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Systematic Review

Digital Start-Up Ecosystems: A Systematic Literature Review and Model Development for South Africa

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Abstract: Digital start-ups play a crucial role in boosting the economies of many countries through technological innovations. Several studies have been conducted assessing digital start-ups or digital entrepreneurship, mainly from the perspective of the Global North. However, gaps exist in the literature regarding digital ecosystems, especially in the context of developing countries (the Global South), such as South Africa. This study fills this gap by exploring the structure as well as highlighting the hindering factors of the start-up ecosystem in South Africa. In addition, the study explores the influential factors of the digital start-up ecosystem and models that can be used to assess upscaling for the growth of new digital start-up ventures. The study conducted a systematic literature review using the PRISMA framework. The Scopus-indexed database was used to source published peer-reviewed papers on digital ecosystems between 2017 and 2023. Key findings of the study pertaining to South Africa's start-up ecosystem revealed that the country is producing thriving digital start-ups. The current study also identified several challenges that affect the development of digital start-ups in South Africa. Some of the challenges include regulatory barriers, skills shortages, a lack of funding, and a digital infrastructure gap, among others. Furthermore, work is being conducted by ecosystem stakeholders to address these challenges, with a greater collective and cohesive effort needed to effectively address the hindering factors. The study advocates for intervention as well as policy and practitioner implications that could be utilised by ecosystem stakeholders, particularly entrepreneurs in the digital market. The research findings pertain to the South African start-up ecosystem but have greater appeal and relevancy for many developing start-up ecosystems globally, especially in the Global South.

Keywords: digitalization; entrepreneurship; start-ups; business; digital ecosystems; South Africa; systematic literature review (SLR)

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1. Introduction

Over the past decades, technological advancement has started with the first industrial revolution ("steam engines and large quantities of production of goods"), followed by the second industrial revolution ("innovations such as steel production and electricity"), and, after that, the third industrial revolution ("computing and the internet"). The global world has recently been experiencing the fourth industrial revolution, or industry widely known as "4.0 technologies", including technologies such as the Internet of Things (IoT), cloud computing, blockchain technology, 3D-printing, artificial intelligence, machine learning, cybersecurity, digital-twin, and digitalisation, among others. Satalkina and Steiner [1] mentioned that digitalisation is associated with changes related to big data analysis, the adoption of digital technologies, and increased utilisation. Digitisation refers to the "digital conversion of information", whereas "digitalisation is considered for coupling mechanisms between different dimensions of the socio-economical system, including technological, social, economic, and ecological" [1].

Digitalisation determines the transformation of entrepreneurial and business models for different industries; this comes as a result of digitalization requiring an investment in digital technologies, which is considered a capital input and, when combined with labour inputs, yields higher labour productivity. This productivity increase then yields a transformation of both entrepreneurial and business models where and when applied [2].

In the past decade, the world has witnessed the rapid growth of the diffusion and adoption of digital technologies, which have driven inclusive, competitive, and stable economies in different countries [3]. Dabbous et al. [2] examined the interrelationship between digitalisation and economic growth, which varies between developing and developed economies. The results showed that developing countries gain less than developed countries, as developing countries are faced with developmental challenges that reduce their economic growth impact compared with developed countries. These development challengers include access to ICT infrastructure, i.e., digital access and inclusion [4]. Autio and Cao [5] assert that digitalisation impacts economic growth because it is an input that acts as a catalyst for enhancing labour resulting in higher efficiency and productivity. Additionally, digitalisation fosters human capital development through training and education, thus contributing immensely to economic growth [2].

Digital entrepreneurship or digital start-ups are not immune to the economic imbalance that exists between developed and developing economies. Digital start-ups play a role in contributing to economic growth and employment, as asserted by Galpin et al. [6], which aligns with the United Nations Sustainability Goals (SDG 8) of promoting sustained economic growth, full and productive employment, and decent work for all [6], thus making the study as well as the development of digital start-ups and their ecosystems crucial. By definition, a "digital startup" is a digital business (small business) created and driven by rapid growth and scale aspirations to solve a problem or create an opportunity. It makes use of technology as well as other key business attributes to achieve this. Small and medium-sized (SME) enterprises, on the other hand, are classified by definition by the number of workers employed and turnover. A startup can be classified as an SME but differs from other SME's due to the rapid growth and scale aspirations driven by technology [7].

Generally, previous studies [2–5] argue that digitalization remains the primary vehicle that can be a catalyst for digital entrepreneurship or digital start-ups. The rationale, according to Dabbous et al. [2], exhibits that technological investment forms part of a key capital input for digital entrepreneurship or digital start-ups. Niebel [4] substantiates this further by illustrating the impact of ICT and digital infrastructure that form part of the digitalization process on digital start-ups.

Autio and Cao [5] proposed several definitions for digital start-ups; however, no clear consensus has been reached. Autio and Cao [5] defined a digital start-up as "an entrepreneurial venture that is typically a newly emerged, fast-growing business that aims to meet a marketplace need by developing a viable business model around an innovative product, service, process, or platform." It is prudent to note that sometimes the term "digital start-up" is used interchangeably with "digital start-up ecosystems".

