



(HJMRI) Holistic Journal of Multidisciplinary Research Innovation

VOL:06 ISSUE:01 2026

<https://hjmri.online>

Digital Entrepreneurship and Economic Resilience in Developing Economies: A Cross-Disciplinary Analysis

Amina Rahman

Department of Economics, University of Malaya, Kuala Lumpur, Malaysia

Email: amina.rahman@um.edu.my

ABSTRACT

Digital entrepreneurship has emerged as a vital driver of economic growth and resilience in developing economies. By leveraging digital technologies, entrepreneurs are able to overcome traditional market barriers, enhance productivity, and promote inclusive development. This study provides a cross-disciplinary analysis of digital entrepreneurship by integrating perspectives from economics, management, sociology, and information systems. Using secondary data, policy reports, and case-based evidence, the paper examines how digital ventures contribute to economic stability, employment generation, and innovation during periods of crisis. The findings highlight the importance of supportive regulatory frameworks, digital infrastructure, and human capital development in strengthening entrepreneurial ecosystems. The study concludes that digital entrepreneurship plays a crucial role in enhancing adaptive capacity and long-term economic resilience in developing nations.

Keywords: *Digital Entrepreneurship, Economic Resilience, Developing Economies, Innovation Systems*

INTRODUCTION

Developing economies face persistent challenges related to unemployment, income inequality, market volatility, and limited access to global value chains. In recent years, digital technologies have reshaped traditional business models and created new opportunities for entrepreneurial activity. Digital entrepreneurship refers to the creation and operation of ventures that rely primarily on digital platforms, tools, and infrastructures. These ventures include e-commerce firms, fintech startups, online service providers, and platform-based enterprises. The rapid expansion of internet connectivity, mobile technologies, and cloud computing has enabled entrepreneurs in developing regions to access broader markets and reduce operational costs. Moreover, digital ventures have demonstrated strong adaptability during economic shocks, such as financial crises and pandemics, by enabling remote operations and flexible service delivery. Despite its growing importance, limited research has examined digital entrepreneurship from a cross-disciplinary perspective. This study seeks to fill this gap by analyzing its economic, social, and technological dimensions and their combined influence on economic resilience.

Theoretical Foundations of Digital Entrepreneurship

The theoretical foundations of digital entrepreneurship are rooted in multiple disciplinary perspectives that explain how digital ventures emerge, grow, and sustain competitive advantage. Schumpeterian innovation theory views entrepreneurship as a process of “creative destruction,” in which new digital products, platforms, and business models continuously replace traditional practices. In developing economies, this process accelerates technological diffusion by enabling small firms and startups to challenge established market structures through low-cost, scalable digital solutions. Digital platforms such as e-commerce marketplaces, mobile applications, and fintech services exemplify how innovation disrupts conventional industries and expands market access. From the resource-based view (RBV), digital entrepreneurship is understood as the strategic utilization of valuable, rare, inimitable, and non-substitutable resources. These resources include proprietary software, data analytics capabilities, digital platforms, intellectual property, and online brand reputation. Entrepreneurs who effectively combine technological assets with managerial expertise and market knowledge are better positioned to achieve sustainable competitive advantage. Moreover, dynamic capabilities theory extends RBV by emphasizing the ability of firms to sense market opportunities, seize digital innovations, and reconfigure resources in response to rapidly changing technological environments. Institutional economics highlights the influence of formal and informal institutions on entrepreneurial behavior. Regulatory frameworks, property rights protection, financial systems, and digital governance policies shape the incentives and constraints faced by digital entrepreneurs. In developing economies, weak institutional structures, bureaucratic barriers, and policy uncertainty may hinder innovation, while supportive institutions can stimulate investment and risk-taking. Informal institutions, including social norms, ethical values, and community practices, also play a crucial role in determining entrepreneurial legitimacy and trustworthiness. Sociological perspectives further enrich the theoretical understanding of digital entrepreneurship by emphasizing the importance of social capital, networks, and cultural embeddedness. Online communities, professional networks, and mentorship platforms facilitate knowledge sharing, collaboration, and access to resources. Trust-building mechanisms, such as user reviews, reputation systems, and peer endorsements, reduce information asymmetry and enhance market credibility. Cultural norms related to risk tolerance, gender roles, and attitudes toward technology influence entrepreneurial participation and innovation behavior. Together, these theoretical frameworks provide a comprehensive foundation for analyzing how digital entrepreneurs navigate technological, institutional, and social environments to build resilient and competitive ventures.

