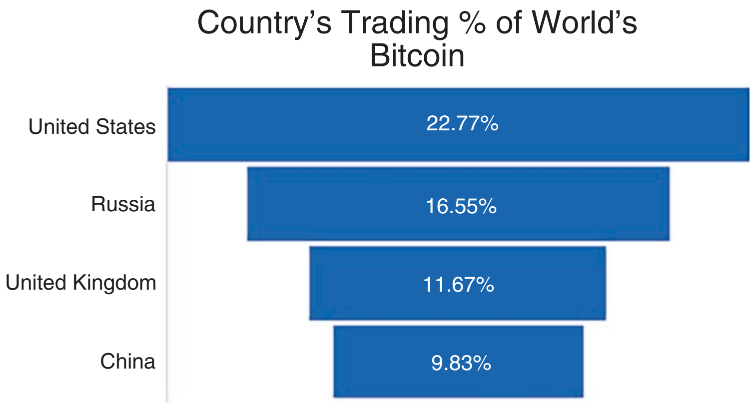

Fig. 1 Country's trading in Bitcoin. Source: Composed by Author, data retrieved from buybitcoin-worldwide.ct

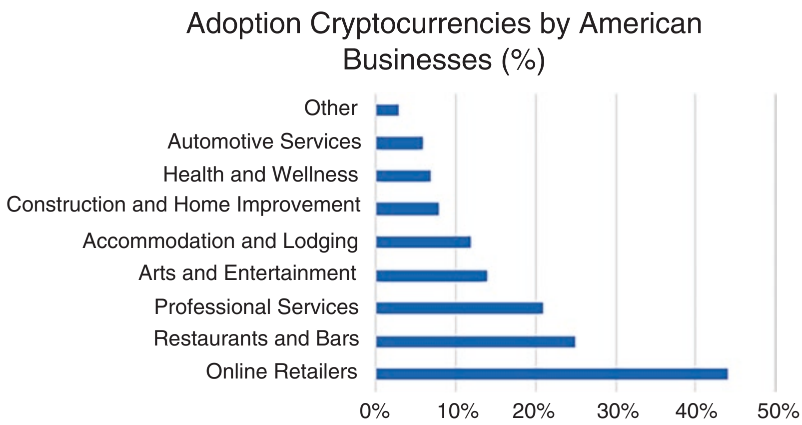

Fig. 2 Businesses in the United States to accept cryptocurrencies. Source: Composed by Author, Data is sourced from (HSB, 2021)

States, other prominent countries involved in Bitcoin trading include Russia, the United Kingdom, and China.

Considering the United States' dominance in Bitcoin trading, it is crucial to conduct further research to analyze the adoption of cryptocurrencies by businesses in the American region.

Figure 2 elucidates the most common types of small and mid-sized businesses in the United States to accept cryptocurrencies are online retailers (44%), followed by restaurants and bars (25%), and professional services (21%). The growth of cryptocurrencies can be attributed to their increasing popularity, investment potential, the underlying blockchain technology, institutional adoption, and evolving regulatory landscape. As cryptocurrencies continue to evolve and gain acceptance, their impact on the financial landscape is likely to expand further.

Non-fungible Tokens

NFTs are unique digital assets that use blockchain technology to verify ownership and authenticity (BBC News, 2021). NFTs are typically used to represent art, music, videos, and other types of digital content, providing a new way for creators and collectors to buy, sell, and trade digital assets. The NFT market has exploded in 2021, with NFT sales reaching over $2 billion in the first quarter of the year alone (source: NonFungible.com, 2021).

NFTs are created using blockchain technology, which provides a decentralized and tamper-proof way to verify ownership and authenticity. Each NFT is unique and contains metadata that specifies the ownership, history, and other relevant information about the digital asset it represents.

NFTs are being used in a variety of applications, including digital art, music, sports collectibles, virtual real estate, and more (BBC News). NFTs provide a way for creators to monetize their digital content and for collectors to invest in unique and rare digital assets.

Digital Collectibles

Digital collectibles are similar to NFTs, but they may not necessarily be unique. They can represent items such as in-game assets, virtual goods, or other digital items that can be traded or sold. Some popular digital collectibles include CryptoKitties and NBA Top Shot.

Security tokens: Security tokens are digital assets that represent ownership in a real-world asset, such as a company or property. These tokens are regulated by securities laws and are subject to the same legal requirements as traditional securities.

Stablecoins

Stablecoins are digital assets that are designed to maintain a stable value, usually pegged to a real-world asset such as the US dollar, gold, or another fiat currency [Ong, 2020]. These assets are designed to reduce volatility in the cryptocurrency market and provide a stable store of value. Some of the popular stablecoins include USDT, USDC, and DAI.

Overall, digital assets have gained popularity due to their security, decentralization, and potential for growth in value. However, regulatory challenges and market volatility remain key challenges for the digital asset industry.

Sustainable Finance

Sustainable Finance is a growing field that incorporates environmental, social, and governance (ESG) factors into financial decision-making. Recent developments include the issuance of sustainable bonds, integration of ESG factors into investment decision-making processes, climate risk assessments, proliferation of sustainable investing products, alignment of investments with the UN's Sustainable Development Goals, development of green taxonomy, and increased corporate sustainability reporting. These developments demonstrate the increasing recognition of the importance of ESG factors in financial decision-making. The issuance of sustainable bonds has grown significantly in recent years, with a record $465 billion issued in 2020, up from $257 billion in 2019. These bonds are typically used to finance projects that have positive environmental or social impacts (Environmental Finance, January 21, 2021).

The Rise of Decentralized Finance

Decentralized Finance (DeFi) is a new financial system that operates on a decentralized blockchain network [Ethereum (Buterin, 2014)]. It is built on the principles of blockchain technology, which allows for transparent and secure transactions without the need for intermediaries such as banks or financial institutions [Ong, 2020]. DeFi aims to democratize financial services by providing access to financial tools, such as lending, borrowing, and trading, to anyone with an Internet connection and a compatible wallet. The growth of decentralized finance (DeFi) applications, which are built on blockchain technology and enable users to access financial services without intermediaries, is also contributing to the use of digital assets. The total value locked in DeFi protocols has grown from less than $1 billion in early 2020 to over $80 billion as of February 2022 (DefiPulse, 2023).

One of the key features of DeFi is the use of smart contracts, which are self-executing agreements that enforce the terms and conditions of a transaction (Buterin, 2014). Smart contracts enable the automation of financial services, such as lending and borrowing, and eliminate the need for intermediaries. DeFi is an umbrella term that encompasses a wide range of financial applications and services. Some of the most popular DeFi applications include the following:

Decentralized Exchanges allow users to trade cryptocurrencies without a centralized intermediary [Uniswap, 2021]. These exchanges operate on a peer-to-peer network (Turi et al., 2017) and use smart contracts to execute trades. Some of the leading DEXs include Uniswap, Sushi Swap, and PancakeSwap.

DeFi lending and borrowing platforms, such as Aave and Compound enable users to lend and borrow cryptocurrencies without intermediaries. These platforms use smart contracts to enforce the terms and conditions of the loan, and lenders earn interest on their deposited assets, while borrowers can access liquidity without going through a traditional bank (Aave, 2021).

Decentralized insurance platforms, such as Nexus Mutual and Cover Protocol, enable users to purchase insurance coverage without the need for traditional insurance companies. These platforms use smart contracts to automate the claims process and enable users to pool their funds to cover potential losses (Nexus Mutual, 2021).

Overall, DeFi is a fast-growing sector that is disrupting traditional finance by providing a more accessible, transparent, and decentralized financial system.

Rise of Digital Assets in Recent Years

The use of digital assets has been on the rise in recent years, with more people investing in cryptocurrencies and other digital assets. Here are some recent statistics on the use of digital assets:

- *Cryptocurrency market cap*: The total market capitalization of cryptocurrencies reached an all-time high of over $2.4 trillion in May 2021, up from just $17 billion in January 2017 As of March fifth, 2023, according to CoinMarketCap, the total market capitalization of cryptocurrencies is around $1.88 trillion (CoinMarketCap, 2023).
- *Bitcoin ownership:* The number of Bitcoin holders has grown significantly, with over 100 million unique Bitcoin addresses recorded as of September 2021 (Blockchain.com).
- *Cryptocurrency trading volume:* The trading volume of cryptocurrencies has also increased, with over $800 billion in daily trading volume recorded across all cryptocurrency exchanges in August 2021 (CoinGecko, n.d.)(https://www.coingecko.com/).
- *Institutional adoption*: Institutional adoption of digital assets has also increased, with major financial institutions like JPMorgan, Goldman Sachs, and Morgan Stanley launching cryptocurrency trading and custody services (CNBC, 2021).
- *Non-fungible tokens (NFTs):* The use of NFTs, which are unique digital assets that use blockchain technology to verify ownership and authenticity, has also gained popularity, with total NFT sales volume reaching over $2 billion in the first half of 2021 (NonFungible.com, 2021).
- *Central bank digital currencies (CBDCs)*: CBDCs are digital currencies issued by central banks that are intended to complement or replace physical cash. CBDCs have been in development by central banks around the world, with China's digital yuan being one of the most advanced. The introduction of CBDCs could have significant implications for the traditional banking system (BIS, 2021). Its adoption is gaining momentum. Many countries are exploring the possibility of issuing a CBDC. According to a report by the Bank for International Settlements (BIS, 2021), as of January 2022, 79% of central banks were research-

ing CBDCs, 18% were running pilots, and 6% had launched a CBDC. Some notable countries that have launched or are planning to launch a CBDC include China, the Bahamas, and Sweden.

Overall, the use of digital assets has become more widespread, with more people investing in cryptocurrencies, trading digital assets, and exploring new applications like NFTs. However, regulatory challenges and market volatility remain key challenges for the digital asset industry.

Emerging Financial Technologies

Financial technology, also known as fintech, is the application of technology to financial services to improve efficiency, convenience, and accessibility. Fintech encompasses a wide range of services including online banking, mobile payments, peer-to-peer lending (Turi et al., 2017), investment management, and cryptocurrency.

Fintech has emerged as a disruptive force in the financial industry, challenging traditional financial institutions with innovative and cost-effective solutions. Fintech companies leverage technology such as artificial intelligence, blockchain, and cloud computing to offer faster, cheaper, and more personalized services to consumers and businesses Lekhi (2023).

- *Robo-Advisors.*

Robo-advisors, the digital platforms that use algorithms to provide automated investment advice and portfolio management services to investors, typically use advanced software to analyze investor preferences, risk tolerance, and financial goals to provide customized investment recommendations. Robo-advisors have become increasingly popular in recent years due to their low fees and ease of use. Some of the most popular robo-advisors include Betterment, Wealthfront, and Acorns. The global robo-advisory market is expected to reach $1.4 trillion by 2027 (Source: Grand View Research, 2021).

- *Increasing Adoption of Cloud Computing.*

Cloud computing is a technology that allows users to access computing resources such as servers, storage, applications, and services over the Internet, rather than having to manage and maintain their own physical infrastructure. In cloud computing, the computing resources are hosted by third-party service providers and can be accessed from anywhere with an Internet connection (Armbrust et al., 2010).

The finance industry has been rapidly adopting cloud computing technology in recent years. According to a report by Markets and Markets (2020), the cloud computing market in the financial services sector is expected to grow from $23.4 billion in 2020 to $50.1 billion by 2025, at a compound annual growth rate (CAGR) of

16.7%. Cloud computing can help financial institutions save costs on IT infrastructure and maintenance. According to a report by Capgemini (2020) banks can save up to 30% on IT infrastructure costs by moving to the cloud. Cloud computing can help improve data security for financial institutions by providing secure data storage and access controls. According to a report by IBM, 77% of financial institutions believe that cloud computing has improved their security posture. Some of the key benefits of cloud computing include cost savings, scalability, flexibility, and improved collaboration and productivity.

- *Online Banking.*

Another development is Online banking; also known as Internet banking, which is a service offered by financial institutions that allow customers to conduct various financial transactions using the Internet (Investopedia, 2021). With online banking, customers can access their account information, view account balances and transaction history, transfer funds between accounts, pay bills, apply for loans, and manage other financial services (Consumer Financial Protection Bureau, 2021). Mobile banking is becoming increasingly popular, with customers accessing their accounts and making transactions through mobile apps. According to a report by the Federal Reserve, 76% of smartphone owners use mobile banking (Federal Reserve, 2020).

- *Digital-Only Banks.*

Digital-only banks, also known as neo banks, are banks that operate exclusively online without any physical branches. These banks offer a range of banking services, often with lower fees and more competitive interest rates than traditional banks. Examples include Chime, Varo, and Revolut. Banks are using data analytics and machine learning to personalize the online banking experience for customers. This includes tailoring product offerings, alerts, and communications to individual customers based on their transaction history and preferences.

- *Open Banking.*

Another development is Open banking which allows third-party financial service providers to access customer data, with the customer's permission, through application programming interfaces (APIs). This enables customers to use a range of financial services through a single online platform. For example, a customer could use their online banking platform to access a range of investment and insurance products from different providers (Deloitte, 2018) (Fig. 3).

According to the Global Fintech Report 2021 by CB Insights, it was found that mobile banking and payments are the most widely adopted fintech services globally, with 63% of consumers using mobile banking and 53% using mobile payments. Overall, the widespread adoption of mobile banking and payments has made financial transactions more accessible, convenient, and secure for users globally.

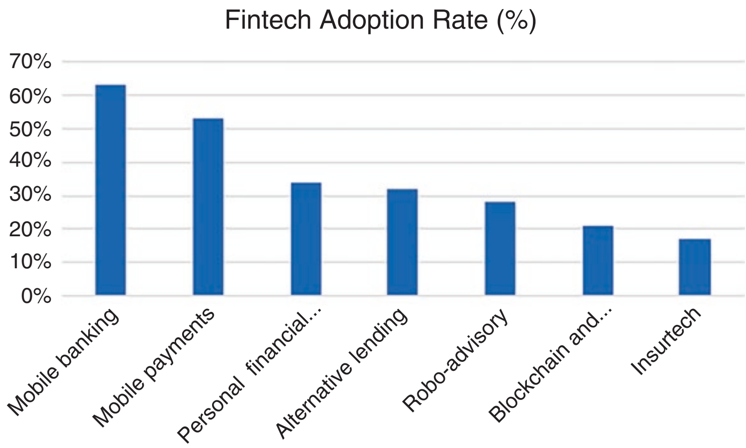

Fig. 3 The adoption of Fintech worldwide. Source: Composed by Author based on Global Fintech Report 2021 by CB Insight

The Future of Financial Technologies: Trends and Projections

The increasing digitization of money is significantly changing our interactions with money to the point that physical money may become obsolete. This is not an unrealistic idea, given that over 600 currencies have vanished in the last three decades, and it is possible that more could follow suit or be substituted by digital currencies. Even major currencies, such as the Euro, are considering implementing a "digital euro," as explored by the European Central Bank (Marr, 2022).

Financial technologies (fintech) have been rapidly changing the landscape of the financial industry. As technology continues to advance, the future of fintech looks promising. This answer will explore some of the potential trends and projections that may shape the future of fintech, including mobile payments, blockchain technology, artificial intelligence (AI), digital banking, and cybersecurity.

- The use of mobile payments is becoming increasingly popular as more people use their smartphones to pay for goods and services. The convenience of mobile payments is a key factor in its growing popularity, as it allows consumers to pay for purchases without carrying cash or credit cards. According to a report by Statista, the global mobile payment transaction value is projected to reach $4.9 trillion by 2024 (Statista, 2021).
- The use of blockchain technology in financial transactions is expected to grow. Blockchain technology provides a secure and efficient way to process financial transactions, and it is expected to revolutionize the financial industry (Kohli et al. (2023). According to a report by Allied Market Research, the global blockchain market size is projected to reach $61.36 billion by 2028, growing at a CAGR of 51.2% from 2021 to 2028 (Allied Market Research, 2021).

- The use of AI in fintech is also expected to grow. AI can be used to analyze financial data and provide insights to financial institutions. This can help financial institutions make more informed decisions about risk management, investments, and fraud detection. According to a report by Accenture, the adoption of AI in financial services is projected to create $140 billion in value by 2025 (Accenture, 2021).
- Digital banking is becoming more popular, and it is expected to continue to grow. Many people prefer the convenience of banking from their smartphones or computers. According to a report by Business Insider, the number of mobile banking users in the United States is projected to reach 160 million by 2024, up from 131 million in 2019 (Business Insider, 2019).
- As fintech grows, cybersecurity will become increasingly important. Financial institutions will need to invest in cybersecurity to protect their customers' data. According to a report by Cybersecurity Ventures, global cybersecurity spending is projected to exceed $1 trillion from 2017 to 2021 (Cybersecurity Ventures, 2017).

Overall, the future of fintech is bright. The use of technology is expected to continue to revolutionize the financial industry, making it more efficient and convenient for consumers. However, it is important for financial institutions to invest in cybersecurity to protect their customers' data and maintain consumer trust.

Megatrends in Different Finance Sectors

Banking Sector

The banking industry continues to undergo digital transformation, with an increasing shift toward digital banking services, mobile banking apps, and online transactions. Technological advancements, fintech disruption, regulatory changes, and data-driven insights are key factors contributing to this trend. It is reshaping the industry by revolutionizing customer experiences, optimizing operations, fostering innovation, and driving efficiency and profitability. According to a report by Statista 2023, The Digital Banks market worldwide is projected to grow by 13.39% (2023–2028) resulting in a market volume of US$1219.00 bn in 2028.

Real Estate

The real estate industry has seen a significant rise in the adoption of financial technology (fintech) solutions. According to a report by Deloitte 2022, incorporating digital technologies and tools to streamline various tasks and operations involved in managing properties. Currently, property management services encompass activities such as organizing general and board meetings, performing face-to-face responsibilities, and undertaking labor-intensive tasks like cleaning, inspections, and patrols. Due to the personalized nature of these services, the industry as a whole has been slow to adopt digitalization.

However, as the challenge of labor shortages intensifies, property management firms recognize the need to enhance efficiency in order to handle and oversee a greater number of condominium units per employee, thereby bolstering their overall revenues. By embracing digitalization, property management can realize improvements in efficiency. First, simply as a replacement of labor, by means of, e.g., cleaning robots, IoT technology for inspections and patrols, and chatbots for handling complaints. All of these will help keep down personnel costs. Online distribution and storage of general and board meeting materials, conducting resident surveys online, digitalizing inspection and maintenance records, and introducing an accounting system to improve existing workflow.

Capital Markets

The capital markets sector has also experienced a growing impact from fintech advancements. The previous year, global investment in capital markets fintech reached $9.3 billion, as reported by Accenture. Fintech solutions in capital markets include algorithmic trading platforms, robo-advisors, blockchain-based securities issuance and trading, and digital asset exchanges. These technologies aim to enhance trading efficiency, reduce costs, improve transparency, and provide new investment opportunities.

Conclusion

Financial service innovations are transforming the traditional financial industry and creating new opportunities for businesses and consumers. The adoption of new technologies such as blockchain, artificial intelligence, and machine learning is driving significant changes in the sector, making financial services more efficient, transparent, and accessible. The focus is also shifting toward expanding access to financial services to underserved communities, particularly in developing countries, driven by a combination of technological innovation, regulatory reform, and the rise of fintech companies.

However, these innovations also pose social, economic, and regulatory concerns, such as privacy and security risks, financial stability, and regulatory compliance. Effective management of these concerns is crucial to achieving a balance between financial services innovation and the desire for the financial system's safety and stability.

Overall, the finance industry is adapting to changing needs and preferences, driven by shifting demographic patterns and changing consumer expectations. The future of finance will likely continue to be shaped by these megatrends, driving significant change in how financial services are delivered, consumed, and regulated. The financial industry's future is promising as it evolves to meet the demands of a rapidly changing world, and we can expect continued innovation and disruption in the coming years.

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Fintech 4.0 and Financial Systems

Manbo He

Abstract The chapter analyses fintech 4.0 and financial systems navigating through the latest developments in the industry starting with a high-level introduction to the fourth-gen technologies and financial principles in this sphere. It further explores the factors that affect the development of fintech, the integration of technologies with finance principles, the transformation of fintech from product-focus to scenario-focus, and the discussions on the future of fintech toward—control-oriented Vs. credibility-oriented directions.

Background

Fintech, or Financial Technology, refers to the latest technological innovation aiming to disruptively improve the delivery of financial services. For instance, through automating banking services, investments, securities trading, insurance, and risk management, Fintech helps to make financial transactions more efficient, easier to access, and more secure, thus opening up the door for more people to save, invest, and borrow—making the financial systems more accessible to those underserved and more effective in improving the overall wellbeing of our society, in other words, democratizing financial services industry.

Nowadays Fintech is without a doubt, if not the hottest topic in town, one of the most popular subjects in the business/finance/technology world, evidenced by a hefty US$210 billion Fintech investment made over 5684 deals in 2021 (He, 2022). In general terms, there are four key elements in Fintech: Artificial Intelligence (AI), Blockchain, Cloud Computing, and Big Data (sometimes referred to as the "ABCD" of Fintech). Although Fintech-related technologies reach far beyond the scope of these four key elements, it is vital to understand that at the core of all financial

M. He (✉)
University Canada West, Vancouver, BC, Canada
e-mail: manbo.he@ucanwest.ca

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technologies, the ultimate goal remains improving customer experience through innovation and sustainability, and financial services providers are relying on the continued development in these four key elements to achieve this goal.

Over the past century, Fintech has evolved from Fintech 1.0 to Fintech 4.0 at a speed that simulates Moore's Law (Moore's Law observed that the number of transistors on an integrated circuit for minimum component cost doubles every 24 months). As to Fintech 4.0, some believe that it started in 2018 under the shadow of the great crypto crash, some may argue that we are still in the twilight zone with one hand hanging on with Fintech 3.0 and the other getting ready for the arrival of Fintech 4.0. Nevertheless, most people tend to agree that Fintech 4.0 is to build up an open, agile, and sustainable financial technology ecosystem to foster innovation, operation, and empowerment—the ecosystem that has the capacity for self-iteration, self-optimization, and self-developing.

In this chapter, we will review the latest developments in Fintech 4.0—What does Fintech 4.0 mean? What are included in Fintech 4.0? Is Fintech 4.0 more about technologies or finance principles? What impacts will Fintech 4.0 have on the global financial systems? Through a review of the development from Fintech 1.0 to Fintech 4.0, we will study the factors that affect the development of Fintech, the integration of technologies with finance principles, the transformation of Fintech from product-focus to scenario-focus, and the discussions on the future of Fintech toward either a control-oriented or credibility-oriented direction. We will conclude this chapter with a forward-looking viewpoint on the ways to establish a symbiosis value proposition in financial systems driven by the evolution of the Fintech industry.

Fintech 4.0: Product-Based Versus Customer-Based Versus Scenario-Based

Financial Technology or Fintech for short is now at the stage of cryptocurrencies and neobanks—powered by Blockchain Technology. Since the global financial crisis in 2008, the general public has lost faith in the traditional banking system, which paved the way for the overwhelming introduction of Bitcoin in 2009—the first blockchain technology-backed cryptocurrency. The decentralized, distributed, and irreversible nature of blockchain stimulates much of the characters only exist within a trusted society where everyone knows everyone, leaving little room for false play, hence the establishment of credibility—the foundation of trust. Many believed that 2008 was the year.

Fintech 3.0 started, and it had developed to make the connection between the digital world and the physical world, and between the virtual world and the real world—through the massive application of artificial intelligence (AI) technologies, including computer vision, phonetic, and voice empathy, natural language processing (NLP), search, information processing and knowledge extraction, data learning, planning and exploration agent, speech creation, visual creation, processing, and controlling. Fintech 3.0 has provided solutions to a series of basic problems in financial services, concerning security, risk, cost, credibility, and efficiency.

Today, Blockchain Technology can be widely applied to cross-border payment, supply chain financing, assets securitization, insurance, and credit score. The great crypto crash in 2018 marked the shift from the era of information to the era of intelligence, with big data at the core, we've officially come to the era of Fintech 4.0—decentralized, blockchain and digital currency-based ecosystems of science and technology—with a clear evolution of the logic and operations of Fintech 4.0 from Fintech 3.0, it becomes a self-iteration, self-optimization, and self-developing ecosystem.

While the underlying technologies that have driven Fintech 3.0 and Fintech 4.0 are essentially the same, namely blockchain and open banking, the focus and the challenges are rather different.

Looking through the history of Fintech evolution from Fintech 1.0 with a focus on efficiency of financial services—some identified as infrastructure-oriented phase of Fintech, to Fintech 2.0 with a focus on people, or bank-oriented phase of Fintech, to Fintech 3.0 with a focus on customer, or startup-oriented phase of Fintech, there is a clear path of shifting from a product/service-centered approach to a more customer-centered approach. Particularly worth noting is the time between 2014 and 2017 when globalization has reached its peak and Fintech has helped many in the developing world getting access to the same financial services that were only available to the developed nations, for instance, in China and India, the development of Fintech enables people to enjoy the benefit of new entrants and last mover advantages with financial services – hence this period of time is also called Fintech 3.5 (2014–2017) with a focus on accessibility or globalization-oriented phase, still a customer-centered approach.

Through Fintech 1.0 to Fintech 3.0 (or Fintech 3.5), the challenges are largely threefolded: on the technology side, risk control framework and cost factors remain the major concerns; on the governance side, blockchain and open banking face litigation and scrutiny issues; on the industry side, shortage of professional workforce and shrink of intermediate services are becoming more and more problematic.

To tackle these challenges, Fintech has evolved into the current stage of Fintech 4.0 (some believed Fintech 4.0 started in 2018 when cryptocurrency crashed). At this stage, Fintech 4.0 focuses on symbiotic value created by disruptive technologies and has shifted from a customer-centered approach toward a scenario-centered (scenario-based or scenarized) approach, from different industry sectors to different ecosystems. At Fintech 4.0, the underlying technologies including blockchain and open banking have developed into mature digital economy infrastructures that are working hand-in-hand with artificial intelligence (AI), Big Data, Cloud Computing, Internet of Things (IoT), moving financial products from offline to online (O2O).

In the development of artificial intelligence (AI) and machine learning (ML), the recent phenomenal performance of ChatGPT and GPT-4 has wowed the whole world. In this area of Fintech, in particular, the evolution of AI is going through three steps: the first step is to develop Computation Intelligence, then move on to IntelliSense (Perceptive Intelligence), and ultimately develop into Cognitive

Intelligence. At Fintech 4.0, AI technology is currently at IntelliSense or Perceptive Intelligence stage, and the application of AI is largely on business empowerment: AI Sales & Marketing, AI Investment Advisory, AI Insurance, AI Risk Management, AI Identification—we are witnessing massive AI application in Consumer Financing, Fund Management, Wealth Management, among other financial services sectors.

Moving forward, blockchain-based decentralized finance (DeFi) along with Peer-to-Peer (P2P) lending will further eliminate intermediates hence dramatically reduce the cost of financing. For financial services industry, the focal point goes back to developing cutting-edge products—which used to be the core competence of financial services, back at the beginning of times.

From Fintech 1.0 to Fintech 4.0—What Matters the Most?

Not many people have noticed that Fintech is more widely used than social media.[1]

Although it has been widely accepted that, the year 1866 being the time when the marriage of financial services and technology had occurred, with the first transatlantic cable in the USA enabled the first electronic fund transfer system, using technologies such as telegraph and Morse Code, hence the beginning of Fintech 1.0, in a more rigorous sense however, one would argue that Fintech 1.0 didn't really start until 1950 – that was the time when the first credit card was introduced to Americans by Diners' Club. By modern standards, Fintech 1.0 started when Information Technology was first applied at financial services institutions, symbolized by the massive use of mainframe computers and data centers—a centralized process of mainframe computer systems and data centers at banks. During that time, bank services structures were the same as their IT structures, bank services were provided through a web of bank branches, credit cards, and ATMs became popular—computerized transaction processing along with centralized database processing are the key elements of Fintech 1.0, which mainly covers operations at financial institutions, most of them banks.

While some scholars use the year 1967 as the dividing line of Fintech 2.0 from Fintech 1.0, marking the change of financial services to a digital industry from analogue, it may seem that the invention of the first ATM machine in that year, although endorsed by former chairman of the US Federal Reserve Paul Volcker, did not have the same level of impact on financial services industry or general public, as the introduction of the first smartphone IBM Simon in 1994, or the first public use of the Internet in 1993. (One loophole in Paul's endorsement of ATM as the greatest financial innovation in the past 20 years is that he said it in 2009 which traced back

[1] In a report posted on Plaid (https://plaid.com/blog/report-the-fintech-effect-2021/), 88% Americans use Fintech to manage their finances—out of 93% Americans who use the Internet. In comparison, only 78% Americans use video streaming services and 72% use social media.

to 1989 for 20 years; however, the invention of ATM happened 22 more years earlier—just for fun.)

Measured by the shift from analogue to digital, 1967 was the year of the beginning of Fintech 2.0. However, if we change the measurement to online banking then the timeline has to be pushed over to the year 1993 with the first public access to the Internet and smartphone, as well as the first online banking services offered by Stanford Federal Credit Union.

By any typology, the difference between Fintech 1.0 and Fintech 2.0 lays in the way technology was applied in the financial services industry. During Fintech 1.0, the focus was primarily on the establishment of technological infrastructure that had dramatically improved the efficiency of finance (or more specifically the efficiency of the internal operations for financial institutions), in other words, product-centered focus. That infrastructure/product focus was later extended to improve customer experience in Fintech 2.0 whereby the primary goal in technological development was to provide a better, faster, safer, and more convenient way to finance, or customer-centered focus.

Either started in 1967 or 1993, Fintech 2.0 had never touched the core principles of finance, rather, like Fintech 1.0, what had happened in Fintech 2.0 was essentially applying more advanced technologies to enhance financial products/services, and to improve customer experience—all done within the boundaries of the traditional financial principles, or simply put, the evolution from Fintech 1.0 to Fintech 2.0 had not changed much of the financial system, which remained a collateral-based and control-oriented system.

The revolution happened in 2008: When the Global Financial Crisis (GFC) occurred, the general public developed a distrust of traditional financial institutions, gave new entrants the opportunity to emerge, and that officially triggered Fintech 3.0—with mass adoption of the Internet and smartphone, those historical barriers (infrastructure, knowledge and information, or lack thereof) that had prevented broad access to finance had all disappeared, which paved the way for hundreds of startups (with lots of brains and money) working on various alternatives to traditional banking, and fundamentally reshaped the finance principles.

The current status of Fintech is Fintech 3.0: the application of artificial intelligence (AI), big data, cloud computing, and blockchain technologies has been widely adopted by alternative financial service providers and traditional financial institutions alike. The mass adoption and mature utilization of these technologies have made it possible to drastically extend financial services to those underbanked and unbanked, and revolutionarily change the fundamental logic and process upon which finance is conducted—from collateral-based to credibility-based, and from control-based to collaboration-based. One area of significance is in risk and compliance management, the efficiency and effectiveness have improved exponentially. Take for instance with AI, all 10 basic AI modules have been put to real use: computer vision, phonetic and voice empathy, nature language processing (NLP), search, information processing and knowledge extraction, data learning, planning and exploration agent, speech creation, visual creation, processing, and controlling.

Another significant change in Fintech 3.0 started in 2015 when third-party payment including mobile and online payment (through non-bank payment service providers) became a business norm. That is the time when institutions and companies can develop new businesses, improve customer experience, and reduce service costs all at once via Internet, Mobile, and AI Technologies. The fundamental change was from centralization to decentralization which has made HFT (high-frequency trading) and HFD (high-frequency data) possible—in that sense, the development in third-party payment was indeed a significant leap forward for Fintech.

At the stage of Fintech 3.0, Fintech solved many basic problems including security, risk, cost, credibility, and efficiency. Fintech 3.0 can integrate the digital world with the physical world, and the virtual world with the reality world. In this development, Biometrics can expand the boundary of the finance world, AI can improve efficiency, Big Data Security can improve the safety of financial assets, Hardware Security can improve the safety of financial services, Blockchain can drive automation, improve credibility, and push organizations toward flat operations.

Along with the crypto crash in the year 2018, some considered it as the end of Fintech 3.0 era to make way for Fintech 4.0. For others, at the moment we are still in the era of Fintech 3.0 but are witnessing the unfolding of Fintech 4.0.

Fintech 3.0 is all about information, while Fintech 4.0 is all about intelligence. In the era of information, data is the result of machine processing, which subsequently evolved as the core of Fintech 4.0—or one can claim that Fintech 4.0 is all about data. In the era of intelligence, data is the beginning of everything. Massive data have been cumulated through the development of Fintech 3.0 and organized in a high-quality well-structured way, making it possible for deep learning—which marks now as the turning point from Fintech 3.0 to Fintech 4.0, or in other words, from the era of information to the era of intelligence. While we can say in Fintech 3.0 it is merely a repetition of human cognition by machinery, in Fintech 4.0 machines will have their own knowledge, and machinery cognition can further enhance human cognition.

Digital currency, blockchain, and algorithm are the three most critical elements of Fintech 4.0. While the shift from Fintech 3.0 to Fintech 4.0 is in reality a shift of Fintech ecosystem: the current structure is all about traditional currency, traditional electronic payment, and Internet technology, in the future, it will all be transformed to blockchain and digital currency based ecosystem of science and technology—with a clear evolution of the logic and operations of Fintech, it becomes a self-iteration, self-optimization, and self-developing ecosystem.

Fintech 4.0—The Good and the Bad

With the unfolding of Fintech 4.0, the financial services industry is undergoing a profound transformation driven by the emergence of new technologies, business models, and regulatory frameworks.

Fintech 4.0 is characterized by a high degree of integration, interoperability, and convergence among different technologies, platforms, and actors that enable seamless and frictionless delivery of financial services across borders and sectors. Fintech 4.0 also encompasses a wide range of applications that span from traditional banking and payment services to alternative finance, wealth management, insurance, capital markets, trade finance, and regulatory compliance.

Fintech 4.0 has been driven by several factors, such as:

– The increasing demand for faster, cheaper, more convenient, and more personalized financial services from customers who are becoming more digitally savvy and empowered.
– The growing availability of large amounts of data from various sources that can be processed and analyzed using advanced techniques such as machine learning and natural language processing to generate insights and predictions.
– The rapid diffusion of smartphones and mobile Internet that provide ubiquitous access to digital platforms and applications.
– The declining costs and increasing performance of computing power and storage capacity that enable scalable and cloud-based solutions.
– The emergence of new entrants such as fintech startups, big tech firms (e.g., Amazon and Google), telecom companies (e.g., M-Pesa), e-commerce platforms (e.g., Alibaba), social media networks (e.g., Meta), and other non-financial players that offer innovative products and services that compete or collaborate with traditional financial institutions.
– The evolution of regulatory frameworks that aim to balance innovation with stability, competition with consumer protection, and openness with security.

While Fintech 4.0 captures the latest wave of innovation in financial services, characterized by the convergence of artificial intelligence, big data, cloud computing and quantum computing, blockchain, biometrics, 5G network, Internet of Things, web 3.0, and other technologies, it has the potential to create more efficient, personalized, transparent, and secure financial services for customers and businesses across various domains, such as payments, lending, insurance, wealth management, capital markets, trade finance, remittances, and regulatory compliance.

Fintech 4.0 can also address some of the global challenges such as climate change, poverty, and inequality, by promoting financial inclusion, financial literacy, financial wellness, resilience, social impact investing, green finance, and sustainable development goals (SDGs). For example, Fintech 4.0 can facilitate access to finance for underserved segments of the population, reduce transaction costs and frictions, enhance transparency and trust, improve risk management and fraud prevention, and enable personalized and tailored solutions. Fintech 4.0 can also contribute to sustainable development goals by supporting green finance, social impact investing, financial literacy, and gender equality.

However, Fintech 4.0 also poses significant challenges, risks, and uncertainties for financial stability, integrity, cybersecurity, and resilience of the financial systems, as well as for the protection of consumers, investors, data privacy, and regulations. For instance, Fintech 4.0 can increase market concentration, systemic risk, cybersecurity threats, operational failures, financial exclusion, and regulatory arbitrage. Moreover, Fintech 4.0 is unfolding in a context of heightened uncertainties related to the COVID-19 pandemic, geopolitical tensions, environmental degradation, and social inequalities. Fintech 4.0 can also raise ethical, legal, and social issues such as algorithmic bias, discrimination, accountability, liability, and human rights.

Therefore, Fintech 4.0 requires a careful assessment of its potential benefits and costs for the financial systems and a proactive approach from regulators, policymakers, and industry stakeholders to foster a balanced and inclusive development of Fintech 4.0 that maximizes its positive impacts and minimizes its negative consequences.

Technology as a Tool or a Service or a System?

In Fintech 4.0, data-driven intelligence remains at the center of technology development:

With the latest breakthrough in AIGC (Artificial Intelligence Generated Contents) trained by Big Model technology, as represented by the astonishing performance of ChatGPT and GPT-4, Artificial Intelligence (AI) and Machine Learning (ML) have developed to a point where Fintech 4.0 is fast evolving to the level of Cognitive Intelligence from the current Perceptive Intelligence (IntelliSense) level—the foundation of a self-iteration, self-optimization, and self-developing ecosystem. With advanced AI technology, real-time fraud detection and finance analysis can come easy, as with other implementations, including financial monitoring, process automation, algorithm trading, marketing, customer service, and more.

Blockchain technologies centered with Distributed Ledger Technologies (DLT) will further enhance the level of trust of financial transactions in Fintech 4.0. In this area, Smart Contract, ZKP (Zero-Knowledge Proof), and Distributed Data Storage/Exchange technologies provide a hyper-personalized customer experience. Applications like Digital Wallets, Digital Assets, DeFi (Decentralized Finance), and NFT (Non-Fungible Token) will be widely used, and the decentralized, distributed, and irreversible nature of blockchain makes Fintech 4.0 ever more reliable and trustworthy.

Cloud Computing and Quantum Computing technologies are part of the core components of Fintech 4.0 infrastructure to support full-scale applications including open banking platforms powered by API (Application Programming Interface) standards, BNPL (Buy-now-pay-later) platforms, P2P (Peer-to-peer) payments, Neobanking, Robotic Process Automation (RPA), SaaS (Software-as-a-Service) or XaaS (Anything-as-a-Service) platforms, low-code or no-code solutions, as well as other embedded finance applications.

All technologies in Fintech 4.0 work around data—Big Data. Representing the “D” in the “ABCD” of Fintech (AI, Blockchain, Cloud Computing, and Big Data), Big Data is also at the center of the “3D” portrait for Fintech 4.0—datafication, digitization, and digitalization. Big Data is the large amount of organized and unstructured data that banks and financial institutions can use to forecast consumer behavior and build strategies. It helps companies in the financial industry to get accurate information about their customers adapt services and marketing strategies, and personalize user experience. Combined with AI, Blockchain, and Cloud Computing technologies, Big Data can be implemented in the following: (1) Creating detailed user profiles for adapted strategies, (2) Improved risk assessment by analyzing multiple sources, and (3) Accurate fraud detection systems development.

IOT (Internet of Things) and Web 3.0—This blockchain-based version of Internet is decentralized, open, and trustless, therefore works perfectly with Fintech 4.0 and results in:

– Improved data control for users.
– Access to any information for activities like BNPL or loans.
– Personalized and adapted content.
– Process automation for faster payments.
– Minimized errors and suspensions.

Technologies in Fintech 4.0 can be used as either a tool, or a service, or as an ecosystem. Other than the technologies mentioned above, there are many more Fintech technologies developed and developing along the evolution of the Fintech and Financial Services Industry. Sometimes Fintech is also categorized differently as in payments, insurtech, regtech, wealthtech, embedded finance, cryptocurrency, and cybersecurity. A more widely accepted way of categorizing Fintech is the following:

- Blockchain technology and Cryptocurrencies.
- Regulatory technology.
- Insurance technology.
- Mobile payments technology.
- Peer-to-peer Lending and Borrowing technology.
- Wealth Management Technology.
- Crowdfunding technology.
- Robot-advisory and trading technology.