Digital start-up ecosystems involve various stakeholders with a role in fostering and supporting technology start-ups that interact as a system, including government, academia, investors, corporations, and incubators, and their role in fostering and supporting technology start-ups that interact as a system [8]. In addition, start-up ecosystems are classified into various levels, such as continental, country, regional, and city levels. They can be ranked based on the quality and quantity of the start-ups and institutions, as well as the overall social and business environment in which they exist. These attributes then distinguish developed start-ups from developing start-up ecosystems. The start-up ecosystem players in developed economies tend to invest more resources in digital start-ups compared to those that exist in developing economies. This results in developed economies having a greater number of successful digital technology start-ups and their start-up ecosystems ranking higher as well. Many African start-up ecosystems, such as South Africa, appear

lower on the global start-up ecosystem rankings [9]. There is a direct correlation between the quality of the start-up ecosystem and its ranking, as that impacts the start-ups being developed in that ecosystem. Start-up success results in social and economic benefits such as job creation (SDG 8), advancements in innovation (SDG 11), reduction of brain drain, and the development of an economy (SDG 9), thus making the study of start-up ecosystems essential [9]. South Africa, classified as a developing startup ecosystem according to Startup Blink [10], is currently ranked 53rd globally in the 2023 Startup Blink Global Startup rankings, dropping three places from its 2022 ranking [10]. More needs to be conducted by South Africa's startup ecosystem stakeholders to improve South Africa's ranking, and thus this research paper focuses on this problem statement while also focusing on developmental elements pertaining to South Africa, which also need to be taken into consideration. The research paper also provides insights that serve as a guide to assist South Africa's startup ecosystem stakeholders.

In Africa, 663 start-ups were established, receiving a total funding of above US$3 billion in 2022, a considerable increase compared to the previous year [11]. The first best-funded start-up ecosystem is Nigeria, with 180 start-ups (US$976,146,000). The second was Egypt (US$811,945,000) with 131 start-ups; Kenya (US$574,809,000) was the third best-funded start-up ecosystem with 91 start-ups; whereas South Africa (US$329,707,000) was the fourth best-funded start-up ecosystem with 78 start-ups [11]. Generally, the report by Disrupt Africa suggests that South Africa invests less in start-ups than the top three African countries. Additionally, the major sectors of start-ups in South Africa are fintech (31.5%), the e-health sector (15.7%), e-commerce, retail (29.6%), and others [11]. This suggests that in South Africa, fintech start-ups are dominant. George [12] claimed that the South African start-up ecosystem has transitioned from the emerging phase and is Africa's most mature start-up ecosystem. In addition, most of the start-up ecosystems are situated in Johannesburg and Cape Town because of the support of the private sector and many start-up support and acceleration programmes [12]. The major challenges in South Africa are high levels of inequality and unemployment. Anwana [13] reported that approximately 68% of South African digital start-ups create employment, contributing significantly to economic growth.

Several studies [3,5,6,12] have been conducted regarding "digital" or "digital entrepreneurship start-ups", and gaps appear, especially in developing countries such as South Africa. Therefore, it is interesting to explore the influence of digital start-up ecosystems and models that assess factors hindering the growth of digital start-ups in an African country such as South Africa. The current study poses the following questions: (1) What factors hinder the scale-up of start-up firms in developing countries, and (2) what models exist that guide the development of start-up ecosystems? The first section of this paper discusses the study methodology. After that, the literature review included the framework for digital start-ups, stages of entrepreneurship for start-ups, opportunities and barriers for start-ups, the South African start-up ecosystem, as well as models and theories for start-ups. The last section presents the discussion, conclusion, and future research.

2. Research Methodology

The study conducted a systematic literature review that is qualitative in nature, which is preferred over other methods for literature review analysis because it is explicit, enhances the reliability of the findings, and reduces bias [3]. The following steps were followed when conducting the systematic literature review, which was registered with CADIMA (a systematic literature review platform); firstly, clearly formulated objectives were developed. Secondly, all studies that meet the eligibility criteria were identified, and lastly, the validity of the included studies was assessed. The steps followed were (1) conducting a systematic review using the Reporting Items for Systematic Review and Meta-analysis Approach (PRISMA) method, including extracting the core categories of digital start-ups; (2) analysing the retrieved peer-reviewed papers; and (3) presenting the results [6].

Historically, the framework for PRISMA was founded in 1987 by Mulrow, who examined 50 review articles and published four manuscripts in leading medical journals between 1985 and 1986 [12]. In 1987, Sacks et al. evaluated the adequacy of reporting using the PRISMA methodology and found that reporting was poor. In 1999, an international group developed QUORAM statement guidance [14]. Surprisingly, the method was revised in 2005 and extended with a twenty-seven-point checklist, including a four-phase PRISMA diagram, to ensure validity and reliability of results. Hence, PRISMA provides a transparent and well-structured report framework as it has been continuously refined [14].

While there is substantial literature on entrepreneurship and the environments that impact entrepreneurs, the study of entrepreneurship ecosystems is on the rise. Yet, still, very little work has been conducted on digital start-ups from developing ecosystems and factors that hinder developing ecosystems (Figure 1).

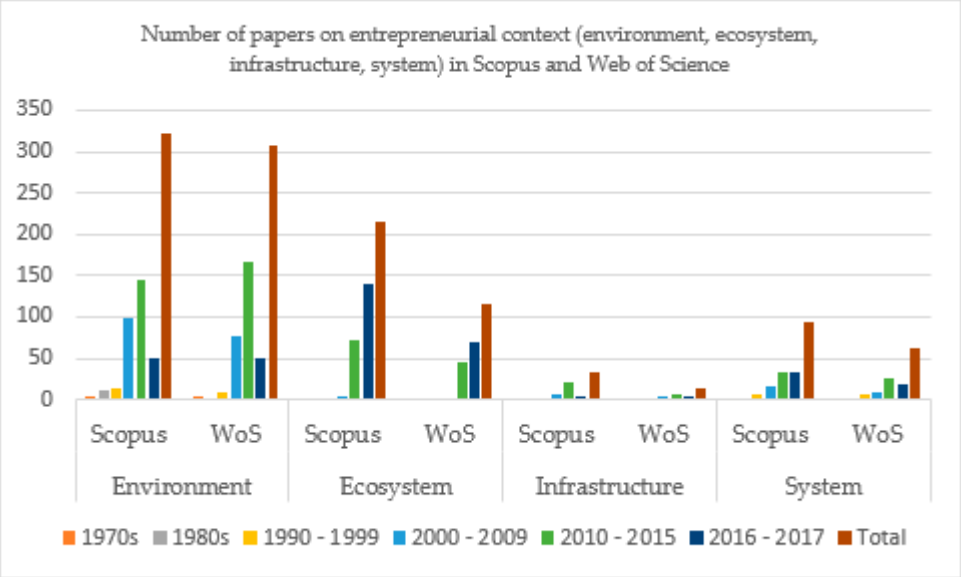

Figure 1. Number of papers on entrepreneurial context (environment, ecosystem, infrastructure, system) in Scopus and Web of Science, 1970s to 2017. Source: Reprinted/adapted with permission from Malecki, E.J. 2018 [15].

