Mediating role in industry 4.0 (4IR) adoptions and sustainable corporate financial growth in developed economies

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Abstract

Purpose: This study explores the role of Industry 4.0 maturity in enhancing corporate financial performance in developed economies. It examines how technological innovation impacts internal business process performance (IBPP), supply chain performance (SCP), and customer performance, which mediate financial outcomes.

Methods: A survey was conducted among 110 manufacturing firms in the United States, selected from a database of 834 eligible companies. The study employed AMOS software for structural equation modelling (SEM) to test hypotheses based on survey data. The maturity of Industry 4.0 technologies in these firms was measured using a comprehensive framework.

Results: The study found that Industry 4.0 maturity significantly improves IBPP and SCP, positively affecting customer performance. Notably, customer performance serves as a full mediator between SCP, IBPP, and financial performance. Firms with higher Industry 4.0 maturity show better financial results due to improved customer engagement and satisfaction.

Limitations: The study's findings are based on a sample of 110 firms, which limits generalizability. Future research with larger and more diverse samples is recommended.

Contributions: This research contributes to understanding how Industry 4.0 technologies influence financial success, providing valuable insights for policymakers and business leaders in manufacturing sectors.

Novelty: The study uniquely examines the complementary roles of IBPP, SCP, and customer performance in mediating the relationship between Industry 4.0 maturity and financial outcomes.

Keywords: *Industry 4.0, financial performance, technological innovation, supply chain performance, business process integration*

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1. Introduction

The Fourth Industrial Revolution (4IR), commonly known as Industry 4.0, signifies a disruptive period defined by sophisticated technologies like artificial intelligence (AI) and the Internet of Things (IoT) (Marcucci, Antomarioni, Ciarapica, & Bevilacqua, 2021). These developments have profoundly influenced every facet of society and the economy, encompassing governance, commerce, and finance. (Cascio & Montealegre, 2016). The economic landscape of the United States has been transformed as digital technologies improve productivity and stimulate wealth generation. Innovations in Industry 4.0

have diminished administrative obstacles, enhanced efficiency, and decreased operating expenses, especially in areas such as banking, which has experienced improved performance via the implementation of digital technologies. (Belinski, Peixe, Frederico, & Garza-Reyes, 2020).

Technological innovation is acknowledged as a vital catalyst for economic progress, impacting living standards and resource efficiency. (Dagada, 2024). Countries that invest in technical innovation typically attain greater per capita income and enhanced economic performance. Nonetheless, inequalities in innovation among advanced and emerging nations highlight the systemic problems affecting these results. (Chashi & Mwanza, 2022). Developed countries often utilise superior initial conditions, high-quality education of their labour forces, and significant investments in R&D. These advantages continue to perpetuate technical supremacy. In contrast, countries without resources have various obstacles to the innovation promotion. (Binz & Truffer, 2017). The enabling potential of every economy for innovation is determined, inter alia, by the quality of its institutions and access to finance. Gereffi (2017).

Good institutional quality determines the incentives for enterprises to invest in research and development, which in turn contributes to technological advancement. A country with strong institutions would be able to protect property rights, enforce contracts, and establish a regulatory environment promoting innovation. Third, in countries like the United States with strong institutions, it is easy to conduct corporations, and an investment climate of stability and safety supports innovation. A developed financial system increases organisations' capacity for new technology adoption considerably. Banks are crucial in capital reallocation from less productive towards more productive sectors, and on this basis, enable companies to take up new ventures or innovations (Tanha et al., 2022). Those firms that are investing in capital-intensive innovations without an immediate payoff but are relevant for long-term growth need access to funds.

Utilising bank finance allows companies operating in competitive markets to use advanced technology in order to rationalise production processes and improve overall productive performance, as Ivanov, Dolgui, and Sokolov (2019). The ability access finance is, therefore, interrelated with technical change and economic productivity. Threfore, the nexus between the financial systems and technological innovation highlights some key roles of quality institutions in facilitating economic growth. While strong financial institutions improve the efficiency of resource allocation towards creative sectors, weak institutions constrain the ability of enterprises to invest in transformational ventures. Institutional structures influence human behaviour and establish the foundation for individual and corporate operations. Countries with robust institutions facilitate innovation and allow less-developed nations to bridge the technical divide with leaders via policy changes and institutional enhancements (Mhlanga, 2022).

Innovation is not limited to research facilities; it frequently arises from cooperation and sharing ideas. Economic agents provide innovative solutions via interactions in marketplaces and across many industries. The interaction across many industries cultivates creativity, propelling innovation beyond conventional research and development environments (Liu, Wei, Ke, Wei, & Hua, 2016). Technological centres like Silicon Valley in the United States illustrate how collaborative ecosystems foster ongoing innovation and draw international talent. Robust institutional structures in these contexts facilitate the advancement and of the commercialisation of novel technologies.

Advanced economies, such as the United States, exemplify the advantages of robust institutions and financial systems; nevertheless, emerging nations have the problem of establishing analogous frameworks (Mkansi & Landman, 2021). Inadequate institutional capability may hinder governments from fostering settings that promote innovation. Institutional changes are pivotal in facilitating the adoption of innovations, safeguarding intellectual property, and attracting foreign investments in emerging countries, all of which are vital for sustainable growth (Mhlanga, 2022).

Technical innovation, institutional quality, and finance availability affect economic growth. The US shows how strong institutions and financial systems boost technical advancement and productivity.

Innovation disparities between nations highlight the need for comprehensive policy frameworks that support research, protect IP, and allow cooperation. As digital technologies improve, economies must emphasise strong institutional frameworks to ensure growth and global competitiveness. Investment and innovation are driven by institutional quality (Moll, 2021). Innovative and imitative nations exist worldwide. Nations with strong institutional structures implement policies well and lead their industries. However, some nations have performed poorly and are clustered with poor institutional quality due to policy failure. Persistence of policy distinguishes innovative nations from others. Stable governments that follow policy consistency are beneficial for innovation. Thus, innovation needs strong institutions. The vast differences in innovation performance between nations are attributed to intellectual property protection, infrastructure, institutional quality, and the rule of law. These characteristics affect innovation as much as technological proficiency (Dagada, 2024). This shows that stable governing nations have reformed their economy. Replication costs rise because strong institutional frameworks enforce long-term intellectual property rights (IPR) protections. Therefore, protection of strong intellectual property rights (IPR) is thought to be essential for stimulating innovation and preventing copycats (Lee et al., 2015). Developmental institutions are considerably inferior to developed ones. Corruption allegedly prevents technical forecasts and social development processes from merging across borders, preventing poorer nations from growing technologically (Moll, 2021). Many studies have examined how institutional quality affects innovation. These studies have been criticised for using weak institutional quality, innovation substitutes, and first-generation econometric methods. Furthermore, in analysing the relationship between institutional quality and innovation, this research focused only on formal institutions while ignoring informal ones (Marcucci et al., 2021).

2. Literature review

The literature makes a strong case for how technological innovation affects productivity. Technological innovation is a primary catalyst of economic growth, and researchers have thoroughly examined the elements that affect it. In the United States, similar to other nations, these elements may be generally classified into three categories: financial, institutional, and economic (Ivanov et al., 2019). Financial considerations encompass bank funding and general financial development, whereas institutional aspects pertain to government policies, regulatory frameworks, property rights protection, and anti-corruption initiatives. The economic factors influencing it include income levels, foreign direct investment or FDI, trade, and knowledge spillovers. Ivanov et al. (2019) said that due to these variables, innovation change occurs both at the firm and nation levels. The enterprises can only invest in research and development at the corporate level, provided they have access to financial resources from bank loans. Technological progress is, then, driven by the spending on research and development.

With access to finance, U.S. firms can better withstand market forces and competitive pressures as a result of new technologies. In empirical analyses, firm size is one of the determinants of innovation since large firms tend to devote greater resources to R and D. This is evident in technology-intensive industries like Silicon Valley, where large companies like Apple and Google commit extensive resources to creating innovative products (Tanha et al., 2022).

Thus, technical change is well-conditioned by national variables such as financial development. An advanced financial system puts resources into productive sectors and thus promotes technological change. U.S. banks, venture capital, and stock markets provide the necessary finance for start-ups and established firms to invest in capital-intensive projects. Strong capital markets encourage entrepreneurship and permit investment by firms in developing and applying new technologies with uncertain or distant payoffs. The institution plays a broader role in influencing the state of the innovative environment. Strong institutions provide an enabling environment that encourages companies to invest in innovative technology by upholding legal protection and the rule of law. In the United States, for example, property rights and intellectual property laws encourage firms to innovate due to the security it guarantees for their inventions. (Tanha et al., 2022). A solid regulatory framework gives the transparency and accessibility needed in the financial markets to enhance the enterprise's capability to raise capital for innovative initiatives. On the other hand, excessive government interferences, which manifest through high levels of taxation or strict controls, may limit a company's capability to invest resources in research and development activities and hence inhibit innovation.

The linkage between the quality of institutions and innovation is an area in which there has been a growing number of studies in recent years. Researchers indicate that government effectiveness, property rights protection, and anti-corruption policies serve as critical drivers in determining change in technology. (Chike, Mbamalu, Oguanobi, & Egbunike, 2023). An empirical analysis using panel data for successive years has indicated that countries with more developed institutional mechanisms register a more significant number and levels of innovation accordingly. For instance, institutions in the United States are functional; therefore, there will be a culture of innovation whereby firms will have confidence in setting up long-term investment portfolios.

In addition, such entities support the United States in maintaining technological dominance through the continuation of a stable legal and regulatory environment. Startups enjoy not only public but also private funding, allowing the creation of a more robust setting for technological innovation to take root and continue to flourish (Tanha et al., 2022).

Along with financial and institutional, economic variables, like foreign direct investment, commerce, and knowledge spillovers, are associated with the process of innovation. FDI inflows bring new technologies and techniques into the US, and its domestic firms are more than eager to adopt and adapt to innovative breakthroughs. International trade strengthens knowledge diffusion, which permits organisations to absorb best practices from around the world in their practice. Collaboration between the university, research centre, and company is especially encouraged through various government-funded programs, a country's innovative capacity through the creation of new concepts and product ideas. Besides, social capital has increasingly become a determinant factor in innovation. According to studies, cooperation, trust, and society networks can cause substantial impacts on creativity beyond pure effects of institutional excellence. Innovation clusters in the US, such as Silicon Valley, have taken advantage of social capital in enabling close cooperation among entrepreneurs, researchers, and investors in the development of new technology. When societal networks combine with supportive institutions, they drive an environment that enables creativity. Technological innovation in the US is driven by a complex interplay between financial, institutional, and economic factors: availability of finance, primarily through bank loans and venture capital, allows enterprises to innovate; strong institutions create legal protection and generate an investment climate conducive to innovation; and economic factors such as trade and foreign investment facilitate knowledge and technology diffusion (Liu et al., 2016)Social capital further reinforces innovation through increased cooperation and individual creativity. Taken together, these factors create the right position for the U.S. to lead technological progress and thus ensure that economic growth and competitiveness will continue. We believe that the conclusions of our research have important implications for policy and practitioners.

We maintain that political stability, accountability, and corruption play significant roles in explaining creativity. Corruption is one of the most important indicators of institutional quality. Furthermore, we discovered that corruption has a detrimental effect on the level of innovation in the same environment. (Jaiyeoba & Iloanya, 2019). We also found that differences in sub-national institutions significantly influenced creativity. Institutional quality raises businesses' confidence in the government's capacity to enact laws and implement policies, eventually encouraging innovation. In conclusion, bank financing gives businesses more capacity for investment and innovation. Therefore, the literature has a wealth of evidence supporting the beneficial effects of bank financing on innovation. However, research has also demonstrated the importance of institutional development for technical innovation. Earlier empirical research, however, focused on the linear relationships between innovation institutional quality and bank finance. Researchers have mostly focused on estimating the non-linear relationship between variables in the recent literature, particularly emphasising the impact of institutional quality. (Neumann, Winkelhaus, Grosse, & Glock, 2021). By investigating the complementarity between bank finance and institutional quality, which influences technological innovation, this study contributes to the body of literature already in existence. As a result, this study's panel regression differs from prior research (Hoosain, Paul, & Ramakrishna, 2020).

Our study is characterised by its methodological rigour, which sets it apart from previous research. To the best of our knowledge, no research has examined how bank financing and institutional quality complement each other to influence technical innovation (Mhlanga, 2020). We anticipate that bank financing and institutional quality will strongly complement one another, substantially impacting technical innovation. The use of first-generation econometric methodologies and flimsy stand-ins for institutional quality and innovation in earlier research on the relationship between bank financing and institutional quality and technical innovation has drawn criticism (Lee et al., 2015). This study closes this gap by using thorough assessments of intuitional quality and other factors that are considered.

In the 1970s, automation significantly transformed the U.S. industry as computer-controlled systems and robotics improved production. Currently, the nation is at the vanguard of the Fourth Industrial Revolution (4IR), propelled by artificial intelligence (AI), the Internet of Things (IoT), machine learning (ML), and Big Data, which provide extensive potential and difficulties (Neumann et al., 2021).

2.1 Artificial Intelligence and Fourth Industrial Revolution Technologies in the United States

Artificial intelligence has emerged as a fundamental component of U.S. innovation, influencing industries including healthcare, agriculture, banking, and transportation. AI-driven models ensure advanced disease prediction and medical treatments to ensure better patient outcomes. IoT sensors and machine learning algorithms applied in agriculture will evaluate soil health and automated irrigation systems, thereby meeting or improving output with the conservation of resources. Artificial intelligence in finance enhances the identification of fraudulent activities and simplifies predictive investment decisions to develop improved risk management strategies. (Chike et al., 2023).

With the emergence of AI, the U.S. economy is projected to grow at a CAGR of 40% from 2019 to 2025 and has the potential to contribute $3.8 trillion in gross value by 2035. With the rapid development of technology the rapid development of technology raises social severe issues related to job displacement and privacy vulnerability (Rozanna & Ahadiat, 2023). A reflective balance is called for that can help achieve equal access to technology and sustainable development.

2.2 Circular Economy: A Path towards Sustainability

In addition to technological advancement, CE has emerged as one of the potential system-level approaches to environmental problems in the U.S. economy. Contrary to the linear approach of "take, make, dispose," a circular economy is based on product reuse, remanufacturing, and recycling-tied waste reduction with efficiency in resource use. (Rozanna & Ahadiat, 2023). This idea first gained visibility in the late 1970s and, ever since, has played an essential role in various discussions about sustainable development.Large US companies are embracing circularity. Apple's efforts to recover components from scrap devices prevent electronic waste, while Tesla works on battery recycling designs to recover key mineral resources. States like California and New York are enacting policies to reduce plastic and electronic waste and spur the production of sustainable materials to meet the UN SDGs on Goal 12: Responsible Consumption and Production and Goal 13: Climate Action.

2.3 The Impact of the Fourth Industrial Revolution on the Expansion of the Circular Economy

The application of technology from the Fourth Industrial Revolution to the circular economy offers significant benefits in managing resources and reducing environmental impact. IoT sensors at manufacturing plants track energy consumption and waste by predictive maintenance. AI-powered recycling systems sort trash more effectively, increasing recovery rates (Zahedi & Piri, 2023). In fusion, Industry 4.0 and circularity ensure more viable industrial practices and economic growth by creating innovative business models based on resource regeneration.

2.4 Obstacles and the Way Forward

Despite these gains, various challenges impede the full realisation of sustainable development programs in the U.S. The digital divide between cities and the countryside, as well as among different socio-economic groups, remains quite a significant challenge. Further bringing down this gap will help ensure that the benefits accrued through technologies of the Fourth Industrial Revolution and/or circular solutions are fairly realised (Zahedi & Piri, 2023). The expansion of broadband is an effort towards the calls for access to digital infrastructures to ensure inclusiveness and engagement in the digital economy. These will only be successful if cooperative engagement is exercised among governments, business sectors, civic society, and international organisations. Indeed, the 2030Vision program is a good example;

These solutions will help the U.S. build a strong, low-carbon economy in line with international goals on the environment (Mashizha, Gumbo, & Chimwe, 2023). To realise this, there is a need to address challenges like the digital divide and ensure technology serves ethical ends. With thoughtful policies and partnerships, the U.S. can lead toward a more circular and equitable transition. Advanced technologies, like convergence, finally gave form to the Fourth Industrial Revolution, changing businesses, society, and everyday life. This new technology list includes AI, IoT, 3D printing, robots, and biotechnology, which continue driving growth in many areas of the United States economy.

These technologies not only open new perspectives in the solution of social problems but also make businesses effective, personalised, and durable. Changes have been observed with regard to intelligent towns and medical breakthroughs. Technology will affect the future of the U.S economy (Mashizha et al., 2023).

2.5 New technologies and the way in which they can be used

Artificial Intelligence, sensors, and next-generation data networks, such as 5G, are the foundation of intelligent systems in cities. For example, smart city apps improve infrastructure management by controlling traffic flow, automatically taking care of trash, and making the public safer with AI-powered camera systems. Face recognition and gait analysis technologies can recognise people in real time, improving security and raising concerns about privacy and ethics (Adekanmbi & Ukpere, 2023).

Three-dimensional printing is changing how things are made by letting companies make unique items whenever needed. This ability to make things quickly and on-demand changes customer markets and makes businesses more efficient in every sector (Ambroise, Prim-Allaz, & Teyssier, 2018).

Biotechnology has also come a long way, leading to significant steps forward in health care and living longer. For example, the Human Genome Project, which began in 1990 and has since mapped the whole human genome, has helped us understand how genes cause illnesses. Stem cell research could help grow new organs and tissues in a lab, allowing for more personalised medical care and regeneration medicines (Adekanmbi & Ukpere, 2023).