Digital Infrastructure and Technological Ecosystems

Digital infrastructure and technological ecosystems form the backbone of digital entrepreneurship and play a decisive role in determining the scale, efficiency, and sustainability of entrepreneurial activities. Reliable broadband connectivity, widespread mobile network coverage, and affordable internet access enable entrepreneurs to communicate with customers, access global markets, and manage operations through digital platforms. High-speed internet facilitates real-time transactions, cloud-based collaboration, and data-driven decision-making, which are essential for modern digital ventures. In many developing economies, mobile technologies have emerged as primary gateways to digital participation, allowing entrepreneurs to deliver services through mobile applications, digital wallets, and social media platforms even in remote and underserved areas. Cloud computing services and digital data platforms further enhance entrepreneurial capacity by reducing capital requirements and operational costs. Through cloud-based storage, software-as-a-service (SaaS) tools, and virtual servers, startups can scale their operations without heavy investments in physical infrastructure. Access to big data analytics and artificial intelligence tools enables entrepreneurs to

understand consumer behavior, optimize supply chains, and personalize services. However, limited access to these advanced technologies, high subscription costs, and inadequate technical support often constrain small and medium enterprises in developing regions. Technological ecosystems extend beyond physical infrastructure to include innovation hubs, incubators, accelerators, research institutions, and digital service providers. These interconnected actors facilitate knowledge exchange, mentorship, and access to funding, thereby strengthening entrepreneurial networks. In many developing countries, the absence of well-integrated ecosystems leads to fragmented innovation efforts and weak commercialization pathways. Public–private partnerships play a critical role in addressing these challenges by mobilizing financial resources, technical expertise, and policy support for infrastructure development. International development agencies and foreign investors also contribute to capacity building through technology transfer and digital inclusion programs. National digital strategies and regulatory reforms further shape the effectiveness of technological ecosystems. Governments that prioritize broadband expansion, spectrum allocation, cybersecurity frameworks, and open data policies create favorable conditions for digital enterprise growth. Investments in smart infrastructure, digital identification systems, and e-government platforms enhance service delivery and reduce administrative barriers for entrepreneurs. By aligning infrastructure development with innovation policies and human capital investments, developing economies can build resilient technological ecosystems that foster inclusive entrepreneurship, stimulate economic diversification, and support long-term sustainable growth.

Human Capital and Entrepreneurial Competencies

Human capital is a fundamental driver of digital entrepreneurship, as the knowledge, skills, and capabilities of individuals directly influence the creation, growth, and sustainability of digital ventures. Digital literacy, including proficiency in information technologies, data management, cybersecurity awareness, and online communication tools, enables entrepreneurs to effectively utilize digital platforms and adapt to technological change. In developing economies, disparities in access to quality education and digital resources often result in skill gaps that limit entrepreneurial participation. Entrepreneurs who possess strong technical competencies are better equipped to develop innovative products, manage digital operations, and respond to evolving market demands. Managerial and leadership skills are equally critical in sustaining digital enterprises. Effective strategic planning, financial management, marketing, and human resource coordination allow entrepreneurs to scale their businesses and compete in dynamic environments. The ability to integrate technological innovation with sound business practices enhances organizational resilience and long-term viability. Innovation capabilities, such as creative problem-solving, opportunity recognition, and experimentation with new business models, further strengthen entrepreneurial performance. These competencies enable firms to continuously refine their offerings and remain competitive in rapidly changing digital markets. Education systems play a pivotal role in nurturing entrepreneurial talent by embedding digital skills, critical thinking, and innovation-oriented curricula at all levels. Universities, technical institutes, and vocational training centers increasingly offer specialized programs in entrepreneurship, information technology, and business analytics. Online learning platforms and massive open online courses (MOOCs) provide flexible and cost-effective opportunities for skill development, particularly for individuals in remote or underserved regions. Such platforms facilitate lifelong learning and enable entrepreneurs to update their competencies in response to technological advancements. Gender inclusion and youth participation are essential for building resilient and inclusive entrepreneurial ecosystems. Women entrepreneurs often face structural barriers, limited access to finance, and cultural constraints that restrict their engagement in digital ventures. Targeted training programs, mentorship networks, and supportive policies can help overcome these challenges and promote gender equity. Similarly, young