As noted in the study [15], researchers have experienced an interest in studying entrepreneurial ecosystems across both research database domains, Scopus and WoS. This indicates the growing importance of ecosystem thinking. Research methodology approaches applied in prior research have been both qualitative and quantitative in nature, with a greater leaning towards qualitative research [16] due to the evolving field of study of startup ecosystems. By definition, an ecosystem [17] refers to a community of living organisms in conjunction with the non-living components of their environment interacting as a system [17]. This means that the study of the environment remains key; however, so does the interaction between the ecosystem components [18], thus making this research on start-up ecosystems really valuable. This approach allows focus beyond just focusing on the environment but on how these components interact with each other with the objective of helping start-ups grow and scale [19].

Numerous approaches to performing literature reviews exist, such as a systematic literature review [20], a systematic mapping study [21], snowballing [22], and a multi-vocal literature review [9]. Among these approaches, researchers in the computer software engineering domain have regularly conducted systematic literature reviews and mapping studies. These approaches are used once adequate researcher peer-reviewed papers concerning a given topic exist. Thus, due to the several peer-reviewed papers identified for this study, a systematic literature review research methodology was applied. Limitations with the systematic literature review exist and include risks of bias, such as assortment

bias, attrition bias, insufficient blinding, and selective conclusion reporting; however, it is still the most effective methodology for this study [23].

Search Terms and Search Criteria

The Scopus-indexed database, which incorporates Science Direct, was used to search for published peer-reviewed papers on digital start-ups or entrepreneurship between 2017 and 2023. The journal topics were computer science, innovation, technology, finance, human capital, entrepreneurship, Business, Management and Accounting, Computer Science, Engineering, Economics, Econometrics, Finance, and Decision Sciences.

Reporting Items for Systematic Review and Meta-analysis Approach (PRISMA) method (Supplementary Materials):

Ordinarily, the PRISMA method is conducted in four main steps: identifying relevant research by searching the database(s), screening abstracts, full-text assessment of retrieved publications, and decision-making regarding eligibility criteria (see Figure 2). The search terms used were "(digital or Technology) AND (start-up OR ecosystems) OR digital transformation and innovation OR artificial intelligence AND economics AND technology OR start-ups AND information communication technology OR Entrepreneur OR Ecosystems AND Start-Ups OR digital platforms or Digital Platforms AND business development." Due to the limited information on digital start-ups, especially in South Africa, the first search identified 85 records, and after that, the researchers removed 10 duplicates; thereafter, 75 records remained for screening. After that, a datasheet with title, author name, year of publication, and abstract was formulated.

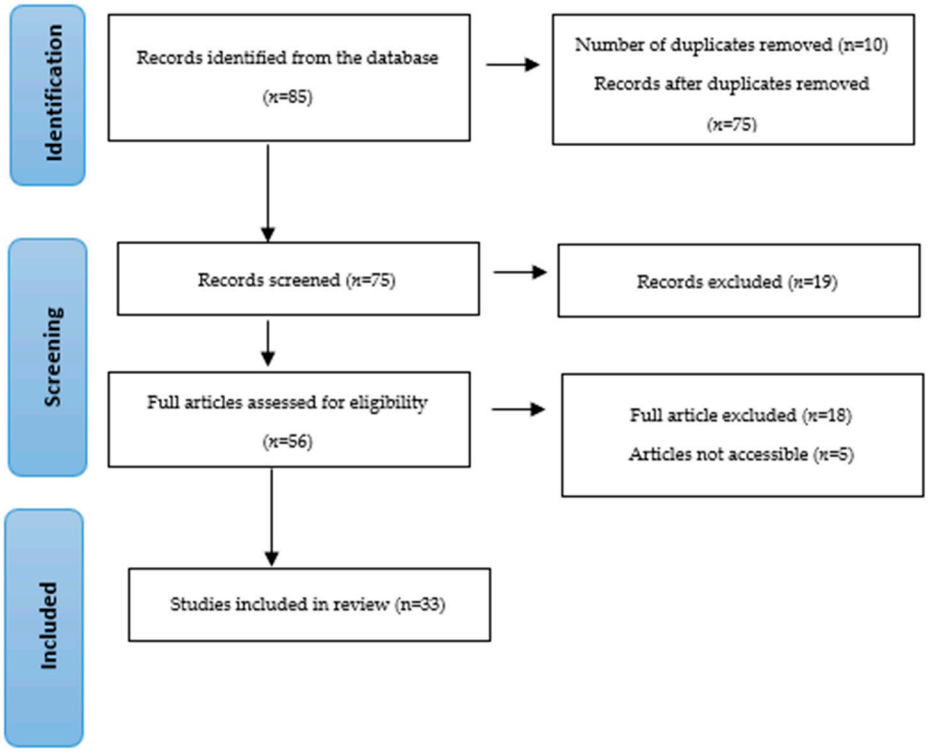

Figure 2. PRISMA flow diagram for new systematic reviews. Author original creative with reference from [14].