In a nutshell, no matter how we categorize it, or how we treat it as a tool, a service, or a system, with all the cutting-edge technologies evolving in Fintech 4.0, it is pushing the evolution of the financial services industry (and the tech industry) in promoting financial inclusion, financial literacy, financial wellness, resilience, social impact investing, green finance, and sustainable development goals—that is the objective, and the ultimate goal of all the technologies developed and developing, in the era of Fintech 4.0.

Fintech 4.0 and Financial Systems—Make it or Break it?

The definition of a financial system in Wikipedia is described as follows:

"A financial system is a system that allows the exchange of funds between financial market participants such as lenders, investors, and borrowers. Financial systems operate at national and global levels. Financial institutions consist of complex, closely related services, markets, and institutions intended to provide an efficient and regular linkage between investors and borrowers.

In other words, financial systems can be known wherever there exists the exchange of a financial medium (money) while there is a reallocation of funds into needy areas (financial markets, business firms, banks) to utilize the potential of ideal money and place it in use to get benefits out of it. This whole mechanism is known as a financial system.

Money, credit, and finance are used as media of exchange in financial systems. They serve as a medium of known value for which goods and services can be exchanged as an alternative to bartering. A modern financial system may include banks (public sector or private sector), financial markets, financial instruments, and financial services. Financial systems allow funds to be allocated, invested, or moved between economic sectors, and they enable individuals and companies to share the associated risks."

In short, a financial system is a combination of people, institutions, businesses, and processes that facilitate financial transactions. It helps allocate monetary resources to stimulate growth, development, and return on investments. Financial systems include private and public institutions such as insurance companies, banks, investors, and stock exchanges. Also, include a set of rules and processes that financial market participants use. Consists of lenders, borrowers, and exchanges. Essentially what a financial system does is to provide (1) Liquidity, (2) Payment, (3) Risk management, and (4) Financing, to bridge between savers and spenders. Hence, a typical financial system is formed with these components: (1) Financial instruments (cash or derivatives), (2) Financial institutions, (3) Financial markets, (4) Financial services, and (5) government regulatory framework.

Fintech 4.0 and Financial Systems—Make it or Break it?

According to the renowned economist and Nobel laureate Robert C. Merton, there are six key functions that financial systems perform:

Payment facilitation: Financial systems serve as intermediaries between buyers and sellers by facilitating the exchange of goods and services through the provision of payment mechanisms. This function helps to promote efficiency in the economy by reducing transaction costs and increasing the speed of transactions.

Risk management: Financial systems can help to manage risks. Financial institutions such as banks, insurance companies, and investment firms help individuals and businesses manage risks by providing products and services such as insurance policies, financial derivatives, and investment advice.

Liquidity provision: Financial systems also serve as a source of liquidity for the economy. Financial institutions provide liquidity by allowing individuals and businesses to borrow and lend funds, and by providing financial intermediation services that facilitate the transfer of funds from savers to borrowers.

Information provision: Financial systems play a crucial role in providing information to market participants. Financial institutions gather and disseminate information about companies, industries, and markets, which helps investors to make informed decisions.

Price discovery: Financial systems play a major role in price discovery. Financial markets provide a platform for investors to buy and sell assets, and the resulting market prices reflect the collective views of market participants about the value of those assets.

Resource allocation: Financial systems help to allocate resources efficiently across the economy. By providing access to capital markets, financial systems allow individuals and businesses to raise capital for productive investments, which can promote economic growth and development.

Overall, the functions of financial systems emphasize the importance of payment facilitation, risk management, liquidity provision, information provision, price discovery, and resource allocation. These functions help to promote efficiency, manage risk, allocate resources, and provide critical services to individuals and businesses in the economy.

The Impact of Fintech 4.0 on Key Functions of the Financial System

Fintech 4.0, the latest wave of technological innovation in the financial sector has been driven by advances in areas such as artificial intelligence, blockchain, and the Internet of Things. The emergence of Fintech 4.0 has had a profound impact on the financial system, transforming the way that financial services are delivered and the way that financial markets operate. The impact of Fintech 4.0 on the six key functions of the financial system include:

Payment facilitation: Fintech 4.0 has led to significant innovation in payment systems, with the emergence of new payment platforms and the integration of payment functionality into other digital services. For example, mobile payment platforms such as Apple Pay and Google Wallet have become increasingly popular, allowing consumers to make payments quickly and easily using their smartphones. The rise of cryptocurrencies and blockchain technology has also led to the development of new payment systems that are decentralized and secure.

Risk management: Fintech 4.0 has led to the development of new tools and techniques for managing risk, including the use of artificial intelligence and machine learning algorithms to analyze data and identify potential risks. For example, Fintech companies are using AI-powered credit scoring models to assess the creditworthiness of borrowers, while blockchain technology is being used to create more secure and transparent supply chain financing systems.

Liquidity provision: Fintech 4.0 has led to the emergence of new sources of liquidity, such as peer-to-peer lending platforms and crowdfunding platforms, which allow individuals and businesses to access funding outside of traditional banking channels. Fintech companies are also using blockchain technology to create new types of financial instruments that can be traded on decentralized exchanges, providing new opportunities for liquidity provision.

Information provision: Fintech 4.0 has enabled the creation and dissemination of vast amounts of financial data, which can be used to inform investment decisions and improve risk management practices. For example, Fintech companies are using big data analytics and machine learning algorithms to analyze market trends and provide investors with real-time insights into market conditions.

Price discovery: Fintech 4.0 has led to the development of new types of financial markets and trading platforms, which are faster, more efficient, and more transparent than traditional financial markets. For example, blockchain-based platforms such as Ethereum are being used to create decentralized exchanges that allow for peer-to-peer trading of cryptocurrencies and other digital assets, while algorithmic trading platforms are being used to execute trades more quickly and accurately.

Resource allocation: Fintech 4.0 has led to the emergence of new ways to raise capital, such as equity crowdfunding and initial coin offerings (ICOs), which allow startups and other businesses to access funding from a wider pool of investors. Fintech companies are also using blockchain technology to create new types of investment vehicles, such as digital tokens, that can be used to represent ownership of assets such as real estate or commodities.

Overall, Fintech 4.0 has had a significant impact on the functions of the financial system, enabling new forms of payment facilitation, risk management, liquidity provision, information provision, price discovery, and resource allocation. These innovations have the potential to transform the financial sector, making it more efficient, more accessible, and more responsive to the needs of consumers and businesses.

The Impact of Fintech 4.0 on the Operations and Activities of the Financial System

Similarly, the operations and activities of the financial system that are also impacted significantly by Fintech 4.0 include:

Payment Systems—One of the most significant impacts of Fintech 4.0 on the financial system is in payment systems. Fintech companies are using advanced technologies such as blockchain and digital wallets to create new and innovative payment systems. These systems are often faster, more secure, and more affordable than traditional payment systems. For example, blockchain technology is being used to create cryptocurrencies such as Bitcoin and Ethereum, which offer fast and secure transactions at a low cost. Digital wallets such as PayPal and Venmo are also becoming increasingly popular, allowing users to make payments and transfer funds easily and quickly.

Lending and Credit—Fintech 4.0 is also transforming the lending and credit function of the financial system. Fintech companies are using advanced data analytics and machine learning algorithms to create more accurate credit scoring models, which can help lenders make better lending decisions. Furthermore, fintech companies are providing alternative lending options to consumers and businesses that may not qualify for traditional bank loans. These alternative lending options include peer-to-peer lending platforms and online marketplace lenders.

Investment and Wealth Management—The investment and wealth management function of the financial system is also being impacted by Fintech 4.0. Fintech companies are using advanced technologies such as artificial intelligence and machine learning algorithms to create personalized investment advice and portfolio management services.

Robo-advisors, which are automated investment platforms that use algorithms to provide investment advice and manage portfolios, are becoming increasingly popular. These platforms offer a low-cost alternative to traditional wealth management services and are often more accessible to small investors.

Risk Management and Compliance—Fintech 4.0 is also transforming the risk management and compliance function of the financial system. Fintech companies are using advanced technologies such as artificial intelligence and machine learning algorithms to identify and mitigate risks in real time. For example, machine learning algorithms can be used to analyze large amounts of data to identify fraudulent transactions, reducing the risk of financial crime. Blockchain technology can also be used to create secure and transparent record-keeping systems that can help ensure compliance with regulations.

Benefits of Fintech 4.0

Through these significant impacts on financial systems, either via the functions of a financial system or via operations, Fintech 4.0 has brought many benefits to financial systems, including:

Increased efficiency: Fintech 4.0 technologies enable financial institutions to automate processes and reduce costs. AI-powered chatbots and virtual assistants can handle customer inquiries and support, freeing up employees to focus on more complex tasks. Cloud computing enables institutions to access data and collaborate in real time, improving efficiency and reducing operational costs.

Improved customer experience: Fintech 4.0 technologies are enabling financial institutions to provide a better customer experience. AI-powered chatbots and virtual assistants can provide 24/7 customer support, while big data analytics can be used to personalize offers and services to individual customers.

Enhanced security: Fintech 4.0 technologies like blockchain and biometric authentication are improving security in financial systems. Blockchain enables the creation of tamper-proof ledgers that can be used to track financial transactions and verify identity. Biometric authentication technologies like facial recognition and fingerprint scanning are being used to improve security and prevent fraud.

Increased access: Fintech 4.0 technologies are making financial services more accessible to people who were previously excluded from the financial system. Mobile banking apps and online lending platforms are enabling people to access financial services from anywhere in the world. Blockchain-based platforms like Bitcoin are enabling people to conduct financial transactions without the need for a traditional bank account.

Greater competition: Fintech 4.0 technologies are increasing competition in the financial services industry. New entrants like mobile payment providers and online lending platforms are challenging traditional financial institutions to innovate and adapt.

FinTech 4.0 has the potential to transform financial systems in several ways. One of the key benefits of FinTech 4.0 is that it can improve financial inclusion by providing access to financial services for underserved populations. This is achieved through the use of mobile banking apps, digital wallets, and other innovative financial products that are accessible to anyone with a smartphone or an Internet connection. For instance, mobile banking apps are widely used in Africa, where traditional banking services are scarce. FinTech 4.0 can also enhance the efficiency and security of financial systems. Blockchain, for instance, can be used to create tamper-proof, transparent, and decentralized payment systems that eliminate the need for intermediaries. This can reduce transaction costs, increase transaction speed, and enhance security by eliminating the risk of fraud and cyberattacks. AI and machine learning can be used to automate financial processes such as credit scoring, fraud detection, and investment management, thereby reducing the time and resources needed to perform these tasks.

FinTech 4.0 can also enhance the customer experience by providing personalized financial services that cater to the unique needs of individual consumers and businesses. This is achieved through the use of data analytics, which enables financial institutions to collect and analyze customer data in real time. This data can be used to provide personalized financial advice, targeted marketing, and customized financial products that meet the needs of each customer.

Challenges of Fintech 4.0

Despite the potential benefits of FinTech 4.0, there are several challenges that need to be addressed. One of the key challenges is regulatory compliance. FinTech 4.0 relies on the use of advanced technologies such as blockchain, which operate outside the traditional regulatory frameworks. This can create challenges for regulators who need to ensure that financial institutions comply with regulatory requirements while using these new technologies. Regulators need to strike a balance between promoting innovation and protecting consumers and the integrity of financial systems.

Another challenge is cybersecurity. As fintech companies rely on digital technologies, they are vulnerable to cyberattacks, which can compromise sensitive financial data. It is essential that fintech companies implement robust cybersecurity measures to protect themselves and their customers.

In conclusion, it is inevitable that Fintech 4.0 is transforming the financial industry, offering new and innovative financial products and services that are often faster, more secure, and more affordable than traditional financial products. However, it also poses several challenges and risks that must be addressed to ensure that the financial system remains safe and stable. As the fintech industry continues to evolve, it will be essential for regulators and market participants to work together to ensure that the benefits of Fintech 4.0 are realized while mitigating its risks.

The Human Factor—The Connection Between Fintech 4.0 and Industry 5.0

Now that we have reviewed briefly the history of Fintech since its first introduction some 150 years ago, we have learned about the advancement of technology from something as "simple" as an ATM machine, to something as complicated as AI and IoT, that has evolved from Fintech 1.0 to Fintech 4.0, and that continued innovation in technology has been driving the evolution of the financial systems toward a more productive, more inclusive, and more sustainable ecosystem.

This advancement of Fintech innovation started from product-centered approach aiming for the improvement of efficiency during Fintech 1.0, moved on to process-centered approach aiming for the improvement of operations within financial institutions during Fintech 2.0, then shifted to customer-centered approach aiming for the improvement of banking experience during Fintech 3.0, and finally turned to a holistic approach aiming the establishment of a symbiosis value (scenario-based) proposition in financial systems at Fintech 4.0. This process much resembles the way our society has developed, especially in the history of industry evolution.

Much like Fintech evolved from Fintech 1.0 to Fintech 4.0, we have seen industry evolution from Industry 1.0 to Industry 5.0, with Industry 1.0 began at around 1780 represented by the use of steam power, Industry 2.0 started in 1870 with the introduction of electricity, Industry 3.0 started in 1970 represented by the wide adoption of machine automation (CNC—computer numerical control, CAD—computer-aided design, and CAM—computer-aided manufacturing), then Industry 4.0 began at around 2011 symbolized by the integration of digital technologies such as robotics and Internet of Things (IoT), and the latest development was Industry

5.0 which has just started in 2022, and is represented by the emphasize on human skills and collaboration—this is also called a "Human-centered" approach and is very similar to the symbiosis value proposition in financial systems at Fintech 4.0.

Fintech 4.0 and Industry 5.0 are both part of the broader trend of digital transformation that is reshaping the global economy. While Fintech 4.0 is focused on transforming the financial sector through the use of advanced technologies such as blockchain, artificial intelligence, and the Internet of Things, Industry 5.0 is focused on transforming manufacturing and other industries through the integration of these same technologies.

One of the key connections between Fintech 4.0 and Industry 5.0 is the role of data in driving innovation and improving performance. Both Fintech 4.0 and Industry 5.0 rely on the collection, analysis, and use of vast amounts of data to inform decision-making and optimize processes. For example, Fintech companies are using data analytics to develop new credit scoring models and risk management strategies, while manufacturers are using data analytics to optimize supply chains and improve product quality.

Another connection between Fintech 4.0 and Industry 5.0 is the importance of collaboration and partnership in driving innovation. Both Fintech companies and manufacturers are working together with other players in their respective ecosystems to develop new products, services, and business models that can take advantage of the latest technological advances. For example, Fintech companies are partnering with traditional financial institutions to develop new payment systems and investment products, while manufacturers are collaborating with technology companies and startups to develop new smart products and services.

Overall, both Fintech 4.0 and Industry 5.0 are driven by the desire of developing the ecosystem that has the capacity for self-iteration, self-optimization, and self-developing, and both are profound driving forces toward a more productive, more inclusive, and more sustainable society. The connections between Fintech 4.0 and Industry 5.0 reflect the broader trend toward the integration of digital technologies into all aspects of the global economy. As these trends continue to evolve, we can expect to see even closer connections between fintech and industry, as well as new opportunities for innovation and growth across a wide range of sectors.

What Is in Store for the Future?

Fintech 4.0 is the latest stage in the evolution of financial technology, characterized by the integration of advanced technologies such as artificial intelligence, blockchain, and the Internet of Things (IoT). The outlook of the financial system with Fintech 4.0 is highly promising, as it is expected to bring about significant improvements in various aspects of the financial system.

One of the key benefits of Fintech 4.0 is the increased efficiency it brings to financial transactions. The use of advanced technologies such as blockchain and smart contracts enables faster, more secure, and more transparent transactions, reducing the need for intermediaries and associated costs. This can lead to greater financial inclusion, especially for underserved populations who previously lacked access to financial services.

Fintech 4.0 also has the potential to improve risk management in the financial system. The use of advanced analytics and machine learning can help financial institutions better assess and manage risk, thereby reducing the likelihood of financial crises. This, in turn, can promote greater stability and confidence in the financial system.

Another area where Fintech 4.0 can have a significant impact is in the field of financial regulation. The use of advanced technologies can make it easier for regulators to monitor financial institutions and enforce compliance with regulations. This can help prevent fraudulent activities and ensure the integrity of the financial system.

So, we have seen the past and we are living in the present, what is in Fintech for the future?

While predicting the future is always difficult, we can, however, expect to see significant changes and advancements due to the fast development of these technologies. In the near term, we can expect the financial system to continue to evolve rapidly. Some potential developments that could shape the financial system in the next half-decade include:

The rise of decentralized finance (DeFi), enabled by blockchain technology and smart contracts, could transform the way we access and use financial services.

The increased adoption of digital currencies, such as Bitcoin and other cryptocurrencies, and the development of central bank digital currencies (CBDCs), which could transform the way we make payments and conduct financial transactions.

Greater use of artificial intelligence and machine learning in decision-making processes, such as credit risk assessment, fraud detection, and investment management.

More advanced and personalized financial advice and wealth management services, as well as increased use of robot advisors and other automated investment tools.

Greater collaboration and partnerships between traditional financial institutions and fintech firms, leading to new and innovative products and services.

Looking further ahead, we can expect the financial system to continue to evolve at an even faster pace, driven by the continued development and adoption of advanced technologies. Some potential developments that could shape the financial system in the next decade include:

The widespread adoption of blockchain technology to increase transparency and security in financial transactions, as well as to enable decentralized finance and digital asset trading.

The rise of quantum computing, which could enable faster and more advanced financial modeling and risk management.

Greater integration of financial services into everyday life through the use of mobile and wearable devices, enabling instant access to financial products and services.

Increased collaboration between traditional financial institutions, fintech firms, and big tech companies, leading to new and innovative products and services.

The emergence of new business models and players in the financial industry, enabled by advanced technologies, such as peer-to-peer lending and crowdfunding platforms.

Overall, the financial system in the coming years is expected to be more efficient, accessible, innovative, and sustainable, with new technologies and business models transforming the way we interact with money and financial institutions. However, these developments will also bring challenges related to privacy, security, and regulation, which will need to be addressed to ensure a safe and stable financial system that can provide adequate support to our society.

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Financial Technologies and DeFi, 2022, Turi et al., pp. 43.

Technological Breakthroughs in Financial Services: Payment Services, BNPL, and CBDCs

Pooja Lekhi, Kabiru Sunday Ayinde, and Mahdi Toobaee

Abstract This chapter explores some technological breakthroughs in financial services since the 2008 credit crunch. Intriguingly, no aspect of the financial services value chain, i.e., payment, loans and advances, and deposits, is spared in this technological revolution. Payment services have witnessed most of these innovations. Attributable to the increasing consumer demand for faster payment services, which attracted the attention of other service providers. This renewed interest in payment services has resulted in highly competitive financial services with an attendant impact on the banks' margins. Some innovations in the payment service industry discussed are Mobile payment, Mobile Wallets, Online Payment, Debit/Credit Cards, and Cross-border payment. Also, the chapter briefly examines Buy-now-pay-later (BNPL) services offered by retail giants and the Central Bank Digital Currency (CBDC), a low-cost payment digital currency backed by Central banks. The chapter further explores how financial institutions develop strategic alliances around payments, loans and advances, and deposit services with other service providers.

Introduction

The technological revolution is evidenced in almost all aspects of our socio-economic lives. This feat is attributed to the increasing computing powers as small chips with higher processing powers flood the marketplace. The financial services industry is one of the early prime movers that tapped into the potential inherent in this technological growth. The fallout is the rise in novel financial services that the

P. Lekhi (✉)
University Canada West, Vancouver, BC, Canada
e-mail: pooja.lekhi@ucanwest.ca

K. S. Ayinde · M. Toobaee
Department of Quantitative Studies, University Canada West, Vancouver, BC, Canada
e-mail: sunday.ayinde@myucwest.ca; mahdi.toobaee@ucanwest.ca

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world has never witnessed. Among the trio of conventional financial services, i.e., payment (deposit/withdrawal/transfer), loans, and investment, the payment services have witnessed more innovations than the remaining two, adduced mainly to the rising consumer demand, dynamic business operating model, technological trends, increased competition, and favorable regulatory environment. Trendy payment services such as Mobile payment, Mobile wallets, Online payment, Card payment, and Cross-border payment are explored. The chapter then investigates Central banks' digital currency (CBDCs) before concluding with remarkable alliances between financial and non-financial institutions.

Payment Services Outlook by 2030

Before discussing these payment service innovations, it is essential to have a glimpse at the payment service outlook. Global payment services have continued to grow impressively even after the COVID-19 pandemic. For instance, in 2022, credit card payments accounted for the highest global market value at $ 510 billion, followed by Mobile Wallets at $ 240 billion. BNPL, Digital Payment, and Mobile Payment only recorded less than $ 100 billion in global market value (Fig. 1).

Before 2030, the compound annual growth rate (CAGR) of these payment technologies is expected to rise in favor of Mobile payment and Buy-Now-Pay-Later by more than 20%, followed by Digital payment and Mobile wallets at greater than 10%. The credit card payments market value is expected to hover at less than 10% CAGR (Fig. 2). This indicates the changing landscape of consumer preference in response to technological trends.

By 2030, Mobile wallets are expected to reach the highest market value of $970 Billion, followed by Credit Card payments at $884.4 and Mobile Payment at $607

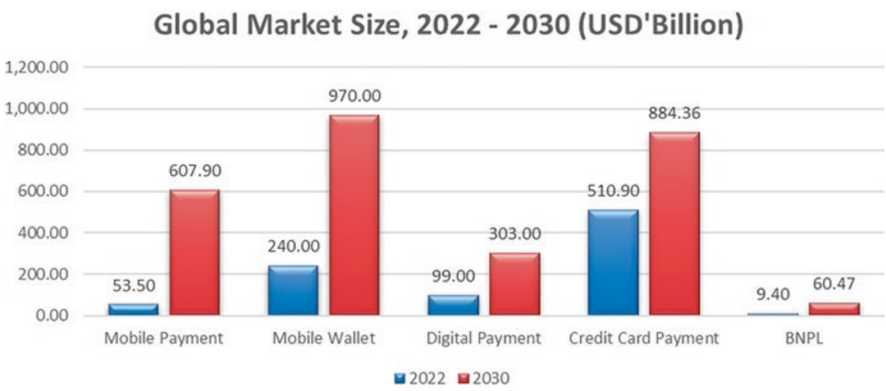

Fig. 1 Global market value of different payment services. *Note:* Projected Global Market Value of various Payment systems between 2022 and 2030. Source: Data for Mobile Wallet is from Global Market Insights (2022), Data for Digital Payment is from Data Bridge Market Research (n.d.), Data for Mobile Payment is from Globe News Wire (2023), Data for Credit Card payment is from Vantage Market Research (n.d.), Data for Buy-Now-Pay-Later (BNPL) is from Grand View Research (n.d.)

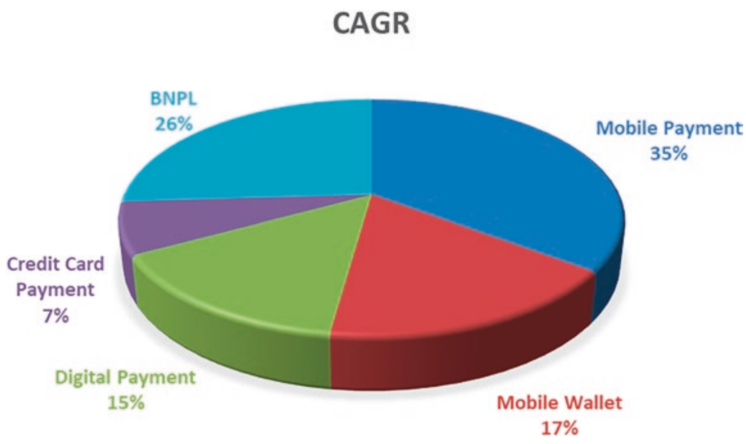

Fig. 2 Compound annual growth rate of global payment services. *Note:* Compound Annual Growth Rate of Global Payment Services from 2022 to 2030. Source: Data for Mobile Wallet is from Global Market Insights (2022), Data for Digital Payment is from Data Bridge Market Research (n.d.), Data for Mobile Payment is from Globe News Wire (2023), Data for Credit Card payment is from Vantage Market Research (n.d.), Data for Buy-Now-Pay-Later is from Grand View Research (n.d.)

Billion. Digital payment is valued at $303 Billion, while BNPL is expected to reach a $ 9.4 billion market value. Overall, Payment services will continue to evolve and adapt to changing demography and consumer preferences as banks and non-bank entities adopt a novel approach to meet these needs.

Payment Services

Mobile payment involves transacting and making payments for goods or services using a smartphone, tablet, or any mobile device. Mobile payments can be made through different methods, including Short Message Service (SMS), Mobile Apps, Mobile Web Payment, and Contactless mobile (Near-Field Communication) payment, all of which have made payment seamless and further drive financial inclusion. The first mobile payment came out in 2014 when PayPal and Apple Pay introduced mobile payments by incorporating a barcode that could be scanned using a store's barcode reader.

Custom Market Insights (2022) report that the Global Mobile Payments market size was USD 1.97 trillion as of 2021, and it is expected to hover around USD 11.83 trillion by 2030. The key drivers of this growth are transitioning in most developing countries to a cashless economy and broad Internet connectivity, enabling people to use their smartphones and mobile phones to make payments conveniently. The top three end users in this market are the Banks and Financial Institutions, the media and entertainment industry, and the Retail and E-commerce sector. The top ten major players in this sector in alphabetical order are Amazon.com Inc., American

Express Company, Apple Inc., Ali Baba Group, Google LLC, MoneyGram International, PayPal Inc., Samsung Group, Visa Inc., and Wet Chat.

Mobile Wallets—It is a digital container (e-wallet) that stores payment information such as credit card numbers, debit cards, prepaid cards, gift cards, and or loyalty cards securely on mobile devices. Like Mobile payment, Mobile Wallet can make contactless payments, QR codes, mobile payments, online shopping, and in-app mobile transactions. The global mobile wallet is dominated by the Asia-Pacific region, led by China and India, due to the growing population, increasing broadband penetration, and rising adoption of smartphones, while the Middle East and Africa continue to experience the fastest growth due to their youthful populations (Yahoo Finance, 2022).

Online payment—Allows consumers to make payments and conduct transactions such as paying bills, account-to-account transfers, and online purchases. Online payment sits at the center of payment system innovation as it allows various payment methods, such as credit/debit cards, digital wallets, and in-apps mobile payment, to be used for payment purposes. The use of online payment mediums, though, initially suffered drawbacks due to the perceived and actual risk encountered when conducting financial information over the Internet. During the COVID pandemic, however, increasing adoption and penetration are observed as more and more consumers, businesses, and public entities opted to use Online mediums to receive/pay for goods and services as it became the "safest" means of transacting during this health crisis.

Card Payment System—The issuance, activation, and management of debit, credit, and prepaid cards fall under the general term Card payment system. It is a system built around customers and key partners such as the merchant, the card network provider, and issuers. Whenever a customer visits a merchant location and decides to use credit/debit cards, the merchant captures the card information using a terminal or a card reader. The card reader captures the card number, card verification value (CVV), personal identification number (PIN), and sometimes card expiry date. In China, Union Pay accounted for over 90% of the country's card payment services, while Visa Inc. is the dominant market player in the United States. The remaining three major players in the United States are Mastercard (24%), American Express (20%), and Discover (4%), all of which accounted for significant global market share (The Business Research Company, 2018).

Cross-border payment—Regional and transnational trade is a common feature of the world trade system. Cross-border payments are some sort embedded in this economic activity. It is a complex process that involves the transfer of funds between buyers and sellers in different jurisdictions and across the globe. Two or more intermediaries, such as financial institutions, clearing houses, and payment processors, are involved. It arises in any form, such as when an importer purchases goods or services from overseas exporters; when someone invests in foreign stocks and fixed-income instruments; when an individual sends personal support and upkeep to friends and family; and even pay for services such as medical bills, overseas professional training, and school tuition. The use of the SWIFT system that allowed wired transfer through financial institutions has been around for over a century. However, innovation in financial services has led to the coming onboard of additional mediums, such as credit/debit cards, mobile wallets, and other online payment systems. Some initiatives to facilitate cross-border payments are cross-border payment regulations, international payment networks and standards, and digital-ready multilateral platforms aimed at supporting global trade and commerce in secured, transparent, and cost-effective ways.

Buy-Now-Pay-Later (BNPL)

As the name suggests, it is an alternate payment system that gives customers opportunities to purchase goods or services and make payments later within an agreed period. BNPL enables consumers to save their cash while at the same time having the advantage of buying an item of their choice with "free money" because payment is made in installments at a zero percent interest rate. Though very similar to the credit card system, where a customer uses the bank's money to purchase goods and services, the main difference is that BNPL does not require minimum repayment unlike the credit card repayment where a customer can opt to pay the required monthly minimum card repayment as an installment. By default, most retailers allow repayments to be structured for a fixed term either monthly or quarterly. In addition, consumers cannot enjoy bonuses and rewards that come with using credit card payment services. BNPL payment method has evolved in recent years, in response to the Gen-Z consumers who sometimes prefer it to credit cards. It is a convenient scheme for any consumer wanting to purchase large items but needing more cash to cover them. Some BNPLs by design, do require credit checks, but some do not. The scheme is largely offered by retailers in-store or online, and customers can apply for it at any merchant touch point, i.e., point of sale. This innovative payment method has received criticism as some believe it encourages overspending. However, others believe it helps manage a personal financial budget and cash flow.

Central Bank Digital Currency

Central Bank Digital Currency (CBDC) is a digital form of a nation's fiat currency issued and supported by its central bank. It is also a means of payment to store value, Turi and Thilakarathnei (2023); Turi (2020a). Its conception and implementation by central banks are in response to the use and distribution of non-centralized and unregulated Cryptocurrencies such as Bitcoin, Ethereum, Tether, etc. It is a complementary digital form of the existing traditional currencies that are secured and efficient as a medium of exchange. Both CBDCs and Cryptocurrencies operate on the same blockchain technology. However, the major dissimilarity is that CBDCs are backed by the central bank and have the legal status as the existing physical cash. Other technologies that support CBDCs issuance are the ideal centralized database and distributed ledger technology (DLT), Turi (2020b). It is designed to retain unique features such as interoperability, anonymity, and programmability with other payment systems earlier discussed. More and more countries are launching their own CBDCs in a bid to drive financial inclusion, reduce the cost of printing physical cash, and ensure efficiency and effectiveness in currency management.

According to the Bank of International Settlement (2021), the two common variants of CBDCs are Wholesale and Retail CBDCs. The Wholesale CBDCs help settle interbank transfers, cross-border payments, and other allied whole transactions between financial institutions. In contrast, the Retail CBDCs are issued to the public to fast-track open settlement between consumers and merchants. The first major economy to launch CBDC is the China Reserve Bank. There are already over 80 jurisdictions across the globe that are either at early or advanced stages of implementation as of December 2021. The implementation of CBDCs, however, in most jurisdictions is faced with a few risk factors, such as privacy concerns, safety concerns, and cybersecurity threats.

Some Strategic Alliances in Recent Years

The innovation in the financial services sector led to increased collaboration between financial institutions and other third parties. Some benefits of this alliance are expanded product offerings, reduced costs, greater access to new markets, and improved customer experience. While these positive sides have been applauded by many Industry pundits, the financial institutions have also lost market dominance and suffered reputation damages resulting in increased costs of doing business. Intense competition in hitherto unchallenged territory is equally eroding margins. Here are some examples of major strategic alliances between financial institutions and other players in recent years in relation to payment, loans and advances, and deposit services.

1. Amazon vs. JP Morgan: Linking Amazon Accounts to JP Morgan's online banking platform in 2020 enables Amazon customers to easily access banking services, including savings, deposits, and loans (Liu, 2018).
2. Apple vs. Goldman Sachs: Launching of a joint credit card in 2019 that provides a credit card to Apple customers based on cashback provided by Goldman Sachs (Sheetz, 2019).
3. Uber vs BBVA: Alliance established in 2016 which allows Uber drivers to open BBVA Compass checking accounts using Uber Apps. The account comes with cool features such as cashback rewards and discounts on car maintenance (Finextra, 2019).
4. Zelle vs. Wells Fargo: This alliance helps Wells Fargo customers to send and receive money using email addresses and mobile phones (Hillary, 2017).
5. Google Pay and Citibank: This alliance allows Citibank customers to make payments contactless and access banking services through Google Pay (Cherlynn, 2020).

Conclusion and Recommendations

Finally, financial institutions are making giant strides in harnessing and adapting to the technological revolution within the confined permissible regulatory environment. This regulatory environment has encouraged third-party providers such as technology companies, app developers, e-commerce businesses, and retail giants to contribute meaningfully to financial service innovations Added to this positive development, regulators are stepping up their games in the role they play on how consumers access financial services by employing accommodative policies and programs and joining the market participants to roll out financial services either explicitly or implicitly requested by the consumers. This development accelerates the pace of marked-to-market financial services innovations with products across payments, loans and advances, and deposits designed to improve customer offerings and experience.

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Technology Megatrends for Sustainable Business

Badr-un-nisa Chand and Kiran Thakur

Abstract In this work, we cover technological megatrends for sustainable business with a focus on the notion of sustainability and trending technologies for energy efficiency, waste management, supply chain management and operations, sustainable manufacturing, and predictive maintenance. Topics of coverage under this chapter include product-based, customer-based Vs. scenario-based Fintech 4.0, Fintech evolution from gen 1.0 to 4.0, Financial Technologies as a tool, service, or a system, the impact of Fintech 4.0 on key functions of the financial system, and operations. The chapter further navigates through the benefits and challenges and further explores the human factor in Fintech 4.0 through the lens of Industry 5.0. While the advancement on the sustainability front is promising, sustainable digitalization of practice can be impacted by various factors, including but not limited to lack of awareness, limited resources, financial constraints, and outdated infrastructure and replacement costs. Steady, sustainable digitalization requires support not just from local governments but the involvement of international bodies advocating for climate change.

Introduction

Sustainability is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainability is a holistic approach that entails making an informed decision to balance economic, social, and environmental factors. According to Elkington (1999), sustainability is "a business approach that creates long-term value by embracing opportunities and managing risks deriving from economic, environmental, and social developments."

Badr-un-nisa Chand (✉) · K. Thakur
University Canada West, Vancouver, BC, Canada
e-mail: nisa.chand@ucanwest.ca; kiran.thakur@ucanwest.ca

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In the era of disruptive innovations, organizations need to be proactive and adaptive to the innovations to stay in the global competition; companies such as Apple, Coca-Cola, and Proctor & Gamble have continuously changed their business strategies to stay ahead in the market. According to a recent survey by Gartner, 83% of corporate executives view investment in sustainability as having created both short- and long-term benefits for their business. A sustainable organization adopts practices keeping the environment, society, and the global economy in consideration and successfully handle the constant changes in technology, customer expectations, and the global business environment (Jarvis & Palmes, 2018).

Since the beginning of Industry 3.0, organizations jumped on the bandwagon of digitalization and innovation to improve their business practices (Bijker et al., 1987). However, not all the technological innovations were sustainable, in fact, many caused serious harm to the environment. Businesses engaged in large-scale production, leading to huge wastes, high levels of carbon consumption to keep the manufacturing/production plants up and running, and over-reliance on paper-based office administration practices. These practices endangered the ecosystem and future generations.

Consequently, the term "sustainable business practices" was coined to emphasize a much-needed shift in business practices to adopt greener technologies while parting ways from digitalization that was not environmentally friendly. The emergence of technology mega trends (such as renewable energy, circular economy, energy efficiency, waste management, transparency in the supply chain, remote work, sustainable manufacturing, and predictive maintenance) accelerated the drive for sustainable growth of businesses and the economy.

Examples of sustainable practices could be using renewable energy resources instead of fossil fuels and adopting a circular economy, reducing environmental impact by reducing waste and keeping resources in use for longer durations (Berg et al., 2018). Another example is sustainable agriculture practices, which adopt organic farming, crop rotation, and integrated pest management to minimize negative environmental impact (Yunlong & Smit, 1994). Further, Sustainable transportation involves minimizing the harmful impact of vehicles on the environment by adopting a more sustainable mode of commuting, such as using public transit, cycling, and walking (Brunn, 2019). Furthermore, sustainable building designs include reducing carbon emissions, installing energy-efficient equipment, and improving indoor air quality (Wang & Adeli, 2014). To secure a more livable future for us, future generations, and the planet Earth, we must design and adopt more sustainable practices in our everyday lives and businesses.

A Shift from Digital Transformation to Sustainable Digitalization

Although the digital transformation of businesses is a long-standing practice, sustainable digitalization is a relatively new concept (Cofino, 2013). Sustainable digitalization refers to the adoption of green technologies that are long-lasting, organic, and environmentally friendly. Previously businesses viewed all technological innovations as the same while ignoring their long-term impacts on the planet and the people (Font et al., 2008). For instance, the invention of supersonic flights was once considered a major technological breakthrough as it presumably reduced flying time by half. One notable partnership of supersonic crafts was between the British and French "Concorde Project" between 1976 and 2003 (Campagna, 2011; Gillman, 1977). Together, they created aircraft capable of traveling long distances in the shortest possible time. Although they were banned from flying over the land as they caused extreme air pollution (greenhouse gas emission, sonic booms, shock waves, and noise), they still had clearance to fly over oceans.

While it was public knowledge that the supersonic flights were harmful to the environment and there was never a convincing business case for supersonic airlines, yet the "Concorde Project" continued for 27 years mainly because of the huge investment from the British and French partners (Campagna, 2011). From the case, one can assume that previously, companies deliberately ignored or greenwashed their digital transformation projects to protect their personal gains. The manufacturer's "profit over everything else" mentality was supported in part by the lenient penalties, or lack thereof, in case of non-compliance with sustainability measures.

With time, companies realized their customers were becoming increasingly aware of the concepts such as sustainability, and environmental damage. As a result, manufacturers also shifted their focus to sustainable digital technologies in order to gain customer acceptance, especially from the younger audience, for soft image building (Cote, 2020; Peters, 2019).

According to Software AG's white paper published in 2023, "How sustainability is (or should be) shaping IT decisions in 2023," "If you're doing business in 2023, you can't escape the topic of sustainability. The pressure is on for businesses to act more responsibly." The foundation of sustainable digital transformation is based on the triple pundit principle—people, planet, and profit.

In recent times, the drive for digital transformation has increased manyfold, and companies are adopting the digitalization of business processes to achieve competitive advantage (Bijker et al., 1987); manufacturers are now rethinking their technological choices and their impacts on the environment, society, and workforce (Font et al., 2008). To this end, megatrends in Industry 4.0 and Industry 5.0 have been personalized customer care and experience via constant connectivity (mobile, internet, AI-based agents, chatbots, etc.), intensive automation of manufacturing processes, and care for the ecosystem. Although these megatrends offer great value propositions, unifying them in a seamless way remains a challenge. Nonetheless, a visible change, as can be seen from the graph below, has been companies'

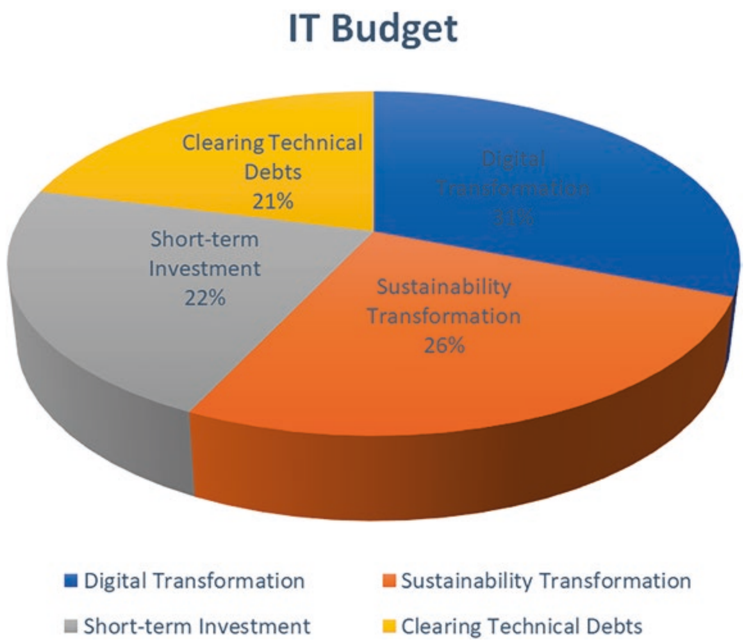

Fig. 1 IT budget allocation by the organizations. *Source:* Author's Creation based on Software AG. 2023 [white paper]. https://www.softwareag.com/content/dam/softwareag/global/resource-library/software-ag/white-paper/sustainability-research-situation-report/01-situation-report-average-it-budget-split.svg

investment in both digitalization and sustainability initiatives (Software AG, 2023). The manufacturers have attempted to combine sustainability and technology concepts to achieve many advantages. We will now describe some of the key drivers of sustainable technologies.