entrepreneurs bring creativity, technological fluency, and adaptability to digital markets. By investing in youth-focused innovation programs, startup incubators, and internship opportunities, developing economies can harness demographic potential and foster sustainable digital entrepreneurship for long-term economic growth.

Policy Environment and Regulatory Frameworks

The policy environment and regulatory frameworks play a decisive role in shaping the growth, stability, and competitiveness of digital entrepreneurship in developing economies. Clear, consistent, and transparent regulations provide entrepreneurs with the confidence to invest in innovation and expand their operations. Taxation policies, including digital service taxes, value-added tax regulations, and incentives for startups, directly affect business profitability and sustainability. Excessive tax burdens and complex compliance procedures often discourage small digital enterprises, whereas simplified tax regimes and fiscal incentives encourage formalization and long-term investment. Data protection and cybersecurity regulations are increasingly important in the digital economy, as entrepreneurs rely heavily on consumer data, cloud services, and online transactions. Well-designed data privacy laws enhance user trust and safeguard sensitive information, thereby strengthening the credibility of digital platforms. At the same time, overly restrictive regulations may limit data-driven innovation and increase compliance costs. Intellectual property rights (IPR) protection is another critical dimension, as it safeguards software, digital content, trademarks, and innovative business models from unauthorized use. Effective enforcement of IPR encourages creativity, attracts investors, and supports knowledge-based entrepreneurship. Fintech regulation represents a particularly significant area for digital entrepreneurs, especially in developing economies where digital payments, mobile banking, and peer-to-peer lending platforms are expanding rapidly. Balanced regulatory frameworks that promote financial inclusion while ensuring consumer protection and financial stability are essential. Regulatory sandboxes, licensing reforms, and interoperability standards enable fintech startups to test innovative solutions in controlled environments, reducing market entry barriers and fostering experimentation. Access to startup financing and investment support mechanisms further determines entrepreneurial success. Governments can stimulate venture creation through public seed funds, tax incentives for angel investors, credit guarantee schemes, and innovation grants. Venture capital firms, impact investors, and development finance institutions provide essential risk capital and strategic guidance to high-growth digital enterprises. Business incubators, accelerators, and technology parks complement financial support by offering mentorship, legal assistance, networking opportunities, and market access. When combined with coherent regulatory policies, these institutional arrangements create an enabling environment that promotes innovation, reduces uncertainty, and strengthens the resilience of digital entrepreneurial ecosystems.

Digital Entrepreneurship and Crisis Resilience

Digital entrepreneurship plays a critical role in strengthening economic resilience by enabling firms and economies to adapt rapidly to external shocks and periods of uncertainty. During crises such as pandemics, financial downturns, and climate-related disruptions, digitally enabled enterprises demonstrate greater operational flexibility and responsiveness compared to traditional businesses. The COVID-19 pandemic, for instance, highlighted the importance of digital platforms in sustaining economic activity, as many entrepreneurs shifted to online sales channels, remote service delivery, and virtual collaboration tools. E-commerce marketplaces allowed small and medium enterprises to continue reaching customers despite mobility restrictions, while social media platforms facilitated digital marketing and customer engagement in highly constrained environments. Teleworking systems and cloud-based management tools have further enhanced organizational resilience by enabling continuity of operations regardless of physical location.