The inclusion criteria were focused on the titles, abstracts, and keywords that matched the predetermined terms in the first stage of the search. The researchers excluded 19 articles with a narrow focus and orientation on the topic, focusing on specific products of digital start-ups; the orientation of the research on the specific case, market, or region; articles not written in the English language; and the absence of inter-relationships with interdisciplinary research. After the screening, 56 articles remained that went through further screening

and included subjects or topics related to digital start-ups, entrepreneurship, or digital ecosystems. There were 38 articles remaining, of which five were not accessible, implying that 33 were considered for the systematic review.

Publication Themes Overview: The publications reviewed have been predominantly segmented into the following:

(a) Entrepreneurial Ecosystems,
(b) Developed Ecosystems,
(c) Startup Ecosystems Development (South Africa),
(d) Ecosystem,
(e) Startup.

These themes reflect the nature of the study, where ecosystem thinking in the form of digital entrepreneurship intersects with start-ups from both developed and developing startup ecosystems such as South Africa [5] (Figure 3).

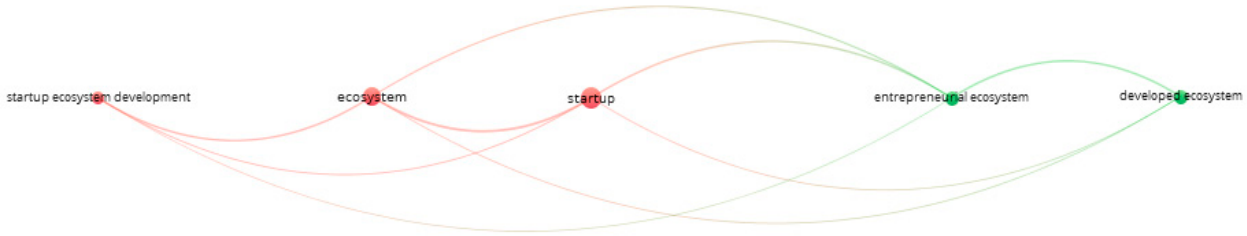

Figure 3. Visual Representation of Publication Themes. Author original creative with reference from [14].

3. Literature Review Results

3.1. The Contextual Framework of Digital Start-Ups

Digital technology start-up ecosystems are multifaceted community structures where entrepreneurs and their technology are the chief actors of the digital venture being created. Below in Table 1 is a systematic review summary of the examined literature that pertains to startup ecosystems. This demonstrates the multifaceted nature of the startup ecosystems in relation to the startup ecosystem under observation (South Africa).

Table 1. Systematic Review Summary Table. Author original creative with reference from [13,15,16,24,25].

Author and Country	Theoretical Framework	Field of Study	Summary of Titles	Study Aims	Main Results Findings
Barykin, Kapustina, Kirillova, Yadykin, Y.A. Konnikov (2020) [24], Russia	Theoretical Model	Entrepreneurial Ecosystems	Economics of Digital Ecosystems	Analysis of entrepreneurial ecosystems	Demonstration of Entrepreneurial ecosystems models and approaches
Malecki (2018) [15], United States of America	Theoretical Model and Approaches	Developed Ecosystems	Entrepreneurship and entrepreneurial ecosystems	Analysis of developed startup ecosystems	Demonstration of elements present in developed startup ecosystems
B. Ndemo, T. Weiss (2017) [26], Hikido (2018) [25], South Africa	Theoretical Model	Startup Ecosystems Development (South Africa)	Digital Entrepreneurship models in South Africa	Analysis of South Africa's startup ecosystem	Demonstration of models and elements present in South Africa's startup ecosystems

Table 1. *Cont.*

Author and Country	Theoretical Framework	Field of Study	Summary of Titles	Study Aims	Main Results Findings
Anwana, (2020) [13], South Africa	Theoretical Framework	Developing Startup Ecosystem	Enhancing the Entrepreneurship Framework in South Africa	Analysis of what makes up a developmental ecosystems	Demonstration of elements that make up an ecosystem
Cukier,. Kon (2018) [16], Brazil, Israel and United States of America	Theoretical Model	Startup	A Maturity Model for Software Start-up Ecosystems	Analysis of the startup environment	Demonstration of elements and models that make up a startup ecosystem

The digital entrepreneur operates within the start-up ecosystem, which is comprised of six main elements.

Technology-based entrepreneurship uses developments in science, computing, information, and communication technologies, or engineering, to create new products using innovation [13]. Additionally, technological firms disrupt the market by affecting job creation, wealth creation, and the development of entrepreneurial role models [13]. This is conducted by deploying their technology solutions into the market, which requires resources such as humans as well as other resources. If successful market adoption is realised, then economic benefits accrue to the entrepreneur. Digital start-ups exhibit these characteristics in the following manner: First, digital start-ups operate in different sectors and are distinguished by the digital technology and infrastructure brought into the business model. Secondly, digital start-ups follow service and business model innovations underpinned by technology. Third, digital start-ups leverage ecosystem architecture for competitive advantage. Lastly, digital start-ups support exponential scalability, such as new ventures [27]. Large enterprises implement open innovation models that allow them to co-create and collaborate with start-ups by leveraging their technology [28]. This provides start-ups with access to markets and plays a crucial role in the start-up ecosystem. Investors also play a key role in developing the start-up ecosystem by providing funding at different stages of the business, including pre-seed, seed, and series funding. High-net-worth individuals tend to provide funding at the pre-seed stage, while venture capital firms fund seed and series funding to help grow the business during the acceleration stage [29].

On the other hand, universities, research centres, and reputable companies provide information on technology and guide entrepreneurs through the technology transfer process. This is conducted by offering incubators and accelerators that train and equip start-up founders with the tools they need to succeed (see Table 2). Incubators are designed to help entrepreneurs validate their business concepts and ideas, while accelerators provide existing companies with funding, networking, and mentorship to develop their minimum viable product [30]. The national, regional, and local governments create an enabling environment for digital technology start-ups by providing tax incentives, talent attraction, ease of doing business, and fostering an investment and legal framework. This includes labour laws, tax laws, intellectual property, patents, and the protection of property rights that are crucial for building a thriving start-up ecosystem and attracting investment [31,32]. A comprehensive legal framework that addresses these elements is essential for fostering a thriving start-up ecosystem.

Table 2. The elements of a start-up ecosystem. Author original creative with reference from [24,29,33–36].

Start-Up Ecosystem Element	Description
Incubators and Accelerators	They help start-up entrepreneurs validate their business concepts and ideas, whereas accelerators provide existing companies (usually in the post-incubation stage) with the means to develop their minimum viable product. Additionally, accelerators provide digital technology start-ups with funding, networking, and mentorship. They play a crucial role in the start-up ecosystem by helping digital technology start-ups grow and scale [29].
Corporates	These are large enterprises and places with open innovation models that co-create and work with digital technology start-ups by leveraging their technology. Corporations are essential in the start-up ecosystem as they provide digital technology start-ups with market access [33].
Investors	Develop the start-up ecosystem. Start-up funding comes in different forms and at different stages of the business. Funding ranges from pre-seed, seed, and then series. High-net-worth individuals play a key role in the pre-seed stage of the start-up's development as they provide the capital for the start-up while it is being incubated. Venture capital firms fund seed and series funding to grow the business while the start-up is accelerating [34].
Government	National, regional, and local governments create an enabling environment for digital technology start-ups through tax incentives, talent attraction, ease of doing business, and fostering an investment and legal framework [35].
Legal Framework	Protection of property rights also determines how investors choose where to invest their funding for digital technology start-ups. A legal framework that includes but is not limited to these elements will be crucial to building a thriving start-up ecosystem [24]. It includes labour laws, tax laws, intellectual property, patents, and their associated bureaucracy.
Talent	Universities and reputable companies run incubators and accelerators that train and equip start-ups with methods to succeed [36]. Universities and research centres provide information on technology that empowers the start-up by preparing the entrepreneur and providing networking opportunities. Universities and research centres also guide entrepreneurs in the technology transfer process. Successful, knowledgeable entrepreneurs serve as guides for beginners.

Satalkina and Steiner [1] noted that digital start-ups are interactive systems that enhance individuals, organisations, regions, and countries. The start-up ecosystem's structural model is divided into four categories. Firstly, ecosystem community start-ups can be formed at the macro-level (network of institutions) or micro-level (one institution) and can be continental, sub-continental, global, regional, or national. On the other hand, the following dimensions can define start-ups: political, legal, and institutional; socio-cultural, economic, and financial; technological, ecological, and infrastructural [3,27]. The primary stakeholders of an ecosystem community are entrepreneurs, business angels, venture capitalists, service providers (legal and marketing), skilled employees, universities, the government, and start-up advisors [37]. Autio and Cao [5] added that community culture, cohesion, and identification are the three main elements determining digital start-ups' success. Second, for digital start-ups to function optimally, resources such as funding, human capital, and specialised services are required. Finance includes business angels, venture capitalists, and crowdfunding, whereas highly skilled personnel are required for human capital.

Regarding venture capitalists, large firms are essential in supporting start-up firms [27]. Third, knowledge creation and sharing within the ecosystem is essential for supporting business innovation; this can be generated through incubator programmes. Lastly, other conditions that should be met include enabling policies; therefore, policymakers should develop policies that encourage start-up establishment. For instance, Nigeria is number one in Africa, with many start-ups functioning well because of enormous funding from the government. Additionally, infrastructure for start-ups to function well is a crucial prerequisite; for example, South Africa is experiencing higher load shedding incidences, which impact digital start-ups' efficiency [3,27,38]. The effects of these inefficiencies include possible delays with the development of technology deployments as release schedules are

impacted by load shedding should staff and its customers do not have adequate back up power in place.

3.2. Stages of Digital Start-Ups

Most new businesses are created to evolve, starting with the invention of an idea; this development is a continuous process. The life cycle of a start-up business is divided into three stages: the early stage, the venture-funded stage, and the late stage. The number of employees may be as minimal as one or two at the early stage, and the primary focus is on bringing the product or service to the target market on a grander scale. If the founder of the start-up has minimal past business experience, the company will require accelerators to advance to this stage. However, due to the high risk involved, investors such as angels and venture capitalists are sceptical at this stage. On average, this phase, known as "ordination ally", can last two years [38–40]. Once the early stage is over, investors such as angels and venture capitalists are eager to fund the start-up, and assistance is directed towards team building to have sufficient capacity and infrastructure to support scaling up. At this stage, the start-up is expected to enjoy tremendous growth. The final stage is referred to as the "late stage", and it is at this point that the start-up has the financial means to support additional projects. Furthermore, the founder of the start-up company has the authority to appoint a Chief Executive Officer (CEO) to oversee the company's day-to-day operations. Recruiting highly skilled personnel is critical to the start-up's long-term success [38,40].

3.3. South African Start-Ups Ecosystems and Improvements Required

South Africa has a history of producing successful digital technology start-ups, especially in the fintech innovation sector [41]. However, the start-up ecosystem still faces many challenges. For instance, large corporations dominate, and issues such as inequality and gender disparities [25], limited access to market opportunities, a lack of financial and social capital [42], and monopolistic competition are the norm. These factors are barriers to entry for digital technology start-ups, and if not addressed, they will continue to hinder the growth of the ecosystem and prevent entrepreneurs from all backgrounds from excelling and scaling up. The research provides a contextual review of the business paradigms within the South African start-up ecosystem, which is crucial for understanding the underlying factors that affect the ecosystem.

Pantin and Lynnise [32] noted that inequality disparities still attenuate the capacity to foster a start-up ecosystem, as demonstrated by the challenges faced by would-be entrepreneurs seeking access to financial capital. Pantin and Lynnise's study suggested that a start-up's success pertains to having sufficient finance in place. Good cash flow, rather than innovative ideas, is more likely to ensure the success of a start-up. Friis-Healy, Nagy, and Kollins [42] argued that undercapitalised start-ups are often managed or owned by disadvantaged groups in South Africa. Research indicates that start-ups with white founders traditionally receive more funding than black-owned start-ups, which could be attributed to the social capital theory [32]. One way to sustain South African start-ups is to increase funding and opportunities via developmental financing institutions. By expanding access to capital and funding, entrepreneurship would become a default setting within the start-up community as business opportunities are more equally apportioned to everybody [32]. Additionally, creating mentorship programmes would be successful for one-way entrepreneurs, and even corporate organisations can be motivated to mentor those launching start-ups [43].

While most entrepreneurs need access to business planning, legal advice, capital, credit facilities, and even marketing expertise, disadvantaged entrepreneurs require access to human and social capital. Previous research suggested that social justice should be practiced for a successful start-up, coupled with education and training programs; this can address and balance existing inequalities [32]. In addition, these traditionally disadvantaged entrepreneurs could be provided access to business incubators, small business development centers, and business accelerators; these programmes can ensure that start-ups succeed

beyond the first year, mainly if support includes technology. For example, Lawrence [44] believes that start-ups with accelerator programmes can survive longer than those without. Another crucial form of support for start-ups is incubators. Non-profit organizations, universities, and other institutional bodies should be encouraged to mentor and even adopt previously disadvantaged entrepreneurs [32,43]. Accelerator programmes that are proactive towards technological advances and technology-based start-ups could actively recruit potential entrepreneurs for start-up programmes. Organisations with mentorship programs could target entrepreneurs who are women or people of color; governments can support such initiatives by offering tax incentives for organisations and venture capitalists that support start-up initiatives for disadvantaged population groups. Angel and venture capital investors could be attracted to such initiatives using tax credits and other financial vehicles to deliver critical resources to disadvantaged individuals and communities that possess entrepreneurial talent [41].

Capacity building for entrepreneurs is key; therefore, high school and university education should be improved to provide a pro-equality curriculum for all population groups, regardless of demographics, culture, and diversity. Current policies should be revised and encourage collaboration within public and private organizations, not as a form of political correctness but rather as a form of countering past wrongdoing and unfairness so that almost anybody can exploit market opportunities [41]. Additionally, well-developed start-ups should train emerging founders so that they gain hands-on experience in the daily management of the business. On the other hand, public and private organisations should invest in education by providing scholarships or subsidies to trigger and implement much-needed social change within South African communities [41]. This can ensure that start-ups in South Africa do not fail at the establishment phase [41].

3.4. Challenges Encountered by Start-Up Ecosystems

The global technology start-up ecosystem faces similar challenges to the South African start-up ecosystem. Newbert et al. [45] noted that social capital determines the success of digital technology start-ups and start-up ecosystems. Additionally, social capital emphasises the importance of access to funding for the survival of digital start-ups [46]. Previous research noted that regulations, support for entrepreneurship, and South Africa's connection to global start-up ecosystems are the main challenges hindering the scaling-up of South African ecosystems. Among these, the lack of local support for entrepreneurship ranked the highest (Table 3).

Table 3. Challenges facing the technology-based entrepreneurship ecosystem in South Africa. Source: Adapted from [13].

Description	Extreme (%)	Serious (%)	Moderate (%)	Slight (%)
To what extent is the regulatory environment to innovation?	23	35	24	18
To what extent is the lack of local connectedness and support an impediment?	56	25	13	6
To what extent is the South African entrepreneurship ecosystem globally connected	6	6	50	38

Digital technology start-up ecosystems face drawback elements, referring to items within the primary domain of the ecosystem enablers (i.e., government, investors) that, if removed, could help nurture and grow the start-up ecosystem (see Figure 4).

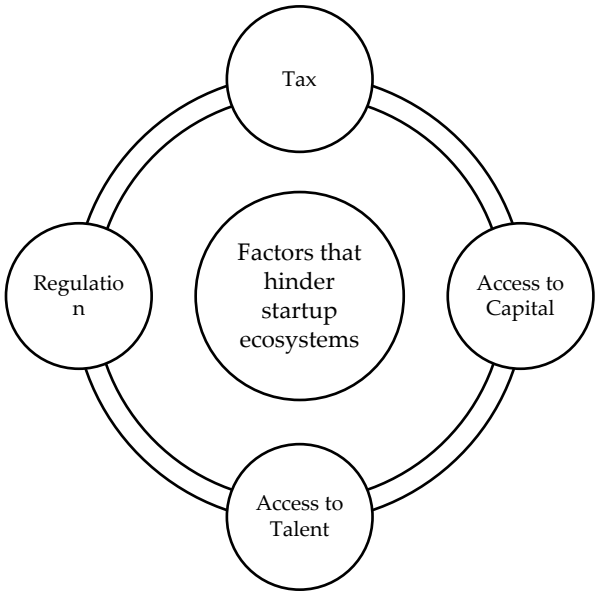

Figure 4. Factors that hinder the development of digital technology start-up ecosystems. Author original creative with reference from [13].

- Tax: Government: Provide tax breaks and incentives to encourage investment in digital technology start-ups by venture capital companies. Therefore, the government should establish a special tax dispensation for qualifying digital technology start-ups to increase their financial capital. Additionally, the government should make it easier for qualifying digital technology start-ups to register and administer Value Added Tax and Pay As You Earn Tax. This permits digital technology start-ups to save on taxes, and savings can be invested back into the business. On the other hand, the government should consider offering tax exemptions for angel investors and other investors as an incentive for investing in start-ups [13].
- Access to Financial Capital: Digital technology start-ups should have fair access to finance by reforming private and public lending practices. Hindering factors for start-ups trying to access capital include not being able to provide collateral and having an optimal credit history, so incentives must be put in place to assist start-up founders [47]. One way to achieve this is by offering incentives for capital contributions to early-stage funding entities that invest in qualifying digital technology start-ups. These incentives should be targeted towards angel investors and venture capital companies, as they have been identified as a source of funding currently underutilised for digital technology start-ups [12].
- Access to talent: Access to talent is essential for digital technology start-ups to grow and scale. Therefore, it is recommended that the government create a framework that allows for more flexible employment regimes, allowing digital technology start-ups to hire and terminate employees without facing negative consequences. The Unemployment Insurance Fund (UIF) should also provide financial guarantees for digital technology start-ups in case they decide to terminate employment contracts. Additionally, special visas (start-up visas) should be made available for talent from outside South Africa, making it an attractive destination for global talent to participate in the South African digital technology start-up ecosystem [13].
- Regulation: Regulatory barriers that impede globalisation and investment in qualifying digital technology start-ups should be removed. The South African Exchange Control Act, a legal framework, affects digital technology start-ups through restrictions on the movement of South African intellectual property offshore and limitations on the amount of money that can be moved offshore. Recommendations are that intellectual property transactions for exchange control purposes be linked with a reporting

framework rather than the current pre-approval model. This would make it easier for digital technology start-ups to access global markets and attract investment [13].

3.5. Start-Up Ecosystem Models, Theories, and Approaches

Understanding the variables that contribute to a start-up ecosystem's success or failure is aided by various conceptual frameworks, such as models, theories, and approaches. Appendix A (Tables A1–A4) present the social capital theory, the World Economic Forum's technique, and other five models (the Frankel and Maital Ecosystem Model, the Brad Fields Boulder Hypothesis Model, the Start-up Ecosystems Lifecycle Model, and the Triple Helix Model).

3.5.1. Social Capital Theory

Bandera and Thomas [46] defined "social capital" as having access to social networks or relationships that might help a start-up acquire access to growth opportunities (Figure 5). According to this theory, access to and use of social capital are critical components of the success of start-ups. Nonetheless, the theory has limitations, and it does not account for variables such as racial or gender identity [42]. Furthermore, the social capital theory is limited in developing start-up ecosystems [25], which may pose challenges in accessing digital resources and ensuring everyone is included (Figure 5).

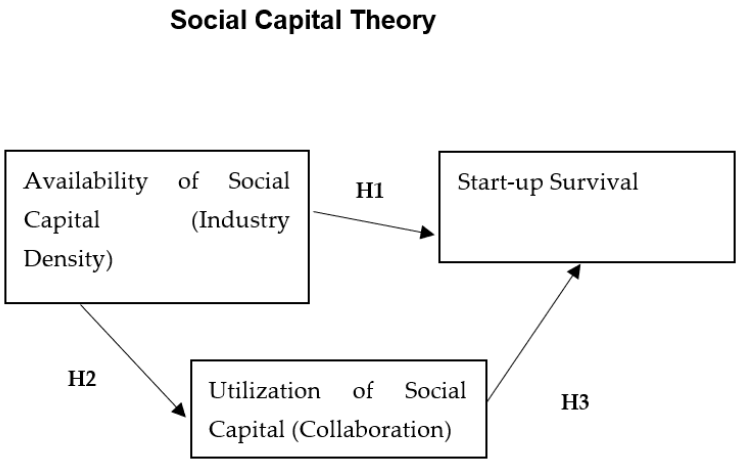

Figure 5. The social capital theory. Source: Reprinted with permission from ref. [46]. Copyright 2019, IEEE.

3.5.2. The World Economic Forum Approach

This approach outlines the essential components of entrepreneurial ecosystems, such as readily available markets, human capital employees, finance, a support system consisting of mentors and advisers, a regulatory framework and infrastructure, education or training, cultural support, and support for the arts. On the other hand, this approach does not consider any developmental factors such as digital access, digital inclusion, or the digital transformation of the public sector [48].

3.5.3. Frankel and Maital Ecosystem Model

This model defines twenty important features that serve as the foundation of a start-up ecosystem. These traits are classified as L1, L2, and L3, with more start-ups in an ecosystem allowing for more engagement and success. L1 represents the lowest range, while L3 represents the maximum. The key attributes of the model include exit strategies, global market access, entrepreneurship in universities, the number of start-ups, access to funding, and others (Table A1). Similarly, this model does not consider developmental aspects such as digital access and inclusion or the public sector's digital transformation. This framework should consider the main attributes and developmental features [48] to understand the environment [16,46] comprehensively.

3.5.4. The Brad Fields Boulder Hypothesis Model

This model covers four critical components of a thriving start-up community. These characteristics include the community being driven by entrepreneurs, being inclusive, delivering high-quality events, and having a long-term commitment from feeders such as the government, universities, service providers, and corporations (Table A2). However, this model does not account for the informal sector or the number of entrepreneurs or people employed in these informal sectors [16]. Both factors should be taken into account. A conceptual framework for digital developmental technology start-up ecosystems might be built by merging the models' major attribute aspects [49] with developmental elements such as digital access, digital inclusion, and digital transformation of the public sector [48]. This would be conducted to improve the models that have already been built.

3.5.5. Start-Up Ecosystems Lifecycle Model and Stangler and Bell-Masterson

The Start-up Ecosystems Lifecycle Model provides a metric attraction score that categorises ecosystem attractiveness into four categories: Emergence, Activation, Integration, and Maturity (Table A3). This score can be regarded as a measure of the ecosystem's overall attractiveness. One component of the attraction measure is the number of digital technology start-ups and giant technology corporations that relocate their headquarters to the ecosystem. Other factors include the number of subsidiary offices built by investors and the number of entrepreneurs that relocate to the ecosystem specifically to launch a start-up. The model gives valuable insights that can be applied to the research and development of a conceptual framework for developing start-up ecosystems. Some insights include prioritising international markets, leveraging cultural ties, and generating government investment matching funds. However, it does not consider ecosystems for building start-up enterprises, such as in developing start-up ecosystems [50]. This prevents it from delivering a complete picture. On the other hand, the Stangler and Bell-Masterson Model evaluates the vitality of start-up ecosystems by considering four fundamental aspects: density, fluidity, connection, and diversity. This model does not account for the changing economic specialisations of start-up ecosystems or the expanding tech sector in developing ecosystems [51]. Furthermore, this model excludes the emerging technology sector (Table A4).

3.5.6. The Triple Helix Model

According to the Triple Helix Model, the development of a start-up ecosystem depends on the collaboration and cooperation of public organisations, enterprises and industries, and universities (Table A4). This concept has been proposed to explain this connection. The confluence of these three elements acts as a catalyst for the expansion and maturation of new digital technology enterprises [26]. Nonetheless, this model ignores several essential factors for ecosystems that support the development of start-up businesses. In these ecosystems, for example, the involvement of the public sector in providing digital services and access to digital identities is critical for start-ups to have in order to use online services [52]. Furthermore, the model ignores the role of open innovation in bridging the gap between digital technology start-ups and larger businesses and industries. According to Manda and Backhouse [48], it is critical to consider the elements stated above while developing a conceptual framework model for a developmental start-up ecosystem.

4. Discussion

This study aimed to assess the factors hindering the development of South Africa's start-up ecosystems while also identifying frameworks or models that can be used to develop a thriving digital ecosystem and, lastly, the policy and practitioner implications. Most sustainable development goals (SDGs) are global strategic goals for development, especially for developing countries. For instance, SDG 4 calls for quality education; SDG 5 advocates for gender equality; SDG 8 calls for decent work and economic growth; SDG 9 calls for industry, innovation, and infrastructure; and SDG 10 calls for reduced inequalities. Regarding development, there is debate about whether South Africa is a developing or

developed country. Despite this, South Africa is classified as a developing country. The World Bank [52] explained that the country has a dual economy with the highest inequality rates and consumption expenditure, and the Gini coefficient was 0.63 in 2022, implying severe income disparity in the country. Interestingly, this is not ideal; start-ups can be crucial in reviving the South African economy [26].

Khatri [53] elucidated that start-ups can boost many nations' economic activity and maximise profits through technological innovations. Assumptions are that this will improve the economy's GDP through returns on investment. Moreover, start-ups use advanced technology; production efficiency and rendering services improve dramatically [54]. Other benefits of start-ups include encouraging competition amongst each other to prevent stagnation, new ideas brought by start-ups contributing to improving the standard of living for communities, and job creation [49].

Findings from the literature revealed that South African start-ups encounter numerous challenges, especially at the initial stage. These include regulatory barriers, skills shortages, a lack of funding, a digital infrastructure gap, poor diversity between start-ups and investor communities, and a minority of entrepreneurs and mentors with experience [12]. Below is a summary of that as well as the interventions required to address these challengers (Table 4):

Table 4. Summary of South Africa's Start-up Ecosystem Challenges and Interventions required. Author original creative with reference from [13,37].

Startup Ecosystem Element	Hindering Factors	Intervention Required
Incubators and Accelerators	Social Capital	Incubators and Accelerators can assist start-up founders by growing their social capital networks in order to attract financial capital [37].
Corporates	Access to Financial Capital	Digital technology start-ups should have fair access to finance by reforming private and public lending practices. One way to achieve this is by offering incentives for capital contributions to early-stage funding entities that invest in qualifying digital technology start-ups. These incentives should be targeted towards angel investors and venture capital companies, as they have been identified as a source of funding that is currently underutilised for digital technology start-ups [13].
Funding: Investors	Access to Financial Capital	Digital technology start-ups should have fair access to finance by reforming private and public lending practices. One way to achieve this is by offering incentives for capital contributions to early-stage funding entities that invest in qualifying digital technology start-ups. These incentives should be targeted towards angel investors and venture capital companies, as they have been identified as a source of funding that is currently underutilised for digital technology start-ups [13].
Government (Regulation)	Tax	The government provides tax breaks and incentives to encourage investment in digital technology start-ups by venture capital companies. Therefore, the government should establish a special tax dispensation for qualifying digital technology start-ups to increase their financial capital. Additionally, the government should make it easier for qualifying digital technology start-ups to register and administer Value Added Tax and Pay as You Earn Tax. This permits digital technology start-ups to save on taxes, and savings can be invested back into the business. On the other hand, the government should consider offering tax exemptions for angel investors and other investors as an incentive for investing in start-ups [13].

Table 4. *Cont.*

Startup Ecosystem Element	Hindering Factors	Intervention Required
Government (Legal Framework)	Regulation	Regulatory barriers that impede globalisation and investment in qualifying digital technology start-ups should be removed. The South African Exchange Control Act, a legal framework, affects digital technology start-ups in two main ways: restrictions on the movement of South African intellectual property offshore and limitations on the amount of money that can be moved offshore. Recommendations are that intellectual property transactions for exchange control purