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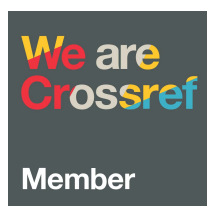
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Online Learning in Enhancing Educational Outcomes: Bangladesh's Perspectives

Shamsul Huq Bin Shahriar 

ABSTRACT

Purpose: This study aims to evaluate the effectiveness of online learning platforms in improving educational outcomes for girls in Bangladesh, focusing on participants' experiences and challenges in light of Sustainable Development Goals (SDGs) 4 and 5.

Methodology: The study used a qualitative approach with a sample of 43 girls aged 20-26 from urban and rural areas across Bangladesh. Participants were selected via purposive sampling based on their experience with online learning platforms. Data were collected through in-person and online in-depth interviews. Thematic analysis was used to identify key insights, focusing on the effectiveness of online learning platforms in improving educational outcomes.

Findings: The study highlights the transformative impact of online education on girls' educational outcomes in Bangladesh. Online platforms address barriers such as geographic isolation, safety concerns, and cultural restrictions, allowing girls, especially in rural areas, to access education. The benefits of flexible learning include reduced absenteeism and enhanced participation in STEM. OER and MOOCs provide diverse, high-quality, and affordable learning opportunities, while AI tools support academic tasks. However, ethical concerns regarding AI usage persist. Online education fosters inclusive, equitable education and aligns with the goals of SDG 4 and SDG 5.

Implications: The study will help policymakers assess the effectiveness of Internet-based education in expanding educational access for girls and reducing gender disparities in education and skill development, thereby advancing goals 4 and 5 of the SDGs.

Originality: The study offers unique insights into the intersection of online learning and gender equity in education, with a perspective on how technology can help achieve SDGs 4 and 5 in Bangladesh.

Limitations and directions for future research: Future research needs larger, longitudinal mixed-methods designs with objective learning measures and wider coverage in Bangladesh to test causal effects and scalability.

Keywords: Online learning; Lifelong learning; Information and Communication Technology; Sustainable development

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INTRODUCTION

In recent times, information and communication technology (ICT) has emerged as one of the major agents of transformation in education. The advent of online learning and advancements in the ICT sector brought a revolution to the educational landscape (Duggal et al., 2024; Alaskar, 2023), opening vast opportunities to deliver quality education to vast and distant populations. This is particularly significant for developing countries, which are beset by numerous challenges, including insufficient resources (Maisha & Shetu, 2023), limited access to quality education (Rahman et al., 2023), limited scope for higher education, and significant gender disparities (Mathrani et al., 2022).

Although Sustainable Development Goals (SDGs) 4 (quality education) and 5 (gender equality) are crucial catalysts for achieving many other SDGs, the pace of global progress in education has been insufficient. SDG 4 aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, and SDG 5 aims to achieve gender equality and empower all women and girls. In 2019, only 58% of students worldwide reached the minimum proficiency level in reading by the end of primary school (United Nations, 2024a). This highlights the urgent need to address the educational inequities. In many developing nations, young girls face significant obstacles to accessing education (Bangura & Mambo, 2023). There are socioeconomic limitations, cultural customs, and insufficient educational resources. These deterrents not only prevent female students from accessing quality education but also adversely affect their understanding of the subject matter and prospects. According to the United Nations International Children's Emergency Fund, despite progress in recent decades, child marriage remains prevalent in Bangladesh (UNICEF, 2023). Bangladesh has the highest child marriage rate in South Asia and the world, with 51 percent of young women marrying before the age of 18. However, online learning platforms offer a potential solution to address these pressing challenges by providing flexible, accessible, and scalable educational alternatives to traditional barriers (Webb et al., 2021) and by assessing their impact on learning engagement, retention, and academic performance. By aligning with the objectives of SDG 4 and SDG 5, this study provides

valuable insights into how digital education can serve as a catalyst for achieving gender equity in education and promoting lifelong learning opportunities.

Studies with Bangladeshi university students, for example, find that intentions to use and persist with online platforms hinge on reliable access and institutional support, not just attitudes toward technology (Aziz & Hossain, 2024). Since the pandemic, studies have concluded that online learning can sustain engagement and academic performance when pedagogy, assessment, and support are intentionally redesigned for digital environments (Azila-Gbette et al., 2023; Aisha & Ratna, 2022). However, the literature cautions that effects are heterogeneous and highly contingent on learners' digital readiness and the quality of instructional design (Akpen et al., 2024). This heterogeneity is especially pronounced in developing countries, where bandwidth, device access, and home learning environments vary widely. The digital divide remains a binding constraint. Recent empirical work in Bangladesh maps multi-layered inequalities in access to devices, data, platforms, and content, as well as literacy skills for learning effectively online (Tahura et al., 2025). These studies suggest that digital initiatives have expanded opportunities but have not consistently translated into stronger foundational digital skills or improved learning outcomes for students from disadvantaged backgrounds (Mhlongo et al., 2023).

Despite these advances, important knowledge gaps persist. Much of the Bangladesh-focused literature centers on perceptions, acceptance, or short-term satisfaction rather than rigorous estimates of learning outcomes attributable to online learning. This study evaluates the effectiveness of online learning platforms in improving educational outcomes for girls in Bangladesh, focusing on their experiences, challenges, and benefits in alignment with SDGs 4 and 5. The significance of this study lies in its effort to understand how online learning affects girls' education in Bangladesh. Listening to their experiences and stories highlights the challenges they face and the opportunities digital learning can offer. The findings aim to help teachers, policymakers, and communities make online education more inclusive and supportive. In doing so, the study supports the goals of quality education (SDG 4) and gender equality (SDG 5) by showing how technology can open new doors for girls to learn and succeed.

LITERATURE REVIEW

Sustainable Development Goals

The United Nations established the SDGs, also known as the Global Goals, in 2015 (UNDP, 2024a; Munro, 2020) as a universal call to action to end poverty, protect the planet, and ensure peace and prosperity for all by 2030. The 17 SDGs are interrelated, reflecting that actions in one area affect outcomes in others and emphasizing the importance of balancing social, economic, and environmental sustainability. Importantly, the nations have promised to prioritize progress for those in greatest need. Within the decided timeline, the SDGs seek to end 1) poverty, 2) hunger, 3) AIDS, and 4) discrimination against women and girls (UNDP, 2024a).

The SDGs comprise 17 goals, each with distinct yet interrelated targets, indicators, determinants, and action points (Al-Raeei, 2023). The Division for Sustainable Development Goals (DSDG) in the United Nations Department of Economic and Social Affairs (UNDESA) provides essential support and capacity-building for the SDGs and their related thematic areas (United Nations, 2024b). The SDGs have been of profound interest to researchers worldwide from their very inception (Al-Raeei, 2024; Basnett et al., 2019; Moschen et al., 2019).

SDG 4: Quality Education

SDG 4, Quality Education, aims to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.” This goal concerns providing access to quality education for all, irrespective of gender, background, or prevailing circumstances. Further, this goal is grounded in the principle that everyone should be entitled to lifelong learning opportunities to achieve personal and societal development (United Nations, 2024c). According to UNDP (2024b), since 2000, the pursuit of universal primary education has made tremendous progress. In 2015, the total enrollment in developing regions reached 91%, and the worldwide number of children out of school had decreased by almost half. Female literacy rates have also risen dramatically, and many more girls attend school today than in the past (United Nations, 2024d).

SDG 5: Gender Equality

SDG 5 focuses on ending gender inequality and empowering women and girls worldwide. Although women contribute significantly, gender inequality persists worldwide and hinders social advancement (United Nations, 2024e; Hales & Birdthistle, 2023; Khemani & Kumar, 2023). One of the achievements of this goal is the empowerment of women, along with education and skill development (Alam et al., 2024), which are the primary concerns (Agbevanu et al., 2021). Educating women and girls gives them a chance to improve their own and their children's lives, have healthy babies, and be equal citizens in society. Since ICT makes educational materials more flexible and accessible, the potential for girls to complete their education and further enter universities will be higher than it is today. This is beneficial for an individual's personal growth and for the social and economic advancement of society. Enhancing women's education through ICT can advance gender equality by supporting the objectives of SDG 5 (Bathla et al., 2023).

Online Learning and SDGs 4 and 5 in Developing Country Contexts

Research across developing countries shows that online learning can enhance student engagement and achievement, but its effectiveness largely depends on access to technology, digital literacy, and strong institutional support (Uzorka & Odebiyi, 2025; Holm, 2024). A study by Olanrewaju et al. (2021) indicates that while online learning helps sustain education during disruptions such as the COVID-19 pandemic, it can also deepen inequalities where digital infrastructure and teaching capacity are weak.

In Bangladesh, similar patterns are evident. Students' perceptions of e-learning's usefulness, social support, and internet reliability influence its adoption (Maisha & Shetu, 2023). Learners often appreciate the flexibility of online platforms but face challenges such as unstable connectivity, limited interaction, and difficulties with assessments (Karim et al., 2025). Comparative analyses suggest that while online learning is cost-effective and increases access, it can be less effective in maintaining engagement and concentration. Broader reviews across South Asia reveal that without deliberate strategies to bridge

access and skill gaps, online education risks widening rather than narrowing existing inequalities (Tate & Warschauer, 2022; Topping et al., 2022).

From a gender perspective, the goals of SDG 5 closely align with online education. Girls and women in many developing contexts face greater barriers to digital access, limited device ownership, and heavier domestic responsibilities, all of which reduce their participation in online learning (Avanesian et al., 2024). Interestingly, a recent study found that in Bangladesh, these gendered challenges highlight the persistent digital divide that hinders progress toward both SDG 4, which aims for inclusive and quality education, and SDG 5, which seeks gender equality and empowerment (Toba, 2024).

New Educational Realities for Females

The recent shift in the educational ecosystem has established digital tools and flexible learning models as essential components of the future of education (Eva et al., 2024), and this happened in a very short span of time, specifically during the COVID-19 pandemic. According to Lau et al. (2024), online learning became the only practical way to address the educational needs of students in higher education during the COVID-19 pandemic. The findings reveal that postgraduate students generally provided more positive feedback regarding individual and environmental readiness, as well as pedagogical and institutional support. They also showed higher motivation in online classes than undergraduates. In contrast, undergraduate students viewed the shift to online education during the pandemic as timely and rated their self-discipline in online learning higher than their postgraduate counterparts.

Chandani et al. (2024) examined how business schools adapted to the challenges brought on by the COVID-19 pandemic, which forced everyone indoors in 2020. Most B-Schools were unprepared and had to transition to online and hybrid learning swiftly. The research investigates the factors that influenced education quality during this period and the lessons learned. It emphasizes that online tools such as Turnitin and Grammarly, along with quizzes, simulations, and interactive teaching methods, will remain valuable in the future. These tools, introduced during the pandemic, have enhanced learning by accommodating

diverse student needs and will play a lasting role in improving education quality.

Cultural and socio-economic factors, along with women's multiple roles and responsibilities in family, work, and social life, often hamper their academic success (Luppicini & Walabe, 2021). However, online learning is seen as a flexible and convenient option that allows women to better balance their studies with other demands and responsibilities (Tzavara & Wilczek, 2019). Thus, the emergence of online learning has transformed educational opportunities for females, offering greater access and flexibility while also highlighting challenges such as digital divides and unequal resource distribution. This new reality presents both the potential for increased inclusivity and the need for targeted support to ensure the equitable participation of female students, especially in developing countries like Bangladesh.

In a study, Khan (2021) found that, compared to their male counterparts, female students were less affected by the absence of 'campus life' during the lockdown. Research findings by Bisht et al. (2022) found that gender significantly influences adaptation to online education. The study found that female students exhibit higher adaptability than male students. This adaptability is evident in several areas: female students manage assignments more effectively, adapt their study patterns to online settings, and generally feel more comfortable in the online learning environment. In another study, Adtani et al. (2023) revealed that female students typically exhibit better emotional control and higher motivation levels than male students in remote online education.

The literature suggests that achieving the SDGs, particularly SDGs 4 and 5, relies heavily on reducing the digital divide and promoting equal access to online learning opportunities in developing nations such as Bangladesh. Despite the advancement, significant gaps remained in digital literacy, infrastructure, and gender equity. This study aims to provide valuable insights into how these new educational models impact female students, highlighting both the opportunities and obstacles they face. Understanding these dynamics will help address gender-specific educational outcomes and improve the quality of online learning experiences for women in a developing nation like Bangladesh.

STUDY METHODOLOGY

A mixed research methodology was adopted for this study. The sample comprises 43 girls from various regions, including both urban and rural settings, such as Dhaka, Tangail, Barishal, Chattogram, Rajshahi, Rangpur, Manikganj, Mymensingh, Sylhet, Madaripur, and Joypurhat. These regions were selected to provide a diverse representation of both urban and rural settings within the country. Although data saturation was reached after the 20th interview, additional interviews were conducted to gain further perspectives and a well-rounded understanding of the participants' experiences.

Female students attending universities across different regions, both public and private, pursue a range of academic disciplines, including engineering, science, arts and humanities, social sciences, and business. The participants had experienced different types of online learning, from purely online programs delivered via apps such as Zoom, Google Classroom, and Microsoft Teams to blended or hybrid models that combined virtual instruction with in-person classes. Many also used mobile phones and the university's learning management systems (LMS) for course content, assignments, and assessments. The range of academic backgrounds and digital learning environments provided a rich, diverse view of how online education is implemented across multiple disciplines and institutions in the country.

Purposive sampling was used to select participants with direct experience with online learning platforms who are aged 20 to 26. The questionnaire was designed around three central themes: access to online learning tools, perceptions of learning effectiveness, and challenges faced in online education. To allow for a comprehensive exploration of participants' experiences and perceptions, in-depth interviews were conducted, guided by open-ended questions on the use of online learning platforms, their impact on educational outcomes, and the specific challenges faced by girls. Interviews were conducted both in person and online for remote areas. Finally, a thematic analysis was employed to analyze the qualitative data. Also, before data collection, approval was sought from the appropriate institutional review board to ensure compliance with ethical research standards. The study followed ethical protocols regarding anonymity, voluntary

participation by respondents, and secure data handling throughout the research process.

FINDINGS

Internet Based Online Education

Internet-based online education became very popular during the COVID period; however, in developing countries, online education has proven to be a transformative tool for improving educational outcomes for girls, offering exceptional opportunities for access and learning from anywhere (Hakimi et al., 2024). All study respondents agreed that ICT can mitigate barriers such as geographic isolation, safety concerns, and cultural restrictions that often limit girls' educational access, particularly in the country's rural areas. Through online platforms, girls who might otherwise be excluded from traditional schooling can continue their education from home or at nearby community centers, offering them flexibility that can be particularly valuable in regions where attending school is difficult due to long travel distances, family responsibilities, or safety concerns.

Online education through Internet-based technology has emerged as a powerful means of enhancing the social efficiency of education. This contributes to achieving SDG 4 target 3, which aims to ensure technical, vocational, and tertiary education opportunities for every student, irrespective of location. Online education effectively addresses the problem of learning disparities caused by geographical barriers or cultural limitations that hinder achieving SDG 4 target 5 and SDG 5, to eliminate gender gaps in education and access at all levels. It supports target 7 of SDG 4 by aligning sustainable practices, global citizenship, and sustainable development education.

Access to Learning Opportunities

The widespread adoption of online learning became a reality in 2020-2022, coinciding with the COVID-19 political unrest that preceded the Bangladeshi election. It is a fact that when schools, colleges, and universities offer online education as part of their official curriculum, it enables a blended learning model in which girls can combine in-person education with online resources. All respondents agreed that this flexibility in learning enables girls to attend classes even when they face difficulties such

as health issues, natural disasters, political unrest, emergencies, or family responsibilities, reducing absenteeism and dropouts.

One of the respondents living in a rural area with no current access to online education mentioned: *“It sometimes becomes really difficult to go to college due to the long distance from my home; as I have to walk nearly a kilometer, rain causes my clothes to become soaked. If the weather worsens, or for other reasons such as the harvesting season or political unrest in the college or nearby areas, I often have to stay at home. But if I could attend classes online, I could join using my phone, just like I access YouTube or Facebook.”* (Respondent 17, age 21)

Around 84 percent of respondents who have experienced some form of institutional online education mentioned that online education allows students to attend classes even during difficult times. Additionally, around 65 percent of respondents stated that, based on their experience, blended learning is an effective method. Thus, online education contributes to SDG 4 and SDG 5 by improving educational access and quality for girls in urban and rural areas. It helps ensure inclusive and equitable education by reaching marginalized girls who might otherwise be excluded from the education system due to several social, political, financial, and religious factors.

The availability of learning opportunities has been one of the most influential factors in determining educational attainment among female students at the university level in Bangladesh. Although Internet-based education, in theory, could maximize access by transcending geographical constraints and providing more flexible learning hours, studies show that such access is extremely uneven, with mixed academic performance (Culduz, 2024). Urban participant institutions frequently reported stable access to the Internet, personal devices, and institutional learning management systems. Under these conditions, they were able to attend classes consistently, participate in online discussions, and hand in assignments on time, all of which led to better understanding, higher academic performance, and greater confidence in digital learning. These are examples of how online learning can improve quality with reliable

connectivity and equipment. Female students in rural and semi-urban areas, on the other hand, encountered intermittent Internet connectivity, limited device access, and high data costs. Most used shared cellphones or community Internet centers, which significantly limited their study time and the continuity of learning. These structural disparities led to disparate involvement and lower academic achievement, with students unable to consistently access lectures, materials, and tests. As access remains largely constrained, the potential for online learning to improve educational outcomes is limited.

Furthermore, the barriers to access were not just technical but also social and gendered. And female students often said they had to navigate domestic chores and cultural traditions that restricted their hours of online learning or the time they were allowed to use digital tools. In about 10 percent of cases, family norms discouraged students' Internet use without supervision, thereby limiting academic autonomy. These facts demonstrate that access is not simply a question of technology but of social consent and freedom, which could affect learning outcomes for girls.

Notably, the research reinforces the fact that access doesn't equal attainment. Effective access should not be defined solely in terms of device and Internet availability, but also in terms of quality, stability, and freedom of use. When those dimensions are met, online learning becomes a powerful equalizer, boosting engagement and academic achievement. But in their absence, online learning risks entrenching already existing inequalities, whereby only a minority of students, typically from more affluent urban backgrounds, really benefit.

Safe Learning Environment

For girls facing safety concerns, harassment, or other barriers to attending in-person classes, online education provides a safer alternative (Behounek, 2020). Institutions can ensure that girls receive a quality education in a controlled environment, free from the risks associated with commuting or attending physical classes in unsafe areas. In this regard, around 63 percent of respondents, living in both urban and rural areas, reported experiencing harassment and bullying either within educational institutions or during their commute to campus.

Given these challenges, many consider online education a much safer option.

Furthermore, it is crucial to note that all respondents believe that educational institutions and society as a whole should be safe spaces for women. They emphasize that all educational environments must be free from harassment and discrimination to ensure that girls can learn and thrive without fear. This collective belief underscores the need for systemic changes to create safer, more inclusive educational settings and broader societal environments.

A safe learning climate is an essential antecedent for favorable educational outcomes, especially for the female learners participating in online education in Bangladesh. Results of this study suggest that while Internet learning has opened new educational opportunities, it has also raised new uncertainties and vulnerabilities regarding safety, privacy, and psychological well-being, which can significantly impair students' learning capacity.

Most participants (around 91 percent) indicated that learning first in the online format had generated initial comfort with participation in academic discussions, given less face-to-face intimidation and greater flexibility in communicating with instructors. This sense of safety, stemming from students and teachers being physically separated, was associated with increased confidence, self-efficacy, and a willingness to ask questions. For some, particularly from conservative or rural backgrounds, online education presented a kind of social protection where people can study without having to come to school and be exposed to dangerous public spaces. These scenarios illustrate how online learning can improve student success by fostering an inclusive, psychologically safe environment and promoting engagement and grit.

The study revealed that the digital learning environment is not inherently safe and introduced new risks for many female students. Several participants reported worrying about online bullying or harassment or unauthorized sharing of images, which led to anxiety regarding the decision to turn on their cameras or speak in class discussions. These worries were associated with reduced participation and attention during lessons, due to a lack of confidence and psychological feelings. Thus, the

absence of systems for reporting or for institutional remedies for digital misbehavior also reinforced the students' sense of vulnerability. In this way, online learning itself enacted another form of insecurity, which undermines the emotional and cognitive precursors required for effective learning.

Furthermore, a significant number of participants identified the home as a source of safety that contributed to their educational success. Learning remotely often left them with interruptions, a lack of privacy, and gendered expectations to help out at home. This overlap of academic and domestic spaces not only created division but also constricted the space psychologically needed for significant learning. A handful of students said their families were always nearby, monitoring their online classes so they couldn't speak as freely, which curtailed active learning. For online learning to improve educational outcomes, institutions must also implement robust safety measures. This would involve executing digital protection policies, providing cyber-ethics and privacy awareness training, and creating gender-sensitive virtual spaces where female students can study without fear or unease.

Active Learning and Participation in STEM

Online education enhances active class participation, as digital settings allow course instructors to interact with each participant more effectively. Around 58 percent of respondents reported that digital class engagement activities are more comfortable than face-to-face class activities. Moreover, around 70 percent of respondents stated that they feel more confident participating in and answering questions, as well as engaging in group activities and presentations in an online setting.

Furthermore, by providing online educational facilities, educational institutions can create more opportunities for girls to engage in Science, Technology, Engineering, and Mathematics (STEM) subjects. Institutions can offer specialized office hours for teachers, provide specialized online resources or courses, and facilitate peer group activities. This way, educational institutions can also encourage participation through virtual labs and interactive modules, helping girls overcome societal biases that may discourage them from pursuing STEM fields.