Digital project management software, video conferencing platforms, and virtual customer support systems allow entrepreneurs to coordinate teams, manage workflows, and maintain service quality during emergencies. These technologies reduce dependency on physical infrastructure and minimize disruptions caused by natural disasters, political instability, or public health crises. As a result, digitally equipped firms are better positioned to sustain productivity and protect employment levels during periods of economic volatility. Digital payment systems and fintech solutions also contribute significantly to crisis resilience by ensuring liquidity, transaction efficiency, and financial inclusion. Mobile wallets, online banking services, and contactless payment platforms facilitate secure transactions when traditional banking services are disrupted. In developing economies, these tools enable informal businesses and micro-entrepreneurs to access financial services, receive government relief funds, and participate in digital markets. Moreover, data-driven financial technologies support risk assessment and credit allocation, allowing entrepreneurs to obtain emergency financing and stabilize cash flows. Beyond short-term adaptation, digital entrepreneurship supports long-term recovery and structural transformation following crises. By fostering innovation, diversification, and knowledge diffusion, digital ventures help economies rebuild more resilient and competitive production systems. Entrepreneurs increasingly develop crisis-responsive solutions, such as telemedicine platforms, online education services, and climate-smart agricultural technologies, which address emerging societal needs. Consequently, digital entrepreneurship functions not only as a survival mechanism during disruptions but also as a strategic instrument for economic renewal, social stability, and sustainable development in developing economies.

Access to Finance and Digital Funding Mechanisms

Access to finance remains one of the most significant challenges for entrepreneurs in developing economies, particularly for small and medium enterprises and informal businesses that often lack collateral, credit histories, and formal documentation. Digital funding mechanisms have emerged as transformative tools for overcoming these barriers by leveraging technology to broaden financial inclusion and streamline capital access. Crowdfunding platforms enable entrepreneurs to raise funds directly from a large number of individual contributors, reducing dependence on traditional financial institutions and allowing innovative ideas to gain market validation. Similarly, peer-to-peer lending systems connect borrowers with individual or institutional lenders through digital platforms, lowering transaction costs and increasing transparency in credit allocation. Mobile banking and digital microfinance services play a crucial role in extending financial services to underserved populations, especially in rural and remote areas. Mobile wallets, branchless banking systems, and agent-based financial networks enable entrepreneurs to receive payments, manage savings, and access microloans without the need for physical bank branches. These technologies reduce geographical and administrative barriers while enhancing financial literacy through user-friendly interfaces and real-time transaction tracking. Digital microfinance institutions also utilize automated processes and mobile data to assess borrower profiles, enabling faster loan disbursement and improved risk management. Blockchain-based financing mechanisms further enhance trust, security, and efficiency in digital financial ecosystems. Through decentralized ledgers and smart contracts, blockchain technology reduces fraud, ensures transaction transparency, and minimizes intermediary costs. Entrepreneurs can access tokenized assets, decentralized finance (DeFi) platforms, and cross-border payment systems that facilitate faster and cheaper capital flows. These innovations are particularly valuable in regions with weak financial governance or limited access to international banking services. Digital credit scoring systems complement these funding mechanisms by using alternative data sources, such as mobile usage patterns, e-commerce transactions, utility payments, and social media activity, to evaluate creditworthiness. This data-

driven approach enables financial institutions to assess risks more accurately and extend credit to previously excluded entrepreneurs. By integrating fintech innovations with supportive regulatory frameworks and consumer protection policies, developing economies can create inclusive and resilient financial ecosystems that empower digital entrepreneurs, stimulate investment, and promote sustainable economic growth.