2.6 Core Technologies of the Fourth Industrial Revolution

The key technologies driving 4IR and their applications are summarised below:

Technology	Example Applications
3D Printing	Custom footwear designed based on individual gait scans (e.g., Adidas)
Artificial Intelligence (AI)	Facial recognition for unlocking smartphones and mass surveillance
Internet of Things (IoT)	Smart refrigerators that reorder groceries automatically
Robotics	Autonomous vacuum cleaners, agricultural fruit pickers, and warehouse robots
Biotechnology	Growing replacement organs through stem cell research
Material Science	Development of lighter, stronger materials for use in aerospace and construction
Quantum Computing	Simulating complex systems, such as the human brain, for research purposes
Energy Innovation	Adoption of electric vehicles to reduce carbon emissions
Blockchain	Cryptocurrencies and decentralized financial applications

2.7 Transformative Influence on Society and the Economy

The amalgamation of these technologies is transforming industries and improving the quality of life throughout the United States. AI and IoT applications are essential for creating interconnected surroundings, enhancing the efficiency of public infrastructure, and customising consumer products. Medicines and diagnostic tools resulting from biotechnology in health serve to increase the life span of an individual while maintaining well-being. Quantum computing, though still in its infancy, promises tremendous capabilities for problem-solving in most fields of medicine or climate modelling stated by Rajapathirana and Hui (2018).

Energy innovation is a critical area of growth. Electric vehicles are becoming available to help America reduce greenhouse gas emissions and promote clean transportation. Materials science advances support these efforts through their enabling of the production of lightweight parts that enhance the functionality of electric vehicles and optimise their energy use (Mahmod, 2022).

It changes the face of the banking world with its ability to securely and transparently handle transactions between peer-to-peer networks. Digital cryptocurrencies, such as Bitcoin, showcase just how blockchain technology can work, even now, as an alternative to traditional monetary institutions regulatory and market volatility issues remain (Mahmod, 2022).

The technologies defining the Fourth Industrial Revolution in the United States are interconnected, thus creating unique opportunities for innovation and economic growth. AI, Robotics, and the Internet of Things existentially push industries by providing automation to most business processes and harnessing the power to do real-time data analytics. Biotechnology offers better health by developing personalised treatment. Meanwhile, research into material science and quantum computing opens new doors in engineering and study. The fact that electric cars and blockchain financial solutions are increasingly used speaks to more focus on sustainability and decentralisation (Chow & Singh, 2022). As these technologies improve, they further enhance productivity and change the way Americans live, work, and interact with each other.

Going forward, it will be about the equity of benefit derived from these technologies. Policymakers will have to balance innovation against privacy and ethics and will be required to create a legislative environment that encourages entrepreneurship and investment. Such a convergence of technologies places the United States in the front row for global innovation, creating the way for a future in which life will be more efficient, cleaner, and more connected (Chow & Singh, 2022).

2.8 Digital Technologies for 4IR

Since the beginning of the Industrial Revolution, technological changes have constantly restructured industries in America. The application of water and steam engines in factories during the 19th-century mechanised production in a way that was previously unimaginable. In addition, at the turn of the 20th century, electricity gfurther boosted productivity through mass production a madny omanufacturing poperatons more efficient. Many automation and computer technologies began to be employed during the 1970s in industries for better operation, reduction of errors, and improvement in production efficiency. Today, the United States is also embarking on a new phase termed Industry 4.0, characterised by marrying digital technologies with industrial processes (Ralston, Blackhurst, Cantor, & Crum, 2015). Industry 4.0 presents an exceptional period in the history of industries as a motivation source toward efficiency, growth, and sustainable development.

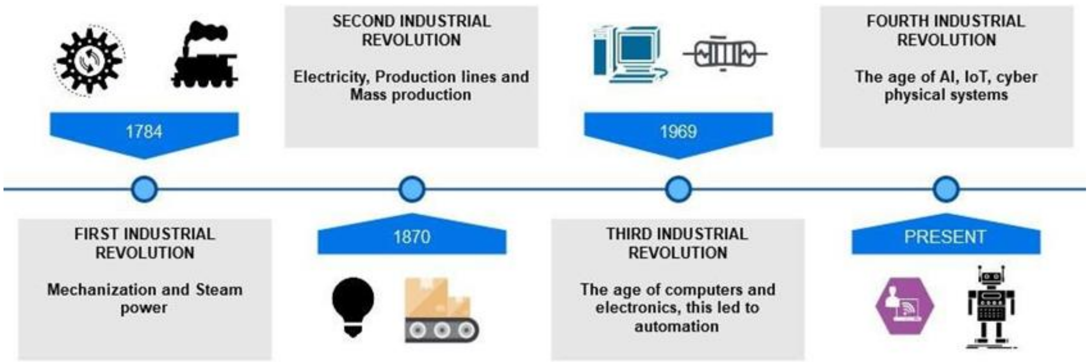

Figure 2.

2.9 Digital Technologies for 4IR

During the Industrial Revolution, we have seen the advancement of technology grow rapidly. Water and steam engines drove factories for the first time back in the 19th century; then, the coming of electricity in the 20th century saw an increase in the production rate, and in the 1970s came automation. We are now standing at a new frontier in digital industrial technology known as Industry 4.0, or the 4IR. The fourth technology wave in the industry allows these cyber-physical systems to communicate with each other through the use of AI, ML, big data, and IoT.

Productivity and growth will both rise with Industry 4.0. Figure 2 shows this timeline of the Industrial Revolution (Agbehadji, Awuzie, & Ngowi, 2021).

The United States then offered the cyberphysical system (CPS), whereas Japan first presented the intelligent manufacturing system (IMS) in the 1980s. The most recent proposals were China Manufacturing 2025 and Germany's Industry 4.0.

Numerous technical developments benefit technologies like artificial intelligence (AI), which creates many opportunities. AI's past is replete with dreams, opportunities, and hope (Su, Cai, Qin, Tao, & Umar, 2021). Our ability to imagine has always been innate. Professionals in the medical field are welcoming the revolution, as they have the potential to cure and prevent diseases in healthcare, agriculture, transportation, social interaction, finance, and innovative city development. Figure 3 displays a chart of the top 10 4IR digital technologies available today. Scientists studying neuroscience and artificial intelligence, such as Dileep George, once said, "Imagine a robot capable of cleaning up nuclear waste or treating Ebola patients." We create success metrics using technologies that are employed to address real-world issues.

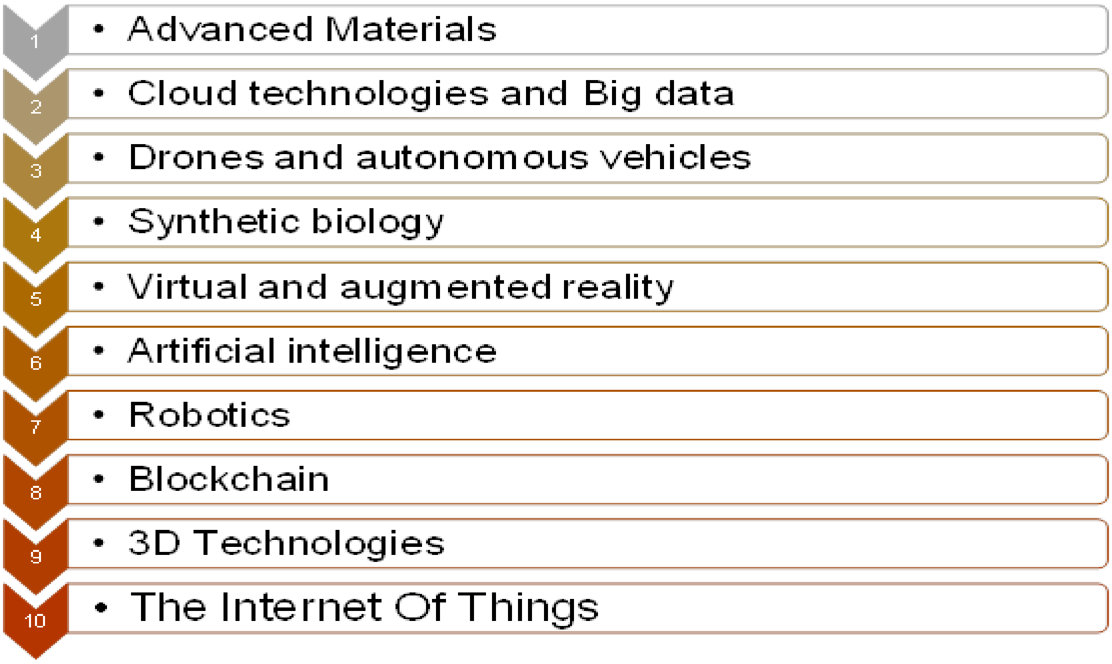

Figure 3. lists the current top 10 4IR digital technologies

These days, this subject is frequently misrepresented in the media, with dystopian depictions of technologies taking away our jobs or even our lives. But what if it became a potent tool in the worldwide effort to achieve the UN SDGs? These technologies are already being applied in many contexts to accomplish other objectives.

2.10 The Ecological Circle

The move from a linear to a circular economy (CE) is the second solution covered in this study (Su, Qin, Tao, & Umar, 2020). The circular economy is becoming increasingly well-known as a resource for solving some of the most difficult sustainable development issues facing the globe. The late 1970s saw a rise in interest as much research demonstrated the connection between sustainability and the circular economy. Using 4IR digital technologies, Figure 4, based on the Ellen MacArthur Foundation butterfly graphic, encapsulates the spirit of the circular economy. The organisation works with many collaborations and industries to advance and expedite the concept of CE, a vital and renewable economy by design. It is founded on three tenets, each with an associated symbol or image that the Allen McArthur Foundation uses (Ardito, Petruzzelli, Panniello, & Garavelli, 2018).

Prevent waste and contamination, Maintain the usage of goods and commodities, and Restore Natural Systems.

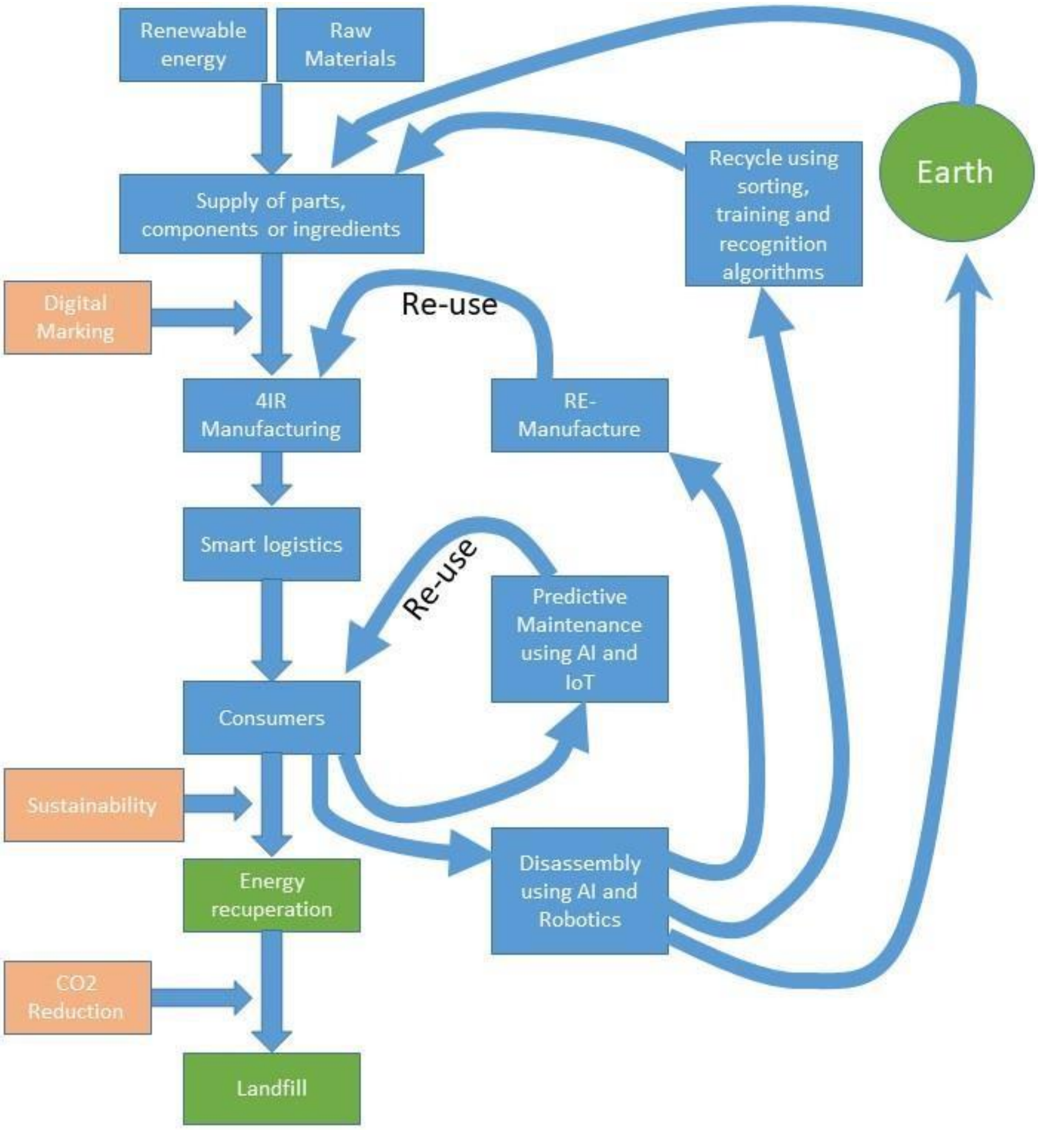

Figure 4.

Figure 4. Adapted from the Ellen MacArthur Foundation butterfly diagram, which uses 4IR digital technologies to capture the essence of a circular economy, this design aims to depict the movement of resources, components, and products while incorporating sustainability and financial value. Although it draws from a variety of theoretical perspectives, this is most obviously influenced by the two material periods of cradle to cradle (cradle to cradle refers to the design and manufacture of products of all kinds in a way that allows them to be genuinely recycled at the end of their life, mimicking the natural cycle of things whereby anything is either recycled or returned to earth, either directly or indirectly, as a completely safe, non-toxic, and biodegradable resource).

Circular thinking has financial and environmental advantages. Environmentally, it conserves nature, establishes essential ecosystems, and lowers greenhouse gas emissions. From an economic perspective, there are savings on resources, economic expansion, job growth, and rising demand (Ardito et al., 2018).

2.11 Study Suggestions

This research introduces a moderated mediation model to investigate the influence of Industry 4.0 maturity, a measure of a company's readiness and adoption of Fourth Industrial Revolution technologies, on corporate financial performance in the United States. The model claimed to be a synthesis of academics and industry insights, explores the effect of internal business processes and performance, supply chain performance, and finally, customer performance on financial outcomes. The results of this study have proved that Industry 4.0 technologies enhance customer performance and, therefore, positive financial outcomes, as would be seen by Arksey and O'Malley (2005).The model identifies the indirect effect of maturity of the Fourth Industrial Revolution on corporate financial performance, where Innovation-Based Product Performance, Supply Chain Performance, and customer performance stand as mediators. Therefore, this work includes the case of Industry 4.0 playing a moderating role in setting the relationship between the base of customer success and financial outcomes. It evidences that "firms with advanced 4IR capability exhibit better financial return due to enhanced customer performance." (Chashi & Mwanza, 2022). The moderated mediation framework was developed and tested; therefore, all the hypotheses were tested using the important use of AMOS software.

Internal business processes are essential for aligning functional operations with organisational objectives to fulfil customer requirements. These processes exemplify strategic planning and performance management initiatives. SCP denotes a cohesive framework that effectively transports products from raw materials to final consumers via distribution networks or retail channels. Customer performance evaluates a firm's capacity to attract, retain, and expand its customer base. Corporate financial performance indicates how a company meets its economic objectives (Cascio & Montealegre, 2016).

This study illustrates how U.S. firms can utilise Industry 4.0 maturity to improve operational efficiency, customer satisfaction, and financial performance by analysing interconnected elements. Regarding the most appropriate way to gauge business financial success, opinions differ (Choi, Chung, Seyha, & Young, 2020) Various techniques, such as surveys, accounting, and market measurements, have been developed. Economic performance is measured in this study using six-item measures (see Section 4.2). This study uses seven-point Likert scales to indicate performance, with responses ranging from "well below the industry average" to "well above the industry average" because enterprises do not readily reveal correct financial data (Makwinja, 2020).

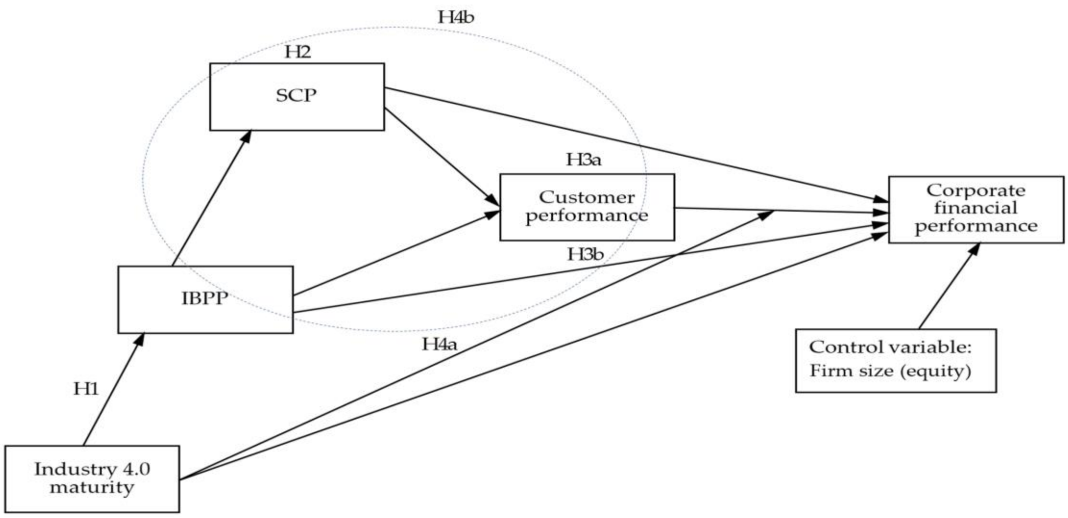

Figure 5. Hypothesised moderated mediation model

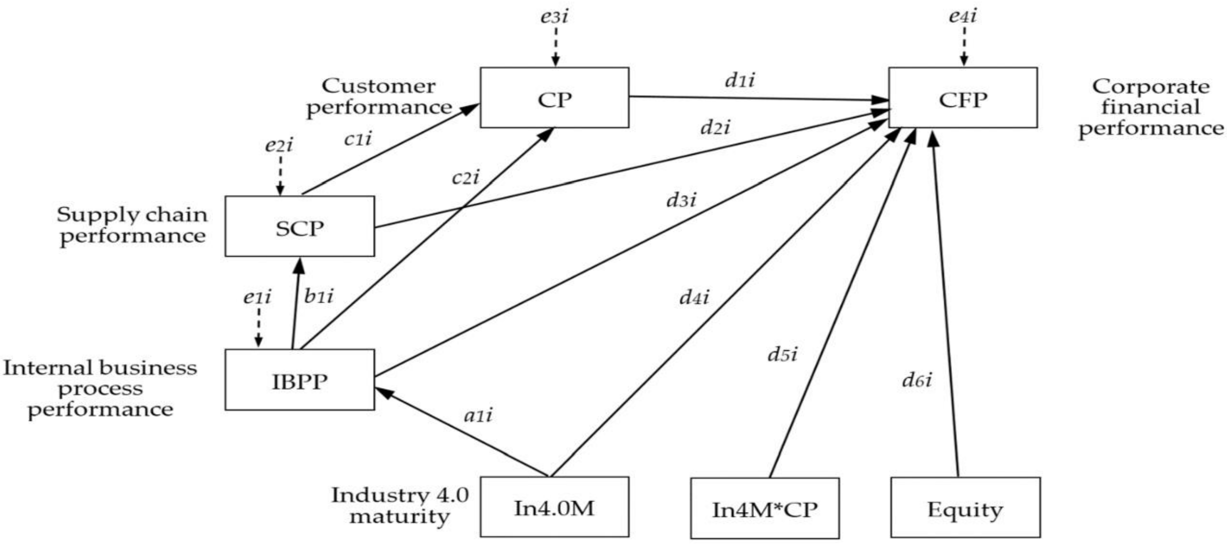

Figure 6. Statistical diagram of the proposed moderated mediation model

Industry 4.0 (4IR) signifies a revolutionary change in industrial processes, propelled by the incorporation of cyber-physical systems that provide uninterrupted communication across production facilities and value chains through open networks. This framework enables instantaneous data interchange within and among enterprises, enhancing both internal and inter-organizational services. Within the U.S. business environment, marked by intense rivalry and shifting consumer expectations, a company's Industry 4.0 maturity—its ability to incorporate and utilise Fourth Industrial Revolution technologies—profoundly affects its operational and financial success (Binz & Truffer, 2017).

This study investigates the impact of Industry 4.0 maturity on critical organisational processes, emphasiing internal business process performance (IBPP), supply chain performance (SCP), and customer performance, and how these elements eventually affect financial results. The study formulates many hypotheses to investigate these links, asserting that firms with heightened Industry 4.0 maturity would demonstrate enhanced operational and financial success (Brougham & Haar, 2018).

2.12 Development of Hypotheses

Hypothesis 1: Industry 4.0 maturity exerts a beneficial influence on IBPP. Organisations exhibiting advanced 4IR maturity improve cooperation and communication among departments and stakeholders, aligning their processes with strategic objectives. As internal integration enhances, organisations acquire the capacity to monitor, assess, and refine performance, leading to more effective company processes (Choi et al., 2020).

Research indicates that SCP facilitates the connection between IBPP and customer performance. SCP denotes the capacity to oversee business activities inside and across supply chain partners, hence enhancing coordination. Improved internal integration enhances external supply chain coordination, hence strengthening supply chain performance (SCP). Thus, enhanced IBPP results in improved customer service since operational efficiency and product quality align with or surpass consumer expectations.

Hypothesis 2: IBPP has a favourable effect on customer performance, with SCP serving as a mediator.

2.13 Fiscal Consequences of IBPP, SCP, and Customer Performance

Multiple research study emphasise that enhancements in IBPP, SCP, and customer performance propel financial success. A comprehensive literature assessment of performance-measurement studies indicates that improved IBPP enhances product quality and service delivery, thus elevating financial results. Research on information technology (IT) proficiency reveals that IT-facilitated supply chain integration has a favourable correlation with both operational and financial success.

Research employing structural equation modeling (SEM) techniques further emphasises the significance of SCP in attaining financial success. Research on 196 organisations indicates that the correlation between IT competency and supply chain performance is vital for financial results. Moreover, data from 124 automakers indicate that supply chain integration mediates the connection between additive manufacturing adoption and supply chain performance, hence further improving financial outcomes (Büchi, Cugno, & Castagnoli, 2020).

Today, the role of customer performance is well-recognised as a critical driver of financial performance. With PLS modelling, using data from manufacturing enterprises, scholars find support for the idea that servitisation-that is, the adding of services to a product offering consumer engagement and, by extension, profitability, which leads to the following hypotheses:
Hypothesis 3a: SCP has a positive influence on financial performance through the effect on customer performance.
Hypothesis 3b: IBPP positively influences financial success via its impact on customer performance.

2.14 Industry 4.0 Maturity as Mediator

The maturity of Industry 4.0 influences IBPP, SCP, and customer performance but also moderates the relationship existing between customer performance and financial performance. Organisations with more developed 4IR maturity integrate customer needs into their manufacturing processes more aptly, therefore improving and customising product flows; this enables them to maintain better relations with customers-which translates to improved satisfaction and better financial performance.

Hypothesis 4a: Industry 4.0 maturity positively influences the positive effect of customer performance on financial performance.
Better Fourth Industrial Revolution capabilities also lead to better customer integration, stronger collaboration among stakeholders, and minimal redundancies within the supply chain operations. As companies increase their operational efficiency and optimisation of supply chains, the supply chain performance and customer performance increase, thereby driving better financial performance. Companies that are thus more mature in terms of Industry 4.0 can, therefore, better connect the dots between operational efficiency and financial performance.

Hypothesis 4b: Industry 4.0 maturity influences financial performance through the synergistic mediating effects of IBPP, SCP, and customer performance. By deploying Fourth Industrial Revolution technology, firms nurture an operational structure that becomes increasingly agile and integrated in such a way that it rapidly responds to market requirements by offering better experiences for consumers.

2.15 Final Assessment

Industry 4.0 is a critical pivot toward data-centric, networked operations with particular implications for organisational performance in the United States. As organizations increasingly take advantage of the technologies of the Fourth Industrial Revolution, their capability to optimize Integrated Business Process Planning, improve Supply Chain Performance, and improve customer performance will increase and thus directly positively affect financial performance. The maturity of Industry 4.0 is a moderator variable, enhancing customer performance and financial outcomes.

In this scenario, organisations must prioritise not only the adoption of Industry 4.0 technologies but also the enhancement of internal integration and supply chain collaboration to realise the full potential of these breakthroughs. The study's hypotheses indicate that enterprises with advanced 4IR skills would attain enhanced operational and financial performance, hence securing long-term success in a competitive and dynamic marketplace (Brougham & Haar, 2018).

3. Research Method

3.1 Participants & procedure

A survey research design is used in this study to investigate the hypotheses. Because Industry 4.0 solutions are primarily meant for production and manufacturing processes, this study focuses on manufacturing companies. Using the Ministry of Economic Affairs databases of the USA, 834 eligible volunteers were randomly chosen and contacted for this study. 230 of the 834 businesses that have committed to implementing or planning to implement Industry 4.0 said they would participate. The survey was completed by 110 people, or 47.83% of the total.

The 110 firms from the USA as human resource managers were asked to participate in this study. Every organisation designated a manager with expertise or understanding of Industry 4.0 to assess the present state of the organisation's Industry 4.0 development. Before the data was gathered, experts from academia and business examined the survey questions for organisation, readability, completeness, and clarity. The established item scales from a thorough literature analysis in the domains of supply chain management, organisation management, and Industry 4.0 form the basis of the questionnaires (Büchi et al., 2020).

There are two sections in the final survey tool. Open-ended questions in Section 1 are used to gather background data on the respondents and the companies, including gender, employment experience, firm size, and industry memberships. Respondents can choose to answer the multiple-choice questions in the second section using a five- or seven-point Likert scale.

According to this study, Industry 4.0 maturity significantly impacts IBPP. In other words, businesses with a high level of Industry 4.0 maturity are more likely to enhance collaboration and internal and external communications and efficiently track business performance about strategic goals, all of which enhance IBPP. As a result, this research posits:
Many recommendations have been incorporated into this study to reduce potential common-method variance (CMV). This includes rearranging the question order, assuring respondents that their names and responses are private, and developing quality scores based on survey measurements from earlier studies. Ninety-three relevant sample companies across 14 distinct industry categories are obtained by excluding survey responses that contain missing data. These industries comprise iron and steel, electric machinery, rubber, optoelectronic, semiconductor, automotive, textiles, food, biotechnology, petrochemical, electrical distribution, electronics, and building and building materials. The participant characteristics are listed in Table 01

Table 1. Sample demographic characteristics
Industry Breakdown

Industry	Total Responses	Percentage	Cumulative Percentage
Chemicals	3	3.2%	3.2%
Biotechnology	7	7.4%	10.6%
Petrochemical	2	2.1%	12.8%
Automotive	6	6.4%	19.1%
Textiles	4	4.3%	23.4%
Food	4	4.3%	27.7%
Rubber	2	2.1%	29.8%
Optoelectronic	7	7.4%	37.2%
Semiconductor	5	5.3%	42.6%
Electrical distribution	2	2.1%	44.7%
Electronics	20	21.3%	66.0%
Iron and steel	4	4.3%	70.2%
Electric machinery	13	13.8%	84.0%
Construction and building materials	2	2.1%	86.2%

Firm Size by Equity ($ millions)

Equity Range	Total Responses	Percentage	Cumulative Percentage
1.00 – 10.00	11	11.8%	11.8%
10.01 – 50.57	15	16.1%	28.0%
50.58 – 892.14	14	15.1%	43.0%
892.15 – 1871.43	13	14.0%	57.0%
1871.44 – 4254.29	14	15.1%	72.0%
4254.30 – 14,764.00	13	14.0%	86.0%
14,764.00+	13	14.0%	100.0%

Job Titles of Respondents

Job Title	Total Responses	Percentage	Cumulative Percentage
CEOs / General Managers	9	9.7%	9.7%
Senior Managers	41	44.1%	53.8%
Managers	15	16.1%	69.9%
Directors	22	23.7%	93.5%

3.2 Metrics and Interpretation

Industry 4.0 level of development. A ten-item scale is used to gauge an organisation's Industry 4.0 maturity. "In1: Select the best description of the company's product development phase," "In3: Select the best description of work-order management in the company's production system," and "In5: Select the best description of materials inventory management (raw materials and work-in-progress) in the company's production system" are examples of item scales. For Industry 4.0 maturity, Cronbach's α value is 0.95.

Industry 4.0 maturity is based on the mean scores of particular measures. The initial industrial generation is defined by oral communication when supervisors transmit work directives to employees. During the second industrial generation, communication transitions to written form, with supervisors issuing official written directives. The third industrial generation facilitates man-to-machine communication via programming, allowing robots to do tasks independently. The transitional phase (3.5 generation) prioritises machine-to-machine communication, but the fourth industrial generation incorporates cloud-based intranet networks, enabling smooth data flow across networked devices. This progression demonstrates the history of communication mechanisms in production systems, highlighting technological breakthroughs and operational efficiency during industrial development.

3.3 Financial outcomes

Measures of corporate financial performance consist of six items. FP1 represents the company's return on sales for the previous 12 months; FP2 the company's ability to control the cost of goods sold for the last 12 months; FP3 the company's earnings per share for the previous 12 months; FP4 the company's return on investment for the past 12 months; FP5 the company's return on assets for the past 12 months; and FP6 the company's return on equity for the past 12 months are the items. Financial performance has a Cronbach's α of 0.95.

This study evaluates the influence of many factors on financial success, employing Chen's six-item scale to analyse customer performance. Examples include "CP1: Our firm's capacity to attract and retain clientele," "CP3: The efficacy of our firm in resolving customer grievances and alleviating their adverse effects," and "CP5: Our customer retention ratio." Given the reliability of customer performance measures supported by a Cronbach α of 0.89.

The research hused a four-item metric to measure the Internal Business Process Performance. The essential constituting elements are "IBPP3: Timely market introduction of new products/ services." And "IBPP1: Constant improvement of production costs and cycle times." This metric, therefore, appraises high reliability with a Cronbach's α value of 0.87.

The SCP is operationalised with an eight-item scale. Sample items include "SCP1: The capacity of our suppliers to manage variations in demand volume," "SCP3: In the ability of our suppliers to meet standards for quality," and "SCP5: The capability of our production system to adapt to fluctuations in customer demand." The SCP measure, with exceptional dependability, has a high Cronbach's α value of 0.93.

This study follows tHarman's single-factor test to check any potential effect of CMV on the sample data. This test provides evidence for whether there exists one single general factor that accounts for the majority of covariance between the measures. The results of the exploratory component analysis show that only 22.78% of the total variance is described by one factor and hence falls well below the threshold of 50%. For this reason, standard method variance does not pose any significant problem in the present study. The size of an organisation could significantly affect its economic performance because size reflects diversified attributes and resource distributions.

This study used market capitalisation as a surrogate for business size, as it is a well-established metric in corporate finance and possesses predictive validity for performance results. The use of Industry 4.0 technology presents significant future commercial opportunities.

The approach for examining the suggested moderated mediation model consists of three steps, employing AMOS software for analysis. The study first develops and verifies the measurement model via confirmatory factor analysis (CFA) with a bootstrap sampling technique. In the subsequent phase, structural equation modelling (SEM) tools are utilised to investigate the proposed correlations among the variables. The third step entails refining the model and deriving conclusions from the hypothesis testing findings, particularly analysing the effects of Industry 4.0 maturity, customer performance, IBPP, and SCP on company financial performance.

4. Results and discussions

4.1 Measurement Outcomes

The measuring model used in this work is congeneric, meaning that its constructs correlate. Industry 4.0 maturity, financial performance, customer performance, IBPP, and SCP are some of the model's constructs. This study evaluates the relative convergence among measures using standardised factoring loadings, average variance extracted (AVE), and composite creditability (CR) to investigate the convergent validity of the measurement model. All standardised factor loadings range from 0.59 to 0.94 (Table 2), are more extensive than the suggested threshold (0.5), and are significant, according to the CFA results with 1000 bootstrap samples.

The corresponding bootstrapping subsequently verified convergence validity bias-corrected 95% CIs excluding zero.

Table 2. Results of Convergent and Discriminant Validity

Construct	Mean	Min	Max	SD	CR	AVE	ASV
Industry 4.0 Maturity	2.58	1	4	0.66	0.91	0.64	0.02
Financial Performance	4.98	3	7	0.94	0.86	0.74	0.21
Customer Performance	5.23	4	7	0.74	0.83	0.60	0.33
IBPP	5.21	4	7	0.77	0.80	0.64	0.40
SCP	5.29	4	7	0.74	0.89	0.68	0.38

Note: AVE = Average Variance Extracted; ASV = Average Shared Squared Variance; SD = Standard Deviation; CR = Composite Reliability.

The descriptive statistics, CRs, AVEs, and average shared squared variances (ASVs) for the measurement model are presented in Table 3. The CR values of Industry 4.0 maturity, financial performance, customer performance, IBPP, and SCP are 0.91, 0.86, 0.83, 0.80, and 0.89, respectively, as shown in Table 2, and they are all higher than the threshold values (0.60). Additionally, Table 2 displays the AVE values for each construct, which are all above the suggested threshold of 0.50 and vary from 0.60 to 0.74. This provides additional evidence that every construct has convergent validity.

Table 3. Bootstrap-Based Structural Model - Unstandardized Regression Weights with 1,000 Bootstraps

Dependent Variable	Independent Variable	Parameter Estimates	Bootstrapping
			B
IBPP	Industry 4.0 Maturity		0.26
SCP	IBPP		0.82
Customer Performance	IBPP		0.47
Customer Performance	SCP		0.28
Financial Performance	SCP		0.19
Financial Performance	Customer Performance		0.38
Financial Performance	IBPP		0.22
Financial Performance	Industry 4.0 Maturity		0.02
Financial Performance	Industry 4.0 Maturity * Customer Performance		0.19
Financial Performance	Equity		0.09

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Model Fit Statistics:

- **Chi-square:** 3.89
- **Degree of Freedom (DF):** 10.00
- **Incremental Fit Index (IFI):** 1.00
- **Tucker–Lewis Index (TLI):** 1.00
- **Comparative Fit Index (CFI):** 1.00

Note: The unit of a corporation's equity is millions. B = coefficient, SE = standard error, CR = critical ratio, p = probability, and CI = confidence interval.

4.2 Hypothesis Testing

This study assesses the relationships between Industry 4.0 maturity, Integrated Business Process Performance (IBPP), Supply Chain Performance (SCP), customer performance, and financial performance. Specifically, the analysis examines the convergent and discriminant validity of these constructs, as presented in Table 2, which reports the Average Shared Variance (ASV) values for IBPP (0.02), SCP (0.21), financial performance (0.33), customer performance (0.40), and Industry 4.0 maturity (0.38). The ASV values are notably lower than the corresponding Average Variance Extracted (AVE) values, which are 0.64, 0.74, 0.60, 0.64, and 0.68, respectively. This finding indicates that the constructs possess discriminant validity, thus confirming that they measure distinct theoretical concepts. Moreover, the measurement model demonstrates a satisfactory overall fit with the data, as indicated by several fit indices: chi-square/degrees of freedom (1.425), incremental fit index (0.95), comparative fit index (0.94), Tucker-Lewis index (0.93), standardised root mean square residual (0.07), and root mean square error of approximation (0.07). The adequacy of the fit is further supported by the use of 1,000 bootstrap samples, reinforcing the reliability of the findings.

Following the validation of the measurement model, this study constructs a single composite score by aggregating the item scales for each of the five constructs. Notably, the AVEs for all constructs exceed the threshold of 0.50, while all items exhibit standardised factor loadings greater than 0.5. These results underscore the validity of the constructs employed in this analysis. Additionally, Cronbach's α values for all five constructs surpass the recommended cutoff of 0.70, affirming their reliability.

The unstandardised regression weights associated with the proposed moderated mediation model are presented in Table 3, derived from a bootstrap-based Structural Equation Modeling (SEM) analysis with 1,000 bootstrap samples. Figure 2 visually illustrates the moderated mediation model, with path values represented as standardised coefficients. The analysis reveals a significant unstandardised path coefficient for the relationship between Industry 4.0 maturity and IBPP ($B = 0.26$, $p < 0.05$), indicating that higher levels of Industry 4.0 maturity positively influence IBPP. The bootstrapping bias-corrected 95% confidence interval (CI) excludes zero, supporting the first hypothesis, which posits a positive relationship between Industry 4.0 maturity and IBPP.

In line with the established hypotheses, the study also identifies significant direct effects of IBPP on SCP ($B = 0.82$, $p < 0.001$) and customer performance ($B = 0.47$, $p < 0.001$). Furthermore, SCP ($B = 0.28$, $p < 0.05$) and customer performance ($B = 0.38$, $p < 0.05$) also exhibit significant positive effects on financial performance. However, the analysis reveals that the direct effects of Industry 4.0 maturity, IBPP, and SCP on financial performance are not statistically significant, as indicated by confidence intervals that include zero.

The results further indicate that the interaction term (Industry 4.0 maturity * Customer performance) possesses a statistically significant unstandardised path coefficient ($B = 0.19$, $p < 0.01$). The bootstrapping test yields a bias-corrected 95% CI of 0.01–0.32, confirming this interaction term's significance. This finding supports Hypothesis 4a, which posits that Industry 4.0 maturity moderates the positive correlation between customer performance and financial performance.

Table 4 presents the bootstrap-based SEM analysis results for the mediation effects based on 1,000 bootstrap samples. The indirect effects of Industry 4.0 maturity on financial performance ($B = 0.17$, bias-corrected 95% CI = [0.03, 0.37]), SCP on financial performance ($B = 0.10$, bias-corrected 95% CI = [0.01, 0.33]), IBPP on financial performance ($B = 0.18$, bias-corrected 95% CI = [0.03, 0.42]), and IBPP on customer performance ($B = 0.23$, bias-corrected 95% CI = [0.01, 0.52]) are all significant at the $p < 0.05$ level. These results validate the study's hypotheses, which propose the following relationships:

1. Customer performance mediates the positive relationship between SCP and financial performance (Hypothesis 2).
2. Industry 4.0 maturity influences financial performance through the multi-mediating effects of IBPP, SCP, and customer performance.
3. Customer performance mediates the positive relationships between SCP and financial performance (Hypothesis 3a) and IBPP and financial performance (Hypothesis 3b).

Table 4. Results of Bootstrap-Based SEM Analysis for Mediations (1,000 Bootstraps)

Theoretical Relationship / Hypothesis	Indirect Effect (B)	Standard Error (SE)	Bootstrapping Bias-Corrected 95% CI	p-value
Hypothesis 2				
IBPP → SCP → Customer Performance	0.23	0.12	[0.01, 0.52]	0.041
Hypothesis 3a				
SCP → Customer Performance → Financial Performance	0.10	0.10	[0.01, 0.33]	0.042
Hypothesis 3b				
IBPP → Customer Performance → Financial Performance	0.18	0.08	[0.03, 0.42]	0.023
Hypothesis 4b				
Industry 4.0 Maturity → IBPP + SCP + Customer Performance → Financial Performance	0.17	0.09	[0.03, 0.37]	0.025
Indirect Effect Paths for Hypothesis 4b				
Path 1: Industry 4.0 Maturity → IBPP → Financial Performance	0.06	0.06	[−0.02, 0.27]	0.145
Path 2: Industry 4.0 Maturity → IBPP → Customer Performance → Financial Performance	0.05	0.04	[0.01, 0.20]	0.028
Path 3: Industry 4.0 Maturity → IBPP → SCP → Customer Performance → Financial Performance	0.02	0.03	[0.01, 0.11]	0.042
Path 4: Industry 4.0 Maturity → IBPP → SCP → Financial Performance	0.04	0.06	[−0.04, 0.20]	0.244

Key:

- **IBPP**: Integrated Business Process Performance
- **SCP**: Supply Chain Performance
- **CI**: Confidence Interval
- **B**: Coefficient

SE: Standard Error. The findings from this study provide substantial evidence for the hypothesized relationships among Industry 4.0 maturity, IBPP, SCP, customer performance, and financial performance, underscoring the importance of these constructs in enhancing organisational outcomes.

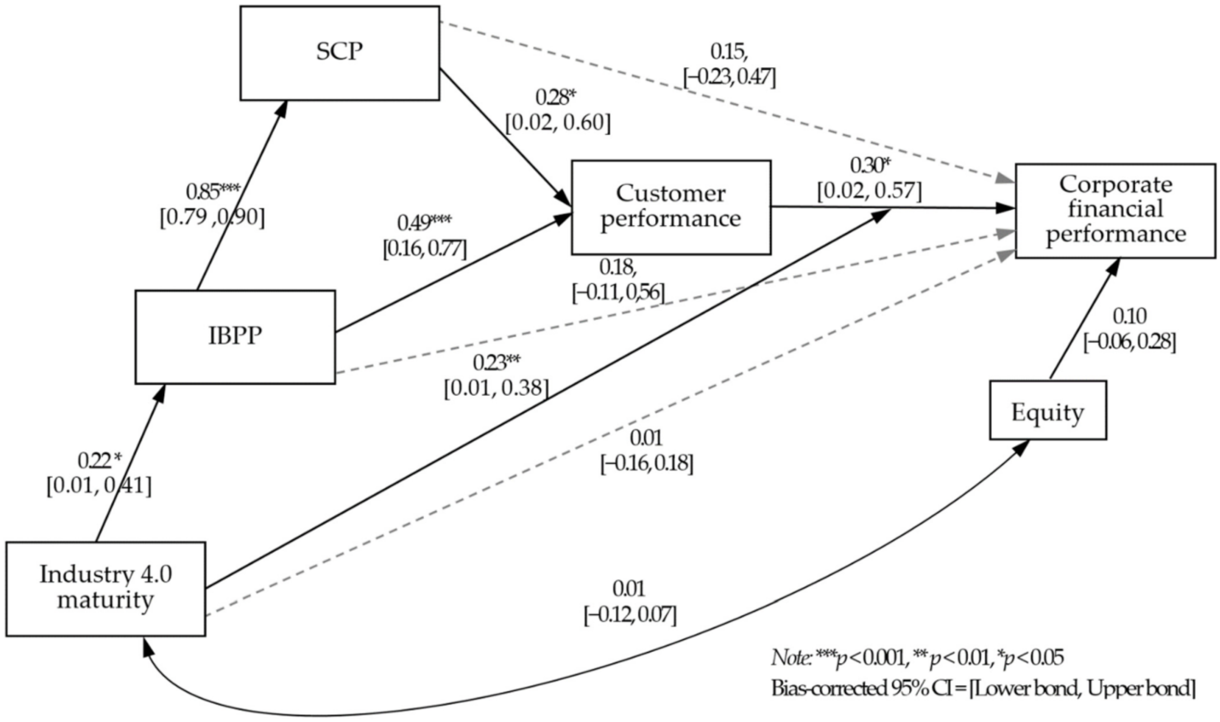

Figure 7. shows the model's 1000 bootstraps-based SEM analysis findings. Path values are standardized coefficients.

Because of this, we have p = probability, B = coefficient, CI = confidence interval, and SE = standard error. Furthermore, the non-significant direct effects of SCP and IBPP on financial performance (refer to Table 3 and Figure 3) imply that the positive correlation between SCP and financial performance and the correlation between IBPP and economic performance is fully mediated by customer performance. Similarly, the lack of a significant direct impact of Industry 4.0 maturity on financial performance suggests that IBPP, SCP, and customer performance fully mediate the relationship between Industry 4.0 maturity and financial performance.

Hypothesis 4b's indirect effect paths are further analysed, and, as the table also demonstrates, only paths two and three (i.e., Industry 4.0 maturity → IBPP → SCP → customer performance → financial performance; B = 0.05, bias-corrected 95% CI = [0.01, 0.20], excluding zero) are significant at $p < 0.05$.

5. Conclusion

This study delves into the pivotal role of Industry 4.0 maturity in shaping corporate financial performance. It underscores the significant contributions of Integrated Business Process Performance (IBPP), Supply Chain Performance (SCP), and customer performance. While previous studies on Industry 4.0 have largely concentrated on technological advancements or their effects on production processes, this research fills the gap by examining the indirect impact of Industry 4.0 maturity on financial performance through various mediating factors.

Results have indicated that Industry 4.0 maturity significantly impacts IBPP, and SCP partially mediates the association between IBPP and customer performance. Besides, customer performance has been found to mediate the association between SCP and financial performance completely, as well as that of

IBPP and financial performance. Surely, it has been found that either IBPP or SCP does not directly influence financial performance but instead has its influence through customer performance.

Moreover, in the context of Industry 4.0, business organisations willing to maximise financial outcomes through IBPP and SCP should give equal focus to the improvement of customer performance. The study illustrates that combined complete mediation of Industry 4.0 maturity and financial performance exists through IBPP, SCP, and customer performance. This shows that such factors are the most crucial in achieving the financial benefits of Industry 4.0 adoption. Quantitative analysis of multi-mediating paths shows that the only significant paths are those related to customer performance; therefore, this is a critical variable to achieve financial success.

This study identifies the moderating influence of maturity regarding Industry 4.0 in the relationship between customer performance and financial performance. A higher level of maturity of Industry 4.0 amplifies the positive relationship between customer performance and financial outcomes.

However, financial performance is lowest when customer performance and maturity of Industry 4.0 are low. Conclusively, the results reflect that firms with higher maturity in Industry 4.0 manifest more striking improvement in financial performance as customer performance increases than firms with lesser maturity in Industry 4.0. These findings represent that effective integration and management of IBPP, SCP, and customer performance are key to unleashing the full potential of Industry 4.0 and attaining sustainable financial growth. Organisations which can effectively use these components at an advanced level of Industry 4.0 maturity are able to improve their financial performance significantly.

The big difference in financial performance between low-rated and high-rated Industry 4.0 maturity firms proves the transformational power of such technologies in corporate performance.

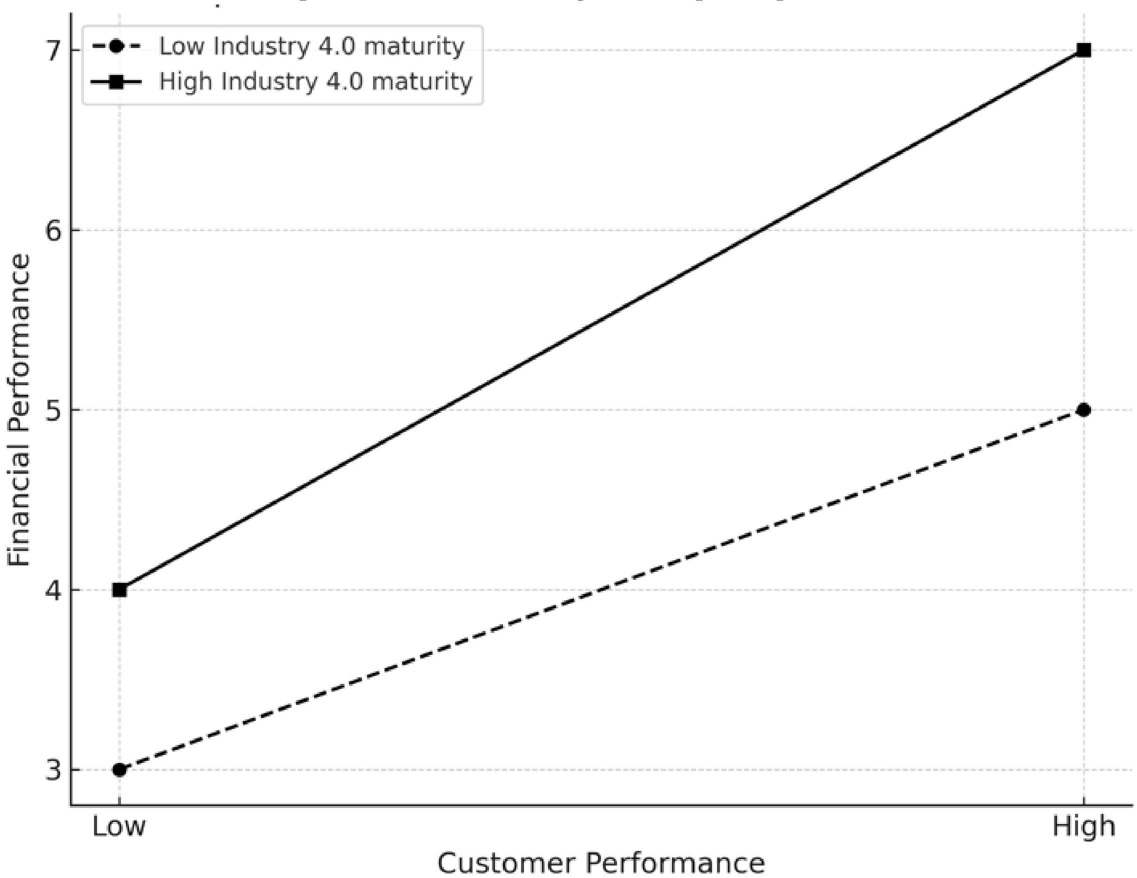

Figure 8. Relationship between customer performance and financial performance at low and high

This study utilises a research methodology that clearly demonstrates the quantitative effects of Industry 4.0 implementation. Table 5 summarises the results for marginal effects, defined as the percentage change in output resulting from a 1% change in input.

The results demonstrate that a 1% rise in Industry 4.0 maturity corresponds to increases of 0.22%, 0.19%, and 0.16% in Integrated Business Process Performance (IBPP), Supply Chain Performance (SCP), and customer performance, respectively. This results in a marginal total effect (MTE) increase of 0.13% in financial performance.

Furthermore, a 1% rise in IBPP leads to corresponding increases of 0.85% in SCP and 0.73% in customer performance. This results in a 0.53% increase in financial performance, marking the highest MTE recorded in the study. A 1% increase in SCP results in a 0.28% increase in customer performance, yielding a 0.23% increase in financial performance.

Table 5. Bootstrap-based SEM Analysis of Standardized Marginal Direct, Indirect, and Total Effects

Variable	Industry 4.0 Maturity (MDE)	Industry 4.0 Maturity (MIE)	Industry 4.0 Maturity (MTE)	IBPP (MDE)	IBPP (MIE)	IBPP (MTE)	SCP (MDE)	SCP (MIE)	SCP (MTE)	Customer Performance (MDE)	Customer Performance (MIE)	Customer Performance (MTE)
IBPP	0.22	0.22	0.22	0.85	0.85	0.85	0.28	0.28	0.28	0.30	0.30	0.30
SCP	0.19	0.19	0.19	0.85	0.85	0.85	0.24	0.24	0.24	0.30	0.30	0.30
Customer Performance	0.16	0.16	0.16	0.49	0.73	0.73	0.28	0.28	0.28	0.30	0.30	0.30
Financial Performance	0.01	0.12	0.13	0.35	0.53	0.53	0.23	0.23	0.23	0.30	0.30	0.30

Note: 1000 bootstraps. MDE = marginal direct effect, MIE = marginal indirect effect, and MTE = marginal total effect.

Several limitations must be considered in this investigation. The survey was sent to 834 prospective firms, but only 110 responded, generating 93 acceptable samples. Using a bootstrap-based strategy enhances generalizability, but future research should test these results with a, more extensive and varied sample.

Second, the hypotheses are founded on a comprehensive study of multidisciplinary literature and are compatible with earlier research on the impact of IBPP, SCP, and customer performance on a company's financial success. However, endogeneity difficulties may arise in the research framework. Industry 4.0 maturity, IBPP, and SCP may affect customer performance, affecting business financial performance. Future research must address endogeneity difficulties, lagged dependent and independent variables, control variables, fixed effects, and the generalised method of moments (GMM) may help.

5.1 Implications

This study found that Industry 4.0 maturity greatly impacts IBPP and that SCP somewhat affects customer performance. Additionally, IBPP and SCP fully affect financial success through customer performance. As Industry 4.0 maturity increases, customer and financial performance are strongly correlated. The findings show that Industry 4.0 increases financial returns for organisations through IBPP, SCP, and customer performance.

This study illuminates how Industry 4.0 maturity affects business financial performance. The direct influence of IBPP on customer performance implies mediators, emphasising the need to investigate them. Future studies should overcome research constraints to understand Industry 4.0 and company success better.

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