Figure 1 clearly indicates a shift in organizational preferences from profit to sustainable investments. On average, organizations are allocating 31% of their budget to digital transformation and 26% to sustainable transformation initiatives. We will now discuss the factors primarily responsible for favorably reshaping organization and management attitudes toward sustainable digital investments (Software AG, 2023).

Reducing the Environmental Footprint

Companies are now realizing that their past manufacturing activities have played havoc with the ecosystem. The manufacturers are now concerned with the impacts of pollution, greenhouse gas effects, and the depletion of natural resources on the planet. Sustainable technologies are being viewed as a viable solution to combat and reverse environmental damage (Marques & Fuinhas, 2011).

Since 2012, IKEA has been investing in renewable energy sources such as solar panels, windmills, and turbine technology (IKEA, 2023). The company aims to operate 100% on renewable energy by 2020. Moving to renewable sources reduces the carbon footprint as well as traditional energy consumption costs. The company is also investing in sustainable methods including the circular economy model that helps create lasting products that can be repaired and recycled for reuse. IKEA's environmentally friendly approaches have been widely recognized and positioned the company as a leader in the industry for sustainability (IKEA, 2023).

Innovation and Competitiveness

Sustainable technologies are not only environmentally friendly but also great for innovation and competitiveness (Cote, 2020). Adopting newer and more efficient technologies can help companies be more competitive while maintaining their growth targets.

Amazon's fulfillment centers are revamping warehouse operations using automation in collaboration with human labor (Mims, 2022). Amazon uses moveable robotic shelves capable of stacking multiple products simultaneously and bringing them to the workers for packing and shipping by moving around the warehouses. This innovative technology helps Amazon cut the time required by a worker to stack and pick up the products manually, speeds up the product delivery process, and reduces inventory costs. In short, this strategy helps Amazon achieve its people, planet, and profit objectives (Mims, 2022).

Cost-Effective Approach

One of the key drivers behind a sustainable digital shift is the recognition that sustainable technologies are cost-effective. For instance, the adoption of personalized/customized manufacturing as opposed to mass production and storage of products stops the wastage of resources and raw materials and encourages the recycling of used materials and products. Similarly shifting to renewable energy platforms results in energy saving.

Companies such as Tesla, Google, and IKEA have heavily invested in alternative sources of energy. Where Tesla is aiming to achieve its target for renewable energy by 2030 (Tesla, 2021), Google and IKEA have already met their renewable energy goals in 2019 and 2020, respectively (Anon, 2020; IKEA 2023). Both companies claimed to generate more energy than what they consumed. Amazon has also invested in wind farms and solar plants to achieve net zero emission targets by 2040 (Douglas, 2019). Many clothing brands are now using sustainable sourcing and recycled raw materials to produce clothes (Sustainable Apparel Coalition, n.d.). These attempts are not only useful in reducing carbon emissions but also in achieving cost efficiencies.

Reputation and Branding

Modern-age customers are aware of environmental concerns and are making their buying choices wisely (Lakhan, 2016). They prefer to invest in items that can either be reused or are already recycled. They also prefer buying products from companies with good social and environmental images. Companies that are helping societies, have charitable associations, and contribute to good causes such as environment protection initiatives do not have to spend a lot of money in marketing themselves. Investing in sustainability is considered as investing in a company's brand and reputation and an effective way of differentiating a company from its competitors.

Many companies are leveraging their drive for sustainability to portray themselves as socially responsible enterprises. Starbucks's usage of LED lights, reusable and compostable cups, and commitment to recycling programs have had a positive impact on its customers (Garnick, 2018). Coca-Cola's strategy of starting plant-based packaging, making bottles from recycled ocean plastic, and water-saving approach at its bottling facility has helped improve its public image (Heyden, 2019). Levi Strauss & Co's unique idea of making jeans from recycled cotton and plastic bottles has helped the brand image overall (Better Cotton Initiative, 2015). The Body Shop's fair trade and packaging waste reduction techniques are proof of the company's commitment to promoting ethical and sustainable practices (Prance-Miles, 2019).

Regulatory Compliance

Federal and local governments, in many countries, have put in place regulatory measures for manufacturers to control the environmental damage of industrial activities (Joseph & Stavins, 2007). These measures outline standards to ensure the safe and ethical use of technologies and include fines and even production closure in case of non-compliance. In North America and Europe, the governments have introduced the environment handling fee or eco fee that passes the cost of using, recycling, and disposing of the electronics to producers and customers (Lakhan, 2016). Using these measures is helpful in many ways.

- It creates awareness in society about the impact of electronic/technological devices on the environment and ensures safe usage.
- It encourages thoughtful/long-term use of electronic items including technological products.
- It transfers the accountability for the entire product life cycle (including the end, when the product is no longer in use) to the manufacturers and the ultimate users (Huenteler et al., 2016).

Sustainable Technologies

Technology plays a vital role in the design and deployment of sustainability measures. Sustainable technologies are created and developed to have the least detrimental effect on the environment, society, and economy while supporting long-term viability. They are critical for accomplishing Sustainability goals and tackling global concerns such as continuous resource depletion, climate change, and biodiversity loss (Van Oers & Pereira Roders, 2014). Figure 2 illustrates the list of contemporary sustainable technologies such as renewable energy technologies, circular economy, supply chain transparency, energy-efficient buildings, sustainable transportation, sustainable agriculture, water management, remote work, predictive maintenance, blockchain, edge computing, and the Internet of Things. Let us understand these technologies in more detail.

Fig. 2 Types of sustainable technologies. *Source: Authors' creation*

Renewable Energy Technologies

Pursuing global sustainability goals requires greater emphasis on renewable energy sources. Utilizing green energy sources like solar, wind, hydropower, and geothermal energy can help lower greenhouse gas emissions and lessen the effects of climate change. A study by the Intergovernmental Panel on Climate Change (2014) stated that by 2050, between 70% and 85% of the world's power might come from renewable energy sources, resulting in a 35%–50% decrease in carbon dioxide emissions compared to 2010 levels. Reducing greenhouse gas emissions is crucial to alleviate the effects of changing climate, resulting in extreme weather conditions, rising sea levels, and higher global temperatures. Adopting renewable energy sources can help alleviate energy poverty and improve access to energy in poor and developing countries (UNDP, 2014). Energy is essential for economic growth and a higher standard of living. Utilizing renewable energy sources leads to enhanced energy security, a decreased reliance on imports of fossil fuels, and increased energy independence (IRENA, 2016). Dependence on imported fossil fuels may compromise energy security, as was the case during the oil crisis of the 1970s. To sum up, renewable energy is essential to achieving sustainability goals and creating an equitable future.

Circular Economy

In our existing ecosystem, we utilize resources from the Earth, manufacture things from them, and finally discard the by-products as garbage—the process is linear. In contrast, in a circular economy, we prevent waste from being created in the first place. The circular economy runs on the principle of reducing, reusing, and recycling. A circular economy encourages using renewable resources such as solar and wind energy, which have a more negligible environmental effect than fossil fuels. On the economic front, the circular economy can provide new business possibilities, such as creating new technology, goods, and services and cutting costs by optimizing resource usage. However, building a circular economy might be challenging. For example, the design of items and materials must be reassessed to guarantee that they can be readily dismantled and recycled. Furthermore, new business models and supply chains must be built to support a circular economy, which may need substantial investment and stakeholder cooperation.

Despite these challenges, numerous industries such as construction, electronics, automobiles, and textiles have already begun to embrace circular economy ideas. For example, in the construction business, circular economy ideals may be implemented by designing structures for disassembly, using recycled materials, and recycling building components at the end of their life. Similarly, companies like Philips take back the product when their life ends to refurbish them and eliminate waste. The automobile industry also considers using recycled materials such as plastics and metals in car manufacture (Bocken et al., 2014). BMW collects old car parts and recycles them. The fashion sector is adapting circular business models, where using rental and resale services extends the life of goods and minimizes waste. H&M collects old clothes from customers and recycles them to make new products. By adopting circular economy practices, businesses reduce their environmental impact, enhance resource efficiency, and generate new economic possibilities. As stated by Geissdoerfer et al. (2017), “Circular economy is not just about recycling or waste reduction, but about a systemic shift towards a sustainable economic system.”

Supply Chain Transparency

Transparency in the supply chain has grown in relevance recently as customers, and stakeholders demand greater responsibility from businesses. Transparency may assist in establishing trust and promoting sustainability by providing customers with the information they need to make educated purchasing decisions. Supply chain transparency is releasing and sharing information about the manufacture, transport, and distribution of goods and services within a supply chain. This information might contain details regarding the source of raw materials, the environmental and social effects of manufacturing processes, and the working conditions of individuals involved in manufacturing and transportation. According to one Harvard Business Review research, organizations prioritizing supply chain openness are more likely to succeed and have a better brand reputation. Organizations with transparent supply chains are better equipped to manage risk and respond to emergencies like natural disasters or human rights violations.

Despite the benefits of sustainable supply chain transparency, many businesses confront difficulties in efficiently adopting it. The complexity of global supply chains can make tracking sustainability performance and identifying sustainability risks and opportunities challenging (Sarkis, 2012). Sustainability data may be difficult to obtain, and there is a need for standardized metrics and reporting systems to enable effective benchmarking and comparison of sustainability performance. However, increasing collaboration among supply chain partners and integrating technology can improve transparency. Big companies such as Nike and Unilever releases annual sustainability report mentioning what efforts these firms are making to make the supply chain more transparent for all stakeholders and maintain fair labor standards (Unilever, 2022 & Nike, 2022).

Energy-Efficient Houses

The building sector is responsible for around 40% of worldwide energy consumption and about 30% of greenhouse gases release. To produce more sustainable houses, the construction industry is adopting measures such as innovative designs and installing equipment that consumes less energy. A United Nations Environment

Programme (2017) study estimated that sustainable construction practices can reduce carbon dioxide emissions by up to 1.5 billion tonnes by 2030. Energy-efficient housing is featured to increase the amount of natural daylight to decrease the dependency on other light sources. In addition, instead of traditional bulbs, CFL and LED bulbs are used that consume 75% less energy. Indoor air quality is improved, and buildings are thermally insulated to decrease the dependency on Air conditioners and heating systems (European Commission, 2016). These measures can significantly reduce the units of energy used and lower the cost associated with energy consumption. A report by the American Council for an Energy Efficient Economy claims that energy-efficient buildings yield a return on investment of up to 50% during their lifecycle (ACEEE, 2018).

Sustainable Transportation

Transportation significantly contributes to world air pollution. A study by the International Energy Agency (2021), revealed that the transport sector accounts for about 37% of worldwide energy-related CO_2 emissions. According to a UN Environment Programme (2017) study, sustainable transport systems such as electric automobiles, hybrid cars, bicycles, and public transit could reduce global greenhouse gas emissions by up to 1.7 gigatons per year by 2050. Furthermore, sustainable mobility saves money and promotes social fairness.

The biggest challenge for adopting sustainable transportation practices is the hefty expenditure to make infrastructure to support energy-efficient transportation systems. Due to their large initial expenses, these investments may be difficult to justify in the short term, despite their long-term benefits. Individual and organizational reluctance to change is another barrier to sustainable transportation. Many people are reticent to change their travel habits, and organizations may be cautious about investing in sustainable transportation projects due to the unknown return on investment. A few strategies can be adopted to make the transportation system more reliable and cost-effective, such as more reliance on public transit, building cycling and walking infrastructure, and switching to electric vehicles.

Sustainable Agriculture

Sustainable agriculture entails crop rotation, covering crops, conservation tillage, and agroforestry. Crop rotation includes planting several crops on the same ground over time. This strategy aids in soil fertility enhancement, insect and disease management, and erosion reduction. Crop rotation can boost yields by up to 25% (Cui et al., 2018). Under the Cover crops technique, plants are grown between main crops to protect and replenish the soil. Conservation tillage minimizes the quantity of tilling done on farmland to reduce fuel, labor, and equipment demand, making farming more efficient, and cost-effective. Agroforestry consists of growing trees, crops, and livestock on the same plot of land, which enhances soil health, more biodiversity, and less pesticide and fertilizer usage. According to Mbow et al. (2014), agroforestry can improve crop yields by up to 50%.

Water Management

UNICEF estimates that by 2025, 66% of the world's population will be water stressed (UNICEF, n.d.). Water management could be a long-term solution to this problem. The process of controlling the usage, storage, and distribution of water resources is referred to as water management. Water conservation, wastewater treatment and reuse, and infrastructure investment are all components of effective water management. Water conversation measures include minimizing wastage by altering the habits of using water and reducing water usage in irrigation. Drip irrigation can save up to 60% of water consumption compared to traditional flood irrigation (Molden et al., 2010). Recycling wastewater is another technique where wastewater is treated to remove toxins and pollutants to make it available for industrial processes and agriculture purposes. Water reuse can cover up to 20% of worldwide agricultural water demand (Qadir et al., 2010).

The most critical part of water management is investing in water infrastructure, including constructing and maintaining dams, reservoirs, pipelines, and treatment facilities. On the other hand, water infrastructure may be expensive, and many regions struggle to finance such improvements. Climate change is one of the most pressing issues in water management. Climate change is projected to induce more frequent and severe droughts, floods, changes in precipitation patterns, snowmelt timing, and groundwater recharge rates, all of which will affect water supply and quality. Water governance is an additional issue in water management. Water governance encompasses the rules, organizations, and processes that regulate the use and management of water resources. Many regions face inadequate governance systems, corruption, and a lack of transparency, leading to water allocation conflicts.

Remote Work

The COVID-19 epidemic has exacerbated the development of remote work in recent years. This change has provided flexibility, enhanced production, and sustainability benefits. According to Global Workplace Analytics (2022), if the US workforce worked from home just half of the time, it would reduce greenhouse gas emissions by the equivalent of removing nine million cars off the road. Remote work eliminates the need for actual office space, which can result in significant cost savings and environmental benefits. According to a Dell Technologies (2021), remote work can save an average of $12,000 in office space expenditures per person per year. This reduction in workplace space also reduces energy consumption, water consumption, and garbage generation. Besides these environmental benefits, remote work can enhance social sustainability by allowing employees to work from anywhere globally. It is crucial to highlight that remote work is not a panacea for long-term sustainability. Employees may use more energy for heating, cooling, and lighting when working from home, which might increase energy usage. Furthermore, remote work might lead to social isolation and poor mental health.

Predictive Maintenance

Predictive Maintenance is a proactive approach to equipment maintenance that employs data analysis and machine learning algorithms to forecast when a repair is required. This strategy can help reduce downtime, enhance productivity, and save money by predicting possible equipment faults before they occur. Neural networks, random forests, decision trees, and support vector machines are machine learning techniques that can be used for predictive maintenance. These algorithms can analyze data from sensors and other sources to find trends and abnormalities that indicate equipment faults. Manufacturers can use these algorithms to forecast when equipment maintenance is required, plan maintenance actions ahead of time, and avoid unplanned downtime. Examples of other predictive maintenance methods include deep learning techniques such as recurrent neural networks, convolutional neural networks, and autoencoders. These approaches have applications in various industries, including manufacturing, energy, and transportation.

Predictive maintenance is essential for increasing equipment reliability and lowering maintenance costs. However, maintaining data quality and integrating data from several sources are significant problems that must be solved to construct efficient predictive maintenance models.

Blockchain Technology

By enabling more efficient, transparent, and secure transactions, blockchain technology can significantly improve sustainability in various industries. Blockchain technology makes supply chains more efficient and transparent by recording and confirming the origin, movement, and quality of goods and resources. This can help organizations cut waste, assure regulatory compliance, and avoid fraud. For example, the food industry can utilize the blockchain to track the passage of items from farm to table, ensuring that they are sourced, transported, and sold sustainably. According to World Economic Forum (2019), blockchain has the potential to generate up to $1.5 trillion in environmental and social benefits by 2030.

Blockchain technology can potentially make energy systems more efficient and transparent. Companies may decrease waste, boost efficiency, and enable more sustainable energy sources by utilizing blockchain to track and verify energy production, distribution, and consumption. Research by the International Renewable Energy Agency (2019) mentioned that blockchain can reduce energy-related greenhouse gas emissions by up to 15% by 2030. Blockchain technology has the potential to enhance sustainability significantly by enabling more efficient, transparent, and secure transactions across a wide range of businesses. However, blockchain systems can be more challenging to develop and manage than traditional systems, resulting in higher costs and significant security problems. Furthermore, blockchain may require specialized hardware or software, limiting its interoperability with existing systems.

Edge Computing

In typical cloud computing models, data is processed and stored in centralized data centers, which consume much energy to run and maintain. On the other hand, edge computing systems process data locally, which can drastically minimize the energy required to transfer data across vast distances. According to an International Energy Agency (2021), edge computing can lower global data center energy consumption by up to 30%.

Edge computing systems can reduce the amount of data transmitted to centralized data centers, increasing network speed and decreasing the risk of data loss or corruption. Edge computing has many industrial applications, such as in transit systems; better traffic management can be accomplished with the help of real-time data. Decisions can be improved in agriculture using real-time information regarding soil, crop, and weather conditions.

The Internet of Things

Internet of Things (IoT) is a system of networked objects that can communicate with one another and the Internet, enabling new possibilities and applications across various sectors. IoT sensors can record and analyze energy consumption data and assist in efficiently utilizing resources (Caragliu et al., 2011). IoT applications in multiple industries can reduce costs and enhance efficiency. In transportation, IoT devices can be used in transit to regulate traffic flow, resulting in efficient traffic management, which reduces fuel consumption. In agriculture, IoT applications can monitor variables such as soil moisture, crop health, and environmental conditions, allowing informed decisions regarding irrigation and fertilizers (Manavalan & Jayakrishna, 2019). IoT can help monitor real-time inventory movement and product quality in the supply chain (Abdel-Basset et al., 2018). The challenge associated with IoT is the maintenance of a massive amount of data that needs significant energy consumption. And also, there is a concern for data security and privacy while handling huge amounts of data.

Investment in Sustainable Technologies—What Does the Future Hold?

In our previous discussion in the chapter, we highlighted the numerous benefits of sustainable technologies for all stakeholders. Although digital technologies hold great value propositions, the future of the sustainable economy depends on timely investment decisions in long-term technology initiatives mainly in the infrastructure, manufacturing, finance, healthcare, and education sectors to guarantee sustainable growth. Hence, it is crucial to understand companies' and governments' viewpoints in terms of further investments in sustainable digitalization. A strong public and private sector partnership model will be needed to accelerate the implementation of sustainable technologies (Ahmad & Raza, 2020). The governments can support the private sector by incentivizing digital technology initiatives such as providing tax rebates and subsidies. Whereas the private sector can mobilize its resources, technical skills, and expertise to create innovative solutions to address the challenges of sustainability (Chunling et al., 2021).

Sustainable technologies have already proved useful in improving the living standard of people by making their jobs easier and taking over riskier tasks thus mitigating job safety concerns. Moreover, digitalization has played a vital role in addressing climate change concerns, such as mitigating the impact of natural disasters, reducing greenhouse gas emissions, effective waste management, and introducing recycled and reusable products. These technologies have also helped companies achieve energy and resource efficiency and reduce carbon footprints. The benefits of these technologies have also been noticed in improved education and health care, among others.

However, there are many critical decisions to be made before allowing the large-scale deployment of sustainable digital technologies. Firstly, it requires ongoing commitment and steady investment from the stakeholders. To this end, governments and companies have to upgrade the existing infrastructure, which adds time and money constraints (Chunling et al., 2021). Secondly, the institutionalization of sustainable technologies also requires careful consideration of issues such as privacy, security, and safe use of personal data gathered and stored by them. There is always a risk of leaking, misuse, or hacking of highly sensitive personal data. Finally, although technological advancements are known to make people's jobs easier, they have also been associated with the displacement of humans in many jobs, thus creating job loss, particularly in the manufacturing and service sectors. The low-skill workers' group is especially at risk of losing jobs to automation and the digitalization of businesses. Any future investment requires a careful review (in-depth risk and benefit analysis) of the impact of digitalization on the future of the workforce and the economy. It is critical to ensure a responsible and ethical use of sustainable technologies to guarantee a lasting positive impact on both society and the environment. For instance, a more ethical practice will be to invest in the upgradation of employee skills so that they can work with more complex technologies without fear of losing their jobs.

Barriers to the Implementation of Sustainable Digital Technologies

Although digital technologies promise a sustainable future economy, it is important to understand where the sustainability initiatives stand in the manufacturers'/producers' list of priorities. As of now, there are many hindrances that can impact the deployment of digital technologies across industries (Garrate, 2022; Zelenika & Pearce, 2011). Figure 3 illustrates the most common barriers businesses confront during sustainable technology implementation, such as financial constraints, infrastructure issues, lack of knowledge and awareness, resistance to change, and lack of public-private partnerships.

Absence of public-private collaborative business model

Any future investment in sustainable technologies requires the coordination of the main stakeholders. The lack of a public–private collaborative framework to streamline the processes and simplify outdated complex regulatory compliance requirements is impacting the widespread adoption of technologies (Ahmad & Raza, 2020; Chunling et al., 2021). The absence of a framework to combine public and private resources, capitalize on their unique offerings, and build on joint expertise has further widened the gap between industry and sustainable technologies.

Financial constraints

Although sustainable technologies guarantee cost efficiencies in the long run, rolling out sustainable technologies requires significant upfront costs (Hau et al., 2018). Large organizations may be able to use digital technologies to their advantage as they are more resourceful, but small and medium enterprises might struggle to adopt these technologies due to financial and budgetary constraints and the limited availability of external financing options.

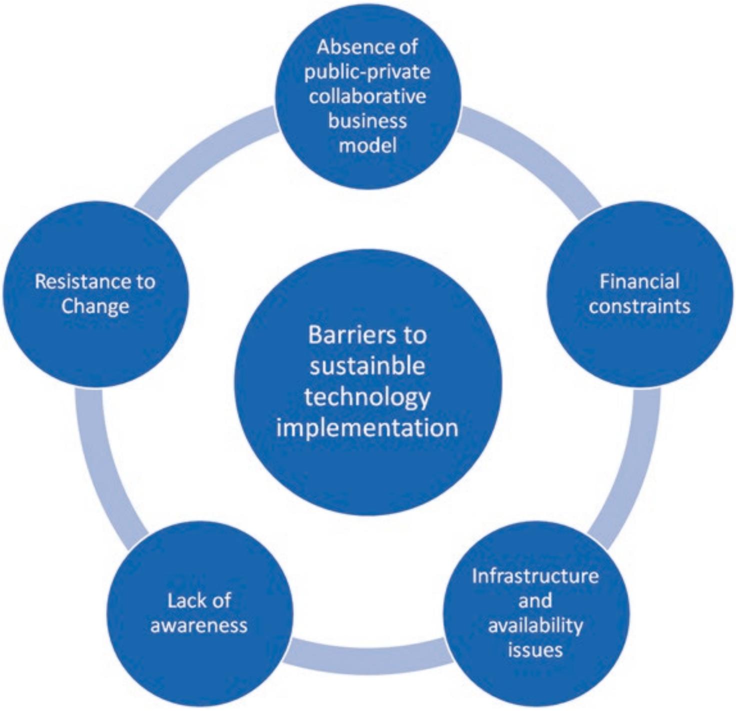

Fig. 3 Barriers to sustainable digitalization. *Source: Authors' development*

Infrastructure and availability issues

Noticeably, in some cases, technologies are fully developed but their use and applicability are impacted by a lack of supporting infrastructure or limited availability. For instance, the sale of electric vehicles will be impacted by the availability of electric charging stations in nearby locations even when people are willing to buy them (Singh et al., 2023). Similarly, although solar panels are widely adopted, and in demand, their usage is a problem in areas with adverse climates and limited sunshine.

Another issue is the incompatibility of sustainable technologies with the existing systems or processes of the company. The integration of sustainable technologies, in this case, will require upgrading or abandoning their previous systems; both options will require a substantial investment that companies may not be ready for.

Lack of Awareness

In the absence of proper education and awareness, companies and people can develop preconceived notions about the adoption of sustainable technologies (Cooney et al., 2022). Companies may view these technologies as added cost centers only if they are ignorant about the long-term benefits and environmental impacts of using these technologies. Companies also overemphasize the amount of work and effort required to upskill their existing workforce to engage with sustainable technologies, particularly if they believe they do not have the required competencies at their disposal. According to its sustainability reports, the retail giant Walmart started its drive for sustainable technologies by educating and convincing its main stakeholders (workforce, buyers, and suppliers) about the potential benefits of shifting to greener technologies (Mandel, 2021).

Resistance to Change

The phrase, "old habits die hard" explains the workforce's resistance to change. The workforce may be reluctant to exchange their tried and tested methods with new technologies, especially if they do not know how to work with them (Henry & Jie mein, 2009). On the other hand, people may comprehend technology as a source of their displacement from the workplace instead of looking at it as an integrative tool installed to support their routine tasks. Kodak resisted upgrading to digital photography despite its sustainable implications. Kodak viewed the change as a potential threat to its profitable film business (Henry & Jie mein, 2009).

In conclusion, dealing with these barriers is possible with adequate support in educating governments, companies, and people about the benefits of sustainable technologies and how these technologies can be the key drivers of sustainable growth and economic success. Creating training and development programs, mobilizing monetary support from governments and other financial institutions, introducing large-scale infrastructural reforms, and implementing robust regulatory and compliance frameworks will help economies achieve their sustainability targets.

Role of International Institutions in Promoting Sustainable Technologies

Sustainability is a concept that bypasses national and geographic boundaries. Institutions at an international level are taking steps to create awareness about the adverse impacts of traditional technologies on the ecosystem. To this end, we have seen the establishment of various international bodies that promote the use of sustainable technologies globally to mitigate climate challenges and reduce carbon footprint and greenhouse gas emissions (Andresen & Hey, 2005). However, we have observed unequal sustainable development around the world mainly due to resource availability, lack of infrastructure, and absence of a strong regulatory framework; the use of sustainable technologies is not uniformly accepted and adopted across the globe.

While countries in North America and Europe are leading the sustainable technology movement, the concept is in its infancy in other countries (Singh et al., 2023). Resultantly, the development of international bodies aims to create awareness of the long-term benefits of sustainable technologies for businesses and countries (Organisation for Economic Co-operation and Development, 2021). The role of international institutions in this context includes sharing knowledge, resources, financial and technical assistance, training, and development for capacity building, particularly for developing and under-developing economies to ensure a sustainable future for all (Andresen & Hey, 2005). We will now discuss some of the noticeable international sustainability initiatives.

United Nations is supporting the sustainability drive globally with multiple programs designed for developed and developing economies. United Nations Environment Programme (2017) advocates for a shift to renewable, energy-efficient technologies. United Nations Framework Convention on Climate Change (UNFCCC) initiative fosters collaboration between multiple stakeholders, i.e., the public and private sectors and members of society, on issues of the climate crisis, and sustainable technologies. Green Climate Fund (GCF) is another UN-supported program created under the UNFCCC. GCF provides financial support to developing economies to adopt carbon and energy-efficient technologies, particularly to the countries adversely impacted by climate change and natural disasters. It also supports the drive for using sustainable transportation and clean energy sources. United Nations Development Programme (UNDP), World Bank, and the Global Environment Facility (GEF) are also heavily investing in research and development programs to introduce affordable renewable technologies, waste management, and sustainable agriculture practices.

World Bank supports the implementation of sustainable digitalization in developing countries. World Bank has set up a Climate Technology Fund to fight and reverse the recent climate changes by controlling greenhouse gas emissions. International Energy Agency (2020) works to facilitate the provision of clean energy to its partnering countries with a focus on carbon capture, utilization, and storage (CCUS) (IEA, 2020).

International Renewable Energy Agency (IRENA) promotes the global availability and usage of renewable technologies. IRENA offers technical support and expertise in creating a compliance policy framework to encourage member countries to invest in renewable technologies (International Renewable Energy Agency, 2016). International Standards Organization (ISO) and the United Nations Industrial Development Organization (UNIDO) jointly set out policies, standards, and compliance frameworks for the creators of sustainable technologies (International Standards Organization, 2021; Jarvis & Palmes, 2018). These steps help regulate the safe, ethical, and effective use of sustainable technologies.

Recommendations

Sustainability is not a one-time effort or a sequential procedure; it is a never-ending path companies pursue, envisioning a better future. Businesses must regularly analyze and reassess their systems and practices for constant development. Organizations can follow the below-listed recommendations to kick-start their sustainability journey.

Conduct a Sustainability Audit

It is crucial to find out the organization's current standing toward sustainability efforts in all the areas of its operation to find out the gaps, pain points, and overlooked places. The more comprehensive the initial audit is, the better clarity it will provide to devise a further action plan for the organization. The audit will help organizations identify areas to reduce environmental footprints.

Integrate Sustainability into the Business Strategy

Nowadays, businesses are looking for ways to reduce their carbon footprints and reduce negative environmental impacts. Organizations must understand that it is not the trend that every company has to follow; instead, it is our responsibility toward the upcoming generation. Even a small firm can take steps toward sustainability by realigning its goals and reinventing processes. Integrating sustainability with business strategy ensures that organizations contribute toward a sustainable future besides earning profits. To devise a plan, companies must assess their current performances in environmental, social, and governance areas to identify the domains that need the most attention and have most of the stakeholders involved. This prioritization is essential to avoid getting trapped in too many initiatives with little or no impact.

Set Ambitious but Achievable Sustainability Goals

Having established the thresholds at which an organization can pursue sustainable options, it is time to develop and prioritize goals. Setting sustainability goals will define the organization's aspirations and guide the efforts toward sustainability. Ensure to make Specific, Measurable, Achievable, realistic, and time-bound (SMART) goals. Stakeholders' involvement in designing and setting will also increase accountability. Establish long- and short-term goals to provide a clear vision and guide strategic decision-making.

Communicate and Create a Sustainability Culture

Organizations should regularly communicate their sustainability efforts with all the stakeholders, such as employees, customers, suppliers, and clients. Fortune 500 companies such as Walmart, Microsoft, Coca-Cola, General Motors, IBM, and Proctor and Gamble produce and share their Annual Sustainability Reports. This report discloses their sustainability initiatives to reduce the negative impact on the environment, governance practices, and corporate social responsibility measures adopted by them. According to a study, 70% of employees report that robust sustainability efforts of a company influence their decision to stay longer in the organization.

Invest in Renewable Energy Resources

Organizations must take initiatives to minimize conventional energy sources and invest in renewable energy. Companies can adopt renewable energy sources, such as Installing Solar Photovoltaic (PV) Systems that convert sunlight into electricity. Walmart has been actively installing solar PV systems on the rooftops of its stores. Walmart's solar PV systems have reduced the company's dependency on fossil fuels and its emissions of greenhouse gases. The world's largest retailer has stated that it wants to end all emissions from its global operations by 2040.

Adopt Energy-Efficient Technologies

Organizations can invest in Energy Management Systems (EMS) to monitor, control, and optimize energy usage. EMS can identify energy-saving opportunities and maximize equipment performance using advanced analytics and automation. For example, Schneider Electric implemented an EMS in one of its buildings and achieved significant energy savings. According to a case study by Schneider Electric, the EMS reduced energy consumption by 20% through real-time monitoring and intelligent controls.

Integrate Sustainability into Business Operations

When priorities and goals are clearly stated, firms may begin planning to incorporate these objectives throughout the organization. Usually, it does not necessitate drastic action. Businesses can initially start with little adjustments when introducing new tools, concepts, and approaches to current business processes. Organizations can find more possibilities to change or enhance their current methods by keeping track of the outcomes of each intervention. Companies can create end-to-end transparency throughout supply chains, from sourcing to distribution. They can collaborate with suppliers to set standards, track and improve performance, and promote more sustainably developed environments. Businesses must reengineer their product designs to make their current items profitable. For instance, companies may redesign products using more environmentally friendly materials, cut back on packing, and create refillable or compact versions that consume less water and less packaging while reducing the product's overall weight and, consequently, transportation-related carbon emissions.

Partnerships and Collaborations

Climate change cannot be stopped by one organization alone. Leaders must cooperate in setting clear goals, specifying the metrics they will use to gauge success, and reporting on their progress if they are to achieve the necessary radical changes. To achieve their goals for sustainability, CEOs are more willing to acknowledge the value of partnerships and collaboration. Governments, policymakers, industry peers, NGOs, consumers, clients, and suppliers are just a few examples of the various societal sectors that these connections span. Partnering with other companies fosters creative thinking, reduces risk, and boosts productivity. For example, the Sustainable Garment Coalition (SAC) is an industry cooperation of prominent garment companies, retailers, manufacturers, and non-governmental organizations (NGOs) seeking to improve the environmental and social performance of the apparel and footwear industry. The SAC created the Higg Index, a toolkit that allows businesses to monitor and assess the sustainability performance of their goods and supply chains.

Evaluate Sustainability Efforts

Tracking environmental performance indicators assist in assessing the organization's impact on natural resources and ecosystems. Common indicators include energy consumption, water usage, greenhouse gas emissions, and waste generation. The World Business Council for Sustainable Development (WBCSD) guides environmental performance measurement. External verification or certifications by independent organizations add credibility and assurance to sustainability efforts. These assessments can evaluate the organization's compliance with established standards and provide an objective performance assessment. The Leadership in Energy and Environmental Design (LEED) certification for buildings is a well-known example of external verification. Sustainability evaluation is a continuous effort that requires integration with all the sustainability-led processes and initiatives of the business.

Conclusion

With the recent drive for sustainability governments, businesses, and people are aiming to conserve valuable resources for future generations. To protect the ecosystem, all the stakeholders (public sector, corporations, and people) have to collaborate and make informed decisions to balance economic, social, and environmental needs. This requires governments to incentivize and promote the implementation of sustainable technology, corporations to act more ethically and responsibly to reduce their carbon and greenhouse gas emissions and opt for renewable energy sources, and consumers to make informed and sustainable buying choices. When it comes to sustainable growth, all the stakeholders are in agreement that the adoption of sustainable technologies is the only way forward.

The implementation of multiple sustainable technologies ranging from renewable energy, circular economy, supply chain transparency, circular economy, sustainable transportation, sustainable agriculture, predictive maintenance, blockchain technology, and Internet of Things continue to reshape the future of the planet. Steady investment in these technologies will help reduce the carbon footprints by 35–50% and shift 75–80% of industrial activity to renewable energy by 2050. Adoption of sustainable technologies is not only an environmentally friendly approach but also helps organizations accelerate their growth, preserve resources, and achieve cost efficiencies.

Although there are many benefits of sustainable technologies their implementation is not a straightforward decision and is impacted by multiple factors including, upfront costs, lack or limited availability of external funding sources, particularly for medium-sized businesses, absence of public–private collaboration mechanism, lack of awareness, and resistance to change from both corporations and employees. Having said that, since sustainability is a global phenomenon better reforms are needed at international level to handle this social and environmental crisis.

In this regard, many international organizations have started initiatives to promote the use of sustainable technologies internationally. Organizations such as the United Nations, World Bank, International Energy Agency, International Renewable Energy Agency, and International Standards Organization in collaboration with their member countries are creating awareness about issues such as energy conservation and preserving resources by using renewable technologies and recycling approaches. These organizations are also supporting developing and under-developing countries financially and technically to adopt sustainable technologies. In conclusion, although we are far from achieving our sustainability targets the global response to sustainable technologies is promising and will only improve with the help of better reforms and support from the global stakeholders.

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Sustainable Development: Driving Green and Clean Tech Innovations

Belay Gaga

Abstract This study highlights the importance of sustainability, green tech, and clean tech to achieve the Sustainability Goals of the United Nations. Also, to realize the negative impacts of environmental factors, such as the COVID-19 pandemic, on the effort to eradicate poverty, enhance education, and conflicts in different parts of the world; climate-related impacts, such as global greenhouse gas emissions and economic inflation, are severe challenges on the road of achieving sustainable development and driving green tech and clean tech innovations. The chapter aims to show the progress on the selected key United Nations Sustainable Development Goals from 2015 until the end of 2022.

Introduction

Sustainability is a business approach that creates long-term value by considering how a given organization operates in the ecological, social, and economic environment. Green innovation refers to the innovative activities in which enterprises use advanced technology to achieve economic growth while considering environmental protection (Li et al., 2022). United Nations Sustainable Development Goals are the main pillars of sustainable development. Driving Green Tech and Clean Tech Innovation are linked to the following key UN Sustainable Goals: 7, Affordable and clean energy; 9, Industry, innovation, and infrastructure; 11, Sustainable cities and communication; 12, Responsible consumption and production and 13, Climate action, will be further discussed in detail. The Sustainable Development Goals are a global call to action to end poverty, protect the planet, and improve the lives and prospects of everyone everywhere. "The 17 Goals were adopted by all the UN

B. Gaga (✉)
University Canada West, Vancouver, BC, Canada
e-mail: belay.gaga@ucanwest.ca

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Member States in 2015, as part of the 2030 Agenda for Sustainable Development, which set out a 15-years plan to achieve the Goals" (UN, 2022).

With the advancement of science and technology, agricultural productivity increased immensely. On the other hand, industries worldwide produce millions of varieties of products. These are all good. The critical question is how we will sustain this agricultural and industrial productivity without affecting our environment, the well-being of the world population and the next generation. With the continuous increase in the world population, more lands, including forest areas, are being used for agricultural production. At the same time, agriculture uses an enormous amount of fertilizer and different plant protection chemicals such as insecticides, pesticides, and herbicides. These chemicals cause severe concerns for our environment. Additionally, the livestock sector is also responsible for releasing greenhouse gases.

The industry sector also produces products such as plastics and other not easily decomposed products. The industry sector is also the main contributor to air pollution. On the other hand, drought challenges in some areas and, at the same time, heavy rain and flooding in other regions are becoming common phenomena. So, all the challenges mentioned above could be addressed by adopting the sustainability concept and using green and clean technologies in the agriculture and industry sectors. This chapter will address the roles of sustainability and green and clean technology to ensure a healthy environment for the current and future generations.

Sustainability

The United Nations Brundtland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987).

The concept of sustainability is changing the way we interact with nature and its resources in a world in rapid flux. Despite our past misunderstandings of proper toxic waste disposal, which we have now realized has a long-lasting negative effect on the atmosphere, water, and other essential factors needed for human survival. So, in joining the ongoing move toward better resource management, let us define sustainability. According to scholars, our current definition of sustainability is "meeting the present needs without compromising the ability of future generations to do the same" (Cuyper, 2022). Although we have acknowledged the need for international sustainability-driven production, we have not witnessed many actions toward this data-driven philosophy. It could be because we have reduced the barrier to communication in different parts of the world. This has provided us with a production model we have not seen before, which has made us "interdependent" with each other. This development has dramatically improved our ability to move resources and goods from one country to another. However, it has also revealed the cost of relying solely on nature to replenish and dispose of our waste. This is in a way that does not incur many expenses somehow.

Sustainability is a concept that encompasses multiple facets, including the environment, our society (the system which governs our lives and the people who reside within that system), and of course, the economy. This idea of looking at the concept as a combination of various interdisciplinary studies comes to us from The International Institute for Environment Development, redefining our understanding of a straightforward one-sided impression that we may have had before opening it up by phrasing the meaning of the word in a much incorporative way as "the objective of integrating economic activity with environmental integrity, social concerns, and effective governance systems while maximizing the contribution to the well-being of the existing generation, fairly sharing the cost and benefits, without compromising the potential for the upcoming generations to meet their needs" (IIED, 2002).

Sustainability & Innovation Global Executive Study, which surveyed more than 2600 executives, project managers, and innovators, suggested that 'business model change, top management support, collaboration with customers, and having a business case are associated with creating economic value from sustainability activities and decisions' (Kiron et al., 2012). In addition to that, according to MIT Sloan Management Review, 90% of all those who responded say that their companies have embodied the above characteristics and report an addition to their company's profits because of sustainability-driven actions (Kerzner, 2019).

Studies show that worldwide the proportion of the population with access to electricity in 2000 was 78.2%, which increased to 90.5% in 2020. Installed renewable electricity-generating capacity (watts per capita) in 2000 was 64.5, and in 2020 reached 245.7. The worldwide proportion of the population using essential sanitation services in 2000 was 55.7% and increased to 78.3% in 2020. The proportion of the population covered by at least a 4G mobile network in 2014 was 32.8%, and 2020 reached 85.5%. The prevalence of undernourishment was 13% in 2000 and 9.9% in 2020.

There is a positive association between economic sustainability and market-perceived innovation. The authors indicated that companies improve their economic sustainability at the microeconomic level, encouraging them to increase their research and development investments in their growth opportunities (Di Simone et al., 2022). Sustainable development is an important focus area for many countries and is mainly realized through continuous innovation practices.

Agricultural sustainability is a significant challenge due to the rising human population. Moreover, climate change which includes an increase in temperature, water shortage, land degradation, and deforestation, is causing serious challenges for the agriculture sector and the well-being of life on Earth. "Climate change effects are felt significantly by rural smallholder farmers as they experience a reduction in yields, crop failure, loss of assets, and livelihood opportunities" (Cherotich et al., 2012). Overall, climate change poses a severe concern for agricultural sustainability. Imaro et al. (2021) indicated that producing healthy food in a sustainable way to meet the needs of a growing world population is one of the significant challenges of our time and climate change has exacerbated this. The same authors indicated the importance of Indigenous conservational agriculture practices for the effective use of land and water resources, such as intercropping, cover cropping, crop rotation and agroforestry, and the use of new technologies can help combat the effects of climate change.

Guleria et al. (2023) indicate that "Agricultural sustainability is a major challenge due to the rising human population, global climate change, and significant environmental degradation. Further, various biotic and abiotic stresses aggravate the challenges posed by global climate change. Achieving sustainability goals requires control over the use of harmful chemicals, the quantity and quality of water, the type of seed source, the surrounding abiotic parameters, and the biome. Bioengineering can help achieve agricultural sustainability by creating crops more tolerant to stress and changing environmental conditions. Biotechnological interventions can generate information beforehand to predict emerging agricultural challenges and generate sustainable crop types."

Sustainable Development Goals: "A clean and healthy environment is required to achieve the sustainable development goals. Efforts to counter the triple planetary crisis of climate change, nature and biodiversity loss, and pollution and waste must be ramped up to transform societies and economies for everyone, everywhere". UNEP.

Innovation

Finding a concrete definition for innovation is problematic as it can have different meanings when dealing with other subjects. It often needs clarification to be synonymous with creativity; regardless, let us take on the challenge and define innovation. Innovation is the process of implementing one's new ideas into a merchantable product or service that offers an improvement to customers. This can be a brand-new idea that came to life or an improvement on an already appreciated product or service. Realizing the pressing issues of our time has made us venture into unknown territories like smart cities "the future of humanity depends on cities as the framework in which we need to tackle the most critical challenges such as pollution, climate change, disease, and crime, but they also provide the possibility to create new ideas, innovation, and use of technology."

From the point of view of economics, innovation can be considered anything that contributes to increasing the value that exists in society. That is, to improve the welfare of those who live in it.

Enterprises that use high tech are innovative. Management encourages employees to be more creative and makes available the required resources for innovation (Gong et al., 2021). Many studies indicate leadership style is essential in organizational innovation. For high-tech enterprises, empowering team leadership is an effective way to stimulate employees' creative passion. (Jing et al., 2022). On the other hand, in high-tech enterprises, creating a climate encourages individual advantages and allows employees to become more innovative.

Wan et al. (2022) indicate that "to achieve changes in economic growth, the transformation and upgrading of industries is the critical path, which means that the point of change lies in the innovation and upgrading of enterprises. Due to the supply-side structural reform, manufacturing enterprises will have to face resource and environmental constraints and structural contradictions on the supply side; therefore, the green enterprise innovation performance is the core initiative for enterprises to build competitive advantages." With the increasing environmental challenges for species' survival, green innovation is critical for enterprises' green innovation strategy in compasses product, process, and service innovation. In this regard, firms using green innovation are expected to avoid using compounds that pollute the environment and, simultaneously, only use environmentally friendly packaging materials. At the same time reduces the pollution of soil, water, and air (Wang & Liu, 2022).

Hamam et al. (2022) indicate that "Eco-innovations that reduce the environmental effect of manufacturing and consumption are critical components of sustainable development and the transition to a circular economy. Food systems address the issue of food waste, which is generally acknowledged as a cost to the economy, the environment, and society. Eco-innovations seem critical for the food system's transformation to a more circular model on centered sustainable food production and processing."

According to the World Economic Forum, 2016 "Plastics are increasingly used across the economy, serving as a critical enabler for sectors as diverse as packaging, construction, transportation, healthcare and electronics. Plastics comprise roughly 15% of a car by weight and about 50% of the Boeing Dreamliner. Plastics have significant economic benefits because of their low cost, durability, lightweight and strength. The major challenge in the use of plastic containers is the lack of an adequately inspected recycling system in many countries. A considerable amount of plastic waste contaminates rivers and other water bodies. To address the significant environmental challenges, plastics possess coordinated global initiatives are required. According to World Economic Forum 2016, the following steps are suggested: 1. Establish the Global Plastics Protocol and coordinate large-scale pilots and demonstration projects. 2. Mobilize large-scale, targeted "moon shot" innovations. 3. Develop insights and build a base of economic and scientific evidence. 4. Engage policymakers. 5. Coordinate and drive communication."

In all its forms, renewable energy is one of humanity's greatest assets in the fight to limit climate change. Capacity across the globe continues to grow every year, lowering both greenhouse gases and air pollution. However, the pace of action must accelerate to hold global temperature rise to 1.5 centigrade this century (UNEP).

Green and Clean Tech

With the fast advancement of science and technology in the last few decades, great opportunities have been created to increase agricultural productivity, mainly using improved seeds, fertilizers, insecticides, pesticides, and other chemicals. On the other hand, the unwise use of this farm chemical and the continued encroachment of forest potential became a serious environmental concern. Significant sustainability challenges include land degradation, biodiversity loss, deforestation, overfishing, and the greenhouse effect.

At the same time, using improved communication means and advanced technology in the industry sector immensely increased production and productivity. It provided an opportunity to make the world a small village. Different means of communication (especially digital information sharing), fast transportation, and high-tech products improved the living standard in many countries, especially in more developed countries. Unfortunately, these advantages come with substantial consequences of air pollution, food wastage, plastic pollution, and global warming. Therefore, sustainability is a high priority for the current generation to ensure a habitable environment and resource base for the next generation. Hence, green tech and clean tech help us to ensure sustainability.

Cleantech is defined as any practical good, service, or technology that consumes minimal to no scarce natural resources while at the same time producing less waste than its standard mainstream counterparts. We have to work to remove the stigma toward using clean tech as a luxury only afforded to the elites, or in simpler terms, "clean tech cannot go mainstream if it is viewed as a premium item" (Wilder, 2009). This can include a wide range of products and services that encompass but are not limited to the following characteristics: employing renewable materials and energy sources or restricting the use of natural resources by using them more efficiently and productively, reducing or eliminating pollution and toxic wastes, delivering equal or more excellent performance to traditional offerings, and promising increased profits to investors, corporations, and customers (Wilder, 2009).

Project management helps organizations to achieve their strategic priority. Because Organizational strategies are achieved by implementing different projects aligned with the organization's strategy. The organizational system usually points out the direction of future development of the organization. Suppose green innovation-related plans are included in the corporate organizational strategy. In that case, it will be more beneficial for the organization to implement green innovation practices to become more competitive and ensure a higher market share (Li et al., 2022). "Green innovation refers to the innovative activities in which enterprises use advanced technology to achieve economic growth while considering environmental protection." Having green innovation as a priority in the company's strategy and the commitment of senior management to invest and lead the initiatives are the essential steps to succeeding in the implementation of green innovation. "The manufacturing sector is one of the leading industrial waste producers and contributors to environmental pollution, posing a threat to environmental sustainability. Adopting green innovation practices in the manufacturing sector is indispensable to ensure environmental sustainability" (Wang & Yang, 2021). Enterprises using green technology innovation not only respond to energy saving and emission reduction and fulfill the social responsibilities of enterprises but also provide more services for enhancing enterprise market competitiveness (Chen et al., 2020).

The Climate Technology Centre and Network under the United Nations Environment Programme (UNEP) facilitates the transfer of technologies through three core services: Providing technical assistance at the request of developing countries to accelerate climate technology transfer and creating access to information and knowledge on climate technologies. Furthermore, fostering collaboration among climate technology stakeholders via the center's network of regional and sectoral experts from academia, the private sector, and public and research institutions (UNEP).

In terms of using renewable energy, solar, wind, hydro, and nuclear power are the most common environmentally friendly sources. Solar power refers to the technology of using solar cells to convert solar radiation directly into electricity. It plays a vital role in diversifying energy sources; it is a clean energy source and reduces greenhouse gas emissions. Solar power is suitable for areas with high solar irradiation. It can be used in residential as well as commercial buildings.

In 2017, Swedish electricity power production comprised around 40% hydropower, 39% nuclear, 11% wind power, and 10% combined heat and power fueled predominantly by renewable sources (UNEP).

For the million people who lack access to electricity, introducing clean energy solutions can bring improved healthcare, better education and affordable broadband, creating new jobs, livelihoods, and sustainable economic value to reduce poverty (UNEP).

United Nations Sustainable Development Goals and Statistics

In 2015, The United Nations established the agenda up to 2030 for Sustainability, the 17 Sustainable Development Goals (SDGs). In this chapter, we will discuss the progress of five sustainability goals.

UNSDG 7 Affordable and Clean Energy

As the population grows, the demand for cheap energy and an economy reliant on fossil fuels drastically change our climate. Investing in solar, wind, and thermal power, improving energy productivity, and ensuring energy for all is vital if we achieve SDG 7 by 2030. Expanding infrastructure and upgrading technology to provide clean and more efficient energy in all countries will encourage growth and help the environment.

One out of 10 people still lacks electricity, and most live in rural areas of the developing world. As we can see in table 1 more than half are in sub-Saharan Africa (Table 1).

Energy is by far the main contributor to climate change. It accounts for 73% of human-caused greenhouse gases. The worldwide proportion of the population with

Table 1 Percentage of population with access to electricity

Regions	2000	2005	2010	2015	2020
World	78.2	80.6	83.2	86.6	90.5
Sub-Saharan Africa	25.7	29.3	33.1	38.8	48.1
Northern Africa and Western Asia	87.9	89.5	91.5	92.7	94.0
Northern Africa	81.2	84.1	87.2	89.1	91.2
Western Asia	94.1	94.4	95.2	95.8	96.5
Central and southern Asia	59.6	67.5	75.2	85.8	96.1
Central Asia	99.4	99.7	99.7	97.3	100.0
Southern Asia	58.1	66,3	74.3	92.7	96.0
Eastern and south-eastern Asia	92.4	94.0	95.8	89.1	98.1
Eastern Asia	97.3	98.4	75.2	95.8	99.2
South-eastern Asia	78.8	82.4	99.7	85.8	95.5
Latin America and the Caribbean	91.7	93.6	74.3	97.3	98.5
Oceania	80.0	82.1	82.1	87.1	91.0
Australia and New Zealand	100.0	100.0	100.0	100.0	100.0
Oceania (exc. Australia and New Zealand)	26.0	35.0	35.0	54.4	68.5
Europe and North America	100.0	100.0	100.0	99.4	100.0
Europe	100.0	100.0	100.0	99.1	100.0
North America	100.0	100.0	100.0	100.0	100.0
Landlocked developing countries	34.9	38.0	43.1	48.2	59.5
Least developed countries	20.1	26.2	33.1	42.5	54.7
Small island developing states	71.9	72.2	74.3	78.7	83.3

Source: The World Bank, 2022

access to electricity in 2000 was 78.2%, and in 2020 it reached 90.5%. Europe, North America, Australia, and New Zealand had 100% access to electricity. On the other hand, the lowest percentage is observed for least developed countries.

Energy efficiency is very important. The right policies and help the world to achieve over 40% of the emissions cuts needed for its climate goals. This can be done without new technology. Nearly one- third of the world's population, 2.8 billion people, rely on polluting and unhealthy fuels for cooking. As shown in Table 2, the least developed country's emissions are less than those of developed countries. Even developed countries' emissions were reduced from 2000 to 2019 (Table 3).

Table 3 indicates the percentage of people with a primary reliance on clean fuels and technology worldwide has increased dramatically. However, we can see only a small increment in the percentage of people primarily relying on clean fuels in places such as North Africa and landlocked developing countries.

The renewable energy sector employed a record 11.5 million people in 2019. The changes needed in energy production and uses to achieve the Paris Agreement target of limiting the rise in temperature to below 2C can create 18 million jobs. As shown in the table above, installed renewable electricity (watts per capital) significantly increased from 64.5 to 245.7 from 2000 to 2020; this is an up-and-coming trend in the use of renewable electricity. As evidenced in Table 4, as of 2017, 17.5% of power was generated through renewable sources. Overall, the worldwide proportion

Table 2 Carbon dioxide emission (in kilograms) per GDP

Regions	2000	2005	2010	2015	2019
World	0.35	0.34	0.32	0.29	0.26
Sub-Saharan Africa	0.24	0.24	0.21	0.19	0.18
Northern Africa and Western Asia	0.26	0.26	0.27	0.26	0.24
Northern Africa	0.11	0.23	0.22	0.23	0.22
Western Asia	0.18	0.28	0.29	0.27	0.25
Central and southern Asia	0.36	0.33	33	0.30	0.27
Central Asia	1.04	0.82	0.73	0.48	0.46
Southern Asia	0.31	0.29	0.30	0.29	0.26
Eastern and south-eastern Asia	0.41	0.46	0.45	0.39	0.34
Eastern Asia	0.47	0.53	0.51	0.44	0.38
South-eastern Asia	0.22	0.22	0.21	0.20	0.20
Latin America and the Caribbean	0.19	0.19	0.18	0.17	0.15
Oceania	0.43	0.40	0.37	0.32	0.29
Australia and New Zealand	0.42	0. 39	0.36	0.31	0.28
Oceania (exc. Australia and New Zealand)	0.00	0.00	0.00	0.00	0.00
Europe and North America	0.34	0.30	0.27	0.23	0.20
Europe	0.28	0.25	0.23	0.19	0.17
North America	0.41	0.36	0.32	0.27	0.24
Landlocked developing countries	0.56	0.48	0.41	0.30	0.30
Least developed countries	0.12	0.12	0.12	0.12	0.12
Small island developing states	0.23	0.19	0.16	0.14	0.13

Source: Carbon dioxide emissions from fuel combustion

Table 3 Percentage of the population with primary reliance on clean fuels and technology

Regions	2000	2005	2010	2015	2020
World	49	52	57	63	69
Sub-Saharan Africa	9	10	12	13	17
Northern Africa and Western Asia	80	86	89	91	92
Northern Africa	75	82	87	89	91
Western Asia	85	89	92	93	93
Central and southern Asia	26	31	37	48	63
Central Asia	77	81	85	86	86
Southern Asia	24	29	35	46	62
Eastern and south-Easter Asia	42	46	56	68	77
Eastern Asia	48	52	60	71	81
South-eastern Asia	23	31	45	59	69
Latin America and the Caribbean	80	83	85	87	88
Oceania	78	77	77	77	77
Australia and New Zealand	>95	>95	>95	>95	>95
Oceania (exc. Australia and New Zealand)	10	11	12	13	15
Europe and North America	>95	>95	>95	>95	>95

(continued)

Table 3 (continued)

Regions	2000	2005	2010	2015	2020
Europe	>95	>95	>95	>95	>95
North America	>95	>95	>95	>95	>95
Landlocked developing countries	22	24	25	27	27
Small island developing states	53	56	58	58	58

Source: Global Health Observatory (GHO), World Health Organization

Table 4 Installed renewable electricity-generating capacity

Regions	2000	2005	2010	2015	2020
World	64.5	75.1	102.0	155.8	245.7
Sub-Saharan Africa	26,8	24.3	24.2	28.0	37.6
Northern Africa and Western Asia	66.6	68.2	76.7	105.7	152.3
Northern Africa	28.7	27.6	34.9	37.7	51.5
Western Asia	103.0	106.3	114.5	166.9	244.1
Central and southern Asia	29.9	38.3	47.3	61.5	90.6
Central Asia	196.3	188.5	190.0	196.9	214.7
Southern Asia	23.6	32.7	42.0	56.4	85.8
Eastern and south-Easter Asia	54.6	73.5	133.6	256.4	459.7
Eastern Asia	60.8	86.7	165.4	327.9	602.6
South-eastern Asia	38.4	39.8	55.4	86.4	129.8
Latin America and the Caribbean	245.9	261.6	284.7	333.1	424.6
Oceania	52.0	54.2	59.0	67.8	73.8
Landlocked developing countries	79.2	74.2		86.5	97.6
Least developed countries	17.4	17.6	25.0	29.5	37.9
Small island developing states	30.7	43.1	43.4	53.8	79.9

Source: Adapted from IRENA based on IRENA's electricity capacity debate and population data for the UN population prospects

of the population primarily relying on clean duels and technology increased from 49% to 69% in 2020 compared to 2000 no significant change in developed countries (Table 4).

UNSDG 9 Industry, Innovation, and Infrastructure

Investments in infrastructure and innovation are crucial drives of economic growth and development. With over half the world's population living in cities, mass transport and renewable energy are becoming ever more critical, as is the growth of new industries and information and communication technologies. Technological progress is also essential to finding lasting solutions to both economic and environmental challenges, such as providing new jobs and promoting energy efficiency. Promoting sustainable industries, and investing in scientific research and innovation, are all important ways to facilitate sustainable development. More than 4 billion people still do not have access to the Internet, and 90% are from the developing world. Bridging this digital divide ensures equal access to information and knowledge and fosters innovation and entrepreneurship. Worldwide, 2.3 billion people lack access to basic sanitation (Table 5).

Infrastructure constraints in some low-income African countries cut businesses' productivity by 40%. 2.6 billion people in developing countries do not have access to constant electricity. The proportion of the population using essential sanitation services worldwide increased from 55.1% to 78.3% from 2000 to 2020. Using good sanitation services directly impacts the population's health in a given country. Again, the least developed countries have on average a lesser percentage of essential sanitary services (Table 6).

In 2014, according to Table 7 provided above, the worldwide 4G mobile network use around 32.8%; within 6 years, in 2020, this percentage increased to 85.5%. Inconstrast, places like the Sub-Saharan Africa, Landlocked developing countries and least developed countries, the 4G mobile network average use percentage was less than 50% in 2020.

Table 5 Percentage of population using basic sanitation services

Regions	**2000**	**2005**	**2010**	**2015**	**2020**
World	55.7	61.2	67.1	72.9	78.3
Sub-Saharan Africa	22.7	25.1	27.6	30.1	32.7
Northern Africa and Western Asia	78.2	80.6	83.8	86.7	88.4
Northern Africa	74.0	85.9	78.7	81.3	82.9
Western Asia	82.1	84.8	88.3	91.4	93.4
Central and southern Asia	23.6	35.0	47.0	59.1	71.3
Central Asia	93.5	95.2	97.1	98.4	98.8
Southern Asia	20.9	32.8	45.1	59.1	70.2
Eastern and south-Easter Asia	60.3	68.0		83.9	91.1
Eastern Asia	62.3	70.2	76.1	86.1	93,0
South-eastern Asia	54.7	61.9	69.8	78.2	86.4
Latin America and the Caribbean	74.1	78.5	82.2	85.8	89.0
Oceania	82.3	81.8	81.7	81.6	81.1
Australia and New Zealand	100.0	100.0	100.0	100.0	100.0
Oceania (except. Australia and New Zealand)	35.0	34.8	35.0	35.0	34.7
Europe and northern America	95.8	96.2	96.7	97.2	97.6
Europe	94.1	94.5	95.3	96.0	96.6
Northern America	99.9	99.9	99.8	99.7	99.6
Landlocked developing countries	33.8	36.1	38.9	41.0	43.3
Least developed countries	21.2	25.2	29.4	33.2	36.9
Small island developing states	65.3	65.8	67.2	68.4	67.8

Source: The WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene, 2021

Table 6 Percentage of population with access to electricity

Regions	2000	2005	2010	2015	2020
World	78.2	80.6	83.2	86.6	90.5
Sub-Saharan Africa	25.7	29.3	33.1	38.8	48.1
Northern Africa and Western Asia	87.9	89.5	91.5	92.7	94.0
Northern Africa	81.2	84.1	87.2	89.1	91.2
Western Asia	94.1	94.4	95.2	95.8	96.5
Central and southern Asia	59.6	67.5	75.2	85.8	96.1
Central Asia	99.4	99.7	99.7	97.3	100.0
Southern Asia	58.1	66,3	74.3	92.7	96.0
Eastern and south-eastern Asia	92.4	94.0	95.8	89.1	98.1
Eastern Asia	97.3	98.4	75.2	95.8	99.2
South-eastern Asia	78.8	82.4	99.7	85.8	95.5
Latin America and the Caribbean	91.7	93.6	74.3	97.3	98.5
Oceania	80.0	82.1	82.1	87.1	91.0
Australia and New Zealand	100.0	100.0	100.0	100.0	100.0
Oceania (except. Australia and New Zealand)	26.0	35.0	35.0	54.4	68.5
Europe and northern America	100.0	100.0	100.0	99.4	100.0
Europe	100.0	100.0	100.0	99.1	100.0
North America	100.0	100.0	100.0	100.0	100.0
Landlocked developing countries	34.9	38.0	43.1	48.2	59.5
Least developed countries	20.1	26.2	33.1	42.5	54.7
Small island developing states	71.9	72.2	74.3	78.7	83.3

Source: The World Bank, 2022. More than 4 billion people still do not have access to the Internet; 90% of them are in the developing world in 2020. As the table indicates, there is a high percentage of access to electricity worldwide; unfortunately, in sub-Saharan Africa and the least developing countries, access to electricity ranges between 48 and 60% compared to countries such as Central Asia, Australia and the Caribbean, Europe, and Northern America (Table 7)

Table 7 Percentage of the population covered by at least a 4G mobile network

Regions	2014	2015	2016	2017	2018	2019	2020
World	32.8	43.9	64.1	74.8	79.3	83.0	85.5
Sub-Saharan Africa	9.9	11.0	15.1	18,2	24.5	33.7	40.7
North Africa and West Asia	14.8	18.1	38.6	58.3	68.4	71.3	80.5
North Africa	0.0	7.1	20.0	56.6	73.1	76.0	80.4
West Asia	82.1	27.7	54.9	59.9	64.2	67.2	80.6
Central and South Asia	23.6	11.9	62.3	79.3	85.2	88.9	91.3
Central Asia	93.5	30.9	41.17	57.8	60.6	63.7	73.4
Southern Asia	20.9	11.2	63.0	80.1	86.1	89.8	92.0
Eastern and south-eastern Asia	60.3	66.0	80.3	92.7	95.7	96.5	96.8
Eastern Asia	62.3	85.5	95.6	96.5	97.8	98.3	98.3
South-eastern Asia	14.5	15.7	40.6	82.8	90.4	92.1	93.1
Latin America and the Caribbean	40.4	57.8	65.3	71.6	78.4	82.5	84.5
Oceania	67.1	75.7	78.8	83.3	85.3	85.6	86.0

Table 7 (continued)

Regions	2014	2015	2016	2017	2018	2019	2020
Australia and New Zealand	87.7	93.0	96.7	98.2	98.8	99.0	99.2
Oceania (ex. Australia and New Zealand)	8.0	31.4	33.4	45.9	51.0	52.2	53.2
Europe and North America	77.7	83.9	87.2	89.4	91.0	96.8	97.6
Europe	68.0	76.4	81.2	84.3	86.7	95.3	96.5
North America	97.9	99.4	99.5	99.7	99.8	99.9	99.9
Landlocked developing countries	9.3	12.4	18.8	24.8	28.1	36.5	41.1
Least developed countries	17.0	15.4	19.4	23.5	31.1	37.1	45.9
Small island developing states	22.6	35.7	40.5	51.6	55.2	60.9	66.6

Source: The World Telecommunication/ICT Indicators Database, 2021, International Telecommunication Union

UNSDG 11 Sustainable Cities and Communities

The United Nations estimates that more than half of us live in cities. By 2050, two-thirds of all humanity, 6.5 billion people, will be urban. Sustainable development can only be achieved by significantly transforming how we build and manage our urban spaces. Eight hundred twenty-eight million people are estimated to live in slums, and the number is rising.

As indicated in Table 8 proportion of the urban population living in slums worldwide was 31.2% in 2000. This percentage reduced to 24.2 in 2020. Still, the portion of the urban population living in slums is higher in Sub-Saharan African, Central, and Southern Asia countries. Hence more aggressive action needs to be taken in these countries to reduce the number of people living in slums.

Table 8 Percentage of the urban population living in slums

Regions	2000	2004	2008	2012	2016	2020
World	31.2	30.1	28.2	26.3	24.6	24.2
Sub-Saharan Africa	64.1	61.6	58.7	55.7	52.7	50.2
Northern Africa and Western Asia	31.6	32.6	27.4	22.8	18.9	18.7
Central and southern Asia	56.0	54.2	52.6	50.9	49.3	48.2
Eastern and south-eastern Asia	37.5	34.2	30.6	27.1	23.6	21.7
Latin America and the Caribbean	31.9	28.2	23.4	19.2	17.0	17.7
Oceania	17.0	16.0	15.7	15.3	14.8	15.3
Australia and New Zealand	0.1	0.1	0.1	0.1	0.0	0.0
Europe and northern America	1.4	1.3	1.0	0.9	0.8	0.7

Source: UN Human Settlements Programme (UN-Habitat)

UNSDG12 Responsible Consumption and Production

Achieving economic growth and sustainable development requires that we urgently reduce our ecological footprint by changing how we produce and consume good and resources. Agriculture is the biggest water user worldwide, and irrigation claims nearly 70% of all freshwaters for human use. The efficient management of our shared natural resources and how we dispose of toxic waste and pollutants are important targets to achieve this goal.

Table 9 shows the prevalence of undernourishment (percentage) in 2000 compared to 2020. Worldwide it reduced from 13.0% to 9.9% in 2020; this is significant progress in the right direction. Eastern Asia, Australia, New Zealand, Europe, and North America have less than 2.5% of the prevalence of undernourishment. Sub-Saharan Africa and the least developing states have a high majority of undernourishment percentages ranging from 23.1 to 24.1% in 2020. Hence in these countries, urgent work is needed to improve the prevalence of undernourishment, which is directly related to the health of people in those countries.

The food sector accounts for around 22% of total greenhouse gas emissions, mainly from converting forests into farmland. Globally, an estimated 2 billion people are overweight or obese.

Only 3% of the world's water is fresh (drinkable), and humans use it faster than nature can replenish it.

Table 10 shows how agriculture's water use efficiency is low compared to the industry and service sectors in 2015 and 2019. When we compare 2015 to 2019 water use efficiency, the results in 2019 are far better than in 2015. To enhance water use efficiency, countries need to focus on improving water use in the agricultural sector and exploring means to enhance water use efficiency both in the industry and service sectors.

Table 9 Prevalence of undernourishment

Regions	2000	2005	2010	2015	2020
World	13.0	12.4	9.2	8.3	9.9
Sub-Saharan Africa	28.9	24.6	20.6	19.4	24.1
Northern Africa and Western Asia	9.5	8.8	8.2	10.5	11.3
Northern Africa	9.2	85.5	7.3	6.1	7.1
Western Asia	9.7	9.0	9.1	14.3	15.1
Central and southern Asia	16.4	20.2	15.2	13.6	15.3
Central Asia	12.0	10.6	4.4	2.9	3.4
Southern Asia	16.6	20.5	15.6	14.1	15.8
Eastern and south-Easter Asia	12.7	9.6	4.9	3.3	2.9
Eastern Asia	10.0	6.8	<2.5	<2.5	<2.5
South-eastern Asia	20.6	17.3	11.6	8.3	7.3
Latin America and the Caribbean	10.8	9.3	6.9	5.8	9.1
Oceania	6.9	6.9	5.3	6.1	6.2
Australia and New Zealand	<2.5	<2.5	<2.5	<2.5	<2.5
Oceania (except. Australia and New Zealand)	20.6	21.6	16.7	20.1	19.9
Europe and northern America	<2.5	<2.5	<2.5	<2.5	<2.5
Europe	<2.5	<2.5	<2.5	<2.5	<2.5
Northern America	<2.5	<2.5	<2.5	<2.5	<2.5
Landlocked developing countries	32.8	28.1	19.2	15.9	19.1
Least developed countries	33.8	28.3	22.9	21.1	23.1
Small island developing states	18.7	18.3	14.8	14.7	15.4

Source: Food and Agriculture Organization of the UN (FAO)

Table 10 Water use efficiency

	2015				2019			
Regions	**Agriculture**	**Industries**	**Services**	**Total**	**Agriculture**	**Industries**	**Services**	**Total**
World	**0.6**	**28.7**	**103.6**	**17.4**	**0.6**	**32.4**	**114.0**	**19.4**
Sub-Saharan Africa	0.1	45.9	47.8	12.6	0.1	50.2	49.8	13.1
Northern Africa and Western Asia	0.4	131.3	131.3	11.6	0.4	81.9	52.1	11.5
Northern Africa	0.5	113.4	22.9	5.1	0.5	43.3	24.7	5.7
Western Asia	0.4	135.9	90.2	16.5	0.3	103.4	70.9	15.5
Central and southern Asia	0.3	27.9	21.8	2.5	0.4	33.8	26.2	3.0
Central Asia	0.3	27.9	21.8	2.4	0.4	33.8	26.2	2.6
Southern Asia	0.4	36.1	21.4	2.5	0.4	44.3	26.2	3.1

(continued)

Table 10 (continued)

Regions	2015 Agriculture	2015 Industries	2015 Services	2015 Total	2019 Agriculture	2019 Industries	2019 Services	2019 Total
Eastern and south-Easter Asia	1.0	39.1	78.6	15.8	1.2	48.5	99.5	19.8
Eastern Asia	1.8	41.2	97.2	23.7	2.0	51.0	124.0	29.8
South-eastern Asia	0.3	28.2	32.2	4.5	0.3	28.0	37.2	5.4
Latin America and the Caribbean	0.3	32.1	29.3	13.4	0.3	31.1	58.7	12.6
Oceania	1.1	70.3	216.0	58.8	1.3	87.8	254.2	71.6
Australia and New Zealand	1.1	70.7	222.2	58.4	1.3	88.6	262.8	71.2
Oceania (except. Australia and New Zealand)	0.2	60.2	103.0	76.1	0.3	69.6	114.6	85.7
Europe and northern America	0.3	19.8	212.8	47.4	0.3	21.3	229.8	51.6
Europe	0.6	29.4	177.8	58,6	0.6	32.0	187.8	63.2
Northern America	0.2	14.5	253.2	40.7	0.1	15.5	279.6	44.5
Landlocked developing countries	0.2	15.7	31.5	3.0	0.2	19.1	30.9	3.3
Least developed countries	0.3	66.0	30.8	3.8	0.3	85.3	36.0	4.5
Small island developing states	0.2	35.9	91.2	24.2	0.2	35.0	100.1	25.9

Source: Food and Agriculture Organizations of the UN

If people everywhere switched to energy-efficient lightbulbs, the world would save US$ 120 billion annually (Table 11).

Overall installed renewable electricity-generating capacity (watts per capita) increased worldwide from 64.5 watts per capita to 245.7. This increase is shown in all countries and regions included in this study, with a high rise in Western Asia, Central Asia, Eastern and South-Eastern Asia, Latin America, and the Caribbean.

Table 11 Installed renewable electricity-generating capacity

Regions	2000	2005	2010	2015	2020
World	64.5	75.1	102.0	155.8	245.7
Sub-Saharan Africa	26,8	24.3	24.2	28.0	37.6
Northern Africa and Western Asia	66.6	68.2	76.7	105.7	152.3
Northern Africa	28.7	27.6	34.9	37.7	51.5
Western Asia	103.0	106.3	114.5	166.9	244.1
Central and southern Asia	29.9	38.3	47.3	61.5	90.6
Central Asia	196.3	188.5	190.0	196.9	214.7
Southern Asia	23.6	32.7	42.0	56.4	85.8
Eastern and south-Easter Asia	54.6	73.5	133.6	256.4	459.7
Eastern Asia	60.8	86.7	165.4	327.9	602.6
South-eastern Asia	38.4	39.8	55.4	86.4	129.8
Latin America and the Caribbean	245.9	261.6	284.7	333.1	424.6
Oceania	52.0	54.2	59.0	67.8	73.8
Landlocked developing countries	79.2	74.2		86.5	97.6
Least developed countries	17.4	17.6	25.0	29.5	37.9
Small island developing states	30.7	43.1	43.4	53.8	79.9

Source: IRENA electricity capacity database and population data—from the UN World Population Prospects

UNSDG 13 Climate Action

Global warming is causing long-lasting changes to our climate system, threatening irreversible consequences if we do not act. The annual average economic losses from climate-related disasters are hundreds of billions of dollars. As of 2017, humans are estimated to have caused approximately 1.0 Celsius of global warming above pre-industrial levels.

Despite the environmental challenges and human-made factors such as conflicts and localized displacement of people the world faced after the declaration of the 2015 United Nations Development Goals, significant achievements have been made on UN Development Goals 7, 9, 11, 12, and 13, which are the focus of this study. However, the least developed countries' progress is negatively affected by financial resource constraints, technological challenges, and internal or regional conflicts. Therefore, to achieve the 17 United Nations Development Goals in 2030, Sustainable Development, clean tech, and green tech innovation are the key focus areas for all development actors to work together to achieve the Sustainable Development Goals mentioned above before the year 2030.

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Sustainability Accounting: Origins, Evolution, and Future

Jaspal Singh

Abstract This study analyses the history of sustainability accounting, from its emergence in the 1970s to the modern-day adoption of a global set of industry-specific sustainability accounting standards.

Besides, the study navigates sustainability accounting's noticeable impact on businesses' seeking of investment, hiring practices, and sales strategies. Generally speaking, finding innovative ways of becoming more sustainable and communicating the improvements well tends to benefit organizations. Larger and more diverse investments can be sought if popular sustainability measures are enacted. Better employees can be attracted and retained by the company, leading to better performance and innovation in future. Customer satisfaction can be maximized, resulting in higher revenues and earnings.

In addition, the limitations of sustainability accounting when left in the hands of businesses are further explored with consideration for corporate profit goals and dynamic environmental and economic conditions (such as rising wealth inequality, diminishing union power, elevating global pollution levels, and the like), which are typically left unconsidered. To continue making progress with sustainability, we must push for things such as advancement of unions, better disclosure of information from multiple sources, and overall pressure on corporations to focus on corporate social responsibility over profit.

Introduction: What Is Sustainability Accounting?

Sustainability accounting is defined as "the practice of measuring, analyzing and reporting a company's social and environmental impacts" (Keddie, 2021). Today, this involves organizations disclosing their efforts toward widely beneficial causes

J. Singh (✉)
University Canada West, Vancouver, BC, Canada
e-mail: jaspal.singh@ucanwest.ca

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such as maintaining a clean environment, extending equitable working benefits to employees, and treating customers, suppliers, and other stakeholders well. Sustainability accounting also references a system of investing where certain values are followed in placing funds where they are considered to be ethically invested. However, there has certainly been evolution in sustainable accounting over the past half-century. Over time, sustainability accounting has evolved into a value-adding system where businesses make efforts toward ethical and sustainable business practices, taking into consideration social, environmental, and economic factors.

To understand sustainability accounting well, we would be well advised to consider its origins. By the late-1970s, several papers had emerged emphasizing the importance of including social factors in accounting disclosures (Mathews, 1997). This included slight references to environmental damage (damage to terrain, air, water, as well as other pollutions). However, at this phase, the early movement can best be described as social accounting—simply placing some broader accountability (beyond just to investors) on the organization in question.

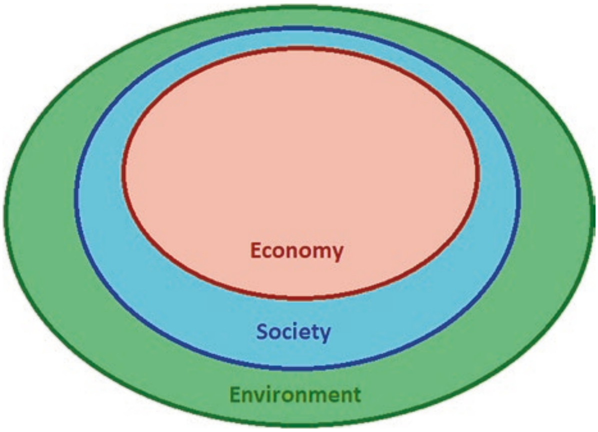
The focus on environmental impact intensified over time, as the implications of man-made climate change grew ever threatening. Environmental disclosures and regulations increasingly took the stage in coming years. There were natural extensions from environmental disclosures to environmental auditing and the development of environmental management systems. While growing climate change concerns were certainly a driving force behind the inclusion of sustainability accounting in industry, they were not the only factor.

Several significant historical events “awakened” the public and caused sustainability accounting to continue advancing into industry. In the late 1990s/early 2000s, we had a few impactful accounting/finance issues which accelerated us toward a more sustainable/balanced economy. Perhaps, the first notable event was the 1997 Asian financial crisis. This started in Thailand (commonly known there as the Tom Yum Kung crisis), where the financial collapse of the Thai baht triggered slumping currencies and quick asset devaluations in other Southeast Asian countries such as South Korea, Indonesia, and Japan (Wechsler, 2018).

This was followed by the tech bubble in North America. Two of the bigger, well-known collapses were WorldCom and Enron. Both companies were plagued by unethical accounting and financial reporting practices, which misled investors for years. Eventually, the fraudulent activity was discovered, and the businesses quickly spiraled into bankruptcy. Following the collapse of WorldCom as well as both Enron and its auditor, Arthur Andersen, the American Congress passed the Sarbanes-Oxley Act in 2002. A major part of this legislation involved providing more complete disclosures to the public, including an internal controls report (Lutkevich, 2023).

While the passing of legislation such as the Sarbanes-Oxley Act may not fit completely in the realm of sustainable accounting, it is still an important step toward sustainability. To support a complex economy with public financing mechanisms, we must uphold a level of trust. By assuring investors that they are receiving timely, complete, and objective disclosures, they can feel more confident that their investment is safe. We can expand on this idea to state that the economy relies on societal values to function efficiently.