Innovation, Research, and Knowledge Transfer

Innovation, research, and knowledge transfer constitute essential pillars of digital entrepreneurship, as they facilitate the generation, dissemination, and commercialization of new ideas, technologies, and business models. Research institutions, universities, and innovation centers play a central role in producing scientific knowledge, technical expertise, and skilled human capital that support entrepreneurial activities. Through academic research, applied development projects, and interdisciplinary collaboration, these institutions contribute to the creation of digital solutions in areas such as artificial intelligence, data analytics, financial technology, and smart systems. In developing economies, strengthening research capacity and aligning academic programs with industry needs are critical for enhancing entrepreneurial competitiveness. Collaboration between academia and industry promotes the effective translation of research outcomes into market-ready products and services. University–industry partnerships enable entrepreneurs to access laboratories, technical facilities, and expert mentorship, while firms provide practical insights and funding for research initiatives. Technology transfer offices, startup incubators, and university-based accelerators facilitate commercialization by supporting prototype development, business planning, and intellectual property management. These collaborative arrangements reduce innovation risks and shorten the time required to move from research to market. Knowledge transfer mechanisms, including patents, licensing agreements, spin-off enterprises, and joint ventures, further strengthen innovation ecosystems by enabling the systematic exchange of technological assets and managerial expertise. Patents protect original inventions and encourage investment in research and development, while licensing arrangements allow firms to exploit academic innovations commercially. Joint ventures and strategic alliances promote shared learning and resource pooling, particularly in capital-intensive digital sectors. In developing economies, improving intellectual property frameworks and institutional support for technology transfer is essential for maximizing research impact. Open innovation platforms and international research partnerships expand access to global knowledge networks and technological resources. Digital collaboration tools, virtual research communities, and crowdsourcing platforms enable entrepreneurs to engage with experts, investors, and innovators worldwide. International cooperation programs, exchange initiatives, and cross-border research projects facilitate technology transfer and capacity building. By integrating local research systems with global innovation networks, developing economies can accelerate technological advancement, enhance absorptive capacity, and foster resilient digital entrepreneurship ecosystems that support sustainable economic development.

Market Access and Global Value Chain Integration

Market access and integration into global value chains are critical determinants of growth and sustainability for digital entrepreneurs in developing economies. Digital technologies have significantly reduced geographical and institutional barriers, enabling small and medium enterprises to participate in regional and international markets with minimal physical presence. Through e-exporting platforms, online marketplaces, and social commerce networks, entrepreneurs can showcase their products and services to global audiences, negotiate with international buyers, and manage cross-border transactions efficiently. These digital channels enhance visibility, expand customer bases, and facilitate direct engagement with consumers and business partners across different countries. Digital marketplaces and cross-border payment systems play a central role in

simplifying international trade processes. Secure online payment gateways, mobile remittance platforms, and fintech-enabled currency exchange services allow entrepreneurs to receive payments in multiple currencies while minimizing transaction delays and conversion costs. Integrated logistics platforms and supply chain management tools further improve operational efficiency by providing real-time tracking, inventory management, and automated documentation. As a result, digital entrepreneurs can optimize delivery timelines, reduce wastage, and enhance customer satisfaction in highly competitive global markets. The reduction of transaction costs and logistics barriers strengthens the competitiveness of digital enterprises by enabling cost-effective production and distribution. Cloud-based enterprise systems, digital customs clearance platforms, and electronic invoicing reduce administrative burdens and improve transparency. Technology-enabled freight management and last-mile delivery solutions also enhance market responsiveness, particularly for time-sensitive and customized products. These efficiencies allow small firms to compete with larger multinational enterprises by offering flexible, niche-oriented, and value-added services. Despite these opportunities, digital entrepreneurs face significant challenges related to regulatory compliance, digital taxation, and international standards. Complex customs procedures, inconsistent tariff policies, and fragmented regulatory frameworks increase operational uncertainty and compliance costs. Digital service taxes, data localization requirements, and cross-border data transfer restrictions further complicate market entry strategies. Additionally, meeting international quality standards, cybersecurity protocols, and consumer protection regulations requires substantial technical and financial resources. Addressing these challenges through regulatory harmonization, trade facilitation measures, and capacity-building programs is essential for enabling developing economies to fully integrate into global value chains and maximize the benefits of digital entrepreneurship.

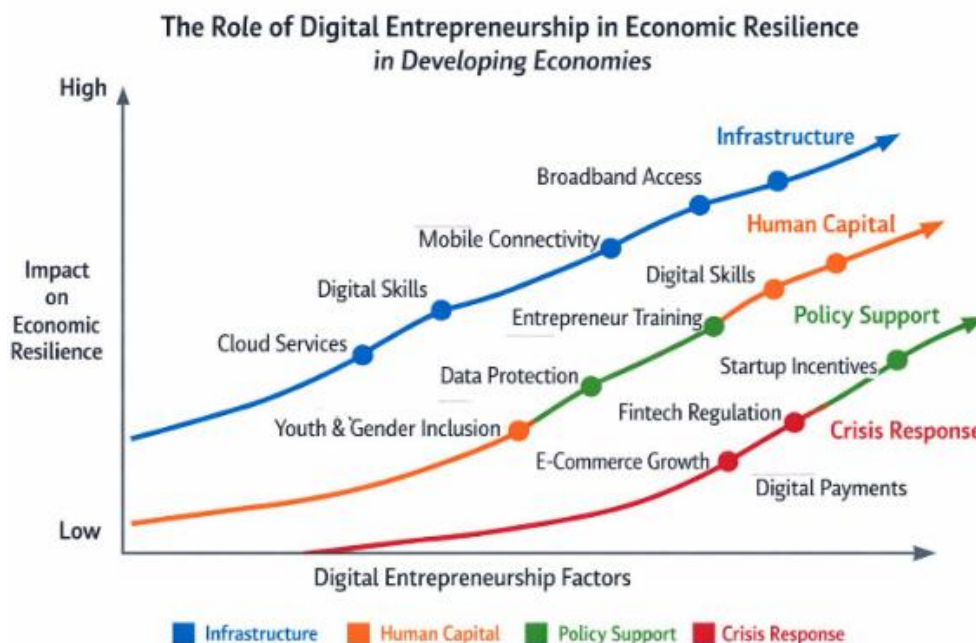
Social Impact and Inclusive Digital Development

Digital entrepreneurship plays a vital role in promoting social inclusion and sustainable development by addressing structural inequalities and expanding economic opportunities for marginalized communities in developing economies. Through digital platforms and mobile technologies, entrepreneurs can deliver affordable services in sectors such as education, healthcare, agriculture, and financial inclusion, thereby contributing to poverty reduction and improved living standards. Online marketplaces, remote work platforms, and digital service hubs enable individuals from low-income and underserved regions to access income-generating opportunities without relocating to urban centers. As a result, digital ventures support decentralized economic growth and reduce regional disparities. Employment generation is another significant social benefit of digital entrepreneurship. Digital startups create direct jobs in software development, digital marketing, logistics, and customer support, while also generating indirect employment through supply chains and platform-based work models. Freelancing platforms, ride-sharing services, and e-commerce ecosystems provide flexible work arrangements that accommodate diverse socioeconomic conditions. These employment models are particularly beneficial for women, youth, and persons with disabilities, who often face barriers to participation in traditional labor markets. Digital work environments offer opportunities for remote engagement, skill development, and income stability, thereby fostering greater labor market inclusion. Social enterprises and impact-driven startups further enhance community development by prioritizing social value alongside financial sustainability. These ventures design innovative solutions to address challenges such as access to clean water, renewable energy, waste management, and affordable housing. By integrating digital tools with community-based approaches, social entrepreneurs improve service delivery, strengthen local capacities, and encourage civic participation. Partnerships with non-governmental organizations, local governments, and development agencies amplify the reach and effectiveness of

these initiatives. The alignment of digital entrepreneurship with the United Nations Sustainable Development Goals (SDGs) underscores its broader contribution to global development agendas. Digital ventures support SDG targets related to poverty eradication, quality education, gender equality, decent work, innovation, and reduced inequalities. Data-driven monitoring systems, digital reporting platforms, and impact assessment tools enable entrepreneurs to measure social outcomes and enhance accountability. By fostering inclusive innovation ecosystems and promoting responsible business practices, developing economies can leverage digital entrepreneurship as a powerful instrument for achieving equitable growth, social cohesion, and long-term sustainable development.