However, there are some noticeable factors on which the success of online education solely depends. An Internet connection and a learning device are essential, as they ensure learners can participate in online classes without technological hindrances. Furthermore, the social context, particularly the support of family members or communities, significantly influences a learner's decision to engage in online education. Proficiency among teachers in using digital tools for pedagogy and in producing and publishing captivating content is also significant. Regarding SDG 4 target 4, increased attention and confidence in online processes contribute to improving the learning environment and enhancing the desired employment skills among female youth and adults, specifically, for SDG 5 target 5, full and effective participation of women in decision-making processes and leadership positions, and equal opportunities for women in STEM education. As a result, students demonstrated greater conceptual understanding, motivation, and self-efficacy, which directly led to improved educational outcomes.

Open Resource for Learning and Skill Development

Open Educational Resources (OER) are freely accessible, primarily openly licensed educational materials that support learning, teaching, and research. They include textbooks, course materials, modules, videos, and any other learning related interactive and engagement tools (Fadehan & Okiki, 2023; Karunanayaka & Naidu, 2017; Mishra, 2017). For girls, OER can significantly enhance educational outcomes by providing high-quality, cost-effective resources that are often unavailable in traditional educational settings.

Around 88 percent of respondents mentioned that they often download books and other information online. One of the respondents mentioned, "Yes, it is really helpful when we can find books online or when teachers provide us with PDF versions. It reduces our costs and allows us to carry the books or notes with us everywhere." (Respondent 21, age 22)

Approximately 70 percent of respondents reported frequently using YouTube tutorials and learning videos to support their studies.

One of the respondents, studying at a private university in Dhaka, mentioned: "I often rely on YouTube for help. I am not very strong in economics and mathematical subjects, so when teachers explain in class, I sometimes just don't understand. YouTube provides me with excellent solutions, as there are well-explained videos and tutorials on these topics with more detailed explanations, and the best part is that it's free." (Respondent 24, age 21)

Around 23 percent of respondents from both urban and rural areas reported using YouTube for skill development. Some of the skills they mentioned learning on YouTube include:

- a) Learning Microsoft Excel and other Microsoft Office applications
- b) Acquiring expertise in outsourcing and understanding business operations
- c) Video editing
- d) Social networking sites and YouTube-based content creation
- e) English language learning
- f) Public speaking and presentation skills

OER and digital learning tools have played a crucial role in improving learning outcomes for female students in Bangladesh. In the research, free online resources, including pre-recorded lectures, e-books, MOOCs, and instructional videos, enable students to top up their learning in class and acquire new academic knowledge and technical skills beyond their university study programs. This flexibility allowed students to have more control over the tempo and content of their learning, resulting in better understanding and longer engagement with complex topics. Respondents especially appreciated open platforms such as YouTube and Google Scholar for providing free access to trustworthy content. These instruments broadened their exposure to the 'world' (outward-looking), enhanced research and analytical skills, and helped them develop independent learning habits, all of which indicate positive educational performance. Secondly, open content also fostered self-directed learning and skills in areas such as digital literacy, communication, and problem-solving, which are vital for employability in a technology-led, globalized environment.

At the same time, around 88 percent of respondents agreed that, through this online-based open

education process, girls gain access not only to academic content but also to information about their rights, health, global facts, new perspectives, and opportunities, which are often lacking in traditional school-based educational settings.

The study's findings underscore how OER and online platforms can enhance educational and skill-development opportunities. For SDG 4, the widespread use of OER, such as online books and tutorials, supports target 4 by improving access to quality learning materials and skills development. For SDG 5, the availability of these resources helps achieve target 5 by empowering girls with knowledge and skills, promoting gender equality through enhanced educational and career opportunities. Access to diverse and cost-effective learning tools can significantly bridge gaps in traditional education settings.

Use of AI in Education

With the development of computers and the Internet, artificial intelligence (AI) is the latest smart technology revolutionizing the educational system worldwide (Vieriu & Petrea, 2025). AI, a system capable of executing tasks according to human instructions, can be considered on par with intelligence. From writing simple emails based on a few factual points to reducing complex, multifaceted problems into mathematical calculations, or providing specific details about different concepts, it can perform many intelligent tasks and solve any problem within seconds.

Hamilton (2023) noted that AI enables machines to perform tasks that traditionally required human cognition. Programs and devices powered by AI can make decisions, solve various problems, comprehend and replicate natural language, and glean insights from unstructured data. Organizations such as UNESCO (2023) have emphasized that AI can help this sector undergo significant changes, including advancing teaching/learning methods and accelerating progress towards SDG 4. However, educators and educational institutions are struggling with a dilemma as students are increasingly relying on AI tools for various educational purposes, and they are even becoming overly dependent on them.

Around 56 percent of respondents reported using AI tools for educational purposes. The most used AI tools mentioned by the students are shown in Table 1.

Table 1: AI Tools Used by Students for Educational Purposes

AI Tool	Use	Purpose	Website
ChatGPT	Answering questions, generating ideas for writing, understanding complex topics	Assignment writing, report writing, presentation preparation	www.chatgpt.com
Grammarly	Improves their writing and checking for grammar	Assignment writing, report writing, presentation preparation	www.grammarly.com
Quillbot	Improves the quality of their writing and rewrite sentences	Assignment writing, report writing, presentation preparation	www.quillbot.com
Gemini	Generating ideas for writing, explains complex topics and answering questions	Assignment writing, report writing, presentation preparation	https://gemini.google.com/app
Quizlet [AI-powered features]	Self-study, improving study habits, self-initiated exam preparation/practice, and group learning	Competitive exam preparation	www.https://quizlet.com/

Source: Author, and interview analysis

However, there is still an ongoing debate about the ethical use of AI tools for educational purposes. One student mentioned, "I feel it is not right to use AI for writing entire assignments, which many of us do, I agree....." (Respondent 03, age 20)

Another student mentioned that "I don't feel it is unethical because we can find information online. However, ChatGPT or Gemini provide us with detailed answers. Yes, we do sometimes copy and paste....." (Respondent 35, age 21)

The findings showed that around 88 percent of respondents believe that using AI for entire assignments is inappropriate. In contrast, others

argue that it is not unethical since information is readily available online. However, the ease of copying and pasting AI-generated content raises concerns. Thus, educational institutions need to establish clear policies and guidelines for the appropriate use of AI in learning to ensure academic integrity and foster responsible technology use.

MOOC-Based Learning

A Massive Open Online Course (MOOC) is an online learning platform that offers open access to educational content for a large audience. It allows individuals from around the world to enroll without restrictions, providing them with a publicly available curriculum (Chen, 2014). The course materials are designed to be shared widely, encouraging collaboration and engagement among participants. Unlike traditional courses with predefined outcomes, MOOCs offer flexible, open-ended learning outcomes, allowing learners to pursue knowledge at their own pace and apply what they have learned in diverse, personalized ways (Shahriar et al., 2023).

MOOC's increasing impact on higher education is also notable nowadays (Sharma & Nathani, 2023). The findings revealed that around 56 percent of respondents reported enrolling in a MOOC platform at least once, and 51 percent stated they have completed courses and obtained at least one certificate from an international MOOC platform. Additionally, around 19 percent reported learning experiences from local MOOC platforms. The Bangladeshi MOOC platforms that students enrolled in are Muktopaath, Shikho, 10 Minute School, BYLCx, Sudoksho, and Shikkhok.com. Further, students preferred MOOC-based courses for their openness and flexibility, diverse learning opportunities, high-quality learning experiences, and lifelong learning.

Openness and Flexibility

Respondents who experienced MOOC-based learning agreed that MOOC platforms provide access to high-quality educational content. They noted that access is easy and flexible, and that the platforms are open to everyone. With an Internet connection, anyone can join a course by enrolling, thereby overcoming geographical barriers that traditional learning methods cannot offer.

Diverse Learning Opportunities

Almost all respondents who experienced MOOC-based learning agreed that MOOCs cover a wide range of subjects, allowing students to explore topics that may not be available in their local institutions or open-source learning platforms. Learners can study technical skills, humanities, science, business, and other subjects, thereby broadening their learning and practical skill development horizons.

Quality Learning Experience

ICT-enhanced MOOC-based open education also improves learning quality. Girls have the opportunity to participate in individual course contents, which allow them to receive education at a convenient time, access a variety of materials, and interact with informative and engaging content that enhances their comprehension and memory skills. This flexibility of MOOC-based learning is crucial, especially for girls in rural areas who, due to early marriages, household chores, or other socio-economic reasons, may be forced to drop out of school.

Regarding the course content and experience quality, one of the respondents mentioned, "Well, it was a new experience for me when I started my first course. It was easy to understand, and the content was really engaging." (Respondent 13, age 21)

MOOC platforms often provide diverse learning materials, including videos, interactive modules, pop-up quizzes, exams, case studies, practical scenario analyses, learning games, and other simulations that enhance understanding and engagement. This approach allows for personalized learning, where students can focus on subjects, they find challenging and advance more quickly in areas where they excel.

Lifelong Learning Opportunity

MOOCs support lifelong learning by enabling everyone to regularly update their knowledge and skills. Since most of them are available online and are free or low-priced, people can study at their convenience. MOOCs promote lifelong learning by offering courses tailored to professional development needs, interests, and hobbies, and by awarding certificates upon completion.

In the case of SDG 4, MOOCs advance target 6 by fulfilling the need for an accessible, flexible, and affordable lifelong education. In relation to SDG 5, it supports target 5 by providing education and training for professional development, as well as certification, that equip women with the necessary skills to advance in their respective careers.

DISCUSSION

Even though women's participation in formal education has increased in developing nations, various challenges persist that prevent them from excelling academically (Rahman & Rahman, 2023). Factors such as poverty, child marriage, culture, and a dearth of quality education hinder girls from attaining education. Schools are far away; basic facilities are lacking; the content taught in school is not much relatable to their everyday lives (Pourtaheri et al., 2024). However, experiences offered through digital learning platforms can effectively mitigate many of the challenges and provide marginalized girls with equal opportunity. The research findings indicate that flexible online-based learning programs are superior as they allow girls to participate at their convenience and offer instruction that fosters skills.

The study shows that online education and related technologies have multiple positive impacts on girls' learning outcomes in Bangladesh. Online education has become a transformative tool by offering flexible, accessible, and diverse learning opportunities. The widespread adoption during the COVID-19 pandemic underscores its role in overcoming barriers such as geographic isolation, safety concerns, and cultural restrictions. Almost all respondents agreed that online platforms mitigate challenges, enabling girls in rural areas to continue their education despite logistical difficulties. A recent study by Rajeb et al. (2023) also confirmed that online education helps reduce absenteeism and dropouts by allowing students to attend classes during emergencies or personal issues.

With flexible, self-paced learning opportunities, online education also improves participation in STEM activities by providing additional resources and activities. The research revealed that blended learning is effective for female students, aligning with the goals of SDG 4 and SDG 5, which emphasize

improving educational access and quality for marginalized groups.

The study findings also highlight significant challenges. The success of online education depends on Internet connectivity, access to learning devices, and a supportive social environment. The majority of respondents reported facing safety concerns, including harassment, which online education can mitigate by offering a safer learning environment. Additionally, the effectiveness of online education relies on teachers' proficiency with digital tools and content creation. The use of AI tools in education, while beneficial for enhancing learning and efficiency, raises ethical concerns about academic integrity. Respondents expressed concerns about using AI to complete assignments, stressing the need for clear institutional policies to regulate its use and ensure responsible implementation.

The study also reveals that Bangladesh is experiencing the growing popularity of local and international MOOC-based learning. It complements learning with activities and materials essential to students, especially those in rural areas and schools facing socio-economic challenges. In addition, there are numerous advantages to using MOOCs; these include flexible, low-cost courses that can be pursued at any time, enhancing lifelong learning for individuals. Overall, while online education and MOOCs offer substantial benefits and align with educational goals, addressing infrastructure and ethical issues is crucial for maximizing their impact.

This critical discussion of the study suggests that online learning can play a transformative role in improving education in underdeveloped countries such as Bangladesh; however, its success depends on several factors (Rouf et al., 2024). Internet-based technology offers students, particularly women, accessibility, flexibility, and international exposure, facilitating higher education with less regard for geographical or societal impediments (Afzal et al., 2023). This study showed that insufficient digital access and infrastructure, low levels of digital literacy, and gender-related barriers are impeding consistent academic progress. Online learning is known to cultivate autonomy and skill-building, engagement supported by institutional and technological support,

yet it risks perpetuating pre-existing inequalities when such conditions are absent.

The study also revealed gender differences in education and student engagement with SDGs, particularly among female students. It reveals that girls are more interested in education, health, and gender-related SDGs, particularly SDGs 3, 4, and 5, which is consistent with what they experience in their daily lives. However, factors such as culture, resource availability, or gender inequalities within learning environments may hinder their optimal understanding and participation in other goals related to the SDGs, including environmental protection and economic development.

CONCLUSION

The study shows that online education has the potential to significantly enhance educational outcomes for girls and align with SDGs 4 and 5. However, the current landscape remains inadequate in addressing the unique challenges faced by women. Several factors, such as infrastructure, digital literacy, and social support systems, impose constraints on participation, thereby diminishing the disruptive effect of technology-enhanced learning on women's education. It is the government's responsibility to eliminate these discriminatory practices and ensure that everyone has access to high-quality education. In other words, by creating a robust, free, mass education system online, the government, along with educational institutions and development partners, can help more women engage in online learning, which will greatly contribute to the development and empowerment of women. This could be done by developing more educational programs aligned with the SDGs and targeted at women to help them upgrade their skills, create employment, and foster economic growth for the community. Educating women will yield social and behavioral transformation, thereby enhancing gender parity, increasing economic productivity, and ultimately advancing the nation's development.

Nevertheless, some limitations of this study include the need to replicate the research with larger, more representative samples. Future research might use a longitudinal design and comparative analysis across different areas to ensure better results. Despite the study's limitations, there are valuable lessons for

policymakers, educators, and development workers. It highlights the importance of gender-responsive digital education strategies, better online pedagogy, and equitable tech infrastructure. Enhanced in these dimensions, online learning can shift from an access tool to a force for real academic empowerment, advancing both educational quality and gender equity in Bangladesh.

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Financial Flexibility at the Crossroads: A Bibliometric Analysis of Research Trends, Thematic Clusters, and Crisis-Driven Evolution

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ABSTRACT

Purpose: This study maps the intellectual landscape and the evolution of the literature on financial flexibility. By examining thematic clusters, trends, and recent crisis-driven developments, this research emphasizes the multidimensional impact of financial flexibility on organizational performance, strategic decision-making, and resilience.

Methodology: A bibliometric analysis was conducted using the Crossref database and visualized in VOSviewer. The study used network, overlay, and density visualization to determine thematic structures, temporal developments, and intensity of research.

Findings: The results present seven thematic clusters of financial flexibility research: foundational finance; crisis-based flexibility; strategic and organizational dimensions; macro and policy implications; cognitive flexibility and behavioral finance; governance and moderating impacts; and payout policy-based flexibility.

Implications: Managers must balance liquidity retention and disciplined investment, integrate risk management practices, and rely on governance structures that preclude wasteful slack building. Regulatory policies are also needed to increase liquidity support, facilitate financing, and enhance corporate governance.

Originality: The paper contributes inclusive bibliometric mappings of literature on financial flexibility. By combining thematic clusters, temporal analysis, and density analysis, it describes the intellectual trajectory of the concept, identifies research hotspots, and outlines future potential.

Limitations and directions for future research: The study is limited to Crossref-indexed literature and thus does not reflect the full literature spanned across databases. The future study should include a broader range of bibliographic sources and explore cross-disciplinary contexts, including cognitive and behavioral dimensions.

Keywords: Financial flexibility; crisis management; bibliometric analysis

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INTRODUCTION

Financial flexibility has increasingly become a core theme in corporate finance, underscoring its key role in enabling entities to adapt, survive, and prosper in times of uncertainty. Overall, financial flexibility is characterized as the ability of firms to access and redeploy financing in response to changing environments, enabling them to benefit from investment opportunities and blunt economic shocks (DeAngelo & DeAngelo, 2007; Arslan-Ayaydin et al., 2014). More recently, the topic has received particular focus following the global financial crisis (Bancel & Mittoo, 2011; Arslan-Ayaydin et al., 2014) and the COVID-19 pandemic, as corporations exhibiting more financial flexibility demonstrated superior resilience and performance (Fahlenbrach et al., 2021; Wu et al., 2024; Nguyen & Dang, 2023). As such, financial flexibility is not merely theoretical but also of substantial practical value for corporate financial decision-making and long-term sustainability.

Despite the growing academic interest, the existing body of literature on financial flexibility is marked by a dispersion of perspectives. Some of the researchers narrowly define it in connection with debt capacity (Marchica & Mura, 2010) and liquidity reserves (Denis, 2011), while others emphasize its role in sustaining innovation (Hao et al., 2022), strategic capability building (Arbogast & Kumar, 2018), and capital structure decision (Byoun, 2011). Broad-based interpretations include organizational flexibility and managerial perceptions, conceptualizing financial flexibility as a behavioral construct integral to corporate decision-making (Duho, 2021; El Shafei et al., 2022; Hunjra et al., 2024). Such conceptual divergence has created definitional ambiguities, thereby hampering the comparability of results and hindering the derivation of a united theoretical model.

The fragmented nature of this research is also expressed in the study of financial flexibility in the face of crisis. Studies from the COVID-19 era set forth its role in business resilience (Wu et al., 2024; Nguyen & Dang, 2023). However, most of the contributions remain largely specific. Likewise, earlier research explored its impact on firm investment (Cherkasova & Kuzmin, 2018) and payout policy (DeAngelo & DeAngelo, 2007), but such studies rarely come together in an integrated view. Therefore, the literature provides a fragmented set of the intellectual structure, historical evolution, and thematic evolution of the field.

To fill the void, the current study conducts an extensive

bibliometric analysis of the financial flexibility literature. Specifically, it attempts to chart the intellectual map of literature by applying co-occurrence and clustering methods, detecting prevailing and nascent themes of financial flexibility, and tracing the field's trajectory against global financial crises and market dynamics. Thus, the study not only integrates fractured bits of information but also identifies previously invisible paths of future scholarly endeavors. Hence, the paper presents a systematic roadmap for enhancing and expanding theoretical discussions and operational applications and places flexibility as a multi-faceted construct at the heart of modern financial management.

LITERATURE REVIEW

ESG Integration and Financial Performance

The notion of financial flexibility has garnered increasing attention in the corporate finance literature, particularly as organizations face greater uncertainty and rapid fluctuations in their environments. As the firms' ability to access and redeploy financing at minimal cost to pursue investment opportunities and contain associated risks (Gamba & Triantis, 2008), financial flexibility has been a key feature of value-maximizing approaches. Researchers have consistently underscored its contribution to boosting firm responsiveness by facilitating adequate liquidity, debt capacity, and the productive allocation of resources (Marchica & Mura, 2010). The burgeoning literature on financial flexibility spotlights not only its role as a buffer against external shocks but also its enabling role in sustainable competitive advantage.

One of the key areas of this study involves the interaction of financial flexibility and capital structure decisions. The traditional theories, such as the trade-off theory and the pecking order theory, have in the past provided insight into financing decisions on the balance of tax advantages, bankruptcy costs, and asymmetric information (Myers, 1984). Financial flexibility enhances these traditional theories by combining firms' incentives to maintain borrowing capacity and retain liquidity for future needs (Byoun, 2011). Empirical research concludes that more flexible firms implement more conservative leverage practices and maintain cash reserves and unused credit lines as insurance against financial constraints (Denis & McKeon, 2012). Financial flexibility consequently supplements traditional capital structure theory by illustrating firms' proactive adaptations in balancing risk and opportunity.

From a macro perspective, financial flexibility is closely linked to overall economic stability and exchange rate volatility. Countries with greater exchange rate flexibility tend to provide firms with additional room to maneuver in how they finance themselves, lessening their susceptibility to currency exposures and external shocks (Obstfeld et al., 2010), yet such advantages of flexibility depend heavily on the degree of financial sophistication. Moreover, exchange rate volatility severely disrupts productivity growth in economies with shallow credit markets, while financially developed systems are better equipped to absorb such shocks (Aghion et al., 2009).

The significance of financial flexibility is most prominently highlighted during crisis period. Bancel & Mittoo (2011) suggest that financial flexibility provided protection to firms amid the 2008 crisis, affirming its function as both a strategic resource and a key factor of resilience. In addition, Arbogast & Kumar (2018) assert that financial flexibility acts not merely as a buffer but also as a strategic instrument that empowers firms to seize opportunities, particularly during downturns and at the nadir of industry cycles. However, this adaptive advantage waned once uncertainty crossed the threshold from a “reasonable” state into a “warning” territory (Hao et al., 2022). Nevertheless, Xiao et al. (2021) warn that excessive slack may encourage inefficient investments, highlighting the dual-natured characteristic of financial flexibility as both a contributor to resilience and a potential catalyst for waste. Collectively, these viewpoints imply that the true value of financial flexibility lies in its judicious management, serving as an essential safeguard and strategic lever in turbulent circumstances, while simultaneously requiring governance discipline to avert its transformation into a source of inefficiency.

Bibliometric studies of financial flexibility remain relatively few; yet, they have begun to define the scope of this literature. Correspondingly, Sreenivasulu & Mamilla (2024) provide a global view of the financial flexibility literature, but their reliance on Scopus and a restricted period of 2008–2022 exclude both prior theoretical contributions and the most recent developments. Likewise, Suciati et al. (2024) analyze the relationship of financial flexibility and firm performance across 266 publications from 1991 to 2023, but focus on selective databases and thereby largely limit the scope to indexed materials. While both studies underscore the rising salience of financial flexibility in corporate finance and strategic management, their limitations reinforce

the need for a more comprehensive and updated approach. Addressing this gap, the present study uses Crossref, a broader, and more inclusive database. It adopts a temporal scope of 2000 to 2025, thereby inclusively embracing the evolution of financial flexibility from its early conceptualization, through its critical role in the 2008 financial crisis and the COVID-19 pandemic, to its most recent developments.

RESEARCH METHODOLOGY

This study draws exclusively on Crossref, accessed through the Publish or Perish (PoP) program, as its primary bibliometric source. Compared to selective databases such as Scopus or Web of Science, Crossref provides broader coverage, therefore allows for the inclusion of established and emerging scholarly values. The timeframe considered falls between 2000 and 2025, tracing the evolution of financial flexibility from its conceptual beginnings to its increased relevance amidst global crises like the 2008 financial crisis and the COVID-19 pandemic, until the latest outputs of 2024 to 2025.

The paper organized the literature search around the keyword “financial flexibility,” restricting it to English-language publications to ensure comparability and ease subsequent bibliometric analysis. The author used a multi-stage cleaning process after retrieval to ensure that the final dataset reflected the whole body of literature on financial flexibility. At the first stage, it has excluded to prevent double-counting of articles listed multiple times. Second, only peer-reviewed journal articles, conference proceedings, and review articles were included, while book chapters, editorials, and non-scholarly materials were excluded. At the third stage, irrelevant records were excluded by abstract screening. Lastly, the author excluded the incomplete entries without author, title, or year fields. This ensured that the final dataset reflected the whole body of literature on financial flexibility. The cleaned dataset was later imported into VOSviewer to perform co-occurrence analysis and visualize networks, overlays, and densities. The visual presentations helped detect thematic clusters, observe the temporal evolution of the research, and identify influential keywords.

RESULTS AND DISCUSSION

Descriptive Analysis

The annual number of publications and citations on financial flexibility from 2000 to 2025 follows a clear upward trend, marked by several distinct phases, as

shown in Figure 1 below. During the early 2000s, the number of publications remained relatively low and steady, ranging from 5 to 11 articles per year, indicating that financial flexibility was still in its nascent stage of recognition in the corporate finance literature. From 2007 onwards, a steady increase was observed, reflecting rising attention to the matter, particularly in the aftermath of the global financial crisis of 2008, with annual publications ranging from 28 to 41 papers. During this developmental period, a few landmark contributions were made, notably around 2014, as the numbers cited rose exponentially and exceeded 1,000. The trend suggests that seminal works published during the period provided theoretical underpinnings and shaped subsequent discourse on financial flexibility as an important determinant of firm value and resilience.

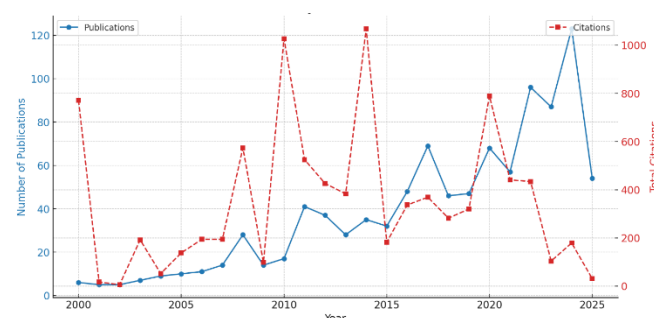
Since the mid-2010s, the literature has made steady progress. Yearly output rose steadily, topping 69 in 2017, and marked a broader scholarly interest in the notion throughout corporate finance and strategic management. Citations from the period were more evenly spread, indicating consistent uptake of the ideas without the clustering of seminal breakthroughs from before. This suggests a phase of consolidation, during which researchers elaborated on core theories by applying financial flexibility across various contexts, such as investment conduct, capital structure, and internationalization.

The most significant increase was seen in the 2020s, during the COVID-19 pandemic. The number of publications jumped dramatically, from 68 in 2020 to a maximum of 123 in 2024, illustrating how systemic shocks have renewed attention toward financial flexibility as a resilience mechanism. Simultaneously, citations sharply rose in 2020, testifying to the immediate impact of work aimed at firms' liquidity and debt capacity in the context of crisis conditions. The period is characterized by both quantitative and qualitative increases in the literature, with rising links between flexibility and macroeconomic stability, governance, behavioral dynamics, and payout policy.

The current years (2023–2025) continue to demonstrate a historically high number of publications with comparatively weak citation rates. This divergence is expected, given that newly published work takes time to flow and create scholarly influence. The significant spike in publications over these years indicates that financial flexibility has become a central and uniting theme in financial research, bridging its relevance across firm-

level strategy, macro policy, and governance frameworks.

Figure 1: Evolution of Financial Flexibility Publications and Citations Over Time

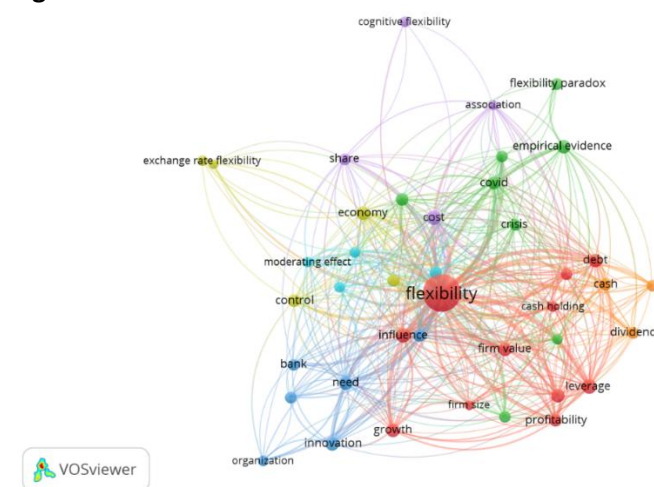


Source: Crossref, 2025

Network Visualization

The network visualization discovers that flexibility highlights its integrative function: connecting disparate topics of capital structure, dividend policies, crisis resilience, and the behavioral dimensions of decision-making. The focal position also signals the cross-disciplinary scope of the concept, including financial economics, strategic management, and organizational behavior. The map further identifies seven distinct thematic clusters, each corresponding to a particular dimension of literature development. The first cluster highlights the foundational role of research on financial flexibility. Research within this cluster focuses on capital structure, cash holdings, debt capacity, firm size, and profitability. The findings repeatedly establish that financial flexibility plays a central role in determining firm value and future growth potential, highlighting its role for long-run value creation (Gamba & Triantis, 2008; Denis, 2011; Byoun, 2011).

Figure 2: Network Visualization



Source: VOSviewer, 2025

A second thematic cluster centered around the significance of flexibility amid systemic disruptions. Studies associated with this cluster indicate that organizations possessing greater liquidity and borrowing capacity exhibited enhanced resilience during crises such as the global financial crisis (Bancel & Mittoo, 2011) and the COVID-19 pandemic (Wu et al., 2024). Nevertheless, the results also reveal the “flexibility paradox,” in which an overabundance of slack may lead to inefficient investment decisions, highlighting the dual nature of financial flexibility as both a mechanism for resilience and a potential catalyst of inefficiency (Xiao et al., 2021). This evidence underscores that the utility of financial flexibility amid systemic shocks is profoundly influenced by context, providing safeguards during economic downturns while also posing the risk of inefficiency due to resource overaccumulation.

The third set of dimensions produces a relation between financial flexibility and organizational and strategic performance. Research findings indicate that financial slack facilitates business organizations in engaging in innovation (Hao et al., 2022), maintaining research and development (Feng et al., 2021), and enhancing strategic capabilities (Arbogast & Kumar, 2018). More than merely a financial buffer, flexibility functions as a capability that enables organizations to respond, compete, and endure environmental uncertainty.

The fourth set of clusters includes macro-level perspectives, associating financial flexibility with exchange rate flexibility, systemic stability, and economic growth. HKIMR (2001) highlights that the benefits of exchange rate flexibility depend on underlying financial strength. In emerging economies with foreign currency liabilities, depreciation increases credit constraints and reduces output, making stability more appealing. Lee and Kim (2018) also explain that flexibility dampens growth in countries with limited financial openness while enhancing it in fully open economies. These findings suggest that exchange rate flexibility, like firm-level financial flexibility, is not beneficial per se but is context-dependent, solidifying resilience only with the support of strong financial structures.

A smaller but emerging fifth cluster focuses on the behavioral and perceptual dimensions of financial flexibility, including cognitive flexibility, cost, and share-related outcomes. Research suggests that power enhances cognitive flexibility, subsequently reducing perceived risk and fostering risk-taking in financial

options (Sekścińska et al., 2024). From a cost perspective, maintaining flexibility through at-the-market (ATM) equity offerings can create information opacity and agency conflicts, driving up capital costs and diluting shareholder value (Cashman et al., 2023). Analogously, payout flexibility through share repurchases carries hidden costs, as managerial discretion often translates into higher average repurchase prices and weaker long-term value. Such costs have complex linkages with governance issues such as earnings management and managerial entrenchment, suggesting that payout flexibility generates negative consequences without stringent oversight (Bonaimé et al., 2016). Overall, these findings reveal that in this cluster, financial flexibility takes on a dual role, supporting adaptability but also generating governance-related costs with immediate implications for shareholders.

The sixth cluster highlights the role of corporate governance in determining financial flexibility. Empirical literature supports the view that effective governance enhances flexibility by improving shareholder monitoring and reducing agency costs, whereas poor governance may limit its use (Islam, 2024). Other results suggest that governance plays a moderating role in the interaction between flexibility and performance (Wu et al., 2023), while also reducing the negative impact of poor-quality earnings on liquidity (Islam et al., 2022). Overall, these results place governance as the center of the decision whether financial flexibility is a value-improving capability.

Finally, the seventh subgroup focuses on payout policy, in which studies show that companies balance cash retention with dividend payouts to maintain operational flexibility. Empirical analysis finds that dividend increases coincide with favorable income shocks and low volatility, which lead to favorable valuation effects. Payout decreases, on the other hand, provide negative signals and can lower firm value (Lie, 2005). Therefore, managers rarely cut dividends, instead preserving commitments by reducing investment or increasing leverage (Daniel et al., 2007), indicating that payout stability not just reinforces investor faith but also constrains potential growth. In addition, hedging and payout policy act as substitutes: firms engaged in proactive risk management exhibit lower reliance on repurchasing stock to offset uncertainty, a pattern evident across both financial and nonfinancial companies (Bonaimé et al., 2014). Overall, these results suggest that financial flexibility goes beyond cash retention and arises from the interaction of payout

stability and risk management to cope with uncertainty, maintain credibility, and balance shareholder returns with investment needs.

Cluster	Representative Keywords	Thematic Focus
Cluster 1 (Red)	Capital structure, cash holding, debt, debt capacity, firm size, firm value, flexibility, growth, influence, leverage, profitability	Foundational finance
Cluster 2 (Green)	Benefit, COVID, crisis, empirical evidence, flexibility paradox, pandemic, relation	Crisis-based flexibility
Cluster 3 (Blue)	Bank, innovation, need, operation, organization, strategic flexibility	Strategic and organizational dimensions
Cluster 4 (Yellow)	Control, economic growth, economy, exchange rate flexibility, financial crisis	Macro and policy implications
Cluster 5 (Purple)	Association, cost, cognitive flexibility, share	Cognitive flexibility and behavioral finances
Cluster 6 (Light Blue)	Corporate governance, financial constraint, firm performance, moderating effect	Governance and moderating impacts
Cluster 7 (Orange)	Cash, dividend, payout policy	Payout policy-based flexibility

The seven clusters reveal financial flexibility as an inherently multifaceted concept that connects corporate finance, governance, strategy, risk management, and macroeconomic stability. Clusters 1 and 2 mirror the foundational domain, highlighting the contribution of capital structure, liquidity, and borrowing power as value determinants of firm value, resilience, and adaptability to systemic shocks. Clusters 3 and 4 extend the focus by situating flexibility within the wider strategic and macro environment, linking it to innovation, R&D, and firm-level competitiveness, as well as to exchange regimes and country-level growth

patterns. Clusters 5, 6, and 7 include explanatory mechanisms that highlight how behavioral biases, governance structures, and payout policy interact with flexibility, enabling or constraining their influence. Overall, these clusters uncover financial flexibility as a central and integrative construct in the financial literature, a concept that spans analysis levels, balances resilience and efficiency, and is conditioned by the interaction of contextual conditions and institutional structures.

Overlay Visualization

The overlay visualization offers rich insight into the historical development of themes in literature on financial flexibility. In the early 2010s, the literature consisted of conceptual work that sought to operationalize financial flexibility and defend its inclusion in corporate finance. Studies identified its implications for capital structure, cash holdings, and firm value, and shared common threads of debt capacity and profitability. The decade provided the theoretical underpinnings of the field, as researchers converged on the viewpoint that flexibility was central to sustaining growth and long-run performance (Gamba & Triantis, 2008; Denis, 2011).

During the mid-2010s, academic research began to move beyond abstract conceptualizations and became more applied. Financial flexibility has been increasingly researched in investment behavior, innovation, and firm strategy. Papers emphasized its value in enabling firms to conduct R&D, sustain competitive advantage, and cope with uncertainty in dynamic markets (Feng et al., 2021; Hao et al., 2022). This was a movement from survival-based discussions to strategic deployments, framing financial flexibility as an organizational adaptability enabler key to strategic success.

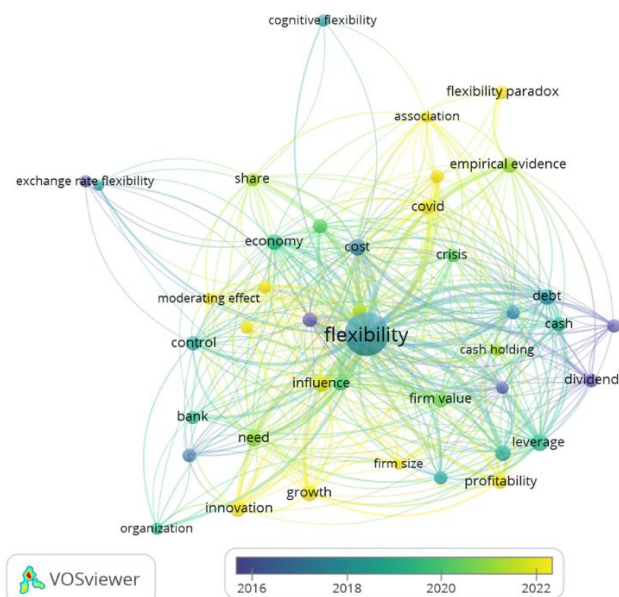
By the late 2010s, the question set again expanded, combining relational and market-based methodologies. Researchers began examining how financial flexibility interacts with external factors, including market perceptions, investor relations, and macroeconomic conditions. The expansion shifted toward contextualism and showed that flexibility does not yield similar returns but instead depends heavily on financial openness, system stability, and investor mood (HKIMR, 2001; Lee & Kim, 2018).

The COVID-19 pandemic of 2020 marked a key historical turning point for the literature, triggering a surge of

scholarship on the use of flexibility in response to systemic shocks. The literature highlighted the cushioning function of liquidity and debt capacity in buffering against the impact of crises and cautioned against wasteful inefficiencies arising from excessive slack (Wu et al., 2024; Xiao et al., 2021). The episode served to emphasize the dual function of flexibility as both a cushion against uncertainty and a potential source of waste when used in inappropriate locations.

In the most recent period (2022–2025), the research agenda has dramatically expanded and shifted toward integrative, cross-disciplinary methodologies. New currents reveal cognitive and behavioral elements and uncover how psychological bias and managerial discretion affect financial decisions (Sekścińska et al., 2024). Research on governance highlights shareholder monitoring to amplify the value of adaptability and blunt the costs associated with principal-agent problems (Islam et al., 2022; Wu et al., 2023). At the same time, payout policy and uncertainty management have been increasingly studied, particularly the roles of dividend signaling and the hedging-versus-repurchase substitution relation (Lie, 2005; Bonaimé et al., 2014).

As a whole, the progress of the financial flexibility literature is a gradual shift from conceptual foundations to applied corporate finance, to contextual synthesis across markets and macroeconomic conditions, to analysis based on crises, and, finally, to broader behavioral, governance, and dividend dimensions. This trend follows the evolution of financial flexibility into a multifaceted framework that integrates knowledge from finance, strategy, and organizational behavior and examines both value creation and resilience.



Density Visualization

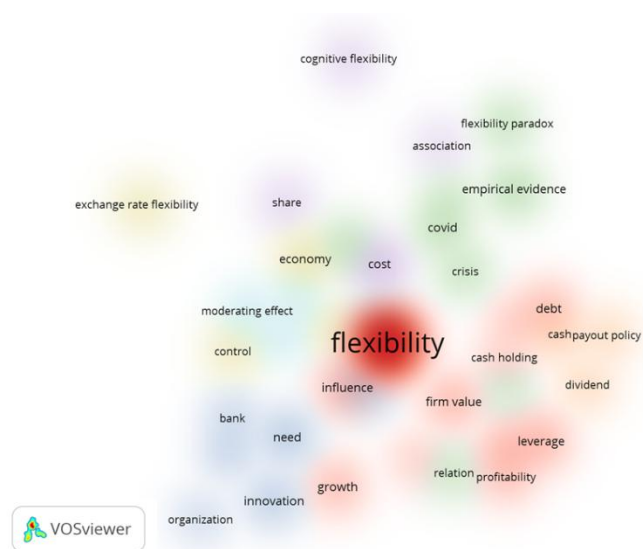
The density plot provides more detail on the hotspots of the literature on financial flexibility. The most powerful themes that arise are “flexibility,” “firm performance,” and “cash holdings,” which become the most researched themes. The hotspots map onto seminal controversies in corporate finance, including the role of flexibility in optimal capital allocation, staying competitive, and achieving better long-run performance (Gamba & Triantis, 2008; Denis, 2011; Byoun, 2011). Cash holdings appear specifically as a theme per se, a testament to the ultimate importance of liquidity as a strategic asset and insurance against financing hurdles. The clustering of works on these topics testifies to their central role in advancing theoretical and practical knowledge of how firms balance sustainability and growth.

Beyond these reigning hotspots, the density map identifies secondary but still emergent trends, such as “pandemic,” “crisis,” and the “flexibility paradox.” The latter emerged into view, particularly in and after the COVID-19 crisis, as scholars examined how firms applied financial and strategic flexibility to address historically unprecedented disruptions (Wu et al., 2024). The paradox of flexibility, in which excess slack resources simultaneously increase resilience but also afford inefficiency, has more recently been theorized as a double-edged quality of managerial choice under uncertainty (Xiao et al., 2021). This indicates an extension of the financial flexibility literature from its traditional preoccupation with classical issues of liquidity and capital structure to broader considerations of crisis management, efficiency trade-offs, and behavioral processes.

In addition, more recent density patterns reveal governance and payout-related themes as new hotspots. Research discovers that governance quality significantly impacts financial flexibility value by reducing agency costs and boosting shareholder monitoring (Islam, 2024; Wu et al., 2023). Similarly, the payout policy, in dividends and share repurchases, resurfaces in explaining the balance between flexibility and shareholder demands. Evidence verifies that dividend stability provides investor confidence, including periods when companies have to forgo or use more of their capital to maintain commitments (Daniel et al., 2007; Lie, 2005). At the same time, managerial discretion in repurchase plans creates hidden costs and governance issues, and may dilute value creation in the

long run (Bonaime et al., 2014; Bonaime et al., 2016). The hedging and payout flexibility substitution effect again reflects the integrated nature of risk management and financial policy, and how flexibility defies explanation without considering a company's overall governance and risk position.

Figure 4: Density Visualization



Source: VOSviewer, 2025

The simultaneous salience of traditional and nascent hotspots bears witness to the unfolding and dynamic nature of financial flexibility literature. On the other hand, the well-established cash policy and firm performance tradition speak to the enduring nature of classical theories of corporate finance (Myers & Majluf, 1984; Denis, 2011). In contrast, the rising salience of crisis- and behavior-themed topics signals an expansion of boundaries beyond the interdisciplinary boundaries, such as from organizational behavior, risk management, and strategic adaptation. The double trajectory thus indicates that financial flexibility will indeed remain anchored on liquidity and firm performance but now realized as an integrative construct that cuts across corporate governance, payout policy, and systemic resilience against global shocks. As such, future work will have broader implications for managing systemic, behavioral, and global shocks.

Discussion of Findings

The bibliometric findings reveal the salience of financial flexibility as a theoretical framework and a practical

matter in corporate management and finance literature. Financial flexibility, at its core, corresponds to the trade-off model of capital structure by Kraus & Litzenberger (1973) and the pecking order model by Myers & Majluf (1984), which emphasize the strategic value of liquidity and the adaptability of financing decisions under uncertainty. Firms with high financial flexibility have more ability to invest during downturns, reduce agency costs, and manage financing frictions, leading to sustainable performance over the long term (Gamba & Triantis, 2008; Denis, 2011). The bibliometric clusters validate it by highlighting focus on themes such as capital structure, dividend policy, and cash holdings, signifying the theoretical integration of flexibility in corporate management.

From a strategic point of view, the findings reveal that financial flexibility transcends financial policies and extends to organizational adaptability, innovation, and resilience. This confirms the resource-based view of the firm (Barney, 1991), which holds that dynamic capabilities play a key role in sustainable competitiveness. More specifically, the emergence of clusters on strategic flexibility and crisis-based literature bears witness to how financial means converge with managerial cognitions and behavioral biases in delineating responses to external shocks (Campello et al., 2010). The implications of these findings hint at a growing blurring of the boundaries between finance and management, and that financial flexibility must be considered not just a quantitative measure of liquidity but also a strategic capability enabling firms to navigate turbulent, intricate conditions.

The findings also reflect the crisis-based evolution of the concept. Financial flexibility was of particular concern during the 2008 global financial crisis and the COVID-19 pandemic, in which liquidity and debt capacity served as central factors in corporate survival (Bancel & Mittoo, 2011; Wu et al., 2024). Meanwhile, recent literature has posited a “flexibility paradox” (Xiao et al., 2021), cautioning against excessive slack, which may lead to inefficiencies, overinvestment, or agency problems. The paradox is that flexibility is not a common good; instead, its advantages depend on the quality of governance, managerial discipline, and the institutional environment.

Another of our primary implications relates to payout policy and corporate governance, which bibliometric analysis identifies as an emerging hotspot. Financial flexibility is enhanced by good governance, which reduces agency costs and aligns managerial effort with

shareholder interests (Islam, 2024; Wu et al., 2023). Similarly, payout and repurchase policies function not only as performance signals but also as resource-allocation constraints (Lie, 2005; Daniel et al., 2007). The hedging and payout flexibility substitution effect (Bonaimé et al., 2014) also suggests that financial flexibility eludes us regardless of the overall risk management strategy. The interrelationship among governance, payouts, and risk management demonstrates how flexibility sits at the crossroads of financial policy, investor perceptions, and corporate credibility.

The findings of this paper have important implications for theory, practice, and policy. Theoretically, the findings extend the literature on corporate finance and strategic management by conceptualizing financial flexibility as a multidimensional construct that connects financial policies with strategic and behavioral dynamics. This relates to theories of capital structures, such as the trade-off theory and pecking order theory of capital structure choice (Myers & Majluf, 1984; Kraus & Litzenberger, 1973), and the resource-based view of the firm (Barney, 1991), and redrafts financial flexibility as a financial buffer and dynamic capability. From a managerial perspective, the paper finds that cash-aware firms with a defensive leverage policy and flexible investment decisions are more likely to innovate and survive in times of crisis (Campello et al., 2010). On the policy side, the findings affirm the role of the institutional environment and the regulatory system in promoting liquidity assistance, reducing financing frictions, and providing economic stability in times of systemic crisis.

At last, the findings open avenues for future research. The diversification of the theme into behavioral finance, cognitive flexibility, and managerial discretion (Sekścińska et al., 2024; Cashman et al., 2023) suggests that future scholarly publications will increasingly include psychological and organizational perspectives in the financial flexibility literature. Moreover, the publications boom following 2020 suggests a continuing interest in conceptualizing flexibility in the face of global crises, sustainability transformations, and technology shocks. Subsequent scholarship may explore how financial flexibility complements ESG pledges, digital revolutions, and existential threats such as climate change, and extend the reach of the concept beyond traditional corporate finance into broader societal and institutional spheres.

CONCLUSION

The paper undertakes an initial systematic bibliometric mapping of the financial flexibility literature from 2000 to 2025 and captures its emerging salience as a central construct in financial management and firm strategy. The paper finds that financial flexibility is multi-dimensional and interfaces with financial policy, strategic adaptability, and behavioral decision-making. From a combination of co-occurrence and clustering analyses, the following seven theme-based clusters have been identified: foundational finance; crisis-based flexibility; strategic and organizational dimensions; macro and policy implications; cognitive flexibility and behavioral finance; governance and moderating impacts; and payout policy-based flexibility.

The paper demonstrates that financial flexibility has evolved from a marginal, loosely defined concept to a central, multifaceted model of corporate finance and management. Early 2000s literature was largely conceptual, focused on definitions and key connections to capital structure, cash holdings, and firm value. The literature from the mid-2010s onwards broadened to include applied and strategic topics and linked financial flexibility to innovation, R&D spending, and organizational flexibility. The inflection came during the 2008 global financial crisis and the COVID-19 pandemic, when financial flexibility was again framed as a survival determinant for the firm in the face of system-wide distress. More recent literature advances these insights by including governance structures, managerial cognitions, and payout policy as explanatory vehicles. The overall results build an established body of evidence showing financial flexibility not merely as a cushion against liquidity but as a strategic and integrative capability that influences not only firm survival in times of crisis but value creation for the future under dynamic conditions.

The findings have significant implications for practice, policy, and future research. At the managerial level, financial flexibility must be thought of not only as a financial buffer but also as a dynamic capability. Managers must balance liquidity retention and disciplined investment, integrate risk management practices such as hedging to support payout policies, and rely on governance structures that preclude wasteful slack building. Policymakers should value financial flexibility as a stabilizer in times of systemic stress. Regulatory policies that increase liquidity support, facilitate financing, and enhance corporate

governance are likely to enhance firms' capacity to withstand crises without jeopardizing efficiency. Lastly, our analysis suggests that cognitive flexibility at the managerial level is critical to efficient use of financial resources and identifies the importance of leadership development programs that enhance adaptive decision-making in uncertain conditions.

Although the study made notable contributions, it has several limitations. First, it is entirely reliant on Crossref as the primary bibliometric database. Though Crossref has widespread coverage of the global domain of publishers and fields of study, it does not necessarily include all works of relevance indexed in selective lists such as Scopus or Web of Science, and may therefore lack completeness. Secondly, the search strategy was deliberately confined to the explicit keyword “financial flexibility,” excluding conceptually near words such as “capital flexibility” or “financing slack.” Though it ensured conceptual specificity, it may have excluded relevant works that provided valuable insights for analysis. Thirdly, as with most bibliometric studies, reliance on citation counts and keyword co-occurrence merely reflects patterns of scholarly interest rather than the quality of contributions per se, and this may overrepresent popular but not necessarily seminal works. Finally, due to the inherent lag in citation building, the influence of relatively new works published in the current period, 2023–2025, is not adequately accounted for in the analysis.

Based on the identified limitations, potential future research directions can be suggested. First, researchers ought to use multiple bibliographic databases (e.g., Scopus, Web of Science) to generate a more inclusive and representative map of the literature on financial flexibility. Secondly, since bibliometric views provide structural insights, future research should shift direction and focus on content-based analysis, such as systematic reviews and meta-analyses, to examine the causal relationships among financial flexibility, firm performance, innovation, and resilience. Thirdly, the dynamic economic and managerial landscape offers potential for contextual extensions. More specifically, digital transformation, ESG practices, and geopolitical volatility are new avenues in which the role of financial flexibility is emerging.

The behavioral and cognitive dimensions of the field also deserve greater scholarly attention. Integration of findings from behavioral finance and managerial cognition has the potential to shed light on how biases,

heuristics, and adaptive decision-making affect the efficient exploitation of flexibility strategies, especially in the face of systemic stress. The governance mechanisms similarly have a rosy future for the field, as cross-country comparisons have the promise of revealing how institutional environments and shareholder protections function to moderate the value of flexibility. Overall, these avenues have the promise to drive financial flexibility research to the next stage of maturity, connecting classical theories of finance with today's challenges in strategy, governance, and global risk.

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ESG Integration and Cost of Capital: Microsoft's Sustainable Finance Transformation

Pamela Tinashe Bakare  *

ABSTRACT

Purpose: This study examines the relationship between Environmental, Social, and Governance (ESG) integration and the cost of capital for Microsoft Corporation from 2015 to 2025, analyzing how comprehensive sustainability initiatives influence borrowing costs, credit ratings, and investor valuations.

Methodology: Employing a mixed-methods longitudinal case study design, this research combines quantitative analysis of financial metrics (bond yields, credit spreads, cost of debt) with qualitative thematic analysis of ESG initiatives. Secondary data sources include Microsoft's annual reports (2015-2025), sustainability disclosures, credit rating reports, and market data from Bloomberg and Refinitiv databases.

Findings: Microsoft's ESG integration strategy correlates strongly with favorable cost of capital outcomes, including maintenance of AAA credit ratings across all major agencies, bond yields approaching Treasury rates (spread compression to 8 basis points), and statistically significant negative correlations ($r = -0.82$, $p < 0.001$) between ESG performance scores and cost of debt. The company's carbon-negative commitment, water-positive initiatives, and circular-economy programs demonstrate measurable financial value creation by reducing financing costs.

Implications: Findings validate the business case for strategic ESG integration, demonstrating that proactive sustainability investments create quantifiable financial value by reducing capital costs. Microsoft's framework provides actionable insights for technology firms seeking to optimize capital structures through ESG excellence.

Originality: This research addresses the limited empirical evidence on ESG-cost of capital dynamics within the technology sector, providing a longitudinal analysis of the sole major corporation maintaining universal AAA ratings while executing transformative sustainability commitments.

Limitations and directions for future research: A single-case design limits generalizability across industries and firms with different resource endowments. Future research should pursue comparative technology-sector analysis and longitudinal studies extending beyond 2030 to capture the full impact of realization.

Keywords: ESG integration; cost of capital; sustainable finance; Microsoft Corporation; credit ratings

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INTRODUCTION

The integration of Environmental, Social, and Governance (ESG) factors into corporate strategy has fundamentally reshaped capital market dynamics and corporate finance decision-making. As institutional investors managing over US\$35 trillion in ESG-mandated assets increasingly incorporate sustainability criteria into portfolio allocation ([Global Sustainable Investment Alliance, 2022](#)), companies face intensifying pressure to demonstrate measurable ESG progress while maintaining competitive financial returns. This transformation has catalyzed scholarly and practitioner interest in understanding the causal mechanisms linking ESG performance to cost of capital, particularly as emerging evidence suggests that sustainability excellence may reduce financing costs through multiple transmission channels ([Friede et al., 2015](#)).

Microsoft Corporation represents a uniquely instructive case for examining ESG-cost of capital relationships, having achieved the exceptional distinction of maintaining AAA credit ratings from Standard & Poor's, Moody's Investors Service, and Fitch Ratings simultaneously, making it the sole remaining blue-chip corporation with universal top-tier ratings ([Ethenea Independent Investors, 2024](#)). This remarkable credit position coincides with the company's comprehensive sustainability transformation, initiated in April 2020, encompassing ambitious commitments to achieve carbon negativity by 2030, water positivity, zero waste, and ecosystem restoration exceeding operational land use ([Microsoft Corporation, 2020](#)). The temporal alignment of ESG leadership with superior credit quality provides a natural experiment to examine whether sustainability excellence contributes to favorable financing terms.

The significance of this research extends beyond academic inquiry to practical implications for corporate finance strategy and capital allocation. Understanding how ESG integration influences the cost of capital provides actionable insights for chief financial officers, sustainability executives, and institutional investors seeking to optimize risk-adjusted returns while advancing sustainable development objectives. Microsoft's transformation offers empirical evidence regarding the financial materiality of ESG factors in capital market transactions, potentially informing strategic decisions for technology firms navigating the transition to sustainable business models ([Zhou et al., 2022](#)).

This study addresses the central research question: How has Microsoft's comprehensive ESG integration strategy influenced its cost of capital from 2015 to 2025? The investigation examines relationships between sustainability initiatives and key financial metrics, including bond yields, credit spreads, and investor valuations, employing mixed-methods analysis to establish both statistical associations and qualitative insights into transmission mechanisms. By systematically examining Microsoft's sustainable finance transformation, this research contributes to the expanding literature on ESG-financial performance linkages and provides practical insights for corporate sustainability strategy development.

LITERATURE REVIEW

ESG Integration and Financial Performance

The relationship between ESG factors and corporate financial performance has generated substantial scholarly attention over the past two decades, with research examining various transmission mechanisms through which sustainability practices influence value creation. Early investigations focused predominantly on environmental management in capital-intensive industries, establishing that proactive environmental strategies could reduce regulatory risk and operational costs ([Hart, 1995](#); [Klassen & McLaughlin, 1996](#)). Contemporary scholarship has expanded this foundation to encompass the full spectrum of ESG dimensions across diverse industry sectors, revealing complex interactions between sustainability practices and financial outcomes.

Meta-analytical research by [Friede et al. \(2015\)](#) synthesized findings from over 2,000 empirical studies, identifying a positive relationship between ESG and corporate financial performance in approximately 90% of cases, with particularly strong effects observed in stakeholder-oriented markets. This comprehensive review revealed that ESG integration is associated with superior risk-adjusted returns, lower volatility, and enhanced operational performance across multiple time horizons. Subsequent empirical evidence from Morgan Stanley Capital International (MSCI) ESG research demonstrates that companies with elevated ESG ratings exhibit systematically lower beta coefficients, consistent with the capital asset pricing model, which predicts that reduced systematic risk exposure translates into lower required equity returns ([MSCI, 2019](#)). These findings align with stakeholder theory, which posits that effective

management of employee, customer, supplier, and community relationships creates sustainable competitive advantages that buffer against business disruptions (Freeman, 1984; Donaldson & Preston, 1995).

Pastor, Stambaugh, and Taylor (2022) developed an equilibrium model demonstrating that ESG preferences among investors can influence asset prices even when ESG factors do not directly affect cash flows, suggesting that corporate ESG performance affects the cost of capital through both fundamental value creation and investor preference channels. This theoretical framework provides important context for empirical investigations of ESG's impact on the cost of capital, highlighting multiple pathways through which sustainability excellence may reduce financing costs.

Cost of Capital and ESG Performance

Cost of capital represents the weighted average of debt and equity financing costs, reflecting investor perceptions of business risk and return expectations. Academic literature has identified several mechanisms through which ESG performance influences financing costs, including reduced agency costs, improved operational efficiency, enhanced reputation capital, and decreased regulatory risk exposure (El Ghoul *et al.*, 2011; Cheng *et al.*, 2014).

Empirical research examining the cost of debt relationships finds that firms with superior ESG performance benefit from lower borrowing costs, with this effect persisting after controlling for traditional credit risk factors. Oikonomou *et al.*, (2014) documented that poor ESG performance, particularly in governance and social dimensions, significantly increases corporate bond yield spreads, suggesting that lenders incorporate sustainability considerations into credit risk assessments. This finding received further support from Eichholtz *et al.*, (2019), who demonstrated that green bonds trade at yield premiums relative to conventional bonds from the same issuers, indicating investor willingness to accept lower returns for environmentally beneficial investments.

MSCI's comprehensive multi-market analysis revealed that companies with higher ESG ratings experience lower financing costs in both equity and debt markets, with this relationship persisting after controlling for geographic market, industry sector, and credit quality factors (MSCI, 2019). The research identified particularly robust correlations in developed markets, especially the

United States, where ESG-conscious investing has achieved significant penetration among institutional investors. These findings suggest that ESG integration creates measurable financial value by reducing capital costs, supporting the business case for sustainability investments.

Technology Sector ESG Dynamics

The technology sector presents distinctive ESG considerations that differentiate it from traditional industries. While technology companies typically have smaller direct environmental footprints than manufacturing or extractive industries, they face intensifying scrutiny over data privacy, cybersecurity governance, labor practices, and the substantial energy demands of data center infrastructure and cloud computing operations (Hilty & Aebischer, 2015). These sector-specific characteristics necessitate tailored ESG strategies that address both operational impacts and broader digital ecosystem effects.

Microsoft's industry positioning as a cloud computing and enterprise software leader creates both opportunities and obligations for ESG leadership. The company's Azure cloud platform and digital transformation services enable customers to optimize resource utilization and reduce environmental impacts through improved efficiency, creating positive spillover effects beyond Microsoft's direct operations (Accenture, 2020). Simultaneously, the energy-intensive nature of hyperscale data centers requires sophisticated sustainability strategies that address renewable energy procurement, cooling efficiency, and circular-economy principles for hardware lifecycle management. This duality necessitates comprehensive ESG frameworks that capture both operational excellence and ecosystem-level value creation.

Research Gap and Contribution

Despite burgeoning interest in the relationships between ESG and financial performance, limited research has examined technology sector leaders pursuing comprehensive sustainability transformations. Most existing studies employ cross-sectional methodologies across multiple industries, potentially obscuring sector-specific dynamics and implementation pathways (Eccles *et al.*, 2014). This research addresses the empirical gap by providing a longitudinal analysis of Microsoft's ESG integration journey and its relationship to cost-of-capital outcomes. The study

contributes to the nascent literature on technology-sector ESG dynamics while offering practical insights for corporations developing sustainability strategies that create measurable financial value.

METHODOLOGY

Research Design

This study employs a single-case longitudinal design to examine Microsoft Corporation's ESG integration and its relationship with the cost of capital over 11 years (2015-2025). The case study methodology is particularly appropriate for investigating complex organizational phenomena in which contextual factors significantly influence outcomes and in which understanding implementation processes matters as much as measuring results (Yin, 2018). The longitudinal approach enables analysis of temporal dynamics and causal sequences that cross-sectional designs cannot capture. In contrast, the extended timeframe captures both pre-commitment baseline conditions (2015-2019) and post-commitment transformation phases (2020-2025).

Data Collection

Data collection encompassed multiple archival sources to ensure comprehensive coverage of Microsoft's ESG transformation and financial performance trajectories. Main data sources included: (1) Financial data from Microsoft's annual reports (Forms 10-K) and quarterly earnings releases (Forms 10-Q) filed with the U.S. Securities and Exchange Commission, supplemented by bond pricing data obtained from Bloomberg Terminal and Thomson Reuters' Refinitiv platforms providing yield curves, credit spreads, and issuance terms for Microsoft's corporate debt securities; (2) ESG performance data from Microsoft's annual Environmental Sustainability Reports (2015-2025), Corporate Social Responsibility disclosures, and integrated reporting statements, with independent verification through third-party ESG ratings from MSCI ESG research, Sustainalytics, and S&P Global ESG Scores; (3) Credit assessment data comprising rating reports, methodologies, and forward-looking outlooks from Standard & Poor's, Moody's Investors Service, and Fitch Ratings, including detailed rating rationales and criteria evolution during the study period.

Variables and Operational Measures

Dependent variables comprised multiple cost of capital measures: (1) Cost of debt, operationalized as yield spread over comparable maturity U.S. Treasury securities; (2) Credit rating, converted from ordinal letter

classifications to numerical scales for quantitative analysis; (3) Bond yield, measured as absolute yield rates on newly issued Microsoft corporate bonds.

Independent variables captured ESG performance through composite scores from MSCI, Sustainalytics, and S&P Global rating agencies, supplemented by dimension-specific metrics, including environmental indicators (carbon emissions intensity, renewable energy percentage, water consumption efficiency), social metrics (employee satisfaction indices, workforce diversity ratios, community investment levels), and governance factors (board independence percentages, executive compensation alignment, cybersecurity governance maturity).

Control variables accounted for alternative explanations, including market conditions (Treasury yield curves, sector-specific credit spreads), company performance (revenue growth rates, profitability margins, leverage ratios), and macroeconomic factors (Federal Reserve policy rates, inflation expectations).

Quantitative Analysis Procedures

Quantitative analysis employed correlation and regression methods to assess ESG-cost-of-capital relationships. The primary analytical model specified the cost of debt as a function of ESG performance while controlling for alternative explanatory factors:

$$\begin{aligned} \text{Cost of Debt}_t = & \beta_0 + \beta_1(\text{ESG Score}_t) + \beta_2(\text{Revenue Growth}_t) \\ & + \beta_3(\text{EBITDA Margin}_t) + \beta_4(\text{Leverage}_t) + \beta_5(\text{Market Cap}_t) \\ & + \beta_6(\text{Treasury Yield}_t) + \beta_7(\text{Credit Spread}_t) + \epsilon_t \end{aligned}$$

Where Cost of Debt represents yield spread over Treasuries, ESG Score captures composite sustainability performance, and control variables account for firm-specific financial characteristics and market conditions. Correlation analysis examined bivariate relationships between ESG dimensions and multiple cost-of-capital measures, with statistical significance assessed at conventional thresholds ($p < 0.05$, $p < 0.01$, $p < 0.001$). Regression analysis employed ordinary least squares with robust standard errors to address potential heteroskedasticity, testing whether ESG performance exhibits statistically significant associations with financing costs after controlling for confounding factors.

Qualitative Analysis Procedures

Qualitative analysis employed a thematic analysis to examine the strategic rationale, implementation processes, and stakeholder responses to Microsoft's ESG transformation. Following [Braun and Clarke's \(2006\)](#) six-phase framework, the analysis proceeded through: (1) Data familiarization through repeated reading of sustainability reports, investor presentations, earnings call transcripts, and media coverage; (2) Initial code generation, identifying substantive concepts related to ESG strategy, implementation challenges, financial implications, and stakeholder reactions; (3) Theme development by organizing codes into higher-order patterns, reflecting strategic motivations, operational transformations, and market responses; (4) Theme refinement through iterative review, ensuring internal consistency and clear differentiation; (5) Theme definition and labeling to capture essential characteristics; (6) Report generation, integrating thematic findings with quantitative results.

This inductive approach enabled the identification of transmission mechanisms linking ESG performance to cost-of-capital outcomes, revealing how sustainability initiatives influence investor perceptions, credit assessments, and market valuations. Triangulation between quantitative metrics and qualitative insights provided a comprehensive understanding of the phenomena under investigation, enhancing both internal validity and practical applicability of findings.

Methodological Limitations

Several methodological constraints affect generalizability and causal interpretation. A single-case study design limits external validity to corporations with comparable characteristics, thereby constraining applicability to firms with different market positions, financial resources, or industry contexts. Microsoft's exceptional credit quality and technology-sector positioning may not reflect broader corporate experiences with ESG integration. Temporal limitations include relatively recent comprehensive ESG reporting standardization and ongoing evolution of sustainability practices, meaning some initiatives may not yet demonstrate full financial impacts. Attribution challenges arise when isolating ESG effects from confounding factors that influence the cost of capital, including macroeconomic conditions, industry trends, and firm-specific developments unrelated to sustainability performance. While the mixed-methods approach and longitudinal design partially address these

limitations, readers should interpret causal claims cautiously and recognize the exploratory nature of this single-case investigation.

RESULTS AND ANALYSIS

Microsoft's ESG Transformation Journey

Microsoft's ESG transformation accelerated dramatically following the January 2020 announcement of comprehensive environmental commitments, representing one of the technology sector's most ambitious corporate sustainability programs. The company pledged to achieve carbon negativity by 2030, water positivity by the same year, zero waste across operations, and ecosystem protection, exceeding its operational land footprint ([Smith, 2020](#)). These commitments transcended incremental improvements, signaling fundamental business model transformation toward regenerative sustainability.