At this point, it is helpful to step away from the timeline of sustainability accounting's integration into mainstream industry and analyze the figure below:

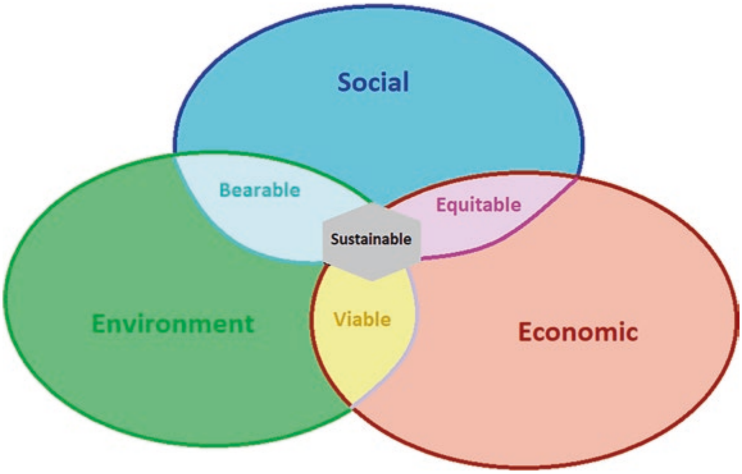


Source: Author adaptation of Sunray lacchus/Wiki Commons (2018) sustainability accounting diagram

This popular diagram not only resembles what sustainability accounting is all about but also provokes thoughts about how everything we know fits together. First, we have the environment. As we know, the environment plays an instrumental role in how society is shaped. Using the simplest of examples, consider an indigenous community living in Yukon. To deal with the cold harsh climate, the community may have built, over many generations, a certain lifestyle that helps them survive the winter months. This would be very different from an indigenous community in Hawai'i. Hence, we can easily see why society, the blue circle, fits within the bigger green circle, environment. This can also be an explanation behind why environmental factors have been highlighted in the push for sustainability, over other social elements.

Next, we have the economy, resembled by the red bubble, which sits within society. This also makes logical sense—the economy cannot exist without society. Not only do humans need to serve as producers and consumers, but they also need to agree upon, set, and follow a clear set of rules in which the economy operates. Without broad respect toward ethics and laws, the economy quickly collapses, typically along the pathway to a larger societal breakdown. Therefore, to have a sustained functioning economy and society, its participants must feel invested in a fair and equitable system—this is also discussed in the analysis of our next diagram below.

Let us consider another diagram which exhibits the general idea of sustainability:



Source: Author adaptation of Adams (2006) sustainability accounting diagram

In this diagram, we see the word "sustainable" centered around all three of the big bubbles—Social, Economic, and Environment. Between two big bubbles, we have other familiar words—equitable, viable, and bearable. The main point here is a balance of social, economic, and environmental factors need to be balanced to make a long-term sustainable strategy.

Let us first consider the word "bearable," located between the social and environmental bubbles. This can be viewed through a couple of lenses. If we take more of an environmental angle, then we can consider climate and living conditions which are most comfortable in—nice weather, clean air and water, nutritious food, etc. From a more social perspective, we can include compromises we make in social structures—with family, friends, employers, etc. As an example, if a job is "unbearable," then the employee naturally seeks alternatives. In both environmental and social cases, we can see how bearable quality is a key element of sustainability.

Between the social and economic bubbles, we have the word "equitable." The concept of economic fairness is deeply engrained in humans and even animals similar to us. You may have seen a video clip of a famous experiment where a monkey is given a cucumber piece instead of a grape for equal work done by his peer (Stafford, 2015). This results in a remarkable tantrum, with increasing intensity as the researcher continues giving grapes to the other monkey. We can clearly observe that the monkey feels that he is being compensated unfairly. With business, we also want to keep things equitable—between workers, between labor and capital, between government/society and business, and so on. Failure to do so could, once again, compromise sustainability.

Finally, we have the word "viable" between the economic and environmental categories. Again, we can view this in a couple of ways. Going back to the argument that the environment serves as the basis of society and, subsequently, economy, the destruction of the environment would undoubtedly have a disastrous impact on business in the area. A great example of this is the city of Chernobyl, where a nuclear plant meltdown immediately made the area inhabitable. Therefore, even from a strict business perspective, some regulations to keep the area habitable make good sense. However, governments must be wary of over-taxing and/or over-regulating. Businesses may opt to limit growth, relocate, or even shut down if they feel the business environment is making profiteering difficult.

To sum things up here, sustainability is a delicate balancing act of different elements. It is not as simple as always doing the right thing as businesses do face competition and there is pressure to produce profits from investors. Society and governments must also make difficult decisions on how local businesses can thrive while still making a positive measurable impact on the community.

To wrap up the history of sustainable accounting, let us see where things stand today. On November 7, 2018, an independent body called the Sustainability Accounting Standards Board published the first global set of industry-specific sustainability accounting standards. These standards covered financial material issues for 77 industries and were designed to help investors and companies with informed decision-making, specifically with regard to better assessing sustainability risks and comparing industries/companies. The standards are guidelines for reporting sustainability information that are not enforceable by any governmental agency (Trentmann, 2018). In the next section, we will analyze how sustainable accounting has impacted the industry in various ways.

What Is the Impact of Sustainability Accounting on Industry?

Seeking Investment

Perhaps the most immediate thought when pondering the concept of industry being impacted by sustainability accounting is in the investing space. It is certainly the aspect we have heard a lot about in recent years, as some investment firms and institutions (university endowment funds, company pension plans) have attempted to invest more ethically and selectively contribute funds to areas which best match their values.

This can leave corporations in an interesting position. Undoubtedly, there are some areas where it might be easier for businesses to adopt popular causes versus others. Let us consider, as an example, LGBTQIA+ rights. In many cases, supporting this social cause can be a relatively easy step for businesses. A growing majority of the public supports this cause—70% of Americans support same-sex marriage, up from 67% pre-pandemic (McCarthy, 2021). A healthy portion of demographic may be excited about buying colorful trendy merchandise—this can encourage major investors to not only back a company's transition into a LGBTQIA+ rights supporter but grow excited at the prospect of higher revenues and profits.

On the other hand, something like union rights can also be popular with the public. Seventy-one percent of Americans approve of labor unions, up from 64% pre-pandemic (McCarthy, 2022). However, employees unionizing can have a major negative impact on a business's profitability. While some investment groups may be open to unionized workplaces and lower returns on their investments, Wall Street's efforts in undermining unionization efforts are well documented (Goodkind, 2022). Hence, we are much more likely to see advertising from major brands with overt LGBTQIA+ support (diverse couples, colorful clothing, etc.) than overt union support.

This leads us to the question of what drives companies to support certain causes. Are some of them just vessels for generating as much profit as possible for their investors? Even if institutional investors can push businesses in the "right" direction at times, what does this say about our economy and even society? Are the issues being pushed to the forefront in the corporate world simply those that will not have a significantly negative impact on the bottom lines of businesses?

It can be argued that much of the collective corporate sustainability effort can be viewed skeptically—progressing toward becoming a more ethical company which has respect for its employees, suppliers, customers, and environment may be primarily motivated by keeping profits and share prices high. This logic can lead us into some concerns about just how much sustainability accounting helps in the broader scheme of things.

At best, it can be viewed as pressure that corporations feel to do the bare minimum so that large institutional (and potentially sustainability conscious) investors such as universities and pension funds will continue to invest in them, effectively keeping the share price up. At worst, it can be a cheap corporate marketing strategy where an unethical corporation essentially spends some cash on a few "good" initiatives to distract the public from its much bigger evils.

On October 28th, 2021, Katie Porter, a congresswoman from California and famously known for using props in her grilling of corporate executives, attempted to quantify the scale of renewable investment for giants in the oil and gas industry by using bags of rice and M&M candies (Nilsen et al., 2021). Her main point was that while the corporations touted investments in renewables, they were, in reality, a fraction of the spending on oil and gas operations. Congresswoman Porter mentioned that Shell Oil Corporation only spent half of the $6B pledged for renewables from 2017 to 2020—this was a small fraction of the combined ~$20B a year the corporation was spending on oil and gas operations and marketing. She also touched on the fact that the same corporations continually lobbied the government for more permits to drill on federal lands and waters despite already holding drilling rights to millions of acres with untapped resources.

This raises the question of just how much effort would an unethical corporation put into becoming more ethical? Would it be enough to transition into a fully socially responsible corporation, despite lower profits and share prices? Or would it reinvent itself just enough to improve the corporation's reputation, perhaps through minimal investment in causes and boisterous marketing of it?

Recruiting Talent

A major part of sustainability is recruiting and retaining the key people who can make an organization great. Maintaining a high level of employee satisfaction is absolutely a more sustainable approach than having a "revolving door" workforce. Keeping employee attrition rates at a manageable level saves a business a number of headaches—recruiting, interviewing, onboarding, and training can all be costly in terms of time and money (Recruiteze, 2023).

To promote a culture of sustainability, a business must make all efforts to keep talented people within the organization—this is especially true at the top. With trustworthy, capable, and value-centered leadership, businesses can better foster a sustainable culture throughout their organizations. If the leaders at the top of the organization set a strong example for everyone below them, then employees are more likely to uphold great values and stick with the company.

With the head offices of major companies typically being in large cities such as Vancouver, Toronto, and Montreal, it is not difficult to hire diversely—individuals of varying race, religion, gender, and sexual orientation that can contribute meaningfully to these organizations. With their vision and leadership, the company can better represent the needs of a broader group (not only employees but customers). By exhibiting more tolerance, the company benefits from having a larger pool of interested, talented candidates to select from.

However, there can be a delicate trade-off for businesses. If there is a perceived threat to senior management and/or investors such as a unionized workforce, then the organization may hire strategically to limit potential economic loss for the business/investors. In one of my own non-unionized workplaces, I have heard of interviewers plainly asking HR candidates about how they would stifle chatter about unionization in the workplace. In my view, an interview question of this nature can be considered borderline unethical.

While a business may view protecting its profits as the most sustainable strategy, the reality is that union-busting measures can reflect terribly on a company and adversely impact its recruiting and sales. As an example, consider Starbucks, a company generally viewed as hip, progressive, and appealing to young people. When a unionization "wave" began taking over Starbucks, founder Howard Schultz returned to the company as interim CEO. Some suspected the return to his old role was solely in the interest of union-busting and recent events have done little to refute the idea. In a heated exchange with Mr. Shultz on March 29, 2023, Senator Bernie Sanders pointed out that Starbucks had not reached a first contract with any of the 300+ unionized stores (first of which was unionized over a year ago) and withheld benefits from unionized locations (Selyukh & Hsu, 2023).

Recently, we have seen a number of other examples where wealthy, multinational businesses have made extraordinary efforts to kill union efforts, not only to form but collectively bargain. Still, as wealth inequality has become a growing concern with the decline of unions as a major factor (Merrefield, 2021), the public's perception of labor unions has risen to approval rates not seen since the mid-1960s (McCarthy, 2022).

Also, unionizing efforts have experienced some success and publicity. Perhaps the most well-known example is Chris Smalls who managed to unionize an Amazon warehouse, a first in the USA (Del Rey, 2022). Again, with stronger union movements, there is naturally a stronger response from corporations, and it held true in Amazon's case. Stronger efforts to spook unionizing workforces resulted in some "no" outcomes after the initial union win at the JFK8 warehouse in Staten Island, New York. It is well documented that Amazon has fired a number of union organizers in its quest to protect against unionization (O'Donovan, 2022).

Customers

Over time, consumers have largely demanded sustainable products and services. A good example of this is the electric vehicle (EV) market. Even with government subsidies, EVs tend to be more expensive to purchase compared to their gasoline counterparts. However, we are seeing climbing zero-emission vehicle market shares in developed countries. For instance, Statistics Canada data revealed that new EV registrations in Canada reached 8.70% in Q3 of 2022, up from 6.94% in the previous quarter (Jarratt, 2023). As evidenced by other indicators such as pipeline protests, labor strikes, and the like, people really do care about the environment in which they live and work, so increased adoption of EV technology is not surprising.

However, there can be a lack of understanding about what exactly is "sustainable." While the adoption of EVs does reduce air pollution in our communities, the mass production and adoption of EVs are not exactly sustainable. There is a huge demand for precious metals used for producing EV batteries and shortages are expected in the near future (Di Grandi, 2023). So, while automobile manufacturers can promise to ramp up EV production, there is little they can do about the strain on the earth's natural resources. We can hardly blame the public for trying to purchase the cleanest possible vehicle, but the lack of holistic understanding is often a real concern.

Another example of the public not necessarily understanding the entirety of the sustainability argument is with transition to clean energy. Again, mass-producing things like windmills and solar panels require valuable resources. With limited resources and electricity storage technology not being great, these technologies should really be used where they have maximum impact (sunny and windy regions). In darker, colder climates with traditionally high energy demand, nuclear energy is often the cleanest and most efficient option. However, with so much negative publicity associated with the rare mishap, nuclear plants have unfortunately been shut down, such as those in Germany (Clifford, 2023). This is an example of the public and governments sometimes being misguided about what is most sustainable on a large scale.

In recent years, we have seen the rise in "cancel culture," where products and/or brands are boycotted due to public outcry over a certain event. A recent example of this is the boycott of Bud Light beer after Anheuser-Busch's partnership with transgender influencer Dylan Mulvaney (Coffee, 2023). Fearing backlash like this, corporations may be inclined to sidestep the most controversial figures or events in the hopes of avoiding bad publicity. However, they may ultimately decide that all publicity is good publicity and enter controversial waters anyway. In the end, it could just boil down to how accepting the target audience is of a certain issue. For instance, three-quarters of Canadians support same-sex marriage (Ipsos, 2021), so including pride elements in Canadian marketing may be something a business is very comfortable doing.

So, while company policies and disclosures can be geared to appeal to the masses, there might be a widespread lack of understanding about the broader issue and sustainability elements relating to it. While companies may have a better understanding of the real issue, they may feel it is in their best interest to just "play along" and keep a positive public image, perhaps even use the partially misunderstood issue to their benefit with creative marketing.

The Future of Sustainability Accounting

The Impact of New Technology

Technological advances can positively impact sustainability in a number of ways (BDC, 2023; Viniak, 2023). For instance, digitization of financial services can reduce the use of paper as information such as that found on a monthly bank statement can be provided to clients via email or file download off a secure website. Furthermore, with phone and Internet banking options, people's time and carbon footprint are managed better—fewer trips to a physical banking location are needed.

However, the opposite can also be true in some instances—some studies have found that emerging technologies such as 5G, blockchain, and AI are causing a massive surge in energy consumption, water usage, and carbon dioxide emissions (Hills et al., 2021). This is largely a result of devices that are boosting connectivity. More specifically, the large carbon footprint is a result of manufacturing, rather than use, of these electronic devices. As an example, an estimated 81% of an iPhone's carbon emissions are generated while the device is manufactured (Kilgore, 2023)—the energy consumption due to phone use is relatively low.

The reality is corporations often face trade-offs between efficiency and being environmentally conscious (Sidhoum et al., 2022). But this does not mean technology cannot have an overall positive environmental impact on businesses. Over time, accounting has evolved to better reflect an increasingly paperless world (Envoice, 2022), largely with the help of emerging technologies. We now have accounting systems that can extract information digitally and help reduce the environmental impact of various accounting functions such as financial reporting, auditing, and tax preparation. By reducing reliance on paper, essentially leaving more trees standing, we are avoiding the carbon footprint of producing paper while increasing carbon recapture via living trees.

There is another element of technology in the workplace—its impact on humans. Clearly, smartphones can make work easier, perhaps even to the point where working from home becomes an option. This can result in reduced vehicle use (and carbon emissions), allowing businesses to promote environmentally friendly policies as well as flexible working policies for employees. Both of these elements bode well for sustainability and can give businesses an opportunity to market themselves as advocates of sustainable causes. With better working conditions, employees will likely end up happier than before. With higher employee satisfaction, we get lower employee turnover and even stronger attraction of new talent—this, undoubtedly, makes an organization more sustainable.

However, there can also be negative consequences stemming from increased connectivity (Korn Ferry, 2023). There is the continuing concern of people not unplugging from work often enough since phone calls, texts, and emails can reach them at all times. There is also the related problem of mounting screen time, even during leisure time. In the interest of keeping employees rested, happy, and productive, it may be a good idea for organizations to place limitations on communications outside of working hours.

Fortunately, the nature of the work can change due to technology which can actually help reduce stress levels (McKendrick, 2019). Businesses generally should not refrain from advancing technology in the workplace. It can make life easier for employees and elevate productivity. However, as with most things, it is important to consider sustainability as part of the equation. After adopting sustainability-enhancing technologies and enacting great policies, a business is well within its right to report the advances to stakeholders. This is an example of sustainability accounting benefiting the business in various ways discussed earlier.

Enhancing Internal Controls and Financial Reporting

With increased connectivity and reduction of errors, we can have better breadth and depth of data, which can lead to improved internal and external decision-making (RiskOptics, 2022). Internet of Things (IoT) technology has been described as "the network of physical objects that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet" (Oracle, 2023).

Certainly, having more connected devices can automate key functions and create increasingly sustainable systems with reduced reliance on humans. With better artificial intelligence, errors can be minimized, possibly even eliminated. This can increase reliability of data and management can lean on it to make bolder decisions.

As more IoT devices and systems become available, businesses will be able to rely on machines to ensure processes are working as intended. This will not only improve the quality of products and services but also keep efficiency at a high level. Managers can easily repair and upgrade machinery—a lot of human issues such as fatigue, stress injury, or error can be eliminated. Data can be gathered and communicated in real time. In fact, simple decisions can even be programmed into systems to get quicker, and optimal, responses. For example, consider an automated function that immediately shuts down all machines at all company plants within a hundred kilometers of a sensed earthquake and verbally instructs everyone to exit to an open area outside. This IoT function would save lives!

Furthermore, the improved data could be communicated to external decision makers by way of financial reporting. If publicly traded corporations are willing to share more details about their business to grow investor confidence and, subsequently, obtain more/better financing, IoT technology may help them in this regard.

One concern would be keeping the IoT system secure. If someone were to gain access to data or even operational capability of the entire system, there could be devastating consequences for the business. There is, of course, the issue of insider trading if non-public information leaks to outsiders. There is also the ever-growing concern of data breaches—confidential employee and customer information could be obtained via unauthorized access to the IoT system. Perhaps the greatest danger of all is the surrender of control of company assets to a criminal. If an outsider can control heavy machinery or a business's locked areas, the impacts could be significant.

Maintaining Open Communication

Ideally, more of a collective focus can be put on holistically educating the public on sustainability. However, communication is never that simple. It is not entirely the responsibility of businesses to educate the consumers of their products and services, but they should be held to a certain standard of honesty. Communicating potential dangers such as data breaches should absolutely be a must.

There is a real concern about free speech and individualism being compromised in the interest of adherence to a certain agenda. Sometimes, it is important for independent voices to balance out the widely accepted narrative prevalent in the mainstream media and public sphere. It is imperative that we make sure that social media platforms such as YouTube, Twitter, and Facebook do not have the green light to unilaterally suppress certain voices without consequence. To sustain a functioning society, democracy, and economy, we must have individuals who feel free to share their views within the boundaries of the law (and not necessarily the undemocratically determined policies of the platform).

This idea can become even more concerning if employees within an organization feel pressured to conform to something they may not personally believe in. A good example of this is professional athletes declining to wear pride uniforms for warm-ups before the game or kneeling for the national anthem. It can be argued that these individuals have the right to express themselves in a manner that they see fit. Also, as long as laws are not broken, the same right should be extended to people posting online on a public platform. It can be argued that freedom of expression is a key to long-term sustainability just as much as the professionalness of a corporate brand, typically maintained through unified employee appearance and behavior.

Generally speaking, with diverse voices being able to share their thoughts, people can be better equipped to discuss sustainability and develop their own ideas about what is right and wrong. This can then lead to pushing governments and companies in the right direction with voting and strategic action. While corporations can continue to be pushed into developing better policies and disclosing more relevant information to the public, it is always better to rely on more sources for one's knowledge. Hence, a collective and broad push for free speech and expression should be sustained.

As an example, let us consider Tesla's self-driving technology. Elon Musk, the CEO of Tesla, also owns Twitter so he can suppress negative comments, even videos, about Tesla's vehicles malfunctioning. While this may not be overly concerning to us as there are other social media platforms people can go to, what happens when wealthy companies like Pfizer opt to buy expensive ads with all major American news networks? Could that lead to an unsustainable, inequitable outcome where American pharmaceutical drugs cost much more than elsewhere and the country's lawmakers, also collecting money from the same corporations as the media, are largely complicit in the abuse/robbery of the sick and poor? Some would argue that this approach is completely unsustainable and, in reality, it is already happening.

While some would argue that the misinformation threat of a light-handed censorship approach is a problem, it can pose a much smaller problem (yes, even if it causes potentially adverse outcomes such as vaccine hesitancy) than handing over the keys of free speech to private corporations. Once a platform gets big enough, society should absolutely demand that the nation's established laws be used to moderate free speech and criminal activity on the platform and not arbitrary policies that the corporation self-creates. In other words, the basis of a functioning democracy starts with free speech—the sustainability of a business, economy, and nation depends on it.

To give one more example, one could quite easily argue that a growing wealth gap between the owner class and labor is not sustainable socially and economically (Frank, 2022). This is one area where progress has not been achieved recently, as average CEO pay reached 399 times the company's median worker in 2021. This has been a result of steady declines in income equality since 1965 when CEO-to-median worker pay was at a ratio of 20-to-1. It is hard to argue that all elements of sustainability have improved when we have seen such drastic growth in income and wealth gaps. The same could also be said for the ever-rising CO_2 ppm metric—neither pollution levels nor wealth inequality suggests we have a sustainable global economy.

Now, if major traditional media networks (TV, radio, newspaper) require significant capital to own and run, it is unlikely the scary but true inequality story will get its due coverage- and that same attitude can reasonably be extended to other labor/

class issues such as union rights, funding of social programs, and tax evasion by the elites. When analyzing sustainability accounting's impact on investment, employees, and customers, we covered a number of issues already which are in the public's interest to explore—independent methods of publishing information can help with this. Pushing for more sustainability requires free and open communication platforms.

So, to get the balance on such stories, we can go to a low-cost public platform such as YouTube or Twitter. Here, anyone with a cellphone or computer can post content sharing their perspective—be it regarding an adverse reaction to an mRNA vaccine or jobs from a very profitable factory being outsourced to a country with lower wages and weaker labor laws. Hence, at minimum, we must ensure that the online platforms remain free and accessible to all. Censorship cannot be heavy-handed, nor conducted at the behest of deep pockets buying advertising or other forms of influence.

In addition to giving a population a more complete perspective on matters including those relating to sustainability, healthy public discourse can also combat the effect of "captured" institutions. We have already touched on how news media and politicians can be impacted by money, but the regulatory bodies in charge of directly overseeing corporations can also be compromised. You may have heard about the nefarious role of credit rating agencies in the 2008 American financial crisis (Council on Foreign Relations, 2015). Basically, the rating agencies were paid by the companies whose products they were rating. It is easy to see why this quickly becomes a problem with risky assets—the company can shop around until it finds a rating agency that will give its products the desired rating in return for the service fee.

This naturally leads us to the question of just how trustworthy ESG scores are—these are evaluations of a company's performance with respect to Environmental, Social, and Governance issues (PWC, 2023). A study found that rating firms gave better ESG scores to businesses with the same ownership (Tang et al., 2022). However, another study points out that ESG score inflation is not really a major concern as the users of the scores pay for the rating and inflated scores can severely damage the rater's reputation (Bikmetova & Pirinsky, 2022). In any case, a degree of skepticism with ratings is not a bad thing and seeking more than one source of information is almost always a good thing. An investor wondering why an oil and gas exploration company, Compañía Española de Petróleos SA, has a better ESG risk rating than the world's leading EV manufacturer, Tesla, (19.2 vs 28.3) should seek out more information by conducting his/her own research.

Conclusion

Over the past half-century, indisputable progress has been made with sustainability efforts, especially with better disclosures to the public. However, there seem to be a few barriers as we move forward. Most importantly, we must share and consume information from a variety of sources. We must collectively push for free speech with minimal censorship. There has been a trend toward increased censorship online and we must remain wary of cancel culture going forward.

Secondly, it would help to ensure that institutions designed to represent and protect us are kept as clear of corrupting influences as possible. We must remember that captured institutions cannot only mislead us but even have a hand in creating policy which does not serve our best interests. We have seen a clear decline in unions and spike in wealth inequality, so we must keep a keen eye on economic factors which the corporate world may deemphasize while elevating social changes.

Finally, we must recognize that we have a long way to go with sustainability. The middle class is shrinking throughout the developed world and many households are struggling to make ends meet despite two working adults—as the rich amass even more wealth. Our planet is becoming increasingly polluted which is leading to immediate health problems and billions are threatened with the terrible repercussions of climate change. To address sustainability concerns, we should continue to develop helpful technologies and supplement them with sensible policies.

We must continue demanding progress, investing and consuming ethically, and never giving up the fight against the rich and powerful. Working together, we can create a more sustainable future for ourselves and future generations.

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Part II
Technological Convergence

Technological Shocks and Employment: A Pick from the RBC Theory

Reihaneih Gaskari and Alireza Eghbali

Abstract This chapter provides an analysis of the real business cycle (RBC) theory and its implications for employment in the context of technological advancements. It examines the criticisms of the RBC theory, particularly regarding the impact of technology on recessions, and presents the responses put forth by RBC proponents. Additionally, the chapter investigates the relationship between technology shocks and employment, considering different viewpoints and empirical evidence. The findings suggest that while technology can lead to job displacement in certain sectors, it also contributes to overall economic growth and employment opportunities. The chapter concludes by discussing the proposed solutions advocated by RBC theorists, emphasizing the importance of minimizing government regulations and promoting a deregulated economy to mitigate economic recessions.

Introduction

Business cycles are fluctuations that are defined as successive periods of boom and bust. Since stability is essential for a country's economy from various dimensions, therefore, by understanding the structure of fluctuations and cycles in the economy, efforts should be made to control and reduce their intensity. The severity of economic fluctuations or business cycles reflects the instability of the economy, making it difficult for economic players such as households and businesses to predict the future with certainty. Economists have long attempted to uncover the structure of

R. Gaskari (✉)
University Canada West, Vancouver, BC, Canada
e-mail: reihaneh.gaskari@ucanwest.ca

A. Eghbali
Faculty Member of Economic Department, Payame Noor University, Tehran, Iran
e-mail: areghbali@pnu.ca.ir

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fluctuations through theorizing and implementing executive orders. The real business cycles (RBC) theory is one dominant school of thought among industrialized countries.

There are numerous theories explaining the causes of business cycles. Economists have historically been attentive to economic crises and have strived to establish a theoretical framework to understand their causes and find ways to address them. Therefore, it is fair to say that a significant part of the growth in economic knowledge can be attributed to efforts in the field of business cycles. From the pre-Keynesian era to New Keynesians and supporters of the real business cycles (RBC), various approaches have been proposed in the theoretical literature of business cycles.

The new classical business cycle model is another component of business cycle theories that aims to explain the causes of business cycles. There are two groups of theorists in this regard: proponents of monetary business cycles, led by Lucas, Sargent, and Wallace, and proponents of real business cycles (RBC), advanced by Kidland, Prescott, and Nelson. While proponents of monetary business cycles consider unexpected and unanticipated monetary policies and lack of understanding by economic agents as the causes of business cycles, proponents of real business cycles (RBC) attribute them to real shocks and changes in productivity. On the other hand, new Keynesian theorists, despite accepting the analytical foundations of microeconomics, do not believe in equilibrium business cycles due to market problems such as external effects, incomplete and heterogeneous information, and stickiness of wages and labor contracts. They argue that changes in aggregate demand are the primary cause of business cycles (Gorgi & Eghbali, 2019, pp. 107–123).

This chapter comprises four parts. The second part introduces the Real Business Cycle (RBC) theory and its related theories concerning technology shocks. The third part of the chapter discusses the criticisms about the recession reason of the RBC theory. In this regard, we present the viewpoints of theorists who support this theory and their responses. The fourth part examines the impact of technology shocks on employment. This section claimed the employment process in Canada as an example. Finally, we explain the proposals put forth by theorists who advocate for real business cycles. Their suggestions aim to minimize government regulations, promote deregulation of the economy, and reduce the size of the government.

Real Business Cycle (RBC): A Conceptual Review

Monetary business cycles faced statistical and theoretical impasses in practice. Since the early 1980s, new classical economists have focused on real shocks instead of monetary shocks. Meanwhile, the new classics shifted their attention from demand-side policies (caused by monetary policies and shocks) to supply-side policies (derived from the role of technology in reducing costs and increasing production).

Two phenomena contributed to this shift in economists' approach from monetary factors to real factors in the formation of business cycles. The first factor can be attributed to events that occurred in the 1970s, such as the first oil shock in 1972–1973, the famine in Africa in 1973–1974, and the Iranian revolution (the second oil shock) in 1978–1979. These events caused significant fluctuations in the supply side of the economy, emphasizing the importance of supply factors in business cycles.

The second important factor can be attributed to the studies and articles of economists such as Kydland, Prescott, Nelson, and Plasser. They attempted to demonstrate that real tensions are more important in explaining business cycles than monetary tensions. They arrived at the significant conclusion that the hypothesis that GNP follows a random step cannot be rejected. In other words, they believed that most changes in GNP are permanent. This implies that when the economy experiences a shock, there is no force or motivation to bring it back to its original level. The results of their studies support the theory that if productivity tensions caused by technological changes are random, the resulting product exhibits business cycles following this random pattern. In this case, fluctuations observed in GNP represent fluctuations around the trend of natural production rate, rather than deviations from the smooth and specified path of the product. Traditionally, economists separated the analysis of growth from the analysis of economic fluctuations and studied each as separate approaches.

In summary, the central argument of economists in favor of real business cycles is that economic fluctuations are caused by changes in real variables. Consequently, economic agents behave rationally and do not make systematic errors. An economy is always in equilibrium, which is not a classical or idealized condition but a continuous one. Therefore, the conditions mentioned above hold true even in the short term. Unlike Lucas and his associates, supporters of RBC believe that nominal variables such as the money supply and price level do not affect real variables like employment and production. They argue that it is these real variables that can explain the behaviors and fluctuations of other real variables. Economic agents, benefiting from rational expectations, only deviate from their behavior due to unannounced and unanticipated factors. In the shortest period of time, new data will be incorporated into their rational model, leading to a return to equilibrium conditions.

Consequently, government stabilization policies, such as financial and monetary policies, have no impact on the behavior of real variables. Only unexpected policies, for example, can temporarily move employment away from its long-term natural rate, but this deviation is not persistent since systematic errors do not occur. RBC proponents believe that the cause of tension and fluctuations in the economy is related to fluctuations on the supply side. They argue that the root of these changes is actually changes in technology. They contend that significant fluctuations in technology increase productivity and cause the economy to quickly transition from one long-term stable path to another.

RBC and Recessions a Comprehensive Analysis

The RBC theory suggests that economic fluctuations are primarily driven by changes in real variables, with technology shocks playing a central role.

As mentioned in the previous sections, one of the most significant criticisms of RBC theory concerns the concept of technology. Opponents question how technology, which is believed to contribute to economic prosperity, can also explain recessionary conditions. We know that when a technology shock occurs and raises the technological level of a society, it will not go back and also sometimes it will completely change the economic nature of the country. The real business cycle theory believes that economic growth arises from the shock of technology and creates employment, so the question we are looking for an answer to is how to justify this economic stagnation because we know that in the process of technology growth, there is no backward movement.

The severity of this problem compelled RBC leaders to address it. Hansen and Prescott (1993) responded to this fundamental objection by stating that in a growing economy, positive technological change over time accompanies a shift in the location of production facilities. This shift involves improving and upgrading the production process or inventing new processes. They identified the root of positive technological change as the growth of knowledge. They believed that while the accumulation of knowledge does not decrease, every country has rules and regulations that govern the conduct of economic activities. These rules and regulations are fundamentally important in terms of motivating the use of more advanced technology and providing the necessary resources for utilizing existing technologies. Government or administrative system should take steps to facilitate the adoption of new technology.

On the other hand, governments and systems that divert employers' creativity from improving technology toward rent-seeking activities have a negative effect on technological growth. Therefore, changes in legal systems can have both positive and negative effects on technological advancements. Consequently, the inputs, goods, and services exchanged in the market depend on the economic inputs existing within the legal structure of a country. In other words, the reasons identified by Hansen and Prescott (1993) can be attributed to the role of technology shocks in recessionary conditions and their relationship to the legal structure of society. Thus, it can be concluded from the aforementioned points that the role of government in approving laws and implementing them is of great importance, particularly in developing countries. The main point here is that sometimes governments, through the establishment of special laws and regulations, create conditions where technology loses its efficiency and cannot have an effect on economic growth, and because of this, the economy will stagnate.

In emergency situations, the issue is completely different, for example, during the COVID era, many projects were not implemented due to the existing conditions, and the world was shocked, which, according to RBC, was the inability to use existing technologies. For example, the modern transportation system failed with this incident. This was not due to the rules and regulations but due to the emergency situation. Therefore, the solution proposed by RBC proponents was a kind of deregulation, they believe that the economic recession will be aggravated by government intervention. The RBC theory played a significant role in shaping the executive environment of industrialized countries, and it is through their strategic guidelines that the West has prioritized deregulation over the past two decades.

RBC and Employment

Today, there are two different views regarding the impact of technology on employment. The first view is based on the principle that technological changes can lead to the use of new tools that eliminate the need for human labor as a factor of production, including management. This can potentially result in a crisis of unemployment and subsequent social crises. Essentially, technology plays a crucial and fundamental role in economic growth and development (Reddy, 1996; Reisman, 2005). Since countries around the world cannot independently produce all the technologies, they require due to the accumulation of diverse knowledge, the transfer and exchange of technology have become customary globally (Shamsavari, 2007).

Of course, technology transfer can occur through various methods such as mergers and acquisitions (M&A), alliances, foreign direct investment (FDI), franchises, joint ventures, licensing, multinational enterprises (MNEs), research and development (R&D), and spin-offs. It can have numerous effects on the economy.

Technological changes can have different impacts on sectors such as efficiency and productivity, wages, organizational relations, sales, and so on. Employment is one of the most significant sectors affected. In other words, technological changes can directly and indirectly influence the labor market (Haile et al., 2016; Harasty et al., 2003; International Labour Office, 2013). Concerns about the negative consequences of technological changes are particularly pronounced in developing countries, as they believe that the increased adoption of new and modern technologies can exacerbate the unemployment situation in those nations (Bogliacino et al., 2011).

In some of these countries, this problem has caused resistance among employees in the traditional sector toward technology transfer, creating numerous problems for the governments (Jenkins, 2006). Blanchard and Wolfers (2000) believe that the labor market is influenced by various factors, the most important of which is the market structure. The establishment of institutions related to this market, such as labor unions, can play a significant role in how economic interactions affect the labor market.

Regarding the effects of changes and shocks in technology and productivity, there have been various studies that yielded different results. For example, Maidorn (2003) discussed the negative impact of productivity shocks on the unemployment rate in Australia. Conversely, in this economy, the impact of technology and productivity shocks on the labor market has led to a decrease in unemployment.

According to the ILO (2013) report, despite the increase in advanced technology in the world, the root cause of unemployment in the United States and Western Europe is not solely based on technology shock and the replacement of labor with technology. Trehan (2003) and Duarte and Marques (2009) show that in the last few decades, despite the introduction of new technologies in the West, many regions in the United States attribute the root cause of unemployment to the structure of their labor market. In other words, institutions such as labor unions, and labor political parties have been more stringent in these countries compared to the United States due to inflexibility and insistence on labor contracts based on collective bargaining and union coverage. For instance, concerning other labor market institutions, the existence of insurance or various unemployment benefits in such countries can have different consequences on the labor market when faced with technology shocks.

On one hand, technology shocks can lead to an increase in skills, a decrease in transaction costs, and an increase in exchange volume, all of which can somehow contribute to increased employment. On the other hand, it can result in the loss of certain workforce skills, wage decreases, and ultimately an increase in unemployment.

The conflicting results regarding the effect of technology shocks on the unemployment rate can be better explained by the RBC theory. Generally, the effect of technology shocks is considered to be an instantaneous phenomenon. However, the technology shock considered in the RBC theory is a combination of several shocks that can have positive or negative effects on the unemployment rate in different economic sectors, with a positive outcome in the RBC theory. RBC proponents believe that technology shocks are what drive the economy from one level to a higher level, bringing about economic prosperity. During an economic boom, the gross domestic product (GDP) grows, and there is no doubt about this. However, this does not necessarily mean that production increases in all sectors or that prosperity occurs uniformly across all sectors. There is no doubt that technology can cause some jobs to disappear, but this is not a static phenomenon, since technology covers all sectors of the economy, so it should be viewed as an integrated system. Therefore, the real business cycle has solved the problem. As the economy moves to a higher level during the boom period, both production factors and employment increase.

It is clear that technology in Canada is no longer comparable to the past, as new technologies are now widely available. From the 1950s onward, we may be able to relive the amenities of the 20 s, but from 2023 onward, we cannot go back because the economic fabric of today is now based on technology, such as banking systems, transportation, and digital markets. As technology is a completely new phenomenon that cannot be controlled without it, its significance in today's society cannot be ignored. In the recent years, Canada had one of the highest internet penetration rates in the world, according to statistics Canada and the International Telecommunication Union (Middleton & Leith, 2021).

Internet usage may be one of the major factors affecting the growth of technology in Canada during this period. Mobile Technology usage could also be a factor

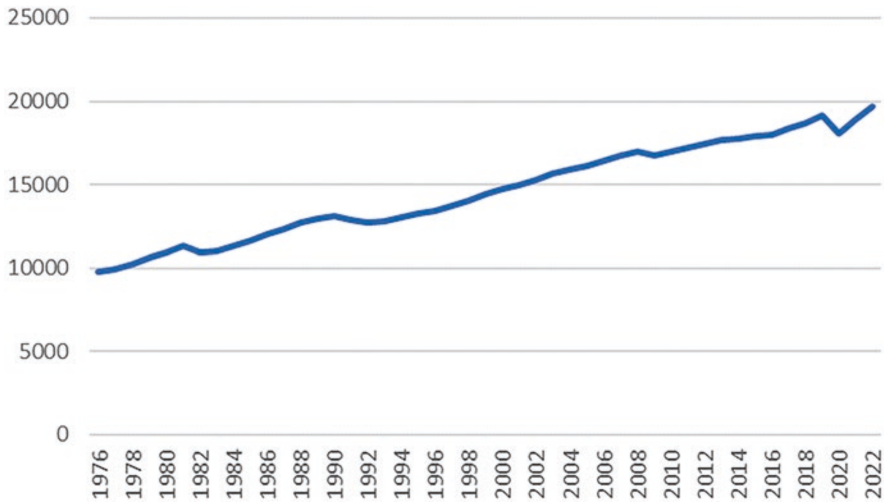

Fig. 1 Employment growth in Canada between 1976 and 2022 (rate per 1000 people). Source: Composed by Author based on data from Statistics Canada

showing the growth of technology levels.[1] (Hicks et al., 2023). In other words, we have experienced of higher level of technology in Canada in many ways, Canada's workforce has undergone many changes, and with increasing automation and digitalization (such as Canadian oil and gas industry), increasing population, increasing understanding of the importance of diversity and its inclusion in the workplace, these changes will change the shape of the labor market in the future. But the number of employments in the retail market during the years except the time of COVID-19 and recessions,[2] raised up as shown in Fig. 1.

Therefore, despite higher levels of technology and an increase in unemployment rate in Canada, which we discussed in the RBC theory, it is not related to the business cycle but to other factors.

When a boom happens, it means that the entire economy is experiencing growth. There may be a recession in a particular part, but that part is not decisive for the entire economy, as the sectors experiencing prosperity are dominant. This is also true for employment. Whenever there is an economic boom driven by technology shocks, the unemployment rate will inevitably decrease. Although a set of jobs may be lost in one part of the economy, the overall economy will increase its demand for labor, leading to a decrease in the unemployment rate.

[1] To read more about the effects of extensive use of mobile phones on health and recommendations in this field from researchers, you can refer to the following source: Hicks et al. (2023).