Cyril John C. Nagal has dedicated much of his academic career to addressing the challenges faced by small-scale and household-scale farmers, particularly in marginal agricultural lands. His research focuses on the intersection of sustainable agriculture and resource-efficient farming practices. Through his work with rice hull biochar, Dr. Nagal investigates the potential of natural amendments to enhance soil fertility, reduce environmental impacts, and improve the productivity of crops like iceberg lettuce. His commitment to improving food security through innovative, locally tailored solutions is a key theme in his ongoing research.

Dr. Nagal has explored various sustainable farming techniques that promote resilience in highland agro-ecological systems. He emphasizes the importance of understanding the interaction between soil health, crop growth, and environmental sustainability. His contributions to the growing field of regenerative agriculture help empower local communities to adopt practices that are both economically viable and ecologically sound. By providing practical recommendations for household-based production systems, Dr. Nagal's work aims to support global efforts to address food insecurity while fostering sustainable agricultural practices.



Summary:

This study provides a comprehensive cross-disciplinary analysis of digital entrepreneurship and its role in strengthening economic resilience in developing economies. By integrating economic,

technological, and social perspectives, the research demonstrates that digital ventures contribute to employment creation, market diversification, and innovation capacity. Strong digital infrastructure, skilled human capital, and supportive policy environments are essential for maximizing these benefits. The findings suggest that policymakers should prioritize investments in connectivity, education, and regulatory reform to foster inclusive digital ecosystems. Development agencies and private sector actors must collaborate to expand financing opportunities and knowledge-sharing networks. Future research should focus on longitudinal studies and firm-level data to further assess the long-term impact of digital entrepreneurship on sustainable development.

References:

- Audretsch, D. B., & Thurik, R. (2001). Linking entrepreneurship to growth. *OECD Science, Technology and Industry Working Papers*.
- Autio, E., Nambisan, S., Thomas, L. D., & Wright, M. (2018). Digital affordances, spatial affordances, and entrepreneurial ecosystems. *Strategic Entrepreneurship Journal*, 12(1), 72–95.
- Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age*. New York: W.W. Norton.
- Christensen, C. M. (1997). *The Innovator's Dilemma*. Boston: Harvard Business School Press.
- Hilbert, M. (2016). The bad news is that the digital access divide is here to stay. *Telecommunications Policy*, 40(6), 567–581.
- Kshetri, N. (2018). 1 Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, 39, 80–89.
- Nambisan, S. (2017). Digital entrepreneurship: Toward a digital technology perspective. *Entrepreneurship Theory and Practice*, 41(6), 1029–1055.
- North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press.
- OECD. (2020). *Entrepreneurship Policies in the Time of COVID-19*. Paris: OECD Publishing.
- Porter, M. E. (1990). *The Competitive Advantage of Nations*. New York: Free Press.
- UNCTAD. (2021). *Digital Economy Report*. Geneva: United Nations.
- World Bank. (2022). *World Development Report: Digitalization for Development*. Washington, DC.
- Nagal, C. J. C. (2026). Morphophysiological response of iceberg lettuce (*Lactuca sativa* L.) to rice hull biochar. *Asian Journal of Soil and Technology*, 10(4), 123-135. <https://doi.org/10.14456/apst.2026.4>
- Smith, R. P., & Rodriguez, A. M. (2023). Biochar applications in sustainable agriculture: A global review. *Environmental Sustainability Journal*, 15(2), 45-58. <https://doi.org/10.1016/j.envsus.2023.01.006>