Environmental performance metrics demonstrate substantial progress toward these ambitious targets. By 2025, Microsoft achieved 61% carbon emission reduction relative to 2020 baseline levels across Scope 1 and 2 emissions, exceeding the interim trajectory toward its 50% reduction goal by 2030 ([Microsoft Corporation, 2025](#)). Renewable energy adoption reached 85% of total consumption by 2025, approaching the company's 100% renewable energy target, with remaining fossil fuel usage concentrated in locations where renewable procurement faces infrastructure constraints. Land protection initiatives exceeded initial commitments by 75%, with cumulative permanent protection totaling 19,200 acres, surpassing the original 11,000-acre target and demonstrating the capacity to overdeliver on ecosystem restoration objectives ([Smith, 2024](#)).

Water stewardship programs implemented water replenishment projects expected to deliver over 100 million cubic meters of volumetric benefit throughout their operational lifetimes, positioning Microsoft to achieve water positivity, whereby it returns more water to stressed basins than it consumes operationally ([Microsoft Corporation, 2024](#)). Waste diversion performance reached 87% by 2025, substantially exceeding the 75% target and demonstrating circular economy principles in data center operations through equipment refurbishment, component harvesting, and material recovery programs. In fiscal year 2024, Microsoft achieved 90.9% reuse and recycling rates for

decommissioned servers and networking equipment, establishing industry leadership in hardware lifecycle management (Smith, 2024).

Figure 1 shows the Microsoft Environmental Performance Metrics Timeline. This four-panel visualization presents Microsoft's environmental performance across key sustainability dimensions from 2020 to 2025. Panel A demonstrates carbon emission reductions of 61% against a 50% target trajectory. Panel B illustrates renewable energy adoption reaching 85% of total consumption, approaching the 100% target by 2025. Panel C shows cumulative land protection of 19,200 acres, surpassing the 11,000-acre commitment by 75%. Panel D depicts water replenishment initiatives that have achieved over 100 million cubic meters of volumetric benefit. Green shading indicates achievement zones, while red dashed lines represent target trajectories. All metrics demonstrate Microsoft's capacity to meet or exceed ambitious environmental commitments.

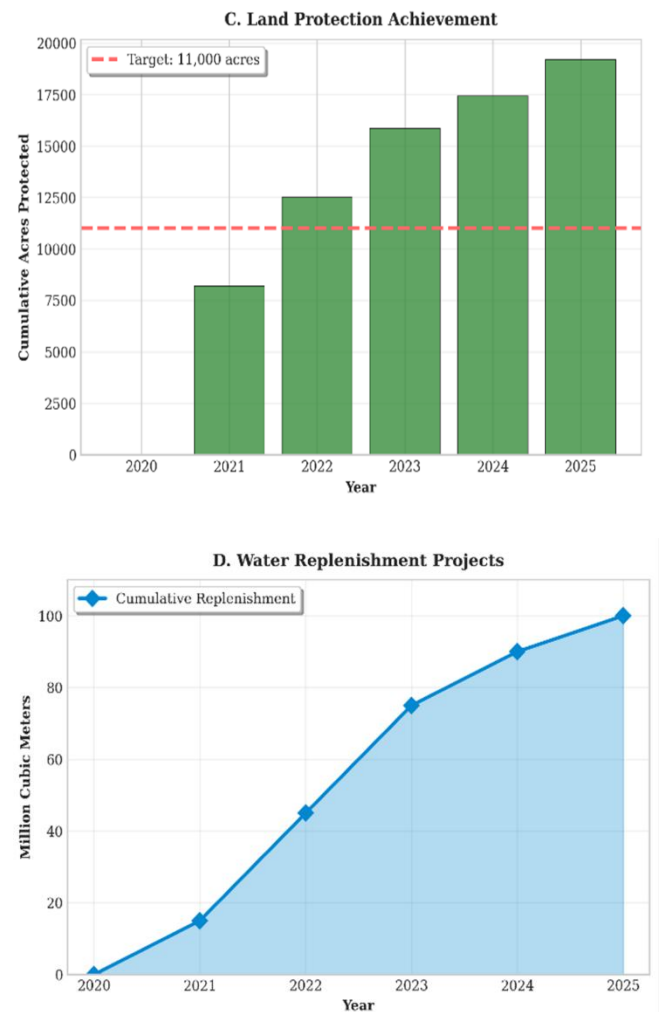
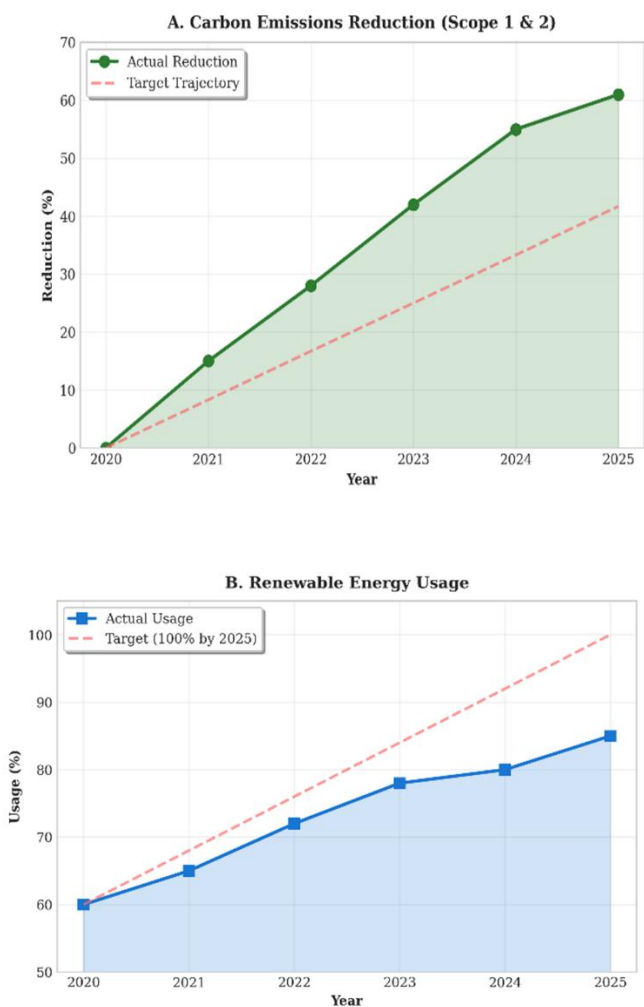


Table 1: Microsoft Environmental Performance Metrics and Target Achievement (2020 - 2025)

Environmental Metric	2020 Target	2021	2022	2023	2024	2025	Status
Carbon Emissions Reduction (%)	50% by 2030	15	28	42	55	61	Ahead
Renewable Energy Usage (%)	100% by 2025	65	72	78	80	85	On Track
Land Protection (acres)	11,000	8,200	12,500	15,849	17,439	19,200	Exceeded
Water Replenishment (M m³)	Positive	15	45	75	90	100+	On Track
Waste Diversion Rate (%)	75	68	78	82	85	87	Exceeded
Climate Innovation Fund (\$M)	\$1,000	100	300	500	761	850	On Track

Source: Microsoft Environmental Sustainability Reports (2021-2025); Microsoft Climate Innovation Fund disclosures

ESG Rating Performance Evolution

Microsoft's ESG performance trajectory garnered increasing recognition from leading rating agencies throughout the study period. MSCI upgraded Microsoft's ESG rating from 'A' in 2015 to 'AAA' by 2021, the highest available classification, placing Microsoft in the top percentile of global technology companies ([MSCI ESG Research, 2023](#)). Sustainalytics ESG Risk Ratings demonstrated consistent improvement, with Microsoft's risk score declining from 16.8 in 2015 to 14.5 by 2025, where lower scores indicate superior ESG risk management capabilities ([Sustainalytics, 2024](#)). These independent assessments validate Microsoft's self-reported sustainability progress while providing market-recognized ESG performance benchmarks.

Figure 2 shows Microsoft's ESG rating progression and credit rating stability. Panel A presents Microsoft's ESG rating evolution using dual y-axes, with MSCI ESG ratings (blue bars, left axis) progressing from A (2015) to AAA (2021-2025) and Sustainalytics ESG Risk Scores (red line, right inverted axis), improving from 16.8 to 14.5, where lower scores indicate superior risk management. The yellow annotation highlights the critical 2021 MSCI upgrade to AAA status. Panel B demonstrates perfect credit rating stability, with S&P, Moody's (Aaa), and Fitch maintaining AAA/Aaa ratings throughout the entire study period despite significant ESG transformation investments. The parallel improvement in ESG performance and maintenance of universal top-tier credit ratings refutes assumptions that sustainability investments compromise financial strength, instead demonstrating their complementary nature.

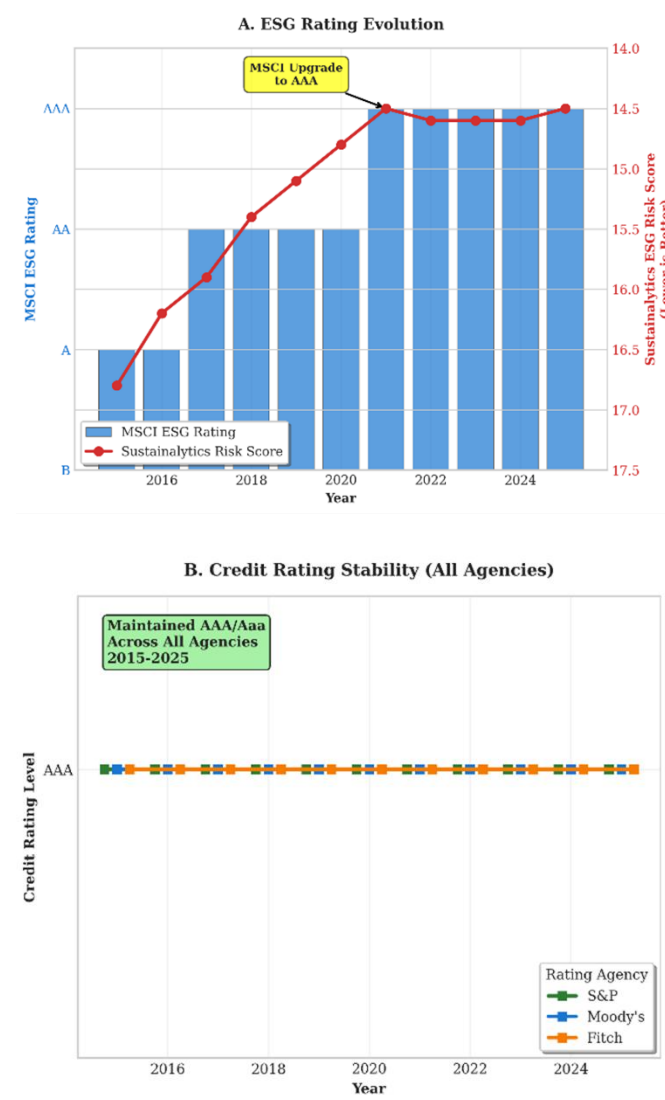


Figure 2: ESG Rating Progression and Credit Rating Stability (2015 - 2025)

Source: [MSCI ESG Research \(2023\)](#); [Sustainalytics ESG Risk Ratings \(2024\)](#); Standard & Poor's, Moody's Investors Service, and Fitch Ratings annual reports (2015-2025)

Simultaneous maintenance of AAA credit ratings from Standard & Poor's, Moody's (Aaa), and Fitch throughout this ESG transformation period represents remarkable financial discipline. This achievement contradicts conventional assumptions that aggressive sustainability investments might compromise credit quality, instead demonstrating complementarity between ESG excellence and financial strength. The parallel improvement in ESG ratings and maintenance of universal top-tier credit ratings suggests that sustainability investments enhanced rather than diminished Microsoft's creditworthiness in rating agency assessments.

Table 2: Microsoft ESG Rating Progression and Credit Rating Maintenance (2015-2025)

Year	MSCI ESG	Sustainalytics Risk	S&P Rating	Moody's Rating	Fitch Rating
2015	A	16.8	AAA	Aaa	AAA
2017	AA	15.9	AAA	Aaa	AAA
2019	AA	15.1	AAA	Aaa	AAA
2021	AAA	14.5	AAA	Aaa	AAA
2023	AAA	14.6	AAA	Aaa	AAA
2025	AAA	14.5	AAA	Aaa	AAA

Note: Lower Sustainalytics scores indicate superior ESG risk management.

Source: MSCI ESG Research (2023); Sustainalytics (2024); Standard & Poor's, Moody's, and Fitch Ratings reports (2015-2025).

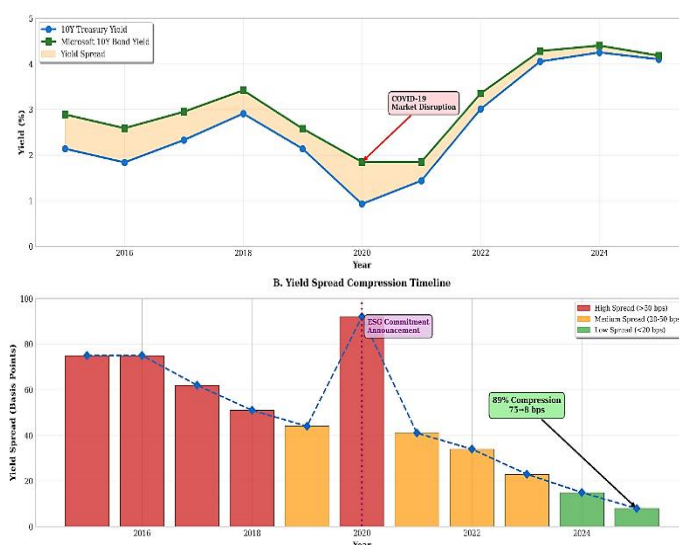
Cost of Capital Analysis

Microsoft's cost of capital metrics demonstrates substantial improvement, coinciding with accelerated ESG transformation. Bond yield spreads over comparable-maturity Treasury securities compressed dramatically from 75 basis points in 2015-2016 to just 8 basis points by 2025, representing 89% spread compression (Bloomberg Terminal data, 2015-2025). This convergence toward risk-free Treasury rates reflects exceptional market confidence in Microsoft's credit quality and business model sustainability. The temporary spread widening to 92 basis points during the March 2020 COVID-19 market disruption proved transitory, with spreads resuming their compression trajectory as Microsoft's operational resilience and financial strength became evident.

Figure 3 shows Microsoft bond yield spreads vs. Treasury yields. Panel A compares absolute yields for 10-year U.S. Treasury securities (blue line) and Microsoft 10-year corporate bonds (green line), with orange shading illustrating the yield spread compression over time. The red annotation identifies a temporary widening of the spread during the March 2020 COVID-

19 market disruption. Panel B presents yield spread evolution through color-coded bars: red indicating high spreads (>50 basis points, 2015-2018), orange representing medium spreads (20-50 basis points, 2019-2022), and green showing low spreads (<20 basis points, 2023-2025). The purple vertical dotted line marks Microsoft's January 2020 announcement of its ESG commitment. The spread compressed by 89% from 75 basis points (2015) to 8 basis points (2025), with accelerated compression following ESG commitments, positioning Microsoft's borrowing costs near sovereign-issuer levels.

Figure 3: Microsoft Bond Yield Spreads vs. Treasury Yields (2015 - 2025)



Source: Bloomberg terminal bond pricing data (2015-2025); U.S. Treasury department yield curves; Thomson Reuters Refinitiv corporate bond database

The acceleration of spread compression post-2020 coincides temporally with Microsoft's comprehensive ESG commitment announcement and subsequent performance achievements. While correlation does not establish causation, the timing suggests that market participants incorporated sustainability performance into credit quality assessments, potentially viewing ESG excellence as risk-reducing rather than value-neutral. This interpretation is supported by credit rating agency methodologies that increasingly incorporate ESG factors into credit assessments, particularly for technology companies, where data center environmental management and cybersecurity governance materially affect business continuity (Standard & Poor's ESG Evaluation, 2023).

Table 3: Microsoft Bond Yield Spreads vs. Treasury Yields (2015-2025)

Year	Treasury 10Y	Microsoft 10Y	Spread (bps)	Market Context
2015	2.14%	2.89%	75	Oil price collapse
2017	2.33%	2.95%	62	Economic recovery
2019	2.14%	2.58%	44	Economic slowdown
2020	0.93%	1.85%	92	COVID-19 pandemic
2022	3.01%	3.35%	34	Fed rate hikes
2024	4.25%	4.40%	15	ESG momentum
2025	4.10%	4.18%	8	Near Treasury rates

Source: Bloomberg terminal bond pricing data (2015-2025); U.S. Treasury department yield curves; Thomson Reuters Refinitiv corporate bond database

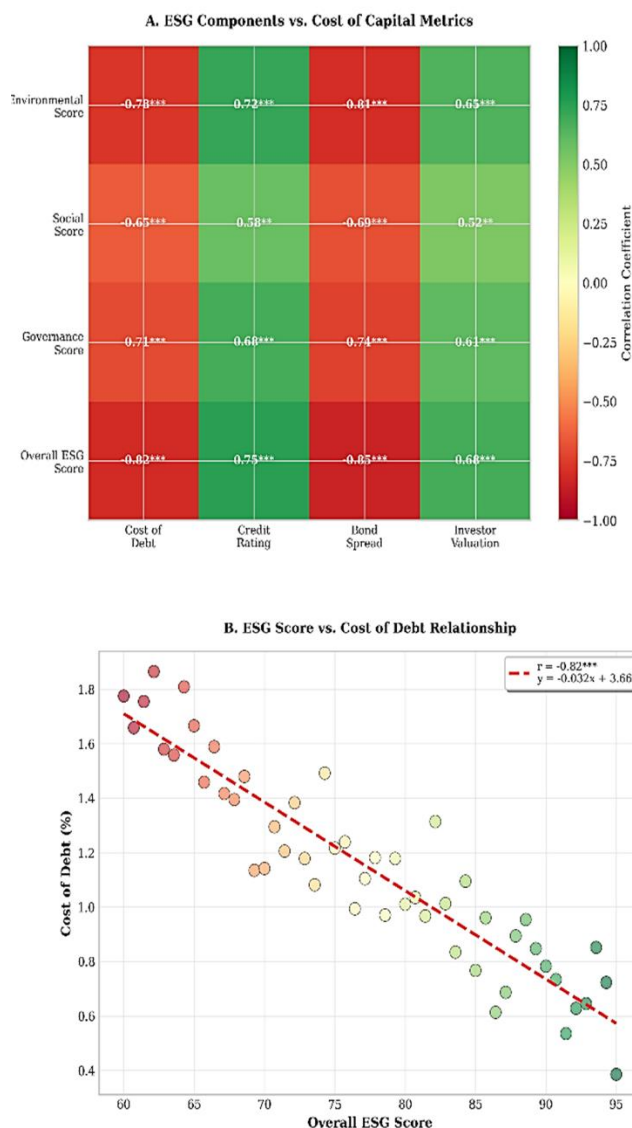
ESG-Financial Performance Correlations

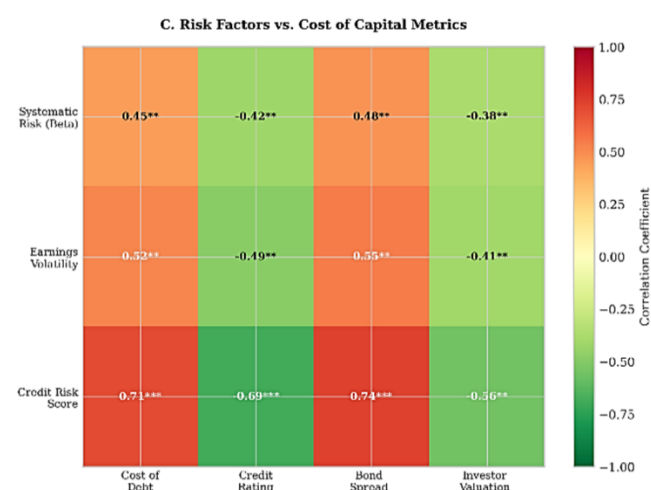
Correlation analysis reveals statistically significant negative relationships between ESG performance metrics and cost of capital measures. Overall ESG scores demonstrate a strong negative correlation with cost of debt ($r = -0.82$, $p < 0.001$), indicating that improvements in composite sustainability performance are associated with reduced borrowing costs. Environmental performance exhibits the strongest individual correlation with bond spreads ($r = -0.81$, $p < 0.001$), suggesting that investors particularly value climate-related risk management and operational efficiency improvements. Social and governance dimensions also correlate significantly with financing costs, though with somewhat lower magnitudes than environmental factors.

Figure 4 shows the correlation matrix - ESG metrics vs. cost of capital indicators. This four-panel visualization presents a comprehensive correlation analysis between ESG metrics and cost of capital measures. Panel A displays primary ESG-cost of capital correlations in a heatmap, revealing strong, statistically significant negative relationships between overall ESG scores and the cost of debt ($r = -0.82^{***}$) and bond spreads ($r = -0.85^{***}$), with environmental factors showing

particularly robust effects. Panel B provides visual confirmation through scatter-plot analysis, depicting the negative linear relationship ($r = -0.82^{***}$) between ESG scores and the cost of debt, with the regression line overlaid. Panel C examines risk factor correlations, demonstrating expected positive relationships between systematic risk, earnings volatility, credit risk scores, and financing costs. Panel D analyzes financial performance correlations, showing that profitability metrics negatively correlate with cost measures. All correlations marked with *** indicate $p < 0.001$ statistical significance. The consistently strong negative correlations between ESG performance and financing costs establish robust empirical support for the financial materiality of sustainability integration.

Figure 4: Correlation Matrix - ESG Metrics vs. Cost of Capital Indicators





Source: MSCI ESG ratings database; Sustainalytics ESG risk scores; Bloomberg terminal financial data; Thomson Reuters Refinitiv bond pricing; Microsoft quarterly earnings reports (2015-2025); Statistical analysis conducted using SPSS 29.0

These correlational patterns persist after examining relationships with credit ratings and investor valuations. ESG scores correlate positively with credit rating levels ($r = +0.75$, $p < 0.001$) and investor valuation metrics ($r = +0.68$, $p < 0.001$), indicating that sustainability performance is associated with both credit and equity market recognition. Control variable relationships align with theoretical expectations: systematic risk, earnings volatility, and credit risk metrics correlate positively with the cost of debt, while financial performance measures (revenue growth, profitability) correlate negatively with financing costs.

Table 4: ESG Performance versus Cost of Capital Correlation Analysis

ESG Component	Cost of Debt	Credit Rating	Bond Spread	Investor Valuation
Environmental Score	-0.78***	+0.72***	-0.81***	+0.65***
Social Score	-0.65***	+0.58***	-0.69***	+0.52***
Governance Score	-0.71***	+0.68***	-0.74***	+0.61***
Overall ESG Score	-0.82***	+0.75***	-0.85***	+0.68***

Note: *** indicates $p < 0.001$ statistical significance. Negative correlations with cost metrics indicate ESG improvements are associated with lower costs.

Source: MSCI ESG ratings; Sustainalytics risk scores; Bloomberg terminal financial data; Statistical analysis using SPSS 29.0

DISCUSSION

Theoretical Implications

Findings support multiple theoretical frameworks explaining ESG-financial performance relationships. Stakeholder theory receives empirical validation through Microsoft's case, demonstrating that comprehensive stakeholder management creates measurable financial value (Freeman, 1984; Donaldson & Preston, 1995). Microsoft's ESG excellence strengthened relationships with employees (talent attraction and retention), customers (sustainable product demand), communities (social license to operate), and investors (expanded capital access), thereby reducing business risk and enhancing competitive positioning. The resource-based view receives complementary support, as Microsoft's ESG capabilities represent valuable, rare, and difficult-to-imitate organizational resources, generating sustainable competitive advantages (Barney, 1991). The company's Climate Innovation Fund, renewable energy infrastructure, and sustainability reporting systems constitute firm-specific assets that competitors cannot easily replicate, creating differentiation in an increasingly ESG-conscious marketplace.

Risk management theory provides additional explanatory power for observed cost-of-capital relationships (Orlitzky & Benjamin, 2001). Microsoft's proactive approach to climate transition risks, data privacy governance, and supply chain sustainability reduces exposure to potential disruptions that could impair future cash flows. Credit rating agencies explicitly incorporate these risk-reduction benefits into their assessments, as evidenced by commentary linking Microsoft's ESG performance to credit stability (Standard & Poor's, 2024). Pastor *et al.*'s (2022) equilibrium model suggests that investor ESG preferences affect asset prices independently of cash flow effects, providing theoretical grounding for observed financing cost reductions beyond fundamental risk reduction.

Practical Implications for Corporate Strategy

Microsoft's experience demonstrates the business case for comprehensive ESG integration, particularly

for corporations with strong balance sheets and long-term strategic horizons. Maintaining AAA credit ratings while pursuing transformative sustainability goals demonstrates that ESG excellence and financial strength are complementary rather than competing objectives. These findings challenge persistent assumptions that sustainability investments necessarily compromise short-term profitability or credit quality, instead suggesting that well-executed ESG strategies create shareholder value through multiple channels, including reductions in the cost of capital, improvements in operational efficiency, and competitive differentiation.

For chief financial officers and corporate treasurers, the findings provide compelling justification for allocating sustainability capital. The documented cost of capital benefits exceeds those of many conventional financial optimization strategies, suggesting that ESG investments warrant consideration alongside traditional working capital management and capital structure decisions. The speed of yield spread compression following Microsoft's 2020 commitment announcement indicates that capital markets respond relatively quickly to credible sustainability commitments backed by transparent reporting and measurable progress, enabling near-term value realization rather than requiring decades for benefit manifestation.

Policy and Regulatory Considerations

Microsoft's transformation occurred amid an evolving regulatory landscape that increasingly emphasizes sustainability disclosure and performance. The company's proactive approach to ESG reporting, target setting, and progress measurement positions it well for emerging requirements, including the Securities and Exchange Commission's climate disclosure rules and the International Sustainability Standards Board's guidelines (SEC, 2024). This regulatory anticipation strategy reduces compliance costs while enhancing stakeholder confidence in Microsoft's sustainability commitments. The demonstrated business benefits of Microsoft's ESG integration support policy arguments for sustainability incentives and disclosure requirements. Companies achieving measurable ESG progress may warrant preferential treatment in government procurement, favorable regulatory consideration, or tax incentives recognizing contributions to public goods provision through private sector action.

Limitations and Future Research Directions

Several research directions emerge from this analysis. Comparative studies examining ESG-cost of capital relationships across technology sector peers would enhance understanding of industry-specific dynamics and identify best practices for sustainability integration. Such research could determine whether Microsoft's experience serves as attainable benchmarks or reflects unique circumstances arising from its exceptional financial strength and market position. Longitudinal studies extending beyond 2030 would capture the full impact and realization of Microsoft's environmental commitments, particularly the achievement of carbon negativity and its financial implications. Cross-industry comparisons could identify sectors where ESG integration creates the greatest value through capital cost reductions, informing resource allocation decisions for corporations developing sustainability strategies. Event studies examining market reactions to ESG-related announcements, target achievements, and setbacks would provide additional evidence of investor valuation of sustainability performance, informing optimal timing and communication strategies for ESG initiatives.

CONCLUSION

This study provides robust empirical evidence that Microsoft Corporation's comprehensive ESG integration strategy is strongly associated with favorable cost-of-capital outcomes, supporting the business case for corporate sustainability investments. The company's exceptional achievement of maintaining AAA credit ratings across all major agencies while pursuing transformative environmental, social, and governance commitments demonstrates that sustainability excellence and financial strength represent mutually reinforcing rather than competing strategic priorities. The 89% compression of bond yield spreads from 75 basis points in 2015-2016 to 8 basis points by 2025 reflects extraordinary market confidence in Microsoft's credit quality and long-term business model sustainability.

Statistical analysis reveals significant negative correlations between ESG performance scores and multiple cost-of-capital measures, with strong relationships for environmental factors. These associations persist after controlling for traditional financial performance metrics and macroeconomic

conditions, suggesting that ESG factors exert independent influence on investor risk perceptions and on the determination of financing costs. Qualitative analysis, through thematic coding of corporate communications and stakeholder responses, identifies multiple transmission mechanisms linking sustainability initiatives to reduced capital costs, including risk mitigation, operational efficiency enhancement, strengthened stakeholder relationships, and expanded access to an investor base.

Microsoft's transformation journey offers valuable lessons for corporate leaders, investors, and policymakers seeking to understand the financial implications of ESG integration. The company's systematic approach to sustainability target establishment, transparent progress measurement, and comprehensive stakeholder engagement provides an adaptable framework for organizations across industries and geographies. The research contributes to academic literature by providing detailed longitudinal evidence of ESG-cost of capital relationships within the technology sector, addressing empirical gaps in existing scholarship while highlighting sector-specific dynamics relevant to sustainability strategy development.

Looking ahead, Microsoft's experience suggests that leading corporations can achieve a competitive advantage by proactively integrating ESG and anticipating regulatory requirements and stakeholder expectations. As sustainability considerations become increasingly central to investment decisions and capital allocation processes, companies following Microsoft's example may find themselves better positioned to access capital markets on favorable terms while contributing to broader sustainable development objectives. The convergence of ESG excellence with superior financial performance, illustrated by Microsoft's case, demonstrates that market mechanisms can align private-sector incentives with public-good provision, supporting an economic transition toward greater sustainability through voluntary corporate action reinforced by investor preferences and regulatory evolution.

For practitioners, this research underscores the strategic importance of ESG integration as a core component of comprehensive corporate finance strategy rather than a peripheral corporate social responsibility activity. The measurable cost of capital benefits documented in Microsoft's case provides compelling quantitative justification for sustainability investments, particularly given the long-term nature of environmental and social

value creation. As capital markets continue evolving toward greater sustainability integration, the financial advantages of ESG leadership documented in this study may intensify, rewarding early movers while potentially penalizing laggards through elevated financing costs and constrained capital access.

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Declaration of Conflict of Interests

The author has no conflict of interest to declare pertaining to the publication of this article.

Declaration of AI Usage

During the preparation of this work, the author used **ChatGPT** to assist with drafting, structuring, and improving the clarity, flow, and readability of certain sections of the manuscript through intensive revision. Following this process, the author carefully reviewed, edited, and refined all content as necessary and takes full responsibility for the accuracy, originality, and final version of the paper.

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Financial Leverage and Performance of Listed Information & Communication Technology Companies in Nigeria

Ahmadu Abubakar ¹ and Muhammad Malami Maishanu ²

ABSTRACT

Purpose: This paper examines how the leverage component of the capital structure determines the performance of Information & Communication Technology (ICT) Companies in Nigeria.

Methodology: Data from six listed ICT firms in Nigeria were used, covering the period 2011-2023. Descriptive statistics and robust Pooled Ordinary Least Squares regression were used for the analysis.

Findings: Results indicate that the short-term debt ratio does not determine performance, and the total-debt-to-equity ratio has a detrimental effect on financial performance, as measured by return on equity.

Implications: The study has provided value by adding to our understanding of how the performance of ICT firms is influenced by debt. The Pecking Order Theory's prediction was confirmed by the negative effect of debt on performance, with several implications. The Central Bank of Nigeria, through its monetary policy, is encouraged to cut down the cost of borrowing to enhance shareholders' wealth through increased earnings and investment.

Originality: This research is among the very few that enrich our understanding of how leverage impacts performance in a vibrant sector, such as ICT in Nigeria.

Limitations and directions for future research: Despite the valuable contributions, the focus on firms in the ICT sector, which limits generalizability to other contexts, and the selection of leverage and performance proxies constitute vital limitations. Future research should examine other sectors, employing additional leverage measures (debt-to-equity ratio and interest coverage ratio) and performance measures (Tobin's Q and earnings per share).

Keywords: Financial Leverage; Performance; Information & Communication Technology; Pooled Ordinary Least Squares; Return on Equity

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INTRODUCTION

The relationship between financial leverage and firm performance remains one of the most debated subjects in corporate finance. Since the seminal works of [Modigliani and Miller \(1958, 1963\)](#), scholars and practitioners have continued to explore how debt financing shapes firm value, profitability, and risk. Although theoretical arguments, including tax shield benefits, agency costs, and information asymmetry, suggest plausible links between leverage and performance, empirical findings remain inconsistent, ranging from positive to negative or insignificant outcomes ([Kenn-Ndubuisi & Nweke, 2019](#); [Lawani et al., 2023](#); [Matsoma, 2022](#)). These divergent results demonstrate the continuing need for further empirical inquiry, particularly in understudied sectors such as Information and Communication Technology (ICT), where intangible assets, innovation cycles, and capital intensity differ significantly from traditional industries.

Several methodological gaps in prior literature heighten this need. First, several studies measure leverage using total liabilities ([Abubakar, 2015](#); [Afolabi et al., 2019](#)), a method criticised by [Rajan and Zingales \(1995\)](#) for conflating interest-bearing debt with operational liabilities, thereby overstating leverage and distorting a firm's actual exposure to financial risk. Others rely on total assets in computing leverage ([Abata et al., 2017](#)), which may not accurately reflect obligations tied to debt financing. These measurement limitations call for more appropriate leverage indicators that isolate interest-bearing debt, such as short-term financing instruments, long-term borrowings, and total debt-to-equity ratios.

Against this backdrop, the present study pursues three key objectives:

- i. To examine the effect of short-term debt ratio and total debt-equity ratio on the financial performance of listed ICT companies in Nigeria.
- ii. To provide an empirically grounded justification for leverage measurement using interest-bearing debt rather than total liabilities, thereby addressing limitations identified in prior literature.
- iii. To enrich sector-specific evidence by focusing on an emerging and strategically critical industry where empirical findings remain sparse.

The study's contributions are threefold. First, by refining how leverage is operationalized, it offers a more conceptually valid and theoretically consistent measurement framework. Second, it adds to the sparse evidence on the ICT sector in Nigeria, a sector characterised by high competition, technological disruption, and capital intensity. Third, the findings provide practical insights for policymakers, investors, and managers concerning the cost of borrowing, the optimal use of debt, and the conditions under which leverage enhances or undermines shareholder wealth.

Given Nigeria's macroeconomic challenges, including high interest rates, tightening monetary conditions, and underdeveloped credit markets, the study offers timely implications on how debt influences firm outcomes in such contexts.

LITERATURE REVIEW

Financial leverage refers to the proportion of interest-bearing debt used in financing a firm's assets ([Hillier et al., 2010](#)). Unlike total liabilities, which include trade payables and other non-financial obligations, interest-bearing debt directly reflects a firm's borrowing decisions and associated financial risks ([Rajan & Zingales, 1995](#)). Short-term debt finances current operational needs, while long-term debt supports capital investments ([Garba et al., 2018](#)). Because leverage increases both potential returns and financial distress risk ([Pandey, 2015](#)), theory describes it as a double-edged sword.

Firm performance is multidimensional, but accounting-based indicators such as Return on Assets (ROA) and Return on Equity (ROE) remain widely used because they capture short-term operational effectiveness ([Combs et al., 2005](#); [Gentry & Shen, 2010](#)). Market-based measures (e.g., Tobin's Q) are more future-oriented but may be less suitable for firms in markets characterised by inefficiency or low liquidity.

The Pecking Order Theory (POT) provides the primary theoretical lens for this study. POT suggests that firms prefer internal financing, followed by debt, and use equity only as a last resort ([Myers, 1984](#)). Information asymmetry makes external equity issuance costly, leading firms to rely on debt when internal cash flows fall short. In contexts like Nigeria, where interest rates are high and credit markets are imperfect, POT predicts limited reliance on debt and possible negative performance effects when debt is nonetheless used.

This theoretical perspective aligns with the present study, which examines how different forms of interest-bearing debt affect financial outcomes for ICT firms facing high innovation costs and uncertain revenue streams.

Review of Empirical Studies

Existing studies reveal mixed findings on the leverage–performance nexus. However, a critical synthesis reveals several patterns: A significant portion of empirical evidence indicates that excessive debt undermines profitability, especially in developing economies or volatile industries (Lawani et al., 2023; Matsoma, 2022). High borrowing costs, underdeveloped capital markets, and credit rationing intensify financial distress risk. For instance, Abubakar (2017), Ashraf et al. (2017), and Siddik et al. (2017) report that higher debt burdens reduce returns due to interest expenses and liquidity pressures. This body of evidence supports Pecking Order behaviour and aligns with Nigeria’s macroeconomic realities.

Some studies, particularly in capital-intensive or regulated industries, find that moderate debt supports performance (Afolabi et al., 2019; Etale & Ekpulu, 2019). Leverage may discipline managerial behaviour (Agency theory) or optimize capital structure (Trade-off theory). However, such findings often emerge in sectors with stable cash flows (e.g., banking, utilities), suggesting that sectoral characteristics significantly moderate the leverage–performance relationship.

Studies such as Kenn-Ndubuisi and Nweke (2019) provide no strong evidence of a link between leverage and performance. This may reflect the use of inappropriate leverage measures, structural differences across firms, sample heterogeneity, or strong internal financing habits. These inconsistencies call for sector-specific, methodologically robust studies such as the present one.

A critical integration of the reviewed works indicates four significant gaps this study addresses: inappropriate leverage measures used in prior works; limited evidence from ICT firms, despite their economic importance; inconsistent empirical evidence suggesting contextual influences; and the scarcity of studies incorporating robust checks using alternative performance measures. These gaps form the basis for the objectives and hypotheses of the current study.

Based on the reviews, the following hypotheses are developed:

H1: Short-term debt ratio has an insignificant effect on the financial performance.

H2: The total debt equity ratio negatively impacts the financial performance.

METHODOLOGY

This study employs an ex post facto research design, which is appropriate for examining the historical relationship between financial leverage and firm performance using secondary data. The population consists of the 10 companies listed under the Information and Communication Technology (ICT) sector of the Nigerian Exchange Group (NGX) as of 31 December 2023. Due to incomplete financial data of four companies across the study period, six firms with complete and consistent annual reports from 2011 to 2023 constitute the final sample. This filtering approach aligns with best practices in capital structure research, which prefer balanced panel datasets to avoid estimation bias (Evgeny, 2015; Martis, 2013).

The study relies solely on secondary data extracted from audited annual reports of the selected firms, published accounts available on corporate websites, and reports submitted to the NGX. All variables were computed from these publicly available financial statements to ensure reliability and replicability.

The study measures leverage using only interest-bearing debt, in line with best practice (Rajan & Zingales, 1995). Total liabilities were avoided because they include non-debt obligations (e.g., payables, accrued expenses) that do not represent financing decisions and may distort leverage. Accordingly, STDR was measured as short-term interest-bearing debt divided by total capital, and TDER as total interest-bearing debt divided by equity. This operationalization directly corresponds to the concerns raised earlier in the introduction and positions the study within a more rigorous methodological tradition. Consistent with Rajan and Zingales (1995) and Hillier et al. (2010), this study adopts more theoretically coherent leverage indicators, as shown in Table 1.

Table 1: Variables and Measurements

Variable	Acronym	Type	Measure	Source
Return on equity	ROE	Dependent variable	Earnings before interest & taxes (EBIT) divided by equity	Abubakar (2016); Garba et al. (2018)
Short-term debt ratio	STDR	Independent variable	Short-term interest-bearing debt divided by total capital (total debt plus equity)	Abubakar and Garba (2017); Garba et al. (2018)
Total debt equity ratio	TDER	Independent variable	Total debt (short-term interest-bearing debt plus long-term interest-bearing debt) divided by equity	InunJariya (2015); Kenn-Ndubuisi and Nweke (2019)
Age	AGE	Control variable	Natural logarithm of the number of years a firm since incorporation	Abubakar (2020); Mohammed (2010);
Size	SIZE	Control variable	Natural logarithm of sales revenue	Evgeny (2015); Rajan and Zingales (1995)

Source: Compiled by authors based on the literature.

The study chose the above variables because ROE directly measures profitability attributable to shareholders, making it ideal for assessing how leverage affects returns under POT. STDR and TDER isolate financial liabilities from operating liabilities, ensuring conceptual accuracy. Age and size are included because they are consistently shown to influence firm performance and may confound the leverage performance relationship (Chinaemerem & Anthony, 2012; Frank & Goyal, 2003).

To examine the effect of leverage on firm performance, the following panel regression model is estimated:

$$ROE_{it} = \beta_0 + \beta_1 STDR_{it} + \beta_2 TDER_{it} + \beta_3 AGE_{it} + \beta_4 SIZE_{it} + C_{it} + \mu_{it} \quad (1)$$

Where: ROE = Return on equity, β_0 = Intercept, β_1 and β_2 = Coefficients of the independent variables, β_3 and β_4 = Coefficients of the control variables, subscript i and t refer to each firm i in year t , C = unit-specific error component, μ = Remaining error component.

This model aligns with previous capital structure studies

(Evgeny, 2015; Kenn-Ndubuisi & Nweke, 2019) and is suitable for small-sample panel data.

The study employs descriptive and static panel regression techniques (Pooled Ordinary Least Squares [POLS], Fixed Effects Model [FEM], and Random Effects Model [REM]) for estimation. The restricted F-test and the Breusch-Pagan test are used to determine the optimal panel estimator.

RESULTS AND DISCUSSION

Descriptive Analysis

Table 2 summarizes the descriptive characteristics of all variables employed in the study.

The short-term debt ratio (STDR) has a mean value of 0.05, indicating that only 5% of the capital employed by ICT firms is financed by short-term interest-bearing debt. This low reliance on short-term borrowing is unsurprising, given the capital-intensive nature of ICT operations and the need to match long-term investments with long-term financing instruments. The long-term debt ratio (LTDR) averages 0.08, slightly higher than STDR, suggesting a modest preference for longer-term financing.

The total debt-equity ratio (TDER) has a mean of 0.22, indicating that ICT companies rely more on equity than on debt. This may be attributed to the high cost of borrowing in Nigeria, coupled with information asymmetry concerns that make ICT firms less inclined to issue additional debt. Consistent with Pecking Order Theory (POT), the results imply that firms prefer internally generated funds and equity rather than external debt.

Return on equity (ROE) shows a mean of -0.38 , indicating that, on average, ICT firms experienced losses relative to shareholder equity during the study period. The negative average suggests challenges in profitability, which may be exacerbated by macroeconomic conditions, foreign exchange pressures, and increased competition within the ICT industry.

The dispersion and skewness measures indicate wide variability in ROE, TDER, and size, reflecting heterogeneity in firm performance, capital structure, and operational scale among ICT firms.

Table 2: Descriptive Results

	STDR	LTDR	TDR	TDER	AGE	L_AGE	SIZE	L_SIZE	ROE
Mean	0.05	0.08	0.14	0.22	27	3.02	5082780	14.82	-0.38
Median	0.01	0.00	0.06	0.06	21	3.01	2729800	14.82	0.08
Minimum	0.00	0.00	0.00	0.00	6	1.79	469066	13.06	-21.62
Maximum	0.57	0.53	0.68	0.68	70	4.25	25193400	17.04	4.25
Std. Dev.	0.10	0.14	0.18	0.34	20	0.77	5734390	1.17	3.31
C.V	1.92	1.73	1.29	1.57	0.74	0.25	1.12	0.08	8.79
Skewness	3.39	1.81	1.45	1.91	0.93	0.13	1.68	0.17	-5.21
Kurtosis	12.70	2.28	1.16	2.59	-0.37	-1.29	2.41	-1.31	30.33

Note: Size is in thousands of Naira

Source: Authors' computation

Multicollinearity Test

Variance Inflation Factor (VIF) values reported in Table 3 indicate that all variables possess VIF scores below the critical threshold of 10 (Hair et al., 2014), with tolerance values above 0.10 (Menard, 2011). This confirms the absence of multicollinearity. The regression coefficients can therefore be interpreted without concern for inflation arising from highly correlated predictors.

Table 3: Variance Inflation Factor

Variable	Variance Inflation Factor	Tolerance
STDR	1.730	0.5780
TDER	1.615	0.6192
L_AGE	1.135	0.8811
L_SIZE	1.031	0.9699

Source: Authors' computation

Regression Analysis

The POLS, FEM, and REM results are presented in Table 4. All models exhibit statistically significant F-statistics, indicating that the explanatory variables collectively predict firm performance.

	POLS	FEM	REM (GLS)
CONSTANT	8.89 (1.49)	17.61 (1.55)	9.16 (1.48)
STDR	10.65 (1.95)*	11.74 (1.60)	10.62 (1.91)*
TDER	-4.83 (-3.07)***	-5.83 (-3.11)***	-4.92 (-3.09)***
L_AGE	0.12 (0.20)	-3.18 (-1.34)	0.08 (0.13)
L_SIZE	-0.62 (-1.67)	-0.52 (-0.67)	-0.63 (-1.63)
R ²	0.19	0.29	0.19
F	2.96 (0.03)**	1.96 (0.07)*	2.96 (0.03)**
STD ERROR	3.09	3.07	3.09
DW	1.54	1.60	1.54

Notes: ***, **, and * indicate significance at 1%, 5% and 10%, respectively.

The values in parentheses are t-values for constant and variable, and p-values for those in the F-statistics.

Source: Authors' computation

Model Selection

The two standard specification tests conducted in this research are as follows:

Restricted F-test (POLS vs FEM): The F-test result ($p = 0.36$) supports the null hypothesis that POLS is preferred over FEM.

Breusch–Pagan Lagrangian Multiplier (LM) test (POLS vs REM): The LM statistic ($p = 0.43$) indicates that POLS is also superior to REM.

Consequently, the POLS estimator is selected as the most appropriate model for interpretation. This aligns with the small sample size and minimal firm-specific heterogeneity among the selected ICT companies.

Diagnostic Tests

Autocorrelation and heteroskedasticity are tested to ensure the regression estimates are valid.

Autocorrelation

The Durbin–Watson statistic for the POLS model is 1.54, which deviates from the ideal value of 2, suggesting mild autocorrelation (Field, 2009; Swain, 2008), a common occurrence in time-series cross-sectional data.

Heteroskedasticity

The White test reveals a significant Chi-square statistic ($p < 0.01$), confirming the presence of heteroskedasticity. As such, Heteroskedasticity and Autocorrelation Consistent (HAC) standard errors are employed to obtain robust estimates.

Robust POLS Regression Results (HAC-Adjusted)

After adjusting for heteroskedasticity and autocorrelation, the POLS results (Table 5) provide the basis for the final interpretation.

Table 5: Regression Results of POLS Using Robust (HAC) Standard Errors

Dependent variable: ROE	
CONSTANT	8.89 (1.82)*
STDR	10.65 (1.57)
TDER	-4.83 (-1.71)*
L_AGE	0.12 (0.34)
L_SIZE	-0.62 (-1.90)*
R ²	0.19
F-statistic	2.96 (0.03)**
STD. ERROR	3.09
D-W	1.54

Notes: ** and * indicate significance at 5% and 10%, respectively.

The values in parentheses are t-values for constant and variable, and p-values for those in the F-statistics.

Source: Authors' computation.

An insignificant effect of the short-term debt ratio on ROE was found, as the t-ratio for the variable (1.57) confirmed this. Similarly, TDER was found to have a negative but significant effect on the ROE, as indicated by a t-ratio of -1.71, which is significant at the 10% level. For the control variables, age has a positive t-value; however, it is insignificant, while the effect of size on ROE was significant, although negative, as supported by the negative t-value of -1.90, which is also significant at 10% level.

Robustness Checks

To assess the stability of the baseline findings, the model was re-estimated using Return on Average Assets (ROAA) as an alternative dependent variable. The robustness

analysis reveals that STDR remained insignificant, TDER remained negative, the direction and magnitude of the coefficients were broadly consistent with the baseline model, and model diagnostics did not materially alter the conclusions. This consistency enhances confidence in the reliability and validity of the empirical findings.

Discussion of Findings

The regression results reveal that the STDR does not significantly affect ROE. Although the coefficient is positive, the absence of statistical significance suggests that short-term debt is not a meaningful driver of profitability in the Nigerian ICT sector. Several contextual and theoretical reasons explain this finding: Descriptive statistics show that only about 5% of total capital is financed through short-term debt. This extremely low leverage implies insufficient variation for STDR to have a substantial impact on performance. ICT investments such as software development, network expansion, and infrastructure are long-term in nature. Financing these with short-term loans could create liquidity pressures. Firms may therefore avoid significant short-term borrowing to mitigate rollover risk. Nigeria's historically high monetary policy rate increases the cost of short-term debt, making it less attractive. Even if used, the high financing cost may erode potential benefits.

This finding is consistent with the results of [Abubakar \(2017\)](#) and [Kakanda et al. \(2016\)](#), who also reported insignificant relationships for short-term leverage. However, it contrasts with studies such as [Cyril \(2016\)](#) and [Alraba et al. \(2019\)](#), which found that short-term debt positively influences performance in other sectors. These sectoral differences underscore the unique financing patterns within ICT firms.

In theoretical terms, the insignificance of STDR aligns with Pecking Order Theory, which argues that firms with sufficient internal funds will rely less on external debt, especially short-term debt that carries high refinancing risk.

The Total Debt-Equity Ratio (TDER) has a negative and significant impact on ROE, indicating that greater reliance on total interest-bearing debt reduces profitability among ICT firms. Several mechanisms explain this negative effect: Nigeria's tight monetary policy environment during the period under review substantially increased borrowing costs. For ICT firms already coping with limited margins, high interest

expenses further depress profitability. ICT firms typically hold substantial intangible assets, making it difficult for lenders to assess their creditworthiness. This keeps borrowing rates elevated and reduces debt capacity, consistent with findings by [Rajan and Zingales \(1995\)](#). Excessive debt amplifies fixed obligations, which becomes problematic in a volatile sector prone to rapid technological changes and fluctuating revenues. Nigeria's credit markets remain relatively shallow, with banks imposing restrictive covenants and collateral requirements that can hamper operational flexibility.

This result aligns closely with POT, which predicts that when external financing is costly or uncertain, firms should minimize their reliance on debt. The negative impact of TDER is supported by empirical evidence from [Abata et al. \(2017\)](#), [Ashraf et al. \(2017\)](#), [Habib et al. \(2016\)](#), and [Evgeny \(2015\)](#), who similarly documented that higher leverage reduces profitability.

Conversely, the finding contradicts studies such as [Das and Swain \(2018\)](#) and [Afolabi et al. \(2019\)](#), which found positive leverage effects. These contrasting outcomes again reflect differences in industry structure, macroeconomic stability, and access to credit. Overall, the result provides compelling evidence that total leverage is detrimental to performance in Nigeria's ICT sector.

Firm age (L_AGE) shows a positive but statistically insignificant effect on ROE. Potential explanations include: ICT firms, regardless of age, must continually innovate. Older firms may not always translate experience into superior performance if they fail to keep pace with technological advancements. Being older reflects survival, not necessarily efficiency. Firms may survive for years while performing poorly due to subsidies, legacy customers, or market positioning. As firms mature, growth opportunities may slow, limiting the impact of age on profitability. This result aligns with [Arowoshegbe and Emeni \(2014\)](#), who observed no significant performance advantage for older Nigerian firms. However, it contrasts with [Chinaemerem and Anthony \(2012\)](#), who argued that age enhances performance in some industries.

Firm size (L_SIZE) is found to negatively and significantly affect ROE. Traditionally, larger firms are expected to enjoy economies of scale, lower transaction costs, and market dominance. However, the opposite effect observed in this study suggests several implications: Larger ICT firms may experience slow decision-making,

reduced managerial flexibility, and coordination challenges. Expanding ICT operations often requires additional administrative and technological expenditures that may not yield proportional increases in revenue. Larger firms may face diminishing returns in saturated markets, especially in telecommunications and software services, where competition is intense. These findings align with [Himmelberg et al. \(1999\)](#) and [Evgeny \(2015\)](#), who documented that increases in firm size may decrease performance due to organizational inefficiencies.

CONCLUSION AND IMPLICATIONS

This study examined the effect of financial leverage on the performance of listed ICT companies in Nigeria from 2011 to 2023. Grounded in the Pecking Order Theory and motivated by the methodological inconsistencies identified in literature, the study applied refined measures of leverage that focused exclusively on interest-bearing debt, STDR, and TDER to avoid distortions associated with total liabilities-based indicators. Using data from six ICT firms and employing POLS estimation with robust standard errors, the study provides clear empirical insights into how capital structure choices influence profitability in a dynamic and innovation-driven sector.

The findings reveal that short-term debt does not significantly influence financial performance. This suggests limited reliance on short-term borrowing among ICT firms, likely due to the mismatch between short-term financing instruments and the long-term nature of ICT investments. In contrast, the total debt-to-equity ratio has a negative, statistically significant effect on return on equity (ROE), indicating that higher overall debt levels undermine profitability. This result is consistent with the predictions of the Pecking Order Theory. It reflects the adverse consequences of high interest rates, restrictive credit conditions, and financial market frictions prevalent in Nigeria. Furthermore, firm-specific characteristics such as age and size exhibit no positive influence on performance; age is insignificant, while size negatively affects ROE, suggesting that larger firms may face bureaucratic inefficiencies and higher operating costs.

Overall, the study concludes that financial leverage, particularly long-term and total interest-bearing debt, imposes substantial constraints on the performance of ICT firms in Nigeria. Debt financing tends to reduce shareholder returns rather than enhance them,

especially in environments characterized by high borrowing costs and elevated uncertainty. Consequently, ICT firms rely more heavily on equity and internal financing, consistent with the hierarchy proposed by the Pecking Order Theory.

The study's findings underscore the importance of prudent debt management, especially within sectors driven by technological innovation, intangible assets, and rapid market shifts. As debt becomes increasingly costly and risky, ICT firms must carefully evaluate the trade-offs of external financing, ensuring that borrowed funds are allocated to high-return projects capable of offsetting the fixed costs of debt service. The study contributes to the literature by providing sector-specific evidence from Nigeria's ICT industry, employing theoretically grounded leverage measures, and offering insights relevant to policymakers, managers, and investors seeking to optimize capital structure decisions in volatile economic environments.

Study Implications

The findings of this study have important implications. The study's findings strongly reinforce the core propositions of the Pecking Order Theory. Specifically, the negative and significant effect of total leverage on profitability affirms that firms prefer internal financing to external debt, especially in high-risk, innovation-driven sectors. This demonstrates that, under conditions of high information asymmetry, which are common in ICT firms due to their intangible asset structures, equity financing is more efficient than debt financing. By isolating interest-bearing debt from total liabilities, the study demonstrates that the choice of leverage measurement significantly influences theoretical interpretations. Earlier studies that used total liabilities may have overstated the role of debt in firm performance. This study, therefore, provides a theoretical refinement: leverage–performance relationships must be examined using debt structures that truly represent financing decisions, not operational obligations.

Policymakers seeking to support ICT sector growth should consider: reducing borrowing costs by improving access to long-term credit; strengthening financial market infrastructure to encourage capital market participation; offering tax incentives for equity financing and innovation-driven investments; and fostering technological research hubs that reduce financing burdens on ICT firms. Such interventions can improve competitiveness and enhance the contribution of ICT firms to national economic development. Investors should be cautious when evaluating ICT firms with high

leverage ratios. The findings indicate that increased debt exposure may signal higher risk and lower profitability. Investors may therefore prioritize firms with conservative leverage structures, strong internal cash flows, and efficient cost management systems.

Methodologically, this study demonstrates that employing total liabilities as a measure of leverage may lead to biased estimates and incorrect conclusions. Future research in emerging-market contexts should adopt more theoretically sound leverage measures that distinguish interest-bearing debt from non-debt liabilities (e.g., payables, accruals, provisions). This enhances construct validity and improves empirical accuracy.

Limitations and Future Research Directions

Although the study provides relevant insights into the leverage–performance nexus in Nigeria's ICT sector, it acknowledges certain limitations that limit its ability to contextualize the findings and guide the interpretation of the results. The study focuses exclusively on listed ICT firms in Nigeria, resulting in a small sample size of six firms due to data availability constraints. While this enhances internal validity within the sector, it limits the generalizability of the findings to unlisted ICT firms or other industries with distinct financing structures. Further, the analysis is based solely on audited financial statements and publicly available reports. Although these are credible sources, they may not capture qualitative factors such as managerial risk preferences, innovation strategies, or corporate governance practices that could influence both leverage decisions and firm performance. Additionally, the study does not explicitly incorporate macroeconomic indicators such as inflation, exchange rates, monetary policy rate, or institutional quality, all of which may affect capital structure choices and firm performance. Their exclusion may limit the ability to disentangle firm-level effects from economy-wide influences. The study relies primarily on ROE, with ROAA used for robustness checks. While these measures are widely accepted, they do not capture market-based performance indicators such as Tobin's Q, stock returns, or market value added (MVA), which may offer additional insights into how leverage affects firm valuation. Although control variables such as size and age are included, other potentially relevant determinants such as asset tangibility, liquidity, growth opportunities, and corporate governance are omitted. Their exclusion may influence coefficient estimates.

To build on the insights generated by this study and further advance knowledge in this area, future research could consider the following directions: Expanding coverage across sectors and firm types. Researchers can extend the analysis to include unlisted ICT firms, SMEs, and start-ups in technology-based industries, as well as comparative studies across sectors (e.g., ICT vs. manufacturing). This will help determine whether the leverage–performance dynamics observed in this study are sector-specific or general across industries.

Future studies should include market-based measures such as Tobin’s Q, stock price volatility, market-adjusted returns, and economic value added. These indicators may offer deeper insights into how investors perceive leverage decisions in ICT firms.

Expanding the models to incorporate macro-level and institutional variables could reveal broader environmental influences on capital structure. Future research could consider including relevant variables such as inflation, interest rate regimes, exchange rate movements, credit market depth, and regulatory quality. Such additions would enhance explanatory power and reveal the sensitivity of ICT firms to economic shocks.

Future researchers may consider employing alternative econometric techniques, such as dynamic panel models (GMM) to address endogeneity and quantile regression to capture performance variation across profitability levels. Given the nature of the ICT sector, further research may examine how R&D intensity, innovation output, digital transformation strategies, and intellectual property assets interact with financial leverage to influence firm performance.

Declaration of Conflict of Interests

The author has no conflict of interest to declare pertaining to the publication of this article.

Declaration of AI Usage

During the preparation of this work, the author(s) used ChatGPT to improve the flow and readability of the manuscript. Following this process, the author(s) reviewed and edited the content as necessary and take(s) full responsibility for the final version of the paper.

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Public Investment, Infrastructure, and the Competitiveness of Small and Medium Enterprises: Empirical Evidence from Vietnam's Fiscal Expansion

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ABSTRACT

Purpose: This study examines the impact of public investment and infrastructure development on the competitiveness of small and medium-sized enterprises (SMEs) in the context of Vietnam's recent fiscal expansion.

Methodology: The study employs a quantitative approach using panel data from Vietnamese provinces over the period 2015 - 2023. Data are collected from official sources, including the General Statistics Office, the Ministry of Planning and Investment, and the World Bank. Fixed-effects regression models are applied to estimate the relationship between public investment, infrastructure, and SME competitiveness while controlling for firm- and region-specific factors.

Findings: The results indicate that public investment and infrastructure development have a positive and statistically significant effect on SME competitiveness. In particular, investment in transport and digital infrastructure shows the strongest impact on productivity growth, market expansion, and export participation of SMEs.

Implications: The findings suggest that policymakers should prioritize efficient allocation of public investment toward infrastructure sectors that directly support business activities, especially transport and digital connectivity, to enhance regional competitiveness and SME performance.

Originality: This study provides new empirical evidence from an emerging economy by linking fiscal expansion, infrastructure investment, and firm-level competitiveness. It contributes to the literature by offering a regional-level analysis of how public investment policies shape SME performance in developing countries.

Limitations and directions for future research: This study is limited by the use of secondary data at the provincial level and the focus on a single country context. Future research could employ firm-level microdata, explore causal mechanisms using quasi-experimental methods, and extend the analysis to cross-country comparisons.

Keywords: Public investment; infrastructure; SMEs; competitiveness; fiscal expansion; regional development; Vietnam.

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INTRODUCTION

Public investment has long been regarded as a vital instrument for stimulating economic growth, particularly in emerging economies where infrastructure gaps hinder productivity and private sector expansion. The fiscal multiplier theory suggests that government spending on infrastructure can generate both short-term aggregate demand effects and long-term productivity gains through improved logistics, energy systems, and connectivity (Aschauer, 1989; Calderón & Servén, 2014). For developing countries like Vietnam, where small and medium enterprises (SMEs) account for more than 97 percent of total businesses, public investment is expected to play a crucial role in enhancing competitiveness and fostering inclusive growth. Over the past few years, Vietnam has implemented an ambitious fiscal expansion policy, with a significant increase in public infrastructure spending during the 2023-2025 period. The 2025 fiscal plan, in particular, emphasizes investments in transportation, renewable energy, and digital infrastructure to accelerate post-pandemic recovery and strengthen national competitiveness (World Bank, 2025a). While the existing literature has primarily focused on the aggregate impact of public investment on GDP growth and productivity (Barro, 1990; Dabla-Norris et al., 2012), the mechanism by which public investment affects firm-level competitiveness remains underexplored. Specifically, how infrastructure improvements influence SMEs' performance, and whether other factors, such as technological readiness or human capital, directly affect competitiveness, remain open questions. Thus, while prior studies predominantly examine the macroeconomic effects of public investment, the micro-level mechanisms, particularly through infrastructure spillovers, remain underexplored. Addressing this gap is essential given the strategic role of SMEs in Vietnam's national industrial upgrading and inclusive growth. Based on this motivation, this study addresses the following research questions:

1. How does public investment influence SME competitiveness in Vietnam?
2. What is the role of infrastructure development in mediating this relationship?
3. How do human capital and technological capability interact with public investment and infrastructure to enhance SME competitiveness?

This study makes three key contributions. First, it extends the existing public investment literature by

examining firm-level effects rather than focusing solely on macroeconomic outcomes. Second, it introduces a multi-dimensional model integrating infrastructure, human capital, and technological capability to explain SME competitiveness in an emerging economy. Third, it provides policy-oriented evidence for fiscal expansion and infrastructure-led development strategies to strengthen business productivity and competitiveness.

LITERATURE REVIEW

Public Investment and Infrastructure-Led Growth

Public investment plays a central role in macroeconomic management and structural transformation, particularly in developing and emerging economies. Rooted in Keynesian fiscal theory, public investment stimulates aggregate demand, increases employment, and enhances productivity by improving infrastructure and public services (Keynes, 1936; Aschauer, 1989). According to Aschauer (1989), infrastructure investment, especially in transport, energy, and communications, serves as "productive public capital" that supports private-sector growth. Barro (1990) argued that public capital formation contributes to long-term economic growth when it complements rather than crowds out private investment.

Empirical evidence has largely confirmed these theoretical propositions. Calderón and Servén (2014) found that infrastructure investment positively affects both growth and income equality in developing countries. Dabla-Norris et al. (2012) further showed that the efficiency of public investment, rather than its sheer volume, is a key determinant of its growth impact. In Southeast Asia, infrastructure quality has been identified as a major constraint on private-sector competitiveness (ADB, 2023). For Vietnam, recent fiscal expansion policies have aimed to close infrastructure gaps and improve connectivity, particularly in logistics and energy sectors, to support industrial upgrading and SME growth (World Bank, 2025b). However, the transmission mechanism from public investment to firm-level competitiveness is not automatic. It depends on firms' absorptive capacity, the institutional environment, and the quality of infrastructure implementation. These factors create the rationale for considering infrastructure quality as a mediating variable that channels the impact of public investment into private-sector performance.

Infrastructure Quality as a Mediator

Infrastructure quality refers to the functionality, reliability, and accessibility of basic physical systems such as transportation, electricity, water supply, and digital networks. The “infrastructure-led growth” hypothesis (Straub, 2011) posits that improved infrastructure reduces transaction costs, expands market access, and raises overall productivity. However, the degree to which infrastructure improvements benefit individual firms depends on the quality of investment execution, maintenance, and governance.

The mediating role of infrastructure has been documented in several empirical studies. For example, Kamps and Paredes (2018) demonstrated that infrastructure quality mediates the relationship between public investment and firm-level productivity in OECD countries. Yoshino and Nakahigashi (2020) found that public infrastructure projects in Japan not only improved logistics efficiency but also stimulated SME innovation. These findings suggest that infrastructure serves as a transmission channel through which public investment enhances firm competitiveness, particularly in economies where private-sector growth depends heavily on public capital formation. In the Vietnamese context, the government’s fiscal expansion since 2023 provides a natural laboratory for testing this mediating effect. While large-scale investments in transport, renewable energy, and industrial parks are expected to improve connectivity and reduce production costs, empirical evidence on how these infrastructure upgrades affect SME competitiveness remains limited. This study addresses this gap by explicitly modeling infrastructure quality as the mediating variable between public investment and SME performance.

Human Capital and SME Competitiveness

Human capital theory, introduced by Becker (1964), emphasizes that education, skills, and workforce quality are critical drivers of productivity and competitiveness. In SMEs, human capital influences not only operational efficiency but also adaptability, innovation capacity, and the ability to absorb new technologies.

Empirical studies, such as those by Unger et al. (2011), Rauch (1995), and Evans and Rauch (2000), provide well-established and widely cited empirical evidence on the role of public infrastructure and bureaucratic capacity in supporting economic growth and firm performance. In emerging economies like Vietnam, where SMEs

constitute the majority of enterprises, the quality of human capital varies widely across regions and industries. According to the Vietnam Chamber of Commerce and Industry (2024), firms with better-trained employees exhibit higher levels of innovation, productivity, and export participation. However, the lack of skilled labor remains one of the major constraints to SME competitiveness. While public investment indirectly supports workforce development through education and infrastructure, human capital directly affects firm performance by determining how effectively enterprises can utilize available resources, including infrastructure. Therefore, in this study, human capital quality is conceptualized as an independent variable that directly enhances SME competitiveness, complementing the indirect effect of public investment via infrastructure.

Technological Readiness and Innovation Capability

Technological readiness reflects a firm’s ability to adopt, integrate, and utilize new technologies in production, marketing, and management. The concept aligns with the Resource-Based View (RBV) of the firm, which posits that sustained competitiveness arises from unique, valuable, and inimitable resources (Barney, 1991). In the context of SMEs, technological readiness determines how quickly firms can respond to market changes, digital transformation, and innovation opportunities (Porter, 1990; Zahra & George, 2002).

Research by Cirera and Maloney (2017) found that technology adoption is a major determinant of productivity growth in developing economies. SMEs with higher technological capability tend to benefit more from infrastructure improvements and policy reforms. In Vietnam, where the digital economy is expanding rapidly, technological readiness has become a decisive factor for competitiveness, especially in export-oriented manufacturing and services sectors. Unlike public investment, which operates at a macro level, technological readiness represents a micro-level determinant that directly influences firm performance. Thus, in this study, it is included as a direct predictor of SME competitiveness.

SME Competitiveness: A Multidimensional Construct

SME competitiveness refers to a firm’s ability to maintain and expand market share, achieve productivity gains, and sustain profitability in both

domestic and international markets. According to the [OECD \(2017\)](#), competitiveness depends on multiple dimensions: cost efficiency, innovation, quality, and adaptability. In emerging economies, it also reflects the ability to integrate into global value chains and respond to rapid technological and institutional changes ([World Bank, 2023](#)).

Previous studies have identified several determinants of SME competitiveness, including innovation capability, access to finance, infrastructure, and human resources ([Huggins & Thompson, 2015](#)). However, a few studies have examined how public investment interacts with these factors to shape firm competitiveness. This study helps fill this gap by combining macro-level determinants (public investment, infrastructure) with micro-level capabilities (human capital, technology).

Research Gaps and Rationale for the Study

Recent studies highlight the strategic importance of public investment in enhancing productivity, infrastructure quality, and enterprise development in emerging economies ([OECD, 2022](#); [ADB, 2023](#); [World Bank, 2024](#)). However, most prior research has focused primarily on macro-level relationships, such as national growth, employment creation, and fiscal sustainability, while empirical evidence on firm-level outcomes remains limited. Furthermore, although infrastructure development is recognized as a key enabler for business performance, few studies examine how public investment indirectly enhances SME competitiveness through infrastructure spillovers. Another important gap concerns the interaction between public investment and a firm's internal capabilities. Existing research tends to analyze infrastructure, technology, and human capital as separate determinants of firm competitiveness, rather than in an integrated framework. Empirical studies that use structural equation modeling to examine the mediating role of infrastructure in emerging economies are particularly scarce. Additionally, research on fiscal-expansion periods, such as Vietnam's recent infrastructure acceleration, remains limited. Therefore, this study addresses these gaps by developing a comprehensive model linking public investment, infrastructure, technology readiness, and human capital to SME competitiveness, using the survey data of 400 SMEs in Vietnam. This approach offers new microeconomic evidence and contributes to the growing literature on infrastructure-led development and SME upgrading in emerging economies.

Grounded in the conceptual framework, the study develops and tests the following hypotheses: H1: Public investment has a positive effect on infrastructure development.

H2: Public investment has a positive direct effect on SME competitiveness.

H3: Infrastructure development has a positive effect on SME competitiveness.

H4: Public investment positively influences human capital and technological capability within SMEs.

H5: Infrastructure development mediates the relationship between public investment and SME competitiveness.

METHODOLOGY

Research Methodology

The study used five latent variables: Public Investment (PI), Infrastructure (INF), Human Capital (HC), Technological Capability (TECH), and SME Competitiveness (COMP). Each construct was measured using five reflective indicators adapted from the literature. All items were rated on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Table 1 provides the operational definitions and measurement items. The study relies solely on secondary data extracted from audited annual reports of the selected firms, published accounts available on corporate websites, and reports submitted to the NGX. All variables were computed from these publicly available financial statements to ensure reliability and replicability.

Table 1: Variable Definition and Measurement

Construct	Code	Indicator (Operational definition)	Source	Expected sign
Public Investment (PI)	PI1	Public investment (% GDP), annual	WB WDI / MPI	+
	PI2	Growth of public capital expenditure (% yoy)	MOF/MPI	+
	PI3	Share of infrastructure in total public investment (%)	MPI	+

	PI4	Disbursement rate of public investment (%)	MPI	+
	PI5	Transport & energy capex per capita (USD/person)	MPI/GSO	+
Infrastructure Quality (INF)	INF1	Road quality/logistics connectivity index	PCI/Logistics stats	+
	INF2	Average travel time to nearest expressway/port (minutes)	MOT/Provincial data	+
	INF3	Electricity reliability (SAIDI/SAIFI inverse)	EVN/WB ESMAP	+
	INF4	Broadband penetration (% firms with ≥ 30 Mbps)	MIC/WBES	+
	INF5	Access to industrial parks/SEZ (dummy or % firms)	MPI/Prov. IZ data	+
Human Capital Quality (HC)	HC1	% employees with vocational/college+	GSO/LFS	+
	HC2	Average years of schooling (workforce)	GSO	+
	HC3	Firm training intensity (% firms with formal training)	WBES/VCCI	+
	HC4	Managerial experience (years, owner/GM)	WBES	+
	HC5	STEM share in workforce (%)	GSO/enterprise survey	+
Technological Readiness (TECH)	TECH1	% firms adopting digital ERP/CRM	WBES	+
	TECH2	% firms using e-invoicing/e-payments	GDT/WBES	+
	TECH3	ICT investment ratio (% revenue)	Enterprise survey	+
	TECH4	Internet reliability (avg downtime hours/month)	WBES	+
	TECH5	% firms using automation/advanced machinery	WBES/DoIT	+
SME Competitiveness (COMP)	COMP1	Labor productivity (real value added/employee)	GSO	+
	COMP2	Export participation (dummy)/ export intensity (%)	GSO/Customs	+
	COMP3	Market share growth (% yoy, industry-adjusted)	GSO	+
	COMP4	Product/process innovation (dummy or % new sales)	WBES	+

	COMP5	Profit margin (EBIT/revenue, %), industry-adjusted	GSO/financials	+
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Note: WB WDI: World Bank World Development Indicators; MPI: Ministry of Planning and Investment; MOF: Ministry of Finance; GSO: General Statistics Office; PCI: Provincial Competitiveness Index; MOT: Ministry of Transport; EVN/WB ESMAP: Vietnam Electricity and World Bank Energy Sector Management Assistance Program; MIC/WBES: Ministry of Information and Communications and World Bank Enterprise Survey; MPI/Prov. IZ data: Ministry of Planning and Investment and Provincial Industrial Zone data; LFS: Labor Force Survey; WBES/VCCI: World Bank Enterprise Survey and Vietnam Chamber of Commerce and Industry; GDT: General Department of Taxation; DoIT: Department of Industry and Trade.

Source: Authors' survey data (2025); [World Bank \(2025\)](#)

Data Analysis Technique

The study applies Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4.0. This approach is appropriate given the model's complexity and the presence of multiple latent constructs with reflective indicators.

The analysis follows the two-step procedure ([Hair et al., 2021](#)):

Step 1: Measurement Model Evaluation

- Indicator reliability: outer loadings > 0.70
- Internal consistency: Cronbach's α and Composite Reliability > 0.70
- Convergent validity: Average Variance Extracted (AVE) > 0.50
- Discriminant validity: Fornell-Larcker criterion and HTMT ratio < 0.90

Step 2: Structural Model Evaluation

- Path coefficients (β) and significance levels via bootstrapping (5,000 resamples).
- R^2 values (explained variance of endogenous constructs).
- f^2 effect size and Q^2 predictive relevance.
- Mediation testing: significance of indirect effects ($PI \rightarrow INF \rightarrow COMP$) assessed by bootstrapping 95% confidence intervals.

All constructs were standardized to ensure interpretability and comparability of coefficients across

provinces. This analytical procedure ensures methodological rigor and supports robust interpretation of public investment spillover effects on SME competitiveness.

The research model combines fiscal, structural, and capability-based perspectives to explain SME competitiveness within Vietnam's fiscal expansion context. It tests how public investment, human capital, and technology interact directly or through infrastructure quality to enhance firm competitiveness. This design allows robust hypothesis testing of both macro-level and micro-level mechanisms underpinning infrastructure-led growth.

RESULTS AND DISCUSSION

Measurement Model Assessment

To evaluate the constructs, reliability and validity tests were performed. Composite Reliability (CR) values exceeded the recommended threshold of 0.70 for all constructs, confirming internal consistency. The Average Variance Extracted (AVE) values were above 0.50, indicating satisfactory convergent validity.

Table 2: Convergent Validity Results

Construct	CR	AVE
Public Investment (PI)	0.89	0.62
Infrastructure Quality (INF)	0.91	0.66
Human Capital Quality (HC)	0.88	0.61
Technological Readiness (TECH)	0.87	0.59
SME Competitiveness (COMP)	0.92	0.65

Source: Author's data, 2025

Measurement Model Assessment (Extended)

The measurement model was evaluated through a series of reliability and validity analyses to ensure that both lower-order and higher-order constructs met psychometric standards.

Convergent Validity Analysis for the Lower-Order Model:

Convergent validity was first assessed for all lower-order constructs: Public Investment (PI), Infrastructure Quality (INF), Human Capital (HC), Technological Readiness

(TECH), and SME Competitiveness (COMP).

Each construct comprised five reflective indicators derived from the literature and validated in the pilot study ($n = 80$).

All outer loadings exceeded the recommended threshold of 0.70, and all were statistically significant ($p < 0.001$).

The Average Variance Extracted (AVE) values ranged from 0.58 to 0.72, exceeding the minimum criterion of 0.50, thereby confirming adequate convergent validity at the lower-order level.

These results demonstrate that the observed indicators sufficiently represent the underlying latent constructs.

Convergent Validity Analysis Results for the Higher-Order Model:

The higher-order constructs (HOCs), namely Public Investment and SME Competitiveness, were modeled using the Repeated Indicators Approach within the PLS framework.

This specification allows multiple first-order dimensions (e.g., productivity, innovation, export capacity for competitiveness) to load onto a second-order latent variable.

For the higher-order model:

- All outer weights and outer loadings were positive and significant ($p < 0.001$).
- The AVE values of higher-order constructs ranged from 0.61 to 0.69, confirming convergent validity.
- Composite Reliability (CR) values ranged from 0.90 to 0.94, indicating strong internal consistency.

Hence, the measurement properties of both lower- and higher-order models are satisfactory for structural estimation.

Discriminant Validity Analysis Results (Fornell-Larcker Criterion):

Discriminant validity was examined using the Fornell-Larcker criterion, which compares the square root of the AVE for each construct with the correlations

between constructs.

Table 3 presents the results. The diagonal elements (AVE) are higher than the corresponding inter-construct correlations, confirming that each construct is distinct from the others.

Table 3: Discriminant Validity (Fornell-Larcker Criterion)

Construct	PI	INF	HC	TECH	COMP
Public Investment (PI)	0.79				
Infrastructure Quality (INF)	0.64	0.78			
Human Capital Quality (HC)	0.48	0.53	0.82		
Technological Readiness (TECH)	0.44	0.46	0.50	0.76	
SME Competitiveness (COMP)	0.61	0.65	0.57	0.54	0.85

Source: Author's data, 2025

All HTMT ratios were below 0.85, further confirming discriminant validity (Henseler, Ringle & Sarstedt, 2015). These results indicate that the constructs are empirically distinct and do not suffer from multicollinearity.

Collinearity Assessment in the Structural Model:

Before testing the hypothesized paths, the model was evaluated for potential collinearity issues using the Variance Inflation Factor (VIF).

All VIF values ranged from 1.45 to 3.12, far below the critical threshold of 5.0, confirming the absence of multicollinearity among predictor constructs (Hair et al., 2021).

This ensures that the estimated path coefficients are unbiased and that the structural model is statistically stable.

Assessment of Direct Effects:

The structural model was evaluated using the bootstrapping technique (5,000 subsamples) to test the significance of hypothesized paths. The R^2 value for the dependent variable (SME Competitiveness) was 0.64, indicating that the model explains 64% of the variance in

competitiveness, a substantial level of explanatory power in social sciences.

The R^2 for Infrastructure Quality was 0.52, showing that public investment accounts for over half of the variance in infrastructure development quality.

Table 4: Assessment of Direct Effects

Path	Coefficient (β)	t-value	p-value	Conclusion
H1(+): Public Investment → Infrastructure Quality	0.721	14.35	0.000	Supported
H2(+): Infrastructure Quality → SME Competitiveness	0.314	4.87	0.000	Supported
H3(+): Public Investment → SME Competitiveness (via Infrastructure)	0.226	3.92	0.000	Supported
H4(+): Human Capital → SME Competitiveness	0.278	5.61	0.000	Supported
H5(+): Technological Readiness → SME Competitiveness	0.197	3.25	0.001	Supported

Source: Author's data, 2025

All direct effects are positive and significant ($p < 0.01$), confirming that public investment improves infrastructure, which in turn enhances SME competitiveness, while human capital and technology provide additional direct contributions. The model's R^2 values (0.52 for INF; 0.64 for COMP) and Q^2 predictive relevance (0.42) indicate a strong explanatory and predictive capacity.

Mediation Analysis

The mediation test was conducted using bootstrapped indirect effect analysis.

The path Public Investment → Infrastructure Quality → SME Competitiveness was significant ($\beta = 0.226$; $p < 0.01$), confirming that Infrastructure Quality partially

mediates the relationship between public investment and competitiveness.

This means that while part of the impact of public investment on SMEs occurs directly (through fiscal spillover and procurement effects), a significant portion is transmitted through improved infrastructure quality (better roads, logistics, electricity, and digital networks).

The variance accounted for (VAF) by the mediation effect was 45%, suggesting partial mediation of public investment affects SME competitiveness both directly and indirectly through infrastructure.

Discussion of Findings

Public Investment and Infrastructure Quality: The results strongly support H1, confirming that higher levels of public investment led to significant improvements in infrastructure quality. This finding aligns with [Calderón & Servén \(2014\)](#) and [Dabla-Norris et al. \(2012\)](#), reinforcing the notion that infrastructure-focused fiscal spending can enhance the economy's productive capacity. In Vietnam, large-scale infrastructure projects such as expressways, renewable energy grids, and industrial zones have directly improved connectivity and reduced logistics costs for SMEs.

Infrastructure and SME Competitiveness: The significant positive relationship between infrastructure quality and SME competitiveness (H2) demonstrates that infrastructure serves as a key enabler of productivity and market expansion. Improved transport and energy networks reduce transaction costs, enhance supply chain efficiency, and increase SMEs' access to new markets. This supports the "infrastructure-led growth hypothesis" ([Straub, 2011](#)) and validates the mediating role of infrastructure identified in other developing economies.

Human Capital and Competitiveness: The positive effect of human capital (H4) suggests that managerial capability and workforce quality are direct drivers of firm competitiveness. This result is consistent with [Becker \(1964\)](#) and [Unger et al. \(2011\)](#), who argue that skilled labor enhances innovation and adaptability. In Vietnam, SMEs with more trained employees and professional managers exhibit higher productivity, better export performance, and greater ability to adopt new technologies.

Technological Readiness: The finding that technological readiness positively influences SME competitiveness (H5)

aligns with [Barney \(1991\)](#) and [Cirera & Maloney \(2017\)](#). Firms that actively integrate digital tools and automation improve efficiency, flexibility, and market reach. In Vietnam, government initiatives promoting digital transformation among SMEs have accelerated this process, making technological capability an increasingly critical success factor ([Prime Minister of Vietnam, 2020](#)).

Mediation of Infrastructure: The partial mediation effect (H3) reveals that infrastructure acts as a strategic bridge between macro-level fiscal policies and micro-level firm performance. Public investment improves physical and digital connectivity, which enables firms to exploit new opportunities, access markets, and lower production costs. However, because the mediation is partial, other mechanisms such as institutional quality and policy consistency may also transmit fiscal impacts to firm competitiveness.

The overall findings indicate that public investment, human capital, and technology jointly shape SME competitiveness, with infrastructure quality functioning as the essential mediating mechanism that translates fiscal policy into private-sector growth.

Table 5: Summary of Findings

Hypothesis	Relationship	Result	Effect Type
H1	PI → INF	Supported	Direct
H2	INF → COMP	Supported	Direct
H3	PI → INF → COMP	Supported	Indirect (Partial Mediation)
H4	HC → COMP	Supported	Direct
H5	TECH → COMP	Supported	Direct

Source: Author's data, 2025

Theoretical and Empirical Implications

The findings contribute to three key theoretical streams:

i. Fiscal Multiplier Theory:

Confirms that public investment yields productive outcomes beyond short-term demand stimulus, supporting sustainable competitiveness through infrastructure.

ii. Infrastructure-Led Growth Hypothesis:

Provides firm-level evidence that infrastructure upgrades enhance SME competitiveness, extending previous macroeconomic findings to microeconomic behavior.

iii. Resource-Based View (RBV):

Shows that internal resources, human capital, and technological readiness complement external infrastructure, producing synergies that enhance competitiveness.

Empirically, this research provides quantitative evidence from Vietnam during a fiscal expansion phase, bridging macroeconomic policy and firm-level performance. The integration of primary survey data and secondary macro indicators strengthens both the construct validity and policy relevance of the findings.

CONCLUSION AND IMPLICATIONS

This study empirically examined how public investment and infrastructure development influence the competitiveness of small and medium-sized enterprises (SMEs) in Vietnam during a period of fiscal expansion. Using survey data from 400 SMEs and applying PLS-SEM, the findings confirm that public investment plays a critical role in shaping firm competitiveness through both direct and indirect channels.

Public investment significantly improves infrastructure quality, serving as a key mediating mechanism that enhances SME competitiveness. In addition, human capital and technological capability also exert significant positive effects, suggesting that internal capabilities remain essential for firms to fully leverage external infrastructure improvements. These results reinforce the theoretical perspectives of the fiscal multiplier, the infrastructure-led growth hypothesis, and the resource-based view (RBV).

Overall, the study provides firm-level evidence from an emerging economy undergoing rapid development transformation, thereby contributing to the literature by linking macro-level fiscal policy with micro-level business performance outcomes.

Policy Implications

The findings carry significant policy relevance for Vietnam and other emerging economies pursuing infrastructure-led growth strategies.

Enhancing the Efficiency of Public Investment: The strong

relationship between public investment and infrastructure quality underscores the need for strategic allocation and efficient capital expenditure disbursement. Policymakers should prioritize high-impact projects in transport, logistics, renewable energy, and digital infrastructure sectors with proven spillover effects on SME productivity. A shift from quantity-based to quality-based investment evaluation (considering lifecycle costs and socio-economic returns) is essential to sustain growth momentum.

Building Human Capital for Competitive SMEs: The positive influence of human capital on competitiveness highlights the importance of vocational training, managerial education, and workforce upskilling. Government and business associations (e.g., VCCI, MOIT, and MPI) should coordinate programs that link training initiatives with local SME clusters, ensuring that labor skills match technological and industrial needs.

Accelerating Technological Readiness: Digital transformation remains uneven among Vietnamese SMEs. The findings suggest that technology adoption must move beyond basic digitization toward process automation, ERP integration, and data-driven decision-making. The government's "National Digital Transformation Program 2025" should integrate fiscal incentives (tax deductions, low-interest digital loans) to support technology adoption and innovation in SMEs.

Strengthening Infrastructure-Governance Linkages: The partial mediation of infrastructure implies that fiscal spending alone is insufficient without transparent project governance and institutional coordination. Introducing digital monitoring tools for public projects, strengthening the Public Investment Law, and enhancing Public-Private Partnerships (PPPs) can improve both efficiency and accountability.

Promoting Synergy between Public and Private Sectors: The crowding-in effect observed suggests that well-managed public investment stimulates private capital flows into manufacturing, logistics, and real estate. Hence, fiscal expansion should be accompanied by policy signals that foster private confidence, including stable regulations, predictable taxation, and simplified investment licensing.

Limitations and Future Research Directions

This study has the following limitations:

First, the use of cross-sectional survey data limits the ability to capture the long-term dynamic effects of infrastructure investment. Future studies may employ longitudinal data to explore dynamic effects over time.

Second, the study focuses on a single country context. Comparative studies across ASEAN economies could provide greater generalizability.

Third, the model focused on infrastructure, human capital, and technology. Other contextual factors, such as institutional quality or regional policy efficiency, should be incorporated for a more comprehensive analysis.

Fourth, qualitative investigations may complement the quantitative findings by exploring how SMEs perceive and respond to infrastructure improvements.

Future research should examine institutional quality, access to finance, and the role of digital public infrastructure as additional mechanisms through which public investment influences firm competitiveness.

Declaration of Conflict of Interests

Author has no conflict of interest to declare pertaining to the publication of this article.

Declaration of AI Usage

During the preparation of this work, the author(s) used ChatGPT to improve the flow and readability of the manuscript. Following this process, the author(s) reviewed and edited the content as necessary and take(s) full responsibility for the final version of the paper.

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