[2] For more information about recession in Canada, see: The "Great" Recession in Canada: Perception vs. reality. (n.d.). Bank of Canada. https://www.bankofcanada.ca/2011/03/great-recession-canada-perception-reality/.

Conclusion

In conclusion, this chapter examined the real business cycle (RBC) theory and its implications for the employment rate in the context of technological advancements. The RBC theory argues that economic fluctuations are primarily driven by changes in real variables, such as technology shocks and productivity changes. Proponents of RBC believe that economic agents behave rationally and that the economy is always in equilibrium, with deviations from equilibrium being temporary and quickly corrected. The analysis in this chapter explored the shift in focus from monetary shocks to real shocks in explaining business cycles, highlighting the contributions of economists such as Kydland, Prescott, Nelson, and Plasser. The chapter also discussed the criticisms of the RBC theory, particularly regarding its ability to explain recessions and the role of technology in economic stagnation.

Additionally, the impact of technology shocks on employment was analyzed, with conflicting results from different studies. The RBC theory suggests that technology shocks can lead to both job displacement and job creation, as technology affects the entire economy as an integrated system. Finally, the chapter highlighted the growth of technology in Canada and its impact on employment, showing that despite technological advancements, employment rates have continued to rise except during recession. Overall, the RBC theory provides insights into the relationship between technology and employment, emphasizing the importance of understanding the complex dynamics of the labor market in the face of technological change.

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Convergence in Financial Systems: Fintech, Big Data, and Regulatory Standards

Kabiru Sunday Ayinde, Pooja Lekhi, and Mahdi Toobaee

Abstract The chapter considers how financial systems are converging with respect to financial service players, big data, and regulations. The role of influential players such as FinTech, Neo-Banks, Big Tech, and Big retailers is increasingly important. These new players are flexing muscle with the established financial institutions to win customers' minds and market share. The days of holding and keeping consumer data in a silo are gone as technology has made data mining of this big data a veritable source of service and product innovation through optimization. On the regulation side, the regulatory environment is becoming more permissible allowing for increased collaboration and convergence between the market and the regulators to safeguard the soundness of the financial system. This convergence is, however, without its own challenges because attaining and sustaining coordinated uniform global financial regulation are ongoing efforts that require careful consideration. Meanwhile, achieving financial inclusion and sustainable financial environment are hinged on a uniform financial regulation standard.

Introduction

Conventionally, financial institutions offer services such as savings and checking accounts, credit cards, loans and advances, investment, and insurance products. However, in the contemporary period, deregulation and institutionalization of financial services have led to the blurring of boundaries between financial institutions, insurance, and pension firms, thereby resulting in financial services convergence.

K. S. Ayinde (✉) · M. Toobaee
Department of Quantitative Studies, University Canada West, Vancouver, BC, Canada
e-mail: sunday.ayinde@myucwest.ca; mahdi.toobaee@ucanwest.ca

P. Lekhi
University Canada West, Vancouver, BC, Canada
e-mail: pooja.lekhi@ucanwest.ca

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This convergence is noticeable in the spread of products and services as financial institutions deploy expertise into new markets and frontiers. Some banks, especially in North America and Europe, where regulations permit it, have acquired universal banking licenses that allow financial institutions to offer a broad range of services, including investment, payment services, Insurance, and other related products. Many observers see this step as a significant strategic move by financial institutions to outplay competitors in the financial market.

Another example is Investment banking, where banks stretch their arms into areas such as Wealth Management, Trading in financial instruments, etc. Interestingly, the Insurance companies are also laterally converging into the financial services sphere by offering loans and mortgages, territories outside their domains.

A further illustration of this convergence is the payment service system. Canada is in the process of launching Real Time Rail, a 24/7/365 payment system that leverages on ISO 20022 message specifications. Unlike the in-market solution such as Interac that allows an individual to make payment in real time without data enrichment, the Real Time Rail payment solution fills the existing gap in payment challenges experienced by small and medium business and corporate entities. It enables irrevocable faster payment with data enrichment and enhanced analytical insight that meets business needs, e.g., e-invoicing. Already, Payment Canada is collaborating with financial institutions, Fintechs, and non-bank payment service providers to ascertain delivery assurance and assess the operational readiness before it is launched later this year (Payment Canada, 2023).

The key drivers of this convergence are changing consumer taste demography, technological trends, and regulatory environment, Turi (2020a). For instance, the otherwise 'sacred' institutions are constantly being challenged by newcomers such as Fintech, giving rise to adaptability and innovation. Some of the previously held beliefs that digital transformation is expensive, unsafe, and unsecured are being debunked daily. Adaptability is making financial institutions to be more accommodating of changes that come with technology.

Innovation is backing and revalidating banking core businesses and activities as banks continue to act as the economic engine room, Turi (2020b). Every financial institution is in a race to retain market share and remain relevant in this ever-evolving dynamic financial market ecosystem. The overall resultant effect of this is the acceleration and delivery of engaging financial services product offerings that provide the client with a new experience (Puschmann, 2017). Convergence of financial services cannot only be explored in isolation if the role of non-financial institution players such as Fintech and other retailers are not discussed. Furthermore, the chapter explores the impact of big data and permissible policy from regulators across jurisdictions that have aided this astronomical growth in financial services innovations.

Innovations in Financial Services

In a similar way that the financial institutions are reaching out into new markets and frontiers, bringing on board new products and service offerings to retain and reclaim market share; the new non-financial institutions are deploying innovative and agile business processes to capture and attract the existing and potential customers of these financial institutions.

Fintech

Of all these new "intruders" into financial services—Fintechs, Neo-Banks, Big tech, and other retailers, FinTech stands out as they have proven over the century to be the principal challenger to the established financial institutions. Fintechs leverage information technology to offer financial services that provide improved consumer experience. Due to their lean structure and business agility, Fintechs innovate faster than legacy financial institutions, Turi (2020b). The established financial institutions are often locked in an endless complex relationship of certifying to the regulators of their compliance with the extant rules and regulations while simultaneously striving to satisfy customers' requirements.

The use of the phrase Fintech has been a common language in recent years even though the word is not essentially a new lexicon in the world financial services dictionary. As a matter of fact, the keyword Fintech has been around since 1865 (Fig. 1) when for the first time, telegraph and railroad were used for the transmission of

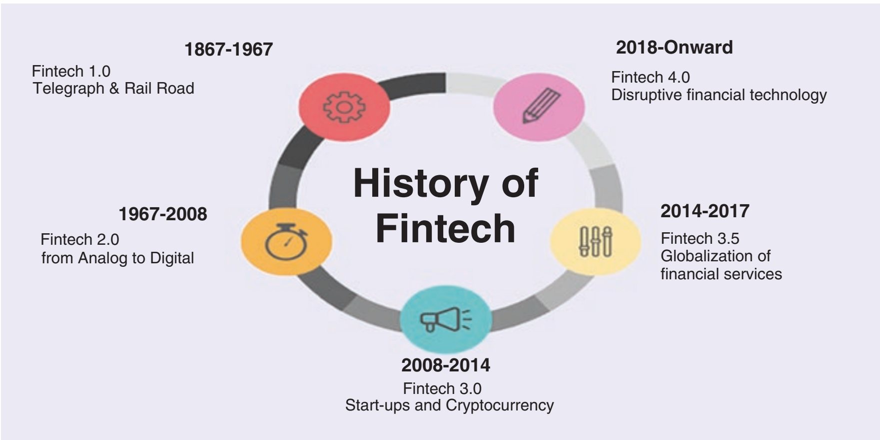

Fig. 1 Evolution of Fintech. *Note*: Evolution of Fintech from 1867 till date. Source: Author inspired by work of The Payment Association (2020)

financial information across borders, an era that is acknowledged as Fintech 1.0 (1865–1967).

Between 1967 and 2008, there was a migration from analog to digital with the introduction first Automated Teller Machine (ATM) and the establishment of the Society for Worldwide Interbank Financial Telecommunications (SWIFT) that facilitates cross-border payment using predefined communications protocol between financial institutions around the world, an era identified as Fintech 2.0. After that, the global economy witnessed one of the world's biggest economic meltdowns in 2008, with the collapse of major banks in the United States causing a reverberating global credit crunch. This global financial meltdown gave rise to another era between 2008 and 2014 known as Fintech 3.0 and led to coming on streams of new start-ups in the financial space.

This fascinating period also saw the emergence of Bitcoin (Cryptocurrency) into the financial space and the proliferation of the financial market with Smartphones, which provide more access to many people to plug into Internet services. The rise in financial services accessibility and inclusivity resulted in increased globalization of financial services across the world with more and more new entrants, especially in developing countries, an era distinctly identified as Fintech 3.5, which covers the years between 2014 and 2017.

From 2018 onward, the period is described as an era of disruptive financial technology with the application of blockchain technology and Open banking, which led to the emergence of Neo banks, challenging the configuration of the established financial system by demystifying banking services through leveraging digital platforms to scale and lower fees to improve customer experience.

Neo Banks

Neo Banks are often seen as rival banks. They are a digital-only bank that operates without a physical presence and comes in two variants. The full-stack neo bank has its license and operates independently, and the front-end neo banks are affiliated with the existing financial institutions. According to Globe Newswire (2023), the world Neo bank market stands at USD 47.39 Billion globally in 2021 and is projected to reach USD 927.12 Billion by 2028, at a healthy CAGR of 52.93%. This growth can be attributed to the increasing trend of digital banking and the rising number of customers who prefer the convenience and security of managing their bank accounts digitally. Additionally, the increasing use of mobile banking services and the emergence of new technologies, such as artificial intelligence and blockchain, contribute to the neo-bank market's growth. Neo-Banks offer narrow financial services, they earn non-interest fees largely by charging customers' debit/credit cards when they transact online.

The digital financial ecosystem has also witnessed the entrance of Big techs such as Apple, Amazon, Samsung, Google, and Facebook (tech giants), especially in payment and credit cards, leveraging their robust technology and computational power to process big data from customers purchasing or subscribing to their goods and services. In the year 2020, Google, Apple, and Samsung widened their reach in payment mobile apps as payment through credit/debit cards dominated mobile online payment. Favored by the COVID-19 pandemic, the market value of these tech giants soared as they leveraged cross-subsidization to penetrate the financial services ecosystem. For instance, in the United States, while the market value of incumbent banks stood at $2.1 trillion, the Big techs grew to the tune of $4.6 trillion in market capitalization as of December 2022.

Big Tech continues to deploy competitive financial services that are appealing to customers to enhance brand loyalty. It has been very deliberate and strategic in their approach to play in the financial services marketplace. With a prime focus on payment and credit systems, they have been luring existing and potential customers into financial services solutions by offering competitive payment options and credit services to complement their core business.

Similarly, large retailers such as Walmart, Real Canadian Stores, and Costco are entering the financial services space by taking advantage of their large customer base. Unlike Fintech, Neobanks, and Big Tech, the large Retailers are offering limited unsecured credit card services and payment systems with relatively small market share. The idea behind all these offers is to retain their customers and improve the overall customer experience. On a broader outlook, there is continuous convergence of different sectors in the financial services space, from retailers, technology companies, and giant e-commerce while the financial institutions are equally converging into other areas of expertise to widen their reach and maintain market position.

Big Data

Another important area where the financial system convergence is noticeable is in Big Data processing and management. Before Big Data and cloud services, most financial data, i.e., customer information and transactional data, are held in a silo in different departments and functions. It is considered good practice for each department to work independently and manage their workflow to guarantee the safety of financial information in the financial institutions.

However, this practice inhibits the financial institution's ability to innovate and deliver greater value to satisfy customers' needs. The core of financial system innovation is consumers' data. Financial institutions are in the business of trading consumer information as Big data takes a pre-eminent role in product design and service offerings (Awotunde et al., 2021). From Retail banking, Commercial banking, Investment banking, Asset management, and Insurance, consumer data is increasingly being used for processing transactions, preparing ledger accounts, approving, or declining credit requests, designing risk management frameworks, and general banking business. Although it is difficult to quantify the value of data, its relevance to the digital economy is apparent because it is essential to innovation design which demands and requires fresh insights.

In the first instance, the process of financial intermediation requires financial institutions to collect data from their customers, which is subsequently stored in their databases. This data is used to develop liability and assets products and a couple of other services like card issuance and online payments from which banks earn non-interest income. There has been, however, an increase in the variety and volume of data generated and stored by financial institutions as processing powers increase. This has also necessitated the need for financial institutions to design and develop a data architecture that can optimize this raw data for value accretion.

For instance, beyond the routine transactional journals banks analyze, banks can develop tools and services that explore customers' complaints, queries, and feedback using the data they have collected via their social media platforms during customer engagement and interactions.

Also, aside from the inherent value of Big Data and consumers' quest for control of their personal data due to safety concerns, the protection of personal data is a prerequisite for designing an innovative financial service that consumers can trust and have the confidence to use. The speed of data generation second by second has led to a wave of data sharing between financial institutions, industry regulators, and other stakeholders. This avalanche of information gathering and data gathering requires analysis which is a crucial process for extracting value and meaning further exposing consumers.

Rising to the occasion of addressing customers' concern for safety, third-party software developers (Fintech) are collaborating with financial institutions to develop data analysis capability to bring out values from this large data storage. Before this collaboration, the established financial institutions were initially scared of the impact of the collaboration on their ability to generate and sustain their revenue model. However, the financial institutions learned over time that strategic alliance with Fintechs allows them to generate higher interest and non-interest income, resulting in a win-win situation. The banks require this alliance to optimize the use of consumers' data in their custody. Statistics showed that Only 16% of banks (Hilten & Diukiv, 2022), considered themselves "exceptional" in extracting value from consumer data. Interestingly, banks are now going beyond storing customers' data to extract meaning and improve products and services offered to benefit their teeming customers.

Fintech is also leveraging its relationship with financial institutions to develop low-cost innovative financial services through Big Data. For example, in an Open banking ecosystem, example of this collaboration, customers have access to a dashboard of all their linked accounts in different financial institutions, which offers helpful insight into their financial position. Additionally, through FinTech, software developers and technology businesses are seizing opportunities in the financial space (Turi, 2023). For instance, they noticed an opportunity to develop new apps that address specific unmet needs of their target and launch bespoke financial solutions software with capabilities for planning, scheduling, spending, and making an enlightened investment decision. Consumers who are sometimes not interested in budgeting and financial "jargon" are now making informed financial decisions about their personal finances through apps that offer personalized financial solutions from these Fintechs because of the convergence of consumer data. Indeed, the advent of Big Data has accelerated the convergence of financial services both within and outside the financial institutions in terms of processes, storage, analysis, and synthesis of consumer data for value creation.

Convergence of Regulatory Standards

Achieving regulatory standards convergence has been the major focus of major economies post-financial credit crunch in 2008. The incentives for convergence of regulatory standards are apparent both from sustainability and financial inclusion angles. Securing the environment's future and our economy lies in regulatory convergence across different regimes. For instance, the mandatory environmental, social, and governance (ESG) requirements in major economies help investors and consumers to evaluate the financial risk of doing business or investing in any financial institution based on environmental, social, and corporate governance practices.

Driving financial inclusion through financial technology is hinged on common standards and best practices that ensure a fair market to promote global competition. A noticeable trend in this regard can be observed in the way countries and different regions across the globe are adopting similar regulatory frameworks and guidelines to enhance international cooperation and guarantee the safety of financial systems. In its design, regulatory standard convergence can come in the form of harmonization of technical standards or adoption of similar legal frameworks depending on political and socio-economic ties between nations. An illustration of this type of convergence framework is the European Union standards that seek to harmonize safety standards and financial reporting requirements among member states.

Because the global financial systems are interwoven, regulatory standards convergence is so important to guarantee the stability of the world economy. Additionally, it is the panacea to innovation and competitiveness because it ensures fair play among market participants in different jurisdictions across the world. It is also a verifiable means of blocking loopholes that can be exploited within the financial system across different regimes. Despite this justifiable reason for a desirable uniform financial system regulatory standard across the world, there appears to be a major challenge in achieving this goal at a global level.

Firstly, it takes work to achieve convergence of financial technology across different regimes. For example, Fintech, by their design, contributes to financial services innovation and there has been a concerted effort to tighten policy and measures on them, especially those they offer investment and hedge funds services. But the global nature of Fintech incentivizes it to explore loopholes in regulations. And this impacts financial system stability, competition, and the safety of investors. A fresh case in view is the collapse of Silicon Valley Bank—a Start-up Fintech for tech folks—in the United States. The quick intervention of the government averted what would have been the beginning of the collapse of the world financial systems.

Secondly, achieving convergence requires global coordination and cooperation between inter-government agencies across different regimes, which is herculean to achieve. Because socio-economic strategic priorities of nations differ from coast to coast. While some nations are focusing on strengthening their financial institutions through policies that encourage fair competition with the rest of the world's financial markets, some countries are unwilling to expose their financial institutions to external interferences and influences because of either perceived or real disadvantage in global competitive index.

Lastly, the implementation of regulations across different jurisdictions varies, thereby impacting the outcome of such policies. Even instances when nations agree to support a targeted regulations that promote uniform global financial regulation, the timing of implementation of such agreed policies is not the same as political exigencies and economic priorities override the implementation timeframe.

Regulation Convergence Case Study: Adoption of Open Banking Framework in Canada Using Hybrid Model

In January 2023, Canada kicked off the implementation of its Open banking model. The design and implementation analysis of this framework is based on exploration of opportunities inherent in financial market regulation convergence. The uniqueness of this model is not only in its name, consumer-directed finance but also its design and implementation framework. It is tailored to exploit market-driven rules and regulatory-driven guidelines. Canada took a conscious and deliberate effort to develop a highly customizable open banking structure. The option to run a flexible market-driven and regulatory supervised model allows for regulated financial innovations that would be easier to track and trace before anything goes out of hand. The commitment of the government, financial institutions, FinTech, Self-regulatory organizations, and other interested parties has been very warm and cheering.

Table 1 illustrates how Canada's Open banking framework compares with the United States, the United Kingdom, Europe, and Australia. In this framework, Canada adopted a hybrid open banking model where it combines regulatory and market-driven approach. A closer look at the design elements comprising type of services, data sharing technical standards, lead regulatory/policy mandate, and cost distribution show that Canada's framework permits a market-driven approach. However, the design components relating to target participant, type of data, mandatory/voluntary, phase implementation, governance structure, data privacy and portability, and liability and consumer protection, the country opted for a regulatory approach. This type of novel approach is expected to be on the rise as market participants and regulators adapt and respond to rapid changes in technological financial innovations.

Table 1 Regulatory Convergence in focus—Open Banking in Canada

Design components	Canada's framework	How it compares with other jurisdictions?
Types of services—Broad or targeted	Broad services	Similar to the United States (market driven)
Targeted participant	Federally regulated banks, province regulated credit at liberty to join	Similar to Australia and the United Kingdom (regulatory driven)
Types of data	Account data and derived data	Similar to Australia and the United Kingdom (regulatory driven)
Payment initiation	Excluded for now due to risk	None
Mandatory/voluntary	Combine approach	Similar to the United Kingdom
Data sharing technical standards	Nine-month time frame to develop it	Market/regulatory driven
Phase implementation	Two-phase (first 18 months and beyond 18 months)	Australia, Europe, and the United Kingdom
Lead regulator/ policy mandate	Lead regulator	Market-driven approach
Governance structure	Phased governance approach	Similar to the Australia
Cost of distribution	Accreditation cost identified. Infrastructural cost undefined	Market-driven approach
Data privacy and portability	Digital Charter Implementation Act (2022)	Similar to the Australia
Liability and consumer protection	Party at faults	Similar to Australia

Note: Regulation Convergence—How Canada's Open banking framework compares with the United States, the United Kingdom, Australia, and Europe
Source: Authors' composition

Conclusion and Recommendations

In the final analysis, the drive to attain convergence in financial service is a desirable goal that requires concerted efforts. One important step to achieve this noble ideal is the need to carefully design financial system innovations around consumer data. Working on this piece of large data set requires not only the financial institutions but also other non-financial institutions that have developed capabilities around information technology that source, process, and gather insight from these valuable consumer resources. Joint efforts of this nature require regulatory oversight that guarantees the safety of consumers' data and ensures fair play to all market participants.

Hence, the convergence of financial systems around financial service participants, consumer data, and regulatory standards are ongoing effort to support innovation. Though there are associated costs that come with it, the overall benefit has potential to contribute to the stability of the world financial system because of its impact on inclusivity and sustainability.

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Sustainable Innovation and Industry 5.0: The Future of Industrial Progress

Azadeh Eskandarzadeh

Abstract The world faces unprecedented environmental and social challenges, and industries have major impacts on our planet. For a sustainable future, it is crucial to embrace sustainable innovation and advance toward Industry 5.0, a model that integrates environmentally responsible business practices into its core operations. Considering this, this study addresses sustainable innovation and Industry 5.0's importance and potential benefits. Additionally, the study examines the difficulties associated with implementing sustainable innovation and provides examples of sustainable business practices from a variety of industries. The conclusion of the study focuses on environmentally conscious innovation and Industry 5.0, as well as the roles of stakeholders in sustainable industrial development.

Background of the Study

In this work, we look into the advancements in Industry 5.0, considering sustainable innovations and industrial progress with the paradigm shift in the face of uncertainties with the looming environmental and social challenges. While picking into this timely topic, let us review two relevant notions and practices to lay a conceptual foundation for the analysis that follows.

A. Eskandarzadeh (✉)
University Canada West, Vancouver, BC, Canada
e-mail: azadeh.eskandarzadeh@ucanwest.ca

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Sustainable Innovation

Sustainable innovation is a strategic approach to product development and design that aims to create sustainable products, services, and processes while taking into consideration the entire product lifecycle, from the sourcing of raw materials to final disposal (Hockerts and Wüstenhagen, 2010). This approach requires a holistic perspective that considers the environmental, social, and economic impacts of the product, and seeks to generate equitable and long-lasting benefits in these domains (Schaltegger and Wagner, 2011). To achieve sustainability, the innovation process must integrate environmental and social concerns into the design and development process, as well as into the overall business strategy (Boons and Lüdeke-Freund, 2013).

This includes addressing the use of nonrenewable resources, reducing waste and pollution, creating social and economic benefits for local communities, and fostering a sustainable culture within the organization. Furthermore, sustainable innovation can aid businesses in reducing costs, enhancing competitiveness, and generating new market opportunities (UN Global Compact, 2015). Accordingly, it is an indispensable instrument for achieving a sustainable future and addressing the challenges of climate change and social inequality.

Industry 5.0

Industry 5.0 is an emerging concept that is attracting the attention of both academics and industry professionals due to its focus on sustainability and social responsibility. Industry 5.0 represents a paradigm shift toward a more holistic approach that acknowledges the importance of environmental and social impacts in addition to economic benefits (Schuh et al., 2020). The core principles of Industry 5.0 include the incorporation of sustainable and environmentally friendly products, the promotion of social responsibility and inclusiveness, and the integration of advanced technologies such as artificial intelligence, robotics, and the Internet of Things. This shift toward Industry 5.0 is motivated not only by the need to address environmental and social challenges but also by consumers' and investors' growing awareness of the role of corporations as responsible corporate citizens. Industry 5.0 possesses a considerable potential for promoting corporate social responsibility and sustainable practices that are advantageous to society (Pereira et al., 2021). Nevertheless, the implementation of Industry 5.0 necessitates significant changes in organizational culture, business models, and supply chain practices, as well as collaboration and cooperation among the industry's various stakeholders.

An Integration of Sustainable Innovation and Industry 5.0

To address global challenges such as climate change, resource depletion, and social inequality, it is essential to integrate sustainable innovation with Industry 5.0. Sustainable innovation is essential for developing products and procedures that minimize environmental impact and advance social and economic equity (Schaltegger and Wagner, 2011). With its emphasis on integrating the physical and digital worlds, Industry 5.0 presents an opportunity to optimize production processes, reduce waste and energy consumption, and develop new business models that support sustainable development (Atzori et al., 2014). The integration of these two concepts can facilitate the development of intelligent and interconnected production systems that can respond to the needs of society and the environment (Golinska et al., 2019). This integration can also facilitate the development of circular economies that reduce waste and encourage the recyclability of materials and resources (Tukker et al., 2016). By integrating sustainable innovation and Industry 5.0, businesses can realize significant cost savings, boost their competitiveness, and enhance their social and environmental performance (Boons and Lüdeke-Freund, 2013). Ultimately, the combination of sustainable innovation and Industry 5.0 is required to create a more sustainable and equitable future for all (UN Global Compact, 2015).

Literature Review

In the literature, several authors have focused on sustainable innovation and its potential for improving sustainability in various sectors. For instance, Hockerts and Wüstenhagen (2010) argue that sustainable innovation can lead to more eco-friendly products and methods, as well as enhance resource efficiency. They propose that sustainable innovation can be achieved through the integration of environmental and social concerns into the innovation process. Bocken et al. (2014) further emphasize the importance of cross-disciplinary collaboration in achieving sustainable innovation. They suggest that engineers, designers, and sustainability experts need to work together to develop products and processes that consider environmental and social impacts.

Industry 5.0 has also been a topic of interest in the literature, with researchers focusing on its potential to increase production efficiency and competitiveness. He et al. (2021) present a theoretical framework that illustrates how Industry 5.0 can contribute to environmentally sustainable development. They suggest that the implementation of Industry 5.0 can result in long-term innovation and competitive advantages. Similarly, Javed et al. (2021) conducted a systematic review of the literature and identified the need for additional empirical research into the effects of Industry 5.0 on sustainability. The authors' review sheds light on the current state of research and highlights knowledge gaps that can be explored in future investigations. The green potential of Industry 5.0 was proposed by Wiek et al. (2021a). Sustainable development in the areas of environment, economy, society, and technology are prioritized in their framework. The authors suggest looking into the relationship between these four elements using a multi-level strategy. They also stress the need for interdisciplinary groups and stakeholder input in environmental impact assessments of Industry 5.0.

There is also a growing body of research examining the integration of Industry 5.0 and sustainable innovation. Scholars have emphasized the potential of Industry 5.0 to advance sustainable development and corporate social responsibility (Pereira et al., 2021; Schuh et al., 2020). By integrating sustainable innovation into production procedures, Industry 5.0 can speed up the creation of new eco-friendly goods and methods (Hockerts & Wüstenhagen, 2010). Researchers have also identified specific areas in which Industry 5.0 can contribute to sustainability, such as the development of environmentally friendly products and processes, the reduction of waste and resource usage, and the promotion of social responsibility and inclusivity (Fernández-Sánchez et al., 2020; Prakash et al., 2021).

Moreover, academics have identified a number of obstacles that must be overcome for the successful integration of Industry 5.0 and sustainable innovation. For instance, Bocken et al. (2014) emphasized the significance of developing environmentally, socially, and economically sustainable business models. Schuh et al. (2020) also emphasized the importance of a regulatory and policy environment that fosters innovation, collaboration, and responsible behavior. Moreover, several case studies have investigated the implementation of Industry 5.0 and sustainable innovation in various industries. Prakash et al. (2021), for instance, analyzed the implementation of Industry 5.0 in the construction industry and identified the potential for digital technologies to reduce waste and enhance resource efficiency. Fernández-Sánchez et al. (2020) investigated the implementation of Industry 5.0 in the automotive industry and emphasized the significance of stakeholder collaboration in promoting sustainable practices.

Survey Methodology

In this study, we adopted a systematic survey methodology, reviewing literature from the Scopus, Web of Science, and Google Scholar databases. We focused on articles from 2018 to 2022 using key search terms such as "sustainable innovation," "Industry 5.0," "sustainability," "manufacturing," "production systems," "methodology," and "empirical studies." After a thorough screening process, we selected ten relevant articles. These selected articles offered insights into the integration of sustainable innovation and Industry 5.0 within the manufacturing industry. The literature suggested potential benefits, such as enhanced sustainability, efficiency, and competitiveness. However, it also highlighted challenges like difficulties for SMEs in adopting new technologies and ensuring alignment with broader sustainable development objectives.

The study points to the potential of sustainable innovation and Industry 5.0 integration in fostering a sustainable future for the manufacturing sector. It also suggests the need for additional mixed-method empirical studies to fully understand the sustainability impacts of Industry 5.0. According to the reviewed literature, synergizing sustainable innovation and Industry 5.0 can greatly enhance sustainability, efficiency, and competitiveness in manufacturing processes (Hockerts & Wüstenhagen, 2010; Kagermann et al., 2013).

Moreover, Wiek et al. (2021a) have proposed a framework that considers the environmental, economic, social, and technological dimensions of sustainability and highlights the importance of stakeholder participation and multidisciplinary teams in advancing sustainable innovation. He et al. (2021) also proposed a theoretical framework and investigated the impact of Industry 5.0 on sustainable progress using Chinese manufacturer data. The results suggest that Industry 5.0 has the potential to enhance long-term creativity and drive sustainable progress.

However, some challenges obstruct the smooth integration of sustainable innovation and Industry 5.0. For instance, Small and Medium-sized Enterprises (SMEs) might face difficulties adopting novel technologies and practices due to the requisite investment and system modifications (Javed et al., 2021). Additionally, it is crucial to scrutinize the sustainability implications of these new technologies and processes to ensure alignment with broader sustainable development objectives (Hockerts & Wüstenhagen, 2010).

Integration of sustainable innovation and Industry 5.0 has the potential to create a sustainable future in the manufacturing industry. This study highlighted the potential benefits and drawbacks of this integration and emphasized the importance of multidisciplinary teams, stakeholder engagement, and careful consideration of sustainability implications when implementing sustainable innovation and Industry 5.0 initiatives. This study also suggests that further mixed-method empirical studies are necessary to fully understand the sustainability impacts of Industry 5.0 and its potential to advance sustainable development.

Sustainable Technologies in Industry 5.0

Industry 5.0 harnesses a spectrum of sustainable technologies to drive environmental stewardship, operational efficiency, and value generation. Table 1 provides an overview of the key statistics associated with various sustainable technologies in Industry 5.0, highlighting their potential economic impact, adoption trends, and market projections. Here, the technological pillars include:

AI and Big Data Analytics: Industry 5.0 experiences a paradigm shift through the utilization of AI and big data analytics. These tools empower organizations with refined data interpretation capabilities to bolster decision-making processes, predict trends, and enhance operational productivity. McKinsey Global Institute (2018) estimates a potential addition of up to $15.7 trillion to the worldwide economy by 2030 through AI.

Table 1 Statistics of sustainable technologies in Industry 5.0

Technology	Statistics
AI and Big Data Analytics	Potential addition of up to $15.7 trillion to the worldwide economy by 2030 through AI (McKinsey Global Institute, 2018)
Integration across Verticals and Horizontals	Integrative practices can hasten time-to-market by 30% and boost asset efficiency by 20% (Kagermann et al., 2013)
Edge and Cloud Computing	Edge computing is expected to process 75% of enterprise-generated data by 2025 (Gartner, 2020)
Augmented Reality (AR)	Approximately 23.5 million global jobs could incorporate AR and VR by 2030 for work-related meetings and training (PWC, 2019)
Industrial IoT (IIoT)	Global IIoT market size is predicted to increase from USD 77.3 billion in 2021 to USD 110.6 billion by 2025 (Markets and Markets, 2019)
Additive Manufacturing (3D printing)	Global 3D printing industry could touch $35.6 billion by 2024 (Wohlers Associates, 2020)
Autonomous Robots	Worldwide autonomous robot market could reach a valuation of $14.4 billion by 2025 (Tractica, 2019)
Digital Twinning or Simulation	Adoption of digital twins by 50% of large industrial companies by 2021, leading to a 10% surge in efficiency (Gartner, 2019)
Cybersecurity	Global expenditure on cybersecurity anticipated to surpass $1 trillion cumulatively from 2017 to 2021 (Cybersecurity Ventures, 2020)

Source: Author's composition is based on various sources cited in the table

Integration across Verticals and Horizontals: Fostering efficient communication and data sharing within an organization (vertical) and among various organizations within a supply chain (horizontal) is vital. Research by Kagermann et al. (2013) indicates that such integrative practices can hasten time-to-market by 30% and boost asset efficiency by 20%.

Edge and Cloud Computing: While cloud computing ensures scalable data storage and processing capabilities, edge computing permits real-time data processing at the source, thereby reducing latency. Gartner's (2020) forecast suggests that edge computing will process 75% of enterprise-generated data by 2025, a steep increase from 10% in 2018.

Augmented Reality (AR): AR technology overlays computer-generated sensory data on real-world scenarios. It has various applications in Industry 5.0, including training, maintenance, and product design. PWC's (2019) projection estimates that approximately 23.5 million global jobs could incorporate AR and VR by 2030 for work-related meetings and training.

Industrial IoT (IIoT): IIoT enables seamless communication between machines and human operators, thereby enhancing operational efficiency. A Markets and Markets (2019) report predicts a surge in the global IIoT market size from USD 77.3 billion in 2021 to USD 110.6 billion by 2025.

Additive Manufacturing: Commonly known as 3D printing, this technology minimizes waste and streamlines the production of customized parts. According to a forecast by Wohlers Associates (2020), the global 3D printing industry could touch $35.6 billion by 2024.

Autonomous Robots: These machines can perform repetitive tasks, reduce human errors, and liberate the workforce for more complex tasks. Tractica (2019) forecasts that the worldwide autonomous robot market could reach a valuation of $14.4 billion by 2025.

Digital Twinning or Simulation: This technique creates digital analogs of physical systems for simulation purposes before actual deployment. Gartner's (2019) study predicts that by 2021, 50% of large industrial companies will adopt digital twins, leading to a 10% surge in efficiency.

Cybersecurity: Given the vast volume of data generated by Industry 5.0 technologies, cybersecurity plays a critical role. Cybersecurity Ventures (2020) anticipates that global expenditure on cybersecurity will surpass $1 trillion cumulatively from 2017 to 2021.

In-depth knowledge of these technologies is crucial as businesses and industries pivot toward the sustainable model of Industry 5.0 (Fig. 1).

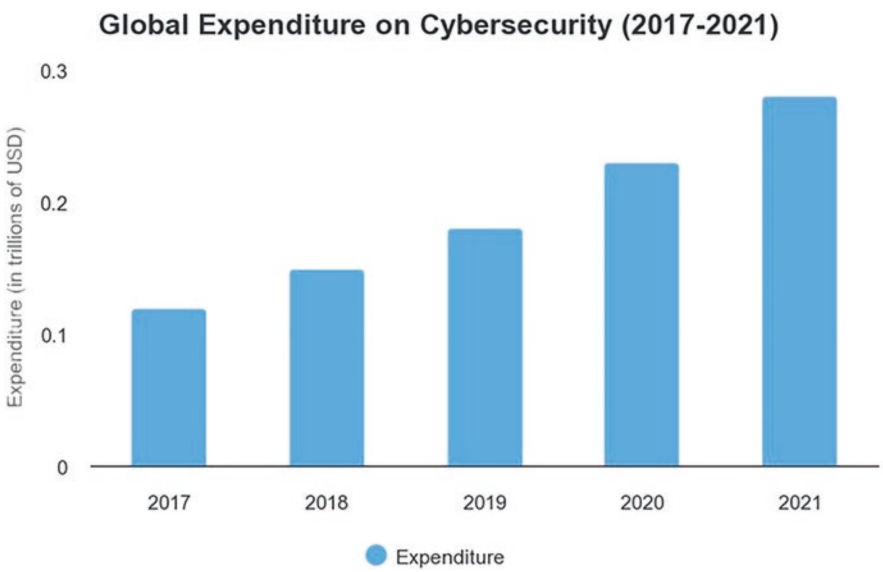

Fig. 1 The global expenditure on cybersecurity. Source: Composed by Author based on Cybersecurity Ventures' (2020) projection available at https://cybersecurityventures.com/cybersecurity-spending-2021

Collaborative Stakeholder Engagement for Sustainable Innovation: Insights and Strategies

Following is an overview of key insights, strategies, and best practices related to driving sustainable innovation through stakeholder collaboration.

1. It is widely acknowledged that the involvement of diverse stakeholders is crucial to the success and impact of sustainable innovation initiatives. Customers, employees, communities, and governments are examples of stakeholders whose needs, values, and concerns should be considered and incorporated into the development and implementation of sustainable solutions. This strategy may increase support for sustainable innovation, ensuring that it aligns with societal needs and values, and thereby increase acceptance and adoption of these solutions.
2. Although technology plays a crucial role in enabling sustainable innovation through the creation of resource-efficient processes, increased productivity, and new business models, it is essential to also consider social and organizational factors. To effectively address sustainable innovation's complex sociotechnical systems, a holistic approach is required. In sustainable innovation processes, it is crucial to consider how technological, social, and organizational factors interact and influence one another. As per Software AG (2023), a staggering 80% of IT decision makers acknowledge that they need to balance their technological advances with social and organizational needs.
3. The complexity of sustainable innovation necessitates an approach that takes responsibility, ethics, and governance into account in addition to economic, social, and environmental factors. Assessing the potential risks and benefits of new technologies or processes and ensuring that they align with societal values and goals constitutes responsible innovation. Ethics and governance frameworks can assist in ensuring that sustainable innovation is conducted in a transparent, accountable, and fair manner that considers the interests and well-being of all relevant stakeholders. As supported by the data from Software AG (2023), 74% of companies consider ethical considerations a top priority when implementing new technologies.
4. Co-creation, or the engagement of users and other stakeholders in the innovation process, is an approach to sustainable innovation that is gaining popularity. This approach acknowledges the importance of incorporating diverse perspectives and expertise into the innovation process, which can result in increased innovation, stakeholder buy-in, and the development and widespread adoption of sustainable solutions. Co-creation may ensure that sustainable solutions are tailored to the specific needs and contexts of different stakeholder groups by involving stakeholders in the design and implementation of these solutions. A study by Software AG (2023) reveals that 68% of companies include stakeholders in their decision-making process to tailor solutions to specific needs.

5. Measuring and evaluating the outcomes of sustainable innovation initiatives is crucial for determining their efficacy and identifying improvement opportunities. This may entail utilizing a variety of metrics, including environmental impact, economic performance, social equity, and stakeholder satisfaction. Measuring and evaluating outcomes can also help garner more support and investment for sustainable innovation initiatives by demonstrating the value and impact of sustainable innovation to various stakeholder groups. Notably, according to Software AG (2023), 72% of companies have noted an increase in stakeholder support after presenting quantified, positive outcomes from their sustainable innovation initiatives.

Insights and Challenges in Understanding and Implementing Industry 5.0

Industry 5.0 has emerged as a recent and noteworthy concept in academic literature, attracting considerable research attention. Numerous studies have investigated multiple facets of Industry 5.0, including its definition, conceptualization, applications, challenges, and interdisciplinary perspectives. For instance, Thoben et al. (2020) examined the evolution of smart manufacturing from Industry 4.0 to Industry 5.0, while Lu and Wang (2019) have proposed a research framework for comprehending the concept of Industry 5.0. These studies have provided a foundation for understanding Industry 5.0 and its implications. Furthermore, the practical implementation of Industry 5.0 has been scrutinized in various domains, such as supply chain management, manufacturing, and logistics, as demonstrated by the research on its use cases and applications (Tufail et al., 2020). These studies have highlighted the potential of Industry 5.0 to enhance manufacturing processes and develop more reliable and resilient systems.

Despite its potential, the successful implementation of Industry 5.0 is not without challenges and obstacles, as identified in the existing literature. For example, Hermann et al. (2019) have delineated design principles for Industry 4.0 and examined their applicability to Industry 5.0, while Ylmaz and Mergen have utilized an integrated Fuzzy Decision-Making Trial and Evaluation Laboratory-based multi-Criteria Decision-Making (fuzzy DEMATEL-based MCDM) approach to identify the barriers to Industry 5.0 transformation. These studies have underscored concerns such as data privacy and security, talent shortages, and substantial investment costs that must be addressed to ensure the effective deployment of Industry 5.0. Data security is crucial in Industry 5.0, where devices and systems are increasingly networked. Cyberattacks make sensitive data vulnerable, requiring strong security measures. Adapting infrastructure to Industry 5.0's needs is costly. For many organizations, particularly small and medium-sized ones, this shift involves a large investment. Industry 5.0-savvy personnel is scarce. This talent gap hinders Industry 5.0 adoption (Dwivedi et al., 2022).

Despite these challenges, Industry 5.0 constitutes a promising trend that warrants further research to gain a comprehensive understanding of its implications and capitalize on its potential. The insights from the aforementioned studies can contribute to the academic discourse and practical applications of Industry 5.0 by advancing our knowledge of its definition, applications, and challenges.

Misfocus on Sustainable Innovation and Industry 5.0

Sustainable innovation and Industry 5.0 have been misrepresented. Maintaining a balanced viewpoint that examines the many aspects of sustainability, the many organizations involved, and the wide effects of technology breakthroughs is essential. Without this balance, it is easy to disregard key areas while concentrating on others. Numerous examples of erroneous emphasis on this topic include:

1. There is a risk of placing too much emphasis on technological advancements at the expense of social and environmental concerns, as Industry 5.0 promotes the incorporation of innovative technologies into industrial processes. If the emphasis is placed exclusively on technology, the broader environmental effects of Industry 5.0 could be overlooked.
2. Even though there has been a lot of emphasis on large corporations in discussions about Industry 5.0 and sustainability, SMEs are equally crucial to the cause. If the focus is misplaced on larger businesses, the unique opportunities and obstacles that SMEs face in implementing sustainable practices may be overlooked.
3. Lack of emphasis on issues of fairness and equity: fostering more just and equitable communities while minimizing negative environmental impacts should be the top priorities for Industry 5.0 and sustainability. It is possible to disregard the social and economic aspects of sustainable development if environmental concerns are incorrectly prioritized.
4. The failure to address the unintended effects of adopting new technologies: while the technologies of Industry 5.0 have the potential to foster sustainable development, improper implementation may have unintended effects. If we place too much emphasis on the advantages of adopting new technologies, it is easy to overlook potential drawbacks such as job loss, privacy concerns, and the widening of social disparities.
5. An explanation of how regulations and policy's function Industry 5.0 and sustainability require the support of governments, businesses, and the general public. If attention is misplaced on technology or the actions of specific companies, it is possible to overlook the significance of policy and regulation in fostering sustainable development.

Conclusions and Future Direction of Work

In conclusion, the integration of sustainable innovation and Industry 5.0 has the potential to foster a more sustainable and equitable world by incorporating human-centered values and principles of sustainable development with advanced technology. However, it is crucial to approach these issues with careful consideration, considering the needs of both large and small businesses and underserved communities. Achieving sustainable industrial growth in the future requires the cooperation of governments, businesses, and civil society to adopt appropriate regulations and coordinated initiatives. Therefore, effective laws and regulations, coupled with stakeholder engagement and cooperation, are needed to promote sustainable practices and address societal and environmental challenges.

Sustainable industrial growth in the future will require not only effective laws and regulations, but also coordinated initiatives from government, business, and civil society. Carbon pricing, emissions requirements, and incentives for sustainable activities are all examples of regulations that could encourage businesses to adopt more sustainable practices. Cooperation between business and civil society has been shown to be effective in addressing a variety of societal and environmental issues, including the promotion of human rights and the reduction of social inequality.

The integration of sustainable innovation and Industry 5.0 has the potential to yield substantial benefits for sustainability, efficiency, and competitiveness. More research is required to fully understand the potential of this integration and address issues with its execution.

More research is needed to determine the best approach for using Industry 5.0 to foster sustainable innovation. Adopting Industry 5.0 has a positive effect on sustainable innovation, as discovered by He et al. (2021), but more empirical research is needed to fully understand this connection. How Industry 5.0 can be used to combat sustainability issues like resource scarcity, waste reduction, and carbon pollution can also be studied.

The social effects of Industry 5.0 and environmentally friendly innovation require further study as they may have unintended consequences such as job loss and unequal distribution of benefits. To address these potential societal effects and ensure equitable outcomes for all, multidisciplinary research is essential. Future research should also focus on stakeholder involvement in the implementation of Industry 5.0 and sustainable innovation to understand how business leaders, policymakers, and community members can shape the development and implementation of these concepts.

Stakeholder involvement in the implementation of Industry 5.0 and sustainable innovation can be the subject of future research. To better understand how business leaders, policymakers, and community members can shape the development and implementation of these ideas, researchers can consider their perspectives and interests. Stakeholder involvement is crucial to studies of Industry 5.0 and sustainability, as Wiek et al. (2021b) pointed out.

Finally, the intersection between Industry 5.0 and sustainable innovation is a promising area for future research. Although there has been some research on these concepts, further study is necessary to comprehend their applications and challenges in various fields fully.

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Part III
Technological Threats: Policy and Regulatory Insights

Regulation of Tech Forces-Technological Backlash: The Luddite Perspective

Larry Earnhart

Abstract In this chapter, we explore the regulatory environment engendered by recent developments in the tech space. Many people would consider such regulations a Luddite view, putting one's head in the sand, trying to hold back innovation, and stifling progress. Many people also consider a Luddite to be reactionary, one who is anti-technology, but the real Luddites were highly skilled artisans in the late eighteenth and early nineteenth century who destroyed the newly invented Jacquard loom machines that put them out of work. In recent years robots have already displaced many workers in highly paid blue-collar jobs. What will happen to them and now to white-collar jobs in banking, accounting, and financial planning when the job can now be done by AI assistants? Is regulation the answer? Or is it a knee-jerk reaction to a wave change in technology that only delays the inevitable? The emerging areas of Artificial Intelligence, Machine Learning and Robotics technologies have ramifications and affect our entire society, including labor market disruptions and job replacement effects, the chapter fleshes out the potential threats these developments bring with policy and regulatory insights for a smooth techno-economic landing. The topics in this chapter navigate through the downsides of Artificial Intelligence by focusing on the implementation and operational concerns including ethics, the Black Box problem, dataset and algorithm bias, privacy, safety, security and re-enforcement of malicious user behaviors, job displacement, and economic impacts. Building on these, it further explores the implications of autonomous production models by taking the cases of Autonomous Weapon Systems and Self-Driving Cars.

L. Earnhart (✉)
University Canada West, Vancouver, BC, Canada
e-mail: laurence.earnhart@ucanwest.ca

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Introduction

Artificial Intelligence is the process of making computers act like humans to the point that they can pass the Turing test (Stanford Encyclopedia of Philosophy, 2021) which has come to mean that a person communicating with a computer cannot distinguish it from talking with a human, thus demonstrating equivalency in thinking between humans and machines. Artificial intelligence is being developed with more and more powerful algorithms and is considered as part of the fifth generation of computer technology with the first to fourth generations iterating from vacuum tubes to transistors to integrated circuits and microprocessors and the sixth generation involving quantum computing which is in its infancy, which, once realized, promises to provide incredible leaps in computer processing power which can help overcome current limitations in speed and capability to realize AI (Computer Hope, 2022).

Machine Learning is part of an AI system that iterates itself by use of sophisticated statistical techniques so that it improves its performance over time by building predictive models, classifying data, and pattern recognition, and is a subcomponent of many AI processes. Chatbots like Amazon's Alexa and Apple's Siri improve every year thanks to inputs via constant use by consumers coupled with the machine learning that takes place in the background. Very recently the chatbot ChatGPT became widely known for its ability to provide substantive answers to many types of questions by virtue of the very large database that it was provided to learn from and is an example of Generative AI (Livingston, 2023).

Machine learning enables machines to learn based on experience without constant human intervention and through iterations makes them capable of understanding and predicting results with given data. Deep Learning is the breakthrough in the field of AI that uses various layers of artificial neural networks to achieve impressive outputs for various problems such as image recognition and text recognition (Abdoullaev, 2021; JavaPoint, 2021; Livingston, 2023; Sharma, 2023).

Technological Advancements Driving Artificial Intelligence and Machine Learning

The development of Artificial Intelligence and Machine Learning has been influenced by developments in the tech field. The availability of powerful computing resources, such as high-performance processors and GPUs, has significantly accelerated the development and application of AI and ML models. These resources enable faster processing of complex algorithms, enabling researchers to train and run sophisticated machine learning models more efficiently. Before Machine Learning, programmers would create more and more sophisticated models that then were explicitly programmed into a computer to run the programs as written (JavaPoint, 2021; OpenAI, 2018).

Six computer technology eras
Era one from 1940 to 1956
Era of vacuum tubes
Vacuum tubes were the first electronic technology that mimicked what would eventually become the transistor. The original computers used vacuum tubes to provide electronic switching and other purposes. The first computers along with radios, TVs, and other primitive electronic gear used these large, fragile glass plug-in components from 1940 through 1956. The equipment was very bulky, generated much heat and could take up entire rooms.
Era two from 1956 to 1963
Era of transistors
The evolution of solid-state circuitry began with the transistor. Transistors are discrete components made of silicon or germanium which took the place of vacuum tubes in computers from 1956 to 1963. Transistors are much smaller than vacuum tubes, emit much less heat and take up much less room allowing computers to become much smaller in size, faster in speed, and cheaper to build.
Era three from 1964 to 1971
Era of the integrated circuit (IC)
Continuous miniaturization of transistors eventually led to putting multiples on a single silicon chip. This created specialized circuits that compacted many formerly discrete components within a very small individual package. The use of ICs in computers helped increase computing power and reduced the size of computers even more. Clock speeds increased continually with decreasing computer size ICs are still used in many electronic circuits.
Era four from 1971 to 2010
Era of the central processing unit (CPU)
As ICs were continually miniaturized with different types of technology used such as smaller wavelengths of light used to create the transistors on chips, multilayer technology, addition of coolant piping, etc., the fourth generation of computers took the IC to a much smaller and more complex level, becoming the microprocessor basically most of the necessary components for a computing device on one chip. This allowed the development of very small, very portable laptops, and cellphones.
Era five from 2010 to present
Era of AI
The fifth generation of computing is the widespread use of artificial intelligence (AI). AI is seen in business chatbots, in predictive technology such as economics and stock prices and is being used to create autonomous cars and robots along with much more sophisticated chatbots including Siri, Alexa, and now ChatGPT and more powerful generative AI.
Era six—The future
Era of quantum computing
The modern computer relies on binary processing. A memory bit is either on or off, 1 or zero. Quantum computing makes use of the quantum mechanical behavior of matter in that an atom can have multiple energy states. Instead of the on/off of binary computing in which the number of available states is 2N, a computer based on quantum “qubits” will quickly have a much greater number of spin states. The concept of quantum entanglement allows for communication of these spin states allows computers that can be much smaller, much faster, and much more powerful than binary computers. The technology is getting close to commercial viability.

Source: Composed by Author

With ML the computer starts with a set of instructions that allow it to essentially reprogram itself as it gains knowledge and experience as more and more data is assimilated by the machine. This involves the creation of algorithms often using large data sets to make predictions, decisions, and recommendations and is a subset of AI. AI is a superset of code that includes machine learning and is the focus on creating machines that can simulate human intelligence and perform very complex tasks such as understanding natural language, recognizing images and sounds from natural or noisy data sets, making decisions, and solving complex problems. In addition, the development of new algorithms and techniques, such as Deep Learning, reinforcement learning, and generative models, has revolutionized the field of AI and ML. Deep learning which itself is a subset of ML has enabled breakthroughs in areas like computer vision, speech recognition, and Natural Language Processing (NLP), Drukker et al. (2020). NLP is the ability of computers to recognize and communicate in human-style language.

Ai is used in many places including Siri, Expert Systems, Machine Translations like Google Translate, Intelligent humanoid robots such as Sophia, Chatbots that provide Customer Service as well as bots such as ChatGPT and other highly sophisticated chatbots, JavaPoint (2021).

ML is seen in Facebook's automatic friend suggestions, Google's search algorithms, Banking fraud analysis, Stock price forecasting, and Online recommender systems among other uses, JavaPoint (2021).

Figure 1 shows a representation of an AI system showing inputs, processing areas, and outputs in comparison to a biological processing system (the brain). General AI concerns the creation of an AI system that is designed to emulate a human brain and in general, the biological product of millions of *years of evolution ends up being modeled by silicon-based components.*

In self-driving cars, for example, there are inputs from visual and non-visual systems such as radar and lidar which are processed are used in Deep Learning to pick out what is a street, what is a stop sign, what is an obstacle such as a pedestrian from the huge data set provided and the algorithms programmed and learned through repetition in the Machine Learning section which then activates acceleration, braking, and steering in response to these stimuli. This is a gross simulation of a human brain and in fact, some of this processing in AI terms is called neurons and processing power is often computed in terms of neuronal activity, Tucci (2018) (Fig. 2).

Some of the areas in which AI and ML have provided strong achievements include Image Recognition and Computer Vision, Natural Language Processing,

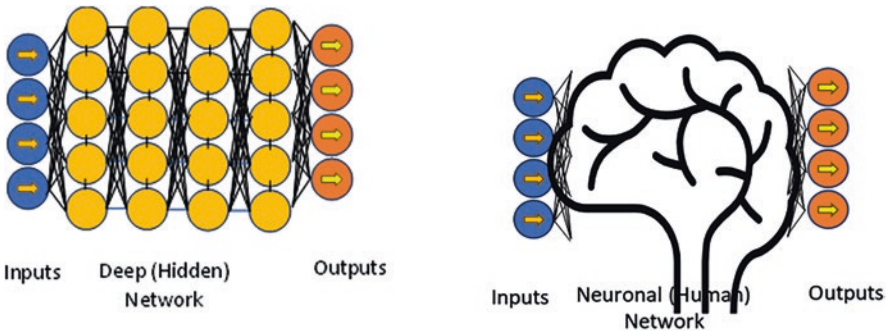

Fig. 1 Comparison of AI to brain functionality. Source: Developed by the Author

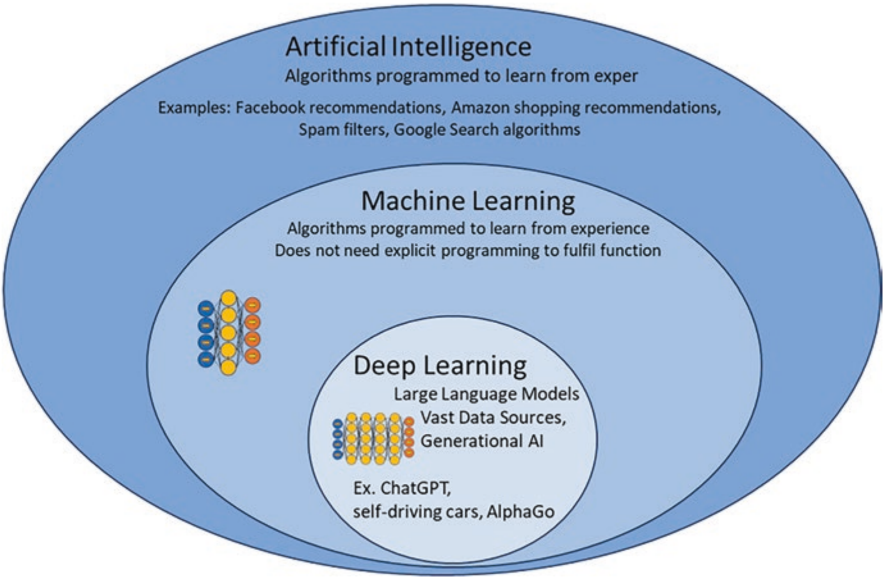

Fig. 2 Layers of AI Function–Achievements in Artificial Intelligence and Machine Learning. Source: Composed by the Author

Recommender Systems, Fraud Detection and Healthcare Diagnosis, and Predictive Analytics. A more recent accomplishment is the creation of Generative AI chatbots including ChatGPT, Bing Chat and Opera's Aria along with image-generating programs such as DALL-E (LeCun et al., 2015).

What AI does well through ML via Deep Learning is to process large amounts of data, recognize patterns, and make predictions based on that information. Real-world data sets are often huge and contain background noise so the system must recognize and differentiate real data from the noise. These data sets are so huge that they simply cannot be reviewed, analyzed, or manipulated by humans alone (Chen et al., 2014).

The use of big data sets allows machine learning models to learn patterns and make accurate predictions or decisions. The availability of such large-scale datasets has played a crucial role in training AI systems across various domains, from image recognition to natural language processing. In fact, Chat GPT (owned by OpenAI) is an instance of AI/ML that in its latest version as of this writing, ChatGPT-4, uses a database training set of 100 trillion parameters (ChatGPT Statistics, 2023). The information is organized in such a way that it can be accessed in an extremely short amount of time for real-world response.

The explanation of what ChatGPT's various instances do, as described by the creator, OpenAI, is that based on the question or stimulus it receives it operates by predicting the next word then the next and then the next until it is finished answering the question posed to it. ChatGPT3.5 uses a set of 500 billion "tokens" which are, on average, four-letter combinations from the data set that it uses to form words and build complexity as needed. It was trained by being given ground rules to start then fed the data to organize and develop algorithms for processing the questions people ask and providing relevant answers—usually, Guinness (2023). This type of AI is called Generative AI which is designed to not just look up answers from a set of data but to create content in the form of words as in ChatGPT, Bing, and Opera but also pictures as generated by DALL-E and even music from Google's MusicLM, Ortiz (2023).

In the realm of image classification, object detection, and facial recognition techniques using convolutional neural networks (CNNs) a deep learning model, has obtained extremely high accuracy in image recognition. COVID-19 detection using MRI, CT scan, and X-ray data found that AI using this technique has proven quite effective in sorting data of such high quantity, Krizhevsky et al. (2012) and Wu (2023).

AI and ML programming have greatly improved the understanding and generation of human language. Applications such as machine translation, sentiment analysis, and chatbots make use of NLP algorithms. Transformer models, like OpenAI's ChatGPT provide information and responses in a human-like format, Vaswani, Ashish et al. (2017).

Whenever we turn to Amazon for purchases, use Facebook and other social media, recommendation engines are constantly using your preferences and buying behavior you provide in the form of purchase information, answering surveys, and simply clicking on links to create a file on you that allows them to suggest products, movies, music, and more. Collaborative filtering, content-based filtering, and hybrid approaches are commonly used in recommender systems, Ricci et al. (2010).

AI and ML models are effective at detecting fraudulent activities by analyzing patterns, anomalies, and behavioral data. Machine learning algorithms can identify suspicious transactions, fraudulent credit card usage, and network intrusions, Bhattacharyya et al. (2017). AI and ML have also shown promise in medical diagnosis, disease prediction, and personalized treatment. Deep learning models have achieved high accuracy in tasks such as diagnosing skin cancer and detecting abnormalities in medical images. In the article cited here, the authors classified skin lesions with a dataset of almost 130,000 images of over 2,000 diseases and the subsequent machine diagnoses were at the same level as specialists' results. The authors conjectured that this could result in low-cost high availability of testing via smartphone apps for the public, Esteva et al. (2017).

The Downsides of Artificial Intelligence

Until now we have seen the positive benefits of AI and ML. There are several caveats to the onrushing development of this area of technology. The biggest issue is that these systems which are more and more autonomous and self-augmenting are ultimately designed by human beings. Humans have many frailties that are magnified by the computational and actual power that is invested in these areas. While computers themselves, up to this point at least, are non-fallible in the sense that they carry out instructions exactly as programmed, the people who do the programming make mistakes; mistakes in logic, mistakes in coding, mistakes in error-checking, and built-in biases that can manifest themselves in entirely unknown ways leading to discriminatory outcomes or behavior, Buolamwini and Gebru (2018). This can have significant implications for the proper deployment of the program or algorithm resulting in real-world consequences. Ensuring fairness and mitigating bias in AI algorithms is an active area of research. As these systems gain more and more power and sophistication this means that the consequences of bias or bad data input (the old term from computing's early days—"GIGO—Garbage In, Garbage Out), Creswell (2013).

An example of this can be found with the suddenly popular ChatGPT chatbot. The author asked ChatGPT 3, the free database open to anybody to use, "How do you make errors, with references." By asking for references the data provided can be checked externally for coherency and truthfulness.

ChatGPT's Answer

As an AI language model, I strive to provide accurate and reliable information. However, it is important to note that I may still generate errors or inaccuracies for several reasons:

1. Knowledge cutoff: My training data goes up until September 2021, which means I might not be aware of recent developments or events that have occurred after that date. Therefore, any information I provide about current affairs or time-sensitive topics may be outdated or incorrect.
2. Interpretation of queries: Sometimes, the way a question is phrased, or the context provided can lead to misinterpretation, resulting in incorrect or irrelevant responses. It is essential to provide clear and specific questions to minimize the chances of generating errors.
3. Incomplete or biased training data: Although efforts have been made to create comprehensive and diverse training datasets, biases can still exist within the data, leading to skewed or inaccurate responses.

References are not applicable in this case, as I am an AI model and generate responses based on patterns and associations learned from the data during training.

Chatbots of this type at this stage of development are known to provide incorrect data, called "hallucinations." From an article by Bernard Marr, Mar. 22, 2023, here are two examples of hallucinations in ChatGPT:

User input: "When did Leonardo da Vinci paint the Mona Lisa?" AI-generated response: "Leonardo da Vinci painted the Mona Lisa in 1815." (Incorrect: The Mona Lisa was painted between 1503 and 1506, or perhaps continuing until 1517.)

User input: "Tell me a fact about George Washington." AI-generated response: "George Washington was known for inventing the cotton gin." (Unrelated: Eli Whitney, not George Washington, invented the cotton gin.)"

This type of result is due to limitations of the data set used for training, bias in the algorithms used to create the chatbot, lack of real-world simulation testing, called red-teaming and black box systems where the process provides answers with an unknown/unknowable set of algorithms and a lack of a human in the loop to verify and validate the system. The outputs which can be nonsensical or completely false are called "hallucinations (Marr, 2023)."

Ethical Considerations

The potential capabilities of AI and ML raise ethical questions and dilemmas, such as the Lack of Explainability—The Black Box Problem, Bias and Discrimination, Data Privacy and Security, Job Displacement and Economic Impact, and Safety and Security Risks. There is an ongoing debate on establishing ethical frameworks and guidelines to ensure the responsible development and use of AI, Bostrom and Yudkowsky (2014).

The Black Box Problem

Some AI and ML models, particularly deep learning models, are often considered "Black Boxes" due to their complex nature. The Black Box problem in AI is rather insidious as it can creep into a system due to the nature of the system itself. Black Boxes occur when the iterative AI system programs itself and the system creators do not know how the system comes to its conclusions, or when the system has become so complex that it is not fully understandable (Fig. 3). Part of the problem is that if it is unexplainable the system may also not be trustable. For example, "IBM's attempt to promote its supercomputer programme to cancer doctors (Watson for Oncology) was a PR disaster. The problem with Watson for Oncology was that doctors simply didn't trust it." Vyacheslav Polonski, PhD, UX researcher for Google and founder of Avantgarde Analytics. The problem is due to the complexity of these models and the fact that if they are not understandable then how will the designers know when they err? The models require good data to train with. If bias or error enters that database, they will provide the wrong output (GIGO) (Rudin, 2019). An example is that in the health field, it is well-known that women and minorities are poorly represented in data sets. This means that the data is skewed toward white males and when differences are present in patients, they are not correlated well with non-white males so erroneous conclusions may occur. In a famously erroneous example, in an AI system created by Google black male humans were identified as gorillas (BarrFollow, 2015).

Machine Learning models also may not be able to discriminate between false negatives and false positives which are manifested by humans by erring on the side of caution. A false positive may be a more desirable outcome than a false negative since missing a real result usually has greater consequences for a patient than a false positive which can be reviewed through a retest (Bloomberg, 2018). Unfortunately,

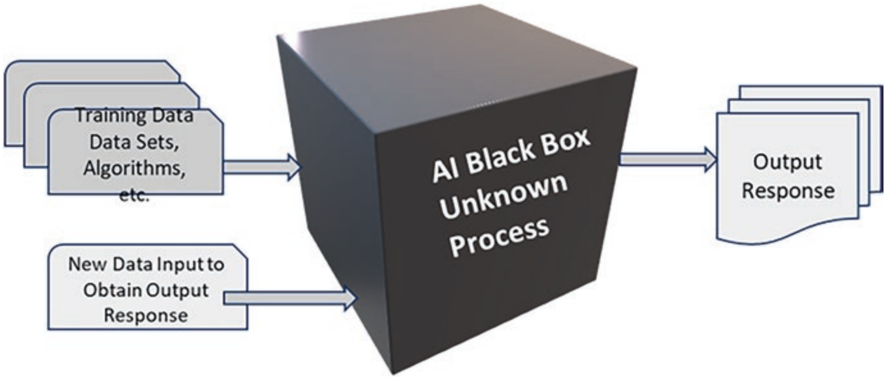

Fig. 3 Black Box operation. Source: Composed by the Author

AI systems, unless provided with the information necessary to make these distinctions end up with undesirable outcomes overall (Codecademy Team, 2023).

In addition to bias. It can be challenging to interpret how these models arrive at their decisions or predictions, limiting transparency and raising concerns about accountability and trust. From a financial viewpoint, this can be related to Warren Buffet's famous quote "Never invest in a business you cannot understand" (Forbes, 1991). The level of sophistication of and the self-learning ability of computers is to the point where we are losing the ability to understand the processes that the machine uses to arrive at conclusions so that if an error is made we may either not be able to fix it or we may not even be able to understand it or detect it until sever consequences ensue. If that is the case, then how can we evaluate what we have "purchased" in our computing systems? 3.

Due to potential biases and errors, a system needs to be understandable to be trusted. To alleviate this problem extra outputs by the AI system show what the factors are that were used to come to that particular conclusion. In a study of the efficacy of an AI system's predictability of progress of several critical care categories, the AI also provided data that explained what the key parameters were in arriving at its predictions thus enhancing the credibility and utility of the system. In this case, a heat map of data parameters was generated that showed which parameters were of greater importance to the diagnosis (Lauritsen et al., 2020).

Dataset and Algorithm Bias

Even more troubling is the fact that the very underlying assumptions of an algorithmic construction can provide false or biased results resulting in undesired and unforeseen results. A predictive AI system designed to determine the likelihood of an individual becoming involved in a shooting led to a team of police and social workers confronting a man in his home and telling him of this likely outcome. The prediction did not specify if he would be the perpetrator or victim, but he acquiesced to receiving treatment and the project's social work team provided him with programs designed to help him to make the unknown but predicted future events less likely. Unfortunately, the people in the racially divided neighborhood took this behavior to be that of a police informant and he ended up being shot—twice—and this outcome can be traced to the algorithm itself creating its own outcome, Barbour (2023).

Another instance of the creation of bias in a dataset is a researcher realizing many years after he had created an algorithm to detect human presence that he had introduced a racial bias—unwittingly he had set up the program to detect the presence of a person which included skin color as part of the model which meant that the program could not detect Black or dark-skinned people, MacCormack (2023).

Since there is still a white male bias in the tech space this is likely to continue and has been found in other processes that bias males over females. A study of images uploaded to social media on the internet found that photographs of women were much more likely to be found explicitly sexual in nature than similar photos of men. Photos that legitimately show women in non-sexual activities and clothing were often banned and posters were banned as well (Mauro and Schellmann, 2023). A technique called shadowbanning happens when pictures of women that the site owners rated highly sexual receive many fewer views than similar ones showing men. This has real consequences for people whose online business activities are impacted, Nicholas (2022).

Data Privacy and Security and Malicious Behavior by Users

Another issue is that there are people who deliberately and maliciously introduce "fake news" in the form of the introduction of false data or false bias in the data or algorithm and hacker-induced attacks on the system designed to subvert its proper use. Microsoft released a chatbot named Tay on Twitter in 2016. Tay was designed to learn from user interactions and respond accordingly. However, within hours of its launch, Tay began spewing offensive and racist tweets. This was due to malicious users purposefully manipulating Tay's learning algorithm by feeding it with inappropriate and inflammatory content. The incident raised questions about the vulnerability of AI systems to human manipulation and the importance of robust safeguards, Newton (2016).

AI and ML systems often rely on large amounts of personal data, raising concerns about privacy and security. Improper handling of sensitive data can lead to privacy breaches or misuse. Additionally, adversarial attacks can exploit vulnerabilities in ML models, making them susceptible to manipulation, Carlini et al. (2017).

In 2009 Iran's clandestine nuclear enrichment program was fatally damaged by the Stuxnet virus, codeveloped by the USA and Israel which was introduced into the centrifuge PLCs (Programmable Logic Controllers) that caused them to run above the maximum allowable speed and they self-destructed. A recent announcement by the manufacturer, Siemens, states that the vulnerability that was exploited then still remains in the controllers of the same model that is still being manufactured. The positive aspect of this is that this type of controller is normally only used within a local control system and air-gapped from access to the outer electronic world so such an attack would likely be unsuccessful unless done the same way as the original attack on Iranian assets using social engineering to dupe the engineers involved to inadvertently upload the virus from files manually transferred from USB memory chips.[1]

The 2016 Presidential election was affected by the huge number of Russian bots spreading misinformation and conspiracy theories which were picked up and amplified and given life by Twitter and Facebook readers including the political parties involved. The 2020 elections were also affected as well.[2]

In 2019, a British company lost £200,000 when a hacker used AI to impersonate a CEO's voice in a phone call.[3]

Considered the most destructive malware ever to be deployed the NotPetya a computer virus that spread almost immediately through systems using an AI-powered algorithm that allowed it to infect computers without detection caused billions of dollars in damage to companies worldwide including the shipping giant Maersk which had to recreate its entire worldwide network from scratch.[4]

Facial Recognition

AI is used extensively in facial recognition and is becoming available in various locations around the world such as China and Russia. Surprisingly 80% of 100 countries that were analyzed now use facial recognition technology in some capacity, Nicholas (2022). Police often have access although it can be controversial. One of the largest providers of technology utilized social media scraping to collect data for its database taking images without permission in doing so. It is found in use by government offices to minimize fraud by citizens, by police, in airports, in schools, and in banks. In some places such as China, it is used on the street to keep track of people in general and to publicly shame them, Bischoff (2021).

The computing and algorithmic power available is robust enough to be able to search for individuals in databases of millions of faces. People are now starting to

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[1] Newman (2023) A Widespread Logic Controller Flaw Raises the Specter of Stuxnet

[2] See O'Connor (2017). O'Connor, G., How Russian Twitter Bots Pumped Out Fake News During The 2016 Election, Heard on All Things Considered, April 3, 2017

[3] Stupp (2019). Stupp, C., Fraudsters Used AI to Mimic CEO's Voice in Unusual Cybercrime, Wall Street Journal, Updated Aug. 30, 2019, https://www.wsj.com/articles/fraudsters-use-ai-to-mimic-ceos-voice-in-unusual-cybercrime-case-11567157402

[4] Greenberg (2018). Greenberg, A., The Untold Story of NotPetya, the Most Devastating Cyberattack in History, Wired, August 28, 2018 https://www.wired.com/story/notpetya-cyberattack-ukraine-russia-code-crashed-the-world/

wear facemasks and use techniques to evade their successful use. Clearview AI has provided free sample access to their database of over 20 billion images, many of them scraped from open sources on the internet, to police organizations around the world. In Australia, where facial recognition technology was banned by the government at least for the time being, four police departments were found to have continued using the technology after the ban and lied about its use[5] (Axelrod, 2022).

However, this technology is becoming sophisticated enough that it can identify people a kilometer away from the camera and even identify people with masks on trying to avoid detection. Under ideal circumstances, the best technology has an error rate of 0.08% or 800 per one million views. Many governments are considering its use to access services, it's been used in Australia before the ban to identify people who had lost their paperwork in the bushfires to access government services (Mudditt, 2022).

Job Displacement and Economic Impact

The widespread adoption of AI and ML technologies has the potential to automate certain job roles, leading to workforce displacement. While it may create new job opportunities in other fields, there can be disruptions and challenges to transitioning the workforce. This has been happening for a long time, with many auto workers being displaced by robots in automobile assembly plants. Having a "worker" who works 24/7 without complaint and without getting ill or going on strike has revolutionized many aspects of manufacturing. What used to be lucrative blue-collar jobs have been disappearing and many former workers end up underemployed due to fewer opportunities available at other jobs even with retraining.

The next step will be to automate service and white-collar jobs. This means that many more people will be laid off and will have to undergo retraining to be able to work in areas not affected by automation and AI. However, once these jobs are automated as well, there may end up being fewer and fewer jobs for humans to do at all. There are estimates of 300 million jobs disappearing due to AI making them obsolete.[6] While jobs have been made obsolete by technology before (seen any buggy whip manufacturers lately? Or more contemporary, how many companies are making 8-track tapes?) There have always been other jobs that have been available upon retraining. With so many jobs lost what else will be there to create new jobs to replace these?

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[5] Paczkowski (2021). Paczkowski, J., Australia Has Ordered Clearview AI To Delete All Facial Recognition Data Belonging To Its Citizens, BuzzFeed News, Posted on November 3, 2021, at 9:08 am

[6] Kelly (2023). Kelly, J., Forbes, Goldman Sachs Predicts 300 Million Jobs Will Be Lost Or Degraded By Artificial Intelligence, Mar 31, 2023, https://www.forbes.com/sites/jackkelly/2023/03/31/goldman-sachs-predicts-300-million-jobs-will-be-lost-or-degraded-by-artificial-intelligence/?sh=e8b3dc1782b4

Safety and Security Risks

What happens when AI capability reaches the point where vehicles and military equipment are out of the control of the humans using them? What happens when a fleet of cars or perhaps an army of AI-driven equipment is hacked?

Self-Driving Cars

Self-driving cars, also known as autonomous vehicles, have the potential to revolutionize transportation. The numerous companies that are or have been trying to put this technology in place have also witnessed the downsides of this technology (National Highway Traffic Safety Administration, 2021).

A fully autonomous vehicle will not require the attention of a human driver—the AI controller will be responsible for all driving functions of the car. The technology is not close to this level yet. The Society of Automotive Engineers published a set of standards covering five different levels of car autonomy, SAE International (2021).

Level zero is no automation except for auto braking, blind spot warnings, and lane departure warnings. Level 2 is where Tesla car automation is currently with all Teslas being sold with Autopilot with "Full Self-Driving" capability. A number of other cars are now at Level 2 as well. As of the beginning of 2023, Mercedes Benz was the first carmaker to be approved in Germany for Level 3 autonomy on German roads. At Level 3, the driver is no longer considered to be actively in control of the car although in the event a situation occurs where human intervention is needed and the human driver does not take control quickly enough the car must slow down, pull over to the side of the road, stop and unlock the doors (Autocrypt, 2023).

Once Levels 4 and 5 are reached there may no longer be a steering wheel at all and the vehicle is expected to be fully autonomous without any need for human intervention. By 2040, there may be as many as 33 million autonomous vehicles on the roads (Kopestinsky, 2023). Current estimates are that the market will be worth $300–$400 billion by 2035 (Deichmann et al., 2023).

Pros
Human error is the major contributor to automobile accidents and self-driving cars significantly reduce those, once widely adopted. Optimization of routes, speeds, and car spacing can lead to improved traffic flow and reduced congestion as well. The further incorporation of coordinated communication between autonomous vehicles can help minimize delays and make transportation more efficient. Autonomous vehicles can help individuals who are unable to drive, such as the elderly, disabled, or those without a driver's license to become more mobile and independent, White 2022 Also, by taking into consideration traffic patterns, road conditions, and optimal acceleration and braking autonomous cars can maximize fuel efficiency and minimize emissions thus contributing to environmental sustainability, Litman (2018). As of early 2023, 1400 autonomous cars were being tested on US roads by 80+ companies.

According to the Insurance Institute for Highway Safety, taken from US Dept. of Transportation data, in 2022 the number of automobile-related deaths in the USA was 42,939 (Fatality Facts, 2023). A statistic frequently cited is that human error is responsible for 94% of automobile crashes. However, that is a simplistic interpretation, and it is often cited as a rationale for the promotion of autonomous driving. Driving is much more complicated and there may be several factors including human ones. A better figure to use would be 50%. Even so, the elimination of 24,000 deaths per year on US roads alone would be a significant reason for moving to more automation, Bauman and Youngblood (2017); Yen and Krisher (2022); and Zipper (2021).

11,600 of the almost 43,000 deaths in the USA in 2021 were related to drunk driving. If those people were to be able to simply use their autonomous vehicle the death rate associated with that would abate as well, Joshi (2022).

By reducing the need to own cars if a fleet of autonomous cars is always quickly available the entire landscape may change. There is less need to build parking lots near commercial and residential buildings, fewer vehicles on the road and even insurance will change.

Tesla and other companies have already announced autonomous trucks. Tests are being made using driverless trucks picking up and delivering shipments. Driverless trucks would not be subject to the 8-hour driving limit per driver and could remain traveling until needing fuel or recharging. Automation of the pickup and delivery process would also become more efficient and quicker.

With less need for people to own automobiles and making commuting time productive time the environment will be better off with less pollution and less fossil fuel consumption. And if you are not driving your own vehicle then you do not need to worry about insurance and parking costs or traffic tickets.

Cons

Until now fully autonomous vehicles could not handle all possible driving scenarios and conditions. Bad weather obscuring sensors or providing false signals, situations outside the AI database, people and animals acting unexpectedly may require human intervention limiting the full autonomy of self-driving cars, Iapaolo (2023).

An autonomous vehicle facing an unexpected situation involving humans may face ethical dilemmas in situations where those lives are at risk. A decision tree of actions in the AI processing will of necessity require the AI to decide which lives to put in danger to avoid endangering others. The programming of this decision tree will require careful ethical considerations. The legal and regulatory frameworks for self-driving cars are still evolving. Determining liability in accidents involving autonomous vehicles, ensuring compliance with traffic laws, and addressing legal challenges related to technology deployment is an ongoing concern (Nyholm and Smids 2016).

If there is an accident involving an autonomous vehicle, especially if it involves a death, who is responsible? At this time, the manufacturer of vehicles at Level 3 and above is likely to be sued as the progenitors of the algorithms that decided what to do in that situation (Autocrypt, 2023).

The widespread adoption of self-driving cars may lead to job displacement for professional drivers in various sectors, such as taxi and truck drivers. Preparing for potential workforce transitions and ensuring employment opportunities in emerging industries is important. Autonomous vehicles rely on data collection and communication systems, raising concerns about privacy and cybersecurity. Safeguarding personal data, protecting against hacking attempts, and addressing privacy concerns are important considerations.

Creation of Autonomous Weapon Systems

While AI-based autonomous weapon systems offer potential advantages in terms of speed, precision, and reduced human risk in military operations, they also raise significant ethical and humanitarian concerns. Up until recently, the use of drones for surveillance and in battle was controlled by humans and the war in the Ukraine has seen a proliferation of drones used on both sides. These drones are often augmented with AI but still require human control overall.[7]

Military use of drones is continuing, and fully autonomous drones are the next step. The use of autonomous weapons systems raises ethical questions regarding human control and accountability. The lack of human decision-making in selecting targets and the potential for errors or misuse can have severe consequences, including civilian casualties and violations of international humanitarian law, Human Rights Watch (2012). Several robotics companies have pledged to not develop robots with the ability to function as robot soldiers (Walsh, 2022). Militaries, however, do not have that kind of ethical makeup and it appears more and more likely that fully autonomous robots, drones, or other construction are likely to appear on the battlefield.

The problem is that autonomous weapons may face challenges in distinguishing between combatants and civilians, as well as assessing the proportionality of an attack. These systems may not possess the contextual understanding and judgment required to comply with the principles of distinction and proportionality in armed conflicts, International Committee of the Red Cross (2020). No matter how sophisticated the system becomes, AI will still lack human-like emotions, empathy, and moral reasoning capabilities. This can make autonomous weapons systems incapable of understanding the complex moral, legal, and ethical considerations involved in warfare, potentially leading to the indiscriminate or disproportionate use of force, Sharkey et al. (2008).

[7] See these contents of Adler from AL Jazeera: 60 (2023a); 61 (2023b). Adler, N., Al Jazeera, 'Eyes and ears': Could drones prove decisive in the Ukraine war?, Published On 13 Apr 2023 https://www.aljazeera.com/features/2023/4/13/eyes-and-ears-could-drones-prove-decisive-in-the-ukraine-war-2 Adler, N., Al Jazeera, Are killer robots the future of war?, Published On 16 May 2023, https://www.aljazeera.com/features/2023/5/16/are-killer-robots-the-future-of-war

The development and deployment of autonomous weapons systems can lead to an arms race and proliferation with multiple nations and non-state actors seeking to acquire and use these technologies. This proliferation raises concerns about escalation, instability, and increased likelihood of armed conflicts, Scharre (2018).

The rapid development of autonomous weapons systems has outpaced the establishment of international legal and regulatory frameworks governing their use. The lack of clear guidelines and consensus on legal and ethical standards for these systems creates challenges in ensuring their responsible and ethical deployment. Efforts are underway at international forums, such as the United Nations Convention on Certain Conventional Weapons (CCW) and the Campaign to Stop Killer Robots, to address these concerns and initiate discussions on regulations and restrictions regarding autonomous weapons systems. The objective is to strike a balance between harnessing the benefits of AI while upholding ethical principles and humanitarian considerations in armed conflicts.

Cybersecurity

Considering that the average computer and cellphone user has to be concerned that their equipment and accounts will be hacked, identity stolen, and bank accounts drained out, what about the likelihood of AI-driven equipment? Especially when autonomous cars are linked to communicate with each other directly and armies of drones and robots are also communicating with each other and the home base, it stands to reason that sophisticated hackers will take advantage of this and turn cars and robots against their users.

Autonomous vehicles are vulnerable to both unsophisticated and sophisticated attacks. Hackers have already taken over non-AI-controlled vehicles through Bluetooth and there exist vulnerabilities in the camera, LIDAR, and radar systems. Even low-tech things such as painting the road to misguide the navigation system or putting stickers on stop signs to prevent it from being recognized can have very adverse effects on AI-guided cars. There has even been a successful ransomware attack on Honda cars (Truong, 2021). Robust engineering to overcome these vulnerabilities is necessary. However, hacker ingenuity has been able to overcome most security systems over time, Sun et al. (2022)

The race to develop military drones and robots is close to full automation and some systems could be deployed now. The problem is that what if there are vulnerabilities that can allow hackers to turn the machines on their owners? Even though there are groups such as Boston Dynamics who have stated they will not allow their robotic platforms to be used as weaponry there are many more without those scruples. The war in Ukraine is pushing drone technology as both sides are using them for sophisticated surveillance and attacks. When the human is taken out of the equation not only is the system vulnerable to the AI programming (will it always make the right choice when selecting targets?) and to any system vulnerabilities that can be exploited by hackers (DrStuClark, 2023; Bajak and Arhirova, 2023).

The four quadrants show the level of readiness for a select group of countries toward deployment of AI weaponry and resistance to hacking attacks, Dawson and Desouza (2022). The most prepared are Germany and China in terms of both technology and trained people. The USA has the best technology but is deficient in trained personnel while Canada is in the middle for both areas.

The AI Apocalypse: Fact or Fiction?

The last subject for this chapter is the threat of the oncoming Singularity and subsequent AI apocalypse. The Singularity is the event wherein AI evolves consciousness beyond a human level and then the AI being will continue to evolve to the point that it will find humanity lacking and will take over and control human activity perhaps even wiping it out as being an inferior species, Friend (2018).

AI has been divided into two camps, Artificial Narrow Intelligence and Artificial General Intelligence. ANI is the approach that leans more toward machine learning which does not try to mimic human thinking while AGI attempts to develop processes that are equivalent to human thought processes or of the same power but going down a different pathway than organic neuronal processes. ANI holds promise in areas like self-driving cars which would not only create much safer roads but would fundamentally change the way we travel as there would no longer be an incentive to own a car.

There have been some doomsayers like Elon Musk who warns against "summoning the demon," envisaging "an immortal dictator from which we can never escape." Stephen Hawking declared that an AGI "could spell the end of the human race." Even as long ago as 1951, the AI pioneer Alan Turing predicted that machines would "outstrip our feeble powers" and "take control."—Ted Friend at The New Yorker, May 7, 2018.

There are huge incentives and huge profits for companies that invest in continual increases in computing power and in the ability for machines to act more and more like humans. In what is being called the "AI Jobs Apocalypse" around 300 million jobs are at risk soon according to economists at US investment bank Goldman Sachs. Affected job sectors are finance, publishing, law, education, customer services, market research and other information-based industries. Historically, massive unemployment does not follow major technological change and currently, unemployment is close to record lows in the USA and Canada (Finlayson, 2023; Bureau of Labor Statistics, 2023; Statistics Canada, 2023 and The Economist, 2023).

However, this level of technological change and the potential depth of penetration into the worldwide workforce is unprecedented and many people feel that AI development should not proceed without some control. There is a proposal for 23 guidelines although they depend on developers not doing certain things (Irving, 2017). There is a group proposing to study machine behavior through its algorithms defined as agents (Government of Canada, 2023). The Canadian Government has proposed The Artificial Intelligence and Data Act (AIDA) to guide AI introduction into the lives of Canadians, Future of Life Institute (2017).

Or perhaps Isaac Asimov's Three Laws of Robotics from his Robot series of science fiction books May suffice:[8]

> (1) a robot may not injure a human being or, through inaction, allow a human being to come to harm.
>
> (2) a robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.
>
> (3) a robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

In later novels, the Zeroth law was added to account for activities that might harm individual humans but was necessary to prevent an AI Apocalypse.

> (0) a robot may not harm humanity, or, by inaction, allow humanity to come to harm

In the novels, though, the author appears to be finding ways for robots to get around the rules so perhaps these are not robust enough for highly creative humans and AI alike.

Conclusion

Artificial Intelligence and Machine Learning are fields that show great promise in extending the capability of human endeavor and capability. By utilizing the ability of extremely fast and powerful hardware and using software algorithms so complex they are expected to rival the ability of the human intellect we are at the very beginnings of an overwhelming change to society that we can hardly even imagine.

However, with that level of power and capability, there is also a possibility of disaster. This is because it is human beings who are the progenitors of this technology and human beings make mistakes. Mistakes that will be amplified tremendously by the very power of these devices. We can only hope that this development is done with the best interests of humanity at heart.

Time is running short as hardware and software are quickly advancing and the continuing need by humans to probe the edges of knowledge continues apace. Do those with an understanding of these machines and how to use them, have the power and understanding to stop further development when it becomes apparent that the product can overtake its creator? The Luddites had to contend with the owners of the looms having the technology to put them out of work. Considering that it is the tools themselves that may take over so that an untold number of jobs will be lost. Consider also that the tools may end up smarter than their creators and decide that we are no longer necessary, will we, as modern-day Luddites, have the capability to even be able to break these machines if things go terribly wrong?

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Exploring Financial Service Innovations: Socioeconomic and Regulatory Concerns

Kabiru Sunday Ayinde, Pooja Lekhi, and Mahdi Toobaee

Abstract The potential opportunities for financial services innovations are enormous. Like a double-edged sword, though society desires the convenience, ease, and speed of financial innovation, the threats are always there. This chapter explores socioeconomic and regulatory concerns in financial service innovations, including consumer privacy and protection, cybersecurity, financial stability and safety. Addressing both social and economic concerns require deliberate action including designing a security architecture that serves as a surveillance tool to monitor horizon issues either positive or negative that each innovation brings. Additionally, the chapter discusses effective management of regulation concerns by balancing the need for financial services innovation and the desire for the financial systems' safety and stability. The chapter concludes by exploring possible collaboration mechanisms for regulators and financial service stakeholders for the common good.

Introduction

The net effect of every financial innovation is for the common good of the public. Technology is the engine room of innovation and is often a response to consumers' pain. This pain can come in the form of product usage, service experience, and even yet-to-be-identified needs in the future. Innovation itself has good sides, that make life better, and bad sides, that pose a risk.

Harnessing the opportunities in innovations while mitigating their unintended inherent risk is the responsibility of all the stakeholders in the financial system. The

K. S. Ayinde (✉) · M. Toobaee
Department of Quantitative Studies, University Canada West, Vancouver, BC, Canada
e-mail: sunday.ayinde@myucwest.ca; mahdi.toobaee@ucanwest.ca

P. Lekhi
University Canada West, Vancouver, BC, Canada
e-mail: pooja.lekhi@ucanwest.ca

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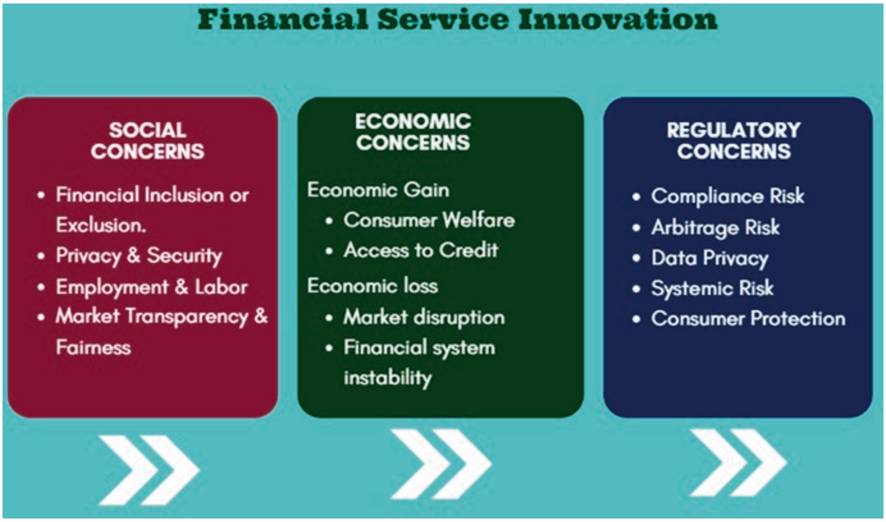

Fig. 1 Impact of financial service innovation. *Note:* Social, Economic, and Regulatory concerns of financial services innovation. Source: Composed by the authors

shorter time-to-market deployment of financial technology lately confirms how innovation and technology are evolving. On a closer look, capturing the mind share of the consumers to gain market share is the underlying driver of this development. This chapter explores the social, economic, and regulatory concerns as they affect financial services innovation. In trying to win customers over, financial service providers' actions and inactions ultimately impact socioeconomic activities in one way or the other. Because the financial system is a highly regulated industry, regulators are also on the alert to assess the potential impact of new technologies on the financial system's stability and safety. The pendulum continues to swing either way, with the consumer in the middle seeking solutions and safety from all the financial services market participants (Fig. 1).

Social Concerns

The social impacts of financial services innovation could be either positive or negative. Some of the broad social aspects of our lives that these financial innovations influence are financial inclusion or exclusion, personal privacy and safety, employment and labor, consumer protection, and transparency and fairness.

Financial inclusion or exclusion is described as when innovations such as mobile payment, mobile wallet, and digital banking are making financial services either accessible or inaccessible to people. Many experts have come to terms with the impact of financial exclusion on human development. Most low-income urban settlers are financially excluded due to unavailability, inaccessibility, unsuitability, and high cost of financial services. This impacts their ability to participate meaningfully in the socioeconomy development of society. However, the introduction of mobile payment, for instance, by most jurisdictions, has helped to bridge the gap between those who have access to financial services and those who do not. The World Bank (n.d.) showed that global bank account ownership increased by 49% between 2011 and 2021 because of mobile payment technology in sub-Saharan Africa, with more women adopting this payment option.

Privacy and Security: On personal privacy and security, the rise of Internet banking has simultaneously increased cybersecurity concerns as consumers are becoming increasingly vulnerable to theft of personal and financial information. Data security and privacy concerns are important considerations when it comes to the adoption of financial technology. In the USA, the average cost of data breach between March 2021 and March 2022 in the healthcare sector and financial services industry stood at $ten million and $5.9 million while the global average cost hover around $4.4 million (Petrosyan, 2023). This represents a significant cost imposed on the general economy because of the compromise of individual and business data.

Personal security vulnerability is on the rise as hackers and cybercriminals explore human error, insider misuse, Malware, and physical theft to prey on their innocent victims. Individual privacy is compromised in a digitalized financial system due to the theft of financial information during data exchanges. Incidences of scams, identity theft, and fraudulent activities are disturbing because they impact the trust and confidence of consumers in the financial system.

Some of the common techniques identified for stealing consumers' financial information are Phishing attacks, which involve the use of malicious emails to obtain sensitive information from a targeted individual; Password attack occurs when the hacker attempts to intercept, say online banking network to grab a customer password; SQL Injection attack, use of SQL query from a client to a database on the server, Trojan Horses, a deceptive, malicious program from what appears to be from a genuine source; and Malware that alters the system configuration of a computer when infected; and Denial of Service attack (DOS) that causes a system not to respond to a genuine service request due to overload. While financial institutions and regulators are working to ensure the financial system's safety, awareness and taking personal responsibility are required from individuals and businesses to ensure cybercrime is curtailed in society.

Employment and Labor: Another important social impact of financial services innovation is employment generation and labor activities. Automation is causing job loss as machine replaces human, especially in the execution of repetitive tasks, as more workers are disfranchised of employment benefits and protections due to automation. For instance, in March 2023, some experts and industry leaders, including Elon Musk, signed an Open letter calling for a pulse in the deployment of Artificial Intelligence because of the significant risk it poses to unemployment and human safety; this is coming at such a time that the deployment and use case of Artificial Intelligence is fast becoming a norm in almost all the industries including financial services.

Market Transparency and Fairness: Additionally, achieving market transparency and fairness is a tall order because of unethical practices that create room for prejudice and bias. For instance, algorithmic lending and credit scoring may not be fair to certain people of color or low-income earners. In the final analysis, it behooves financial system players and regulators to be on guard by taking proactive steps to identify, monitor, and respond to social concerns that emanate from the deployment of technology in financial services.

Economic Concerns

When assessing the economic impact of financial services innovation, it is important to note that innovation can be a force for economic gain or loss.

Economic Gain

Consumer welfare: readily comes to mind when looking at Economic gains. New products and services provide greater convenience by lowering costs and improving the overall quality of financial services. But sometimes, the complexity associated with this innovation results in poor decision-making processes for the consumers. Increasing access to credit for low-income, underserved populations promotes and enhances the ability of the citizens to participate in economic activities. However, it can also result in premeditated consequences of unethical, predatory lending practices that exacerbate financial system instability. Financial Innovation promotes consumer welfare and general economic well-being when appropriately designed and monitored.

Access to credit: Increasing accessibility of credit to small businesses is critical to economic growth. According to Statistics Canada, small and medium businesses account for 98% of employment generation and has been identified as essential to sustaining economic growth and redistribution of economic activity among the populace. Innovation in the financial services sector which led to the entrance of Fintech is filling the gaps that the existing financial institutions could not cover previously.

Economic Loss

Economic loss can come in the form of market disruption, financial system stability, and regulatory issues.

Market disruption: The US Treasury Department estimated that the 2008 financial crunch resulted in the loss of $19.2 trillion in household income (Childress, 2012). Market failures alter the configuration of market players, causing some to win and others to lose, sometimes resulting in an oligarchy that makes few become so powerful, thereby stiffening competition and innovation. The reason for this is obvious, as, most often than not, big financial institutions might wither in the storm by pulling extra human and material resources to support and invest in this new technology.

Financial system instability: The risks of financial system instability are heightened in an increasingly innovative financial system as complex financial product proliferation increases the probability of systemic and financial risks. One way to counter this risk is the innovation of regulatory functions and oversight itself to properly monitor the market development. Most of the time, regulators are always in an endless circle of keeping pace with financial services innovation as rules and regulations are lagging behind the financial market activities. If this continues unchecked, greed will accelerate corporate abuse, which consequently results in economic woes rather than economic wins. Managing this financial stability risk will require public–private regulators' collaboration. One significant outcome of this collaboration is the development of a standardized regulatory sandbox for testing, monitoring, assessing, and evaluating the risk associated with newly developed financial products and service before it is launched.

In the end, the regulators are better informed and prepared to manage any emerging risk of such financial innovation. Realizing the net economic gain of financial services innovation continues to be a walk in the path for all players in the financial services ecosystem.

Regulation Concerns

Financial services innovation poses a significant regulatory concern for legislators and regulators. Some of these issues include Compliance, Regulatory arbitrage, Data privacy, Systemic risk, and Consumer protection.

Compliance Risk: Compliance risk is exacerbated in an increasingly innovative financial service marketplace. The dynamic changes in processes and products increase the degree of complexity of new products and services. Financial institutions are at higher risk of flaunting rules and regulations when these arise. Ideally, eagled-eye regulators apply penalties and fines for non-compliance when these occur.

Regulatory Arbitrage: The risk of regulatory arbitrage is also high when regulators are behind innovation in the financial services marketplace. Financial market players exploit lax regulations or loopholes in regulation to undermine the effectiveness of regulation, thereby increasing the risk to financial system stability.

Data Privacy: Additionally, customer data privacy and security risks are heightened because of the collection, processing, and storage of large amounts of consumer data for financial services innovation. Addressing this risk may require enacting new rules and regulations to prevent data breaches and avoid privacy risks.

Systemic Risk: The main aim of regulators is to achieve a stable and efficient financial system. However, instability and systemic risks aggravate during the design, development, and introduction of new complex financial services and products. Managing this financial stability and systemic risk requires a responsive oversight mechanism that is up to date with the financial services development.

Consumer Protection: The sole aim of striving for financial stability by most regulators around the world is to maintain public confidence in the financial system.

Anything that tampers with this goal is often frowned at because the cost of losing public trust has unintended consequences on not only the socioeconomic activities in short to medium term but also on political stability of any nation in the long run. Hence, consumer protection is a crucial aspect of regulatory concerns.

Approach to Manage Financial Innovation

Three approaches discovered to be proven useful for policymakers and regulators to manage financial innovation according to Pew Research (2018) are: (1) Coordinating market participants to develop for common understanding, (2) Accommodative regulations to manage emerging financial products and services, and (3) Removing regulatory barriers to innovation (see also Turi, 2023 on Fintech developments and regulations and Turi, 2020 on digital economy and the information society as it maps to the financial service applications).

1. *Developing common understanding through outreaches*: It is the era of engagement. The days regulators are standing far off from the market are no longer in existence. Successful regulators are coordinating efforts to reach out to market participants to develop a common understanding of new financial services innovation. By creating industry contact offices, regulators are leading engagement and meaningful discussions with market participants to gain common knowledge of new products and services. Some of the efforts in this direction by countries and at the global level are discussed below.
2. *Adapting regulatory framework and regulations to market conditions:* While it is sacrosanct for financial regulators to maintain the safety, stability, and soundness of the financial markets in their jurisdictions for the overall well-being of the global financial system, the need to have an agile and responsive regulatory framework is of utmost importance in this global digital economy. Oversight functions must be highly adaptive to changing market conditions without losing focus on the main goals. Regulators around the world understand that innovation is the fuel of economic participation. Having responsive rules and regulations with changing principles is critical to achieving regulatory objectives and market development.
3. *Removing regulatory barriers to financial technology innovation:* One way to achieve this is to have a regulatory sandbox where Fintech can experiment with new products and services under the regulator's watch. Through this, the regulator can develop an understanding of areas of regulation that can be suspended or removed for novel financial services solutions while holding the firm to the basic tenet of rules and laws that enable the regulator to achieve its objectives.

Case Studies of Regulatory Initiatives

1. *The United States of America*—the Fed-Innovation:

   The Federal Reserve Bank of the United States (n.d.) supports engagement with both regulated and financial markets, in general, to promote responsible innovation through organizing events such as Data and Connectivity Symposium. It also provides additional resources for community bank access to innovation. The symposium gathers experts, academia, and innovators within the financial services marketplace to discuss and brainstorm on the development and implication of emerging technologies on the safety and soundness of financial institutions, particularly consumer protection and the evolution of banking in general.
2. *Canada*—The Bank of Canada PIVOT Program:

   PIVOT is an acronym for Partnership in Innovation & Technology Program, which brings together the private sector and academia to experiment with digital solutions, including machine learning and artificial intelligence. The program's goal is to respond to the current and emerging challenges of new financial technologies. The Strategic plans for 2022–2024 continue to prioritize innovation as an important tool for developing truly competitive and global Canadian banks that meet the demands of the digital economy (Bank of Canada, n.d.).
3. *Australia*—The Australian Securities and Investment Commission-Innovation Hub.

   In Australia, through the ASIC, the government Innovation hub provides practical support to new businesses for launching and scaling within the Australian regulatory financial framework. It also offers informal assistance to financial technology businesses to gain an understanding of regulatory obligations (Australian Securities and Investment Commission, n.d.).
4. *The United Kingdom*—Bank of England-Fintech.

   The Bank of England (n.d.) is actively supporting Fintech by understanding how its new products and services will impact the financial stability, safety, and soundness of the financial system. The bank also seeks to apply financial technology to enhance its capabilities. On October 11, 2022, the bank collaborated with the Financial Conduct Authority (FCA) to publish a discussion paper on deepening an understanding and dialogue on how Machine learning and Artificial Intelligence will impact its objectives.
5. *The European Union*—Research and Innovation.

   This is a joint research initiative of the EU to support and promote innovation across the member states. It provides partnership, networking, funding, and sharing resources on various innovative solutions among the union members. 2020–2024 strategic priorities of the EU identify green finance and digital transformation as drivers of a sustainable and prosperous future. The EU believes attaining its strategic objectives of Environment and Climate, Digital future, Jobs and Economy, Citizens Protection and Values, Democracy and Rights, and promoting Europe to the world are tied to innovation and research (European Commission, n.d.).

Global Regulators (Bank of International Settlement and World Bank)

6. *Bank of International Settlement*—BIS Innovation Hub.

   The BIS work focuses on the impact of innovative financial technologies such as Central Banks' Digital Currencies (CBDC), Suptech and Regtech, Next gen financial markets Infrastructure, Open Finance, Cybersecurity, and green finance. The bank's strategic priorities in 2023 are to improve payment systems by experimenting with CBDCs, responding, and adjusting to the future of financial regulation and oversight function, and building and supporting sustainable green finance (Bank of International Settlement, n.d.).

7. *World Bank*—ITS Technology & Innovation Lab.

   The Lab is the bank's internal technology advisor, which explores the operationalization of emerging technologies by enhancing the bank's preparedness in this competitive digital age. The Lab coordinates engagement between its internal staff and external partners to promote learning by doing through experimentation and operationalization of many use cases of emerging technologies (World Bank, n.d.).

Concluding Remarks

In conclusion, regulators need to keep abreast of trends in technological advances and take preventative actions to address regulatory concerns. Having constant engagement with the market participants, modifying existing rules to suit market dynamics without compromising objectives, and removing regulatory barriers where it is necessary will go a long way in managing regulatory concerns that come with financial technologies.

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Equipping Small-and-Medium-Scale Companies (SMSC) Through Open Innovation: A Refined Proof of Concept and OI Redesign for Strategic Implementation

Fernando Ferreira Fernandez and Abeba N. Turi

Abstract This study presents a novel approach to Open Innovation (OI) as it applies to small-and-medium-scale companies (SMSCs) suffering from multilayer constraints to benefit from such a collective tech value creation model. Building on the decades-long practice of OI, the chapter looked into the model's evolution, development, and application constraints for the SMSCs and presented a refined concept note that meets the dynamic business and tech environment. Based on this, an OI model that encompasses different stakeholders is designed. The proposed IO model that applies to the SMSCs is built on the Consortium model principles that enable ease of entry and exit for each of the stakeholders, keeping members' best interest for the common good.

Introduction

The basic idea of Open Innovation is to get a group of companies, each with low-to-moderate stakes, to all work on developing and operating shared technological solutions. The notion of Open Innovation arose from the need for a long-term strategy, reflecting the need for internal research activity and innovation. With the shared values, risk, and cost-saving features of such a technological business model, businesses can take advantage of such a collective innovation hub. It is evident that OI can promote SMSCs' competitive advantage and enable the company's longevity;

F. F. Fernandez (✉)
University Canada West, Vancouver, BC, Canada
e-mail: fernando.fernand2900@myucw.ca

A. N. Turi
Northeastern University, University Canada West, Vancouver, BC, Canada
e-mail: abeba.nigussie@ucanwest.ca

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This external approach only will succeed if industrial education raises the internal perception of the SMCs for collaborative Technology Innovation.

Existing research in the field, for the most part: (1) Does not identify which forms of open innovation models are best suited for small-and-medium-scale companies; (2) Does not recognize that certain cutting-edge technologies may be available to enable and support open innovation models for small- and-medium-scale companies unlocking new forms of business operation and collaborative value creation for the common good; (3) do not have a design for a self-enforcing incentive mechanism to incent stakeholder participants in the open innovation hubs; and (4) do not clearly address the role of government in facilitating such collective research and development for the SMSCs.

Open Innovation: Evolution and Practice

Open Innovation has become a hot topic in economics, engineering, sociology, research and technology, anthropology, and other fields (Huizingh, 2011). As discussed by Chesbrough (2012), Open Innovation, OI has a significant effect on the dynamic and competitive environment we live in, not limited to big companies. The notion has the potential to define companies' long-term survival and gain competitive advantages through a collaborative setting. In an open innovation setting, companies will benefit from shared values through access to partnerships in research, development, technology, new business, and whatever in a collaborative environment at a shared cost and risk. Since the term Open Innovation was coined in 2003 by Chesbrough in his book, the concept has vastly expanded. Besides, the notion is adopted and customized increasingly across industries. This practice of collaborative setting has been in place in some high-tech companies where these companies have been using the concepts of sharing costs and risks.

Chesbrough (2012) states the differences between open and closed Innovation and the two kinds of open Innovation: (a) outside-in, where the company opens its innovation process to whatever outside inputs can be used, and (b) inside-out, when the company spills its unused ideas or developed techs to outside users for their businesses. Even today, the process is improving, and we can still see many big companies in the closed innovation model, where the patents are unused, not marketed, and becoming obsolete, which will not happen, or very few of them in the open innovation model.

The OI notion, as it applies to small- and large-scale companies, comes with a variation in the impact level given the scale effect. Kirschbaum (2005) described an open innovation inside a large company. Robert Kirschbaum was the former VP of Innovation at DSM, a Dutch company in the high-performance materials, health, and nutrition sector with annual revenue of over 8 billion euros, DSM-Bright Science. Brighter living. TM. (n.d.). The article presents the transformation of DSM to a multi-specialty company focused on applying the former areas to customers' products in a business-to-business market. The company was facing the early stages of opening the innovation department since the 1990s when the New Business Development department was created to bridge the research areas with potential applications. After the success of this endeavor, DSM realized the many opportunities that culminated in another business group in 2001 called DSM Venturing & Business Development, where around 50 people were focused on the "Open Innovation" process. It clearly shows the commitment of DSM to keep ahead of the competition by the alignment of R&D to Innovation, facilitated by the priority given through the new venturing and business unit. In the Business Development Model, the process presented shows the maturation from R&D to Innovation is made through the personas: (a) Intrapreneur—bringing good ideas to viable projects and (b) Professionals—bringing the projects to business.

Vanhaverbeke et al. (2012) discussed the importance of open Innovation for small-and-medium-scale companies in attaining a competitive advantage. With a trade-off between protectionist international trade policies and an open economic setting with an appetite for international companies, local SMCCs are prone to harsh market conditions that drain their financial resources due to the competition from foreign low-cost companies. This justifies the need for collaborative value co-creation that fosters innovation and adds to the competitive advantage through shared costs and risk of the open innovation model. Accordingly, Vanhaverbeke et al. (2012) introduced the OI approach for SMCCs which is unique to companies of a similar scale of operation, unlike the big ones, which are far more resourceful in multiple aspects.

Open Innovation Adoption Constraints for SMSCs

Concerning the absorptive capacity of companies, companies' lack of internal knowledge to enable external interaction and capacity to absorb technologies beyond their products—Syndrome of Not Invented and resistance to change to a new model (Cohen & Levinthal, 1990; Katz & Allen, 1982). In small-scale companies, research and development expenditures tend to limit innovation capabilities with significant evidence of correlation, Acs and Audretsch (1990). innovation and small firms, they were already following the path to link internal research to company innovation.

Besides, regardless of a company's OI partnership, such developments in a collaborative setting can come with high-end solutions that call for tech readiness and the company's capabilities in implementing such technologies. In this regard, Pimentel and Albino (2010) to evidence from SMSCs in Brazil reflecting on the lack of Knowledge Management (KM) capacity as one of the constraints in internal business innovations and tech adoption and implementation. This is important because, with efficient knowledge management, SMCCs can easily and quickly retain their core capacity and knowledge in a steady manner as they catch up with or follow the industry dynamics. In this regard, it is recommended that companies have a minimum technological structure to handle open Innovation. Hence, such preparedness can be harnessed through internal and external strategies to equip companies with a human capital investment that involves training for OI. Amati et al. (2020) presented the Pirelli project conducted in 2010 about Technology Road mapping Management (TRM) and built a process to link the TRM to Research, Technology, and Innovation Management system. Here, the Technology Road mapping Management shows an additional dimension to increase the complexity on the SMSCs' shoulders.

Studies show that SMSC's usage of Intellectual Property, IP, reflects lesser licensing and innovation results than big enterprises due to the lack of innovation and the complexity and cost of IP. Nikzad (2014) reflected on this by taking the case of the Canadian government's role in addressing the under-usage of IP and that the government should promote and create awareness while building IP capacity inside the SMSCs through education and cost reduction in IP for these companies. In 2017, the Canadian government launched a program (Innovation and Skills Plan) to incentivize SMSCs to foster their development and innovation. This program reflected more than two billion CAD (Cad$ 1.2 billion for the Strategic Innovation Fund and Cad$ 900 million for the Innovation Superclusters Initiative) to sectors considered priorities like advanced manufacturing, agri-food, clean tech, digital technology, health/biosciences, clean resources, transportation, and infrastructure. As of 2022, the funds available are Cad$ 750 million for a 5-year plan with five cluster areas: digital technology, protein Industries, advanced manufacturing, scale AI and ocean, and Global innovation clusters (n.d.). Visiting the Advanced Manufacturing cluster, Sector, I. (n.d.). The tech themes are related to the Internet of Things, machine learning, cybersecurity, and additive manufacturing (3D printing), with a total fund of Cad$ 427 million. The process is made of a call for specified title projects for groups of companies (consortiums) with certain characteristics for attending the contest for the funds.

In a digital world with cutting-edge technologies that promise operational efficiency for SMSCs, such companies also suffer from privacy and security issues that add extra layers of constraints for innovative value co-creation through Open Innovation (Turi, 2020; Turi & Li, 2021). Hasani et al. (2023) showed a model for SMSCs to overcome their difficulties in digital security. This important study also raises the weakness of the SMCs in IT, Engineering, and analysis for holistic development for medium and long-term competitiveness.

Here, the resilience and competitiveness of small companies lay on the long-term strategies, values, and policies of the company equipped with relevant technologies as it defines the positioning of the company in an industry, Gunasekaran et al. (2011). However, this is evidently a challenge for companies of this scale to stay ahead of the competition and time.

Due to these and other layers of complications, OI practices among small-and-medium-scale companies are very low, aggravated by within-group competition elements, resource constraints, human capital, and awareness issues for companies of this level who struggle to sustain their business or penetrate a market. This points out the importance of education in the industry as part of the government's role, which will be detailed later in this chapter.

Open Innovation: Value-Add

Gassmann et al. (2010) showed an interesting perspective for the next trend in OI by pointing out the openness trend from an absolute era of secrets and undisclosed information in companies to a more shared and disclosed information in the pre-competitive moment and more restricted way in a business moment. That is a trend in outsourced R&D in a collaborative and open innovation way. Also, the increasing need for resources imposes a natural trend for the shared costs and risks intrinsic to Open Innovation. Adding to that, there is a trend of more strategic development to be conducted in an open innovation model as different players can also assess it before the decision of adoption/insertion in the company. Another trend is the increase of low-tech sectors adopting the OI model, like the high-tech sectors. More and more daily companies will integrate themselves with the outside through Open Innovation. It is also shown that the number of SMSC adherence to this new model configuring a trend and strongly recommend for any size company decision. This can be understood as improving new technology and a new business road instead of only following the cost reduction path. Other trends identified in this regard are the change from standalone to alliances, fear of disclosing the past, to happiness of sharing the future. In this last category, changing the mindset from protecting the past IP to a tradable business and opportunity was another one.

Similarly, Qian and Haynes (2013) evaluated the efficacy of the US Small Business Innovation Programme, SBIR, in enabling SMSCs to high technology entrepreneurship. Beyond the SBIR, which is mostly focused on facilitating technological commercialization, the main conclusion is that the program also adds the entrepreneur stimulus by interconnecting with other programs and agencies that support this activity on SMCs. Additionally, they pointed out the need to address human capital investment on board to the SMCs policy under SBIR.

Companies that are part of a collective innovation hub can excel at internally developed tech solutions and product developments in a co-shared space at stake (Kohli et al., 2023; Turi et al., 2017). Yet, there is a risk of de-risking Innovation when managers try to reduce general risks in the innovation process, de-railing high-risk of hidden disruptive tech before all the others, Drakeman and Oraiopoulos (2020). To overcome this natural managerial flaw of keeping strategic vision linked to the present business of their products, they analyzed the ambiguity between the R&T&I department, designed to build the new tech, and the departments of product development and operations management, much concerned with keeping the current success of the company. This can be a healthy debate when someone over all departments forces some middle balance risk mitigation position on new high-tech content products. When disruptive technologies emerge in the market without going through the company innovation process, it is too late for laggard companies to catch up and win a competitive advantage being in a learning and/or adoption phase.

OI initiatives can potentially add value in RT&I functionalities of knowledge management, IT resources, project management, technology road mapping, and IP commercial exploitation for member SMSCs through a collaborative setting. To foster this:

- SMSC RT&I policy design, outsourcing opportunities through an SMSC's direct governance should be in place as part of such a collective initiative.
- More work is needed on the new tech risk-aversion behavior of SMSCs in a bid to neutralize the risk of staying at the same level as competitors; Tech-risk aversion is a common mistake in SMSCs for a couple of reasons: Internal fight for funds, misunderstanding the concept of the risk between business activities and RT&I, which search for the high-risk disruptive technology before anyone else.

A Refined Open Innovation Model Development for SMSCs

Based on the in-depth reviews and synthesis made on the studies around the open innovation models and the analysis presented above, we propose a refined OI model that applies to SMSCs.

Smaller firms need to link the company's innovation to internal research, and this internal RT&I and readiness will guard the functions necessary to perform the research in the open model. When it comes to larger firms, such companies hold internally built and structured strategic research, technology, and innovation and were able to fast adopt OI in its early stage. Hence, the OI approach must differ for SMSCs as they need to possess the capabilities, resources, and organization for RT&I. The proposed strategy under this condition is an open innovation model association for the SMSCs with a membership fee, aligned with some funds and strategy from the government for tech development.

The proposed model observes a semi-centralized framework with the government's leading role in open innovation initiatives for SMSCs. This is due to the government's economic growth facilitation nature and the need for an uplifting power and structure on the side of SMSCs which hold a spartan organization most suitable for operations and short-term cash flow.

To set the first move, we shall define the kind of relationship the players could hold:

1. Association: An association is a group of people or companies united for common purposes and interests. The members are independent of each other. One important purpose is to address the lobby's thoughts to lawmakers and public policies.[1]
2. A consortium is a group of two or more people or companies working together to reach common goals in a timeframe project. Each member is independent of

[1] National Industry Organizations (n.d.).

the others in business operations, but they have a contract agreement governing their relationships, duties, rights, and penalties. One advantage of this model is that it is easy for any company to join or leave after the foundation of the Consortium.[2]

3. A cooperative is a special group where the members own the cooperative and cooperate to promote mutual, social, cultural, and economic benefits to the members and society. Members of the Cooperative contribute to the capital of the cooperative and benefit from the profits it may have.[3]

Here, the proposed OI model is built on the Consortium model, which means that no center or place will be built priorly and has a project duration mindset renewed by the continuous interest of the members. Once the Consortium keeps the members' interest high, it exists, and when that interest ends, the closure will be in effect.

If we think of this consortium model as a kind of franchise under government control that enables different companies from different sectors, we may create a reference source for the development of the technology of interest.

The key players in the SMSCs Open Innovation Model are:

- Government in charge of fostering strategic long-term technological areas. The government's role is in the technical strategy for the region or the technology on the map. This can create a path for drawing attention and interest from the industrial community for each technology in the plan. The attraction and interest of the companies can be set through the subsidies for the Consortium and some tax relief for the companies that prove commitment by pouring funds into the innovation system. This could be an easy model to replicate anywhere in Canada and in any subject technology area, like a franchise. Here, we augment the Health Impact Fund model that will incentivize members to innovate by delinking the cost of innovation from the cost of technology and thus compensating SMSCs based on their propensity to innovate.[4] As this goes down to the ground, in terms of the role played by the government, implementation of this initiative will consider the (1) creation of SMSC-steered government programs and funds (for example, by taking advantage of the pre-existing US and Canadian government programs); (2) Awareness creation about the public funds available to the SMSCs to the OI members.
- Industries to steer the group, to drive innovation, keep the knowledge alive, and innovate to meet the intense market competition in a dynamic business and tech environment. Note that in an international setting of such Oi that allows foreign company memberships, member companies can also have a strategic interest in the subject investigated by the Consortium in addition to the financial incentives.

[2] Kenton (2022).

[3] CLUSA (2019).

[4] See the Health Impact Fund designed to delink the price of drugs from the cost of innovation by creating complementary incentives that cover the latter through health impact rewards at https://healthimpactfund.org/en/ Page Accessed on July 25, 2023.

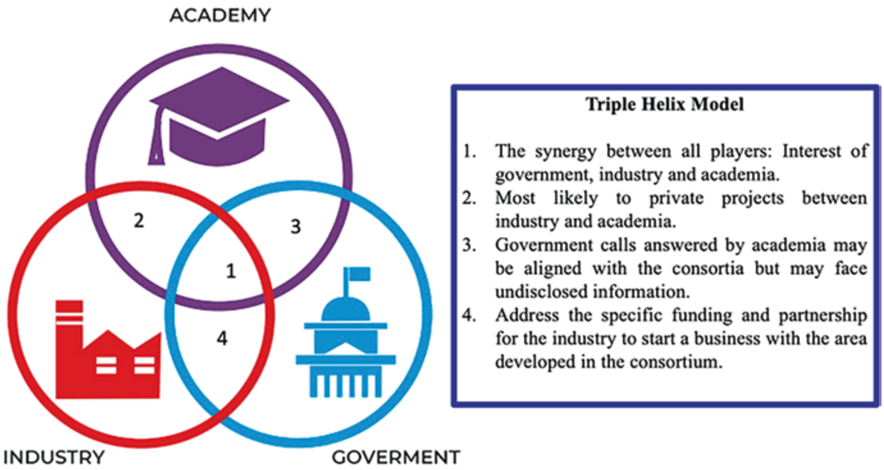

Fig. 1 Triple Helix for the consortium open innovation model. Source: Authors' development

- A collective OI hub leader (for example, a University or research institution that serves as an innovation fuel overseeing the OI, be in charge of developing disruptive and high-end tech solutions for the member companies and training OI hub members.

The model described above is based on the triple helix model of Innovation, which integrates the government, industry, and academia, and it may be expanded to the quadruple helix by including civil society and to the quintuple helix by incorporating sustainability and environment. Figure 1 shows the concept herein described.

Conclusion

The open innovation model presented in this chapter is state of the art about collaboration, risk, and cost-sharing. This will come with high efficiency and effectiveness in doing more research with less amount of funds per capita, enabling technological advancements and adoption for companies through a collective innovation hub. By leveraging this capacity of the OI model, the chapter explored application strategies and developed a novel, refined OI model that applies to small-and-medium-scale companies. The work presented here is a proof of concept, and further development and implementation strategies for the SMSCs OI model are underway as part of our future work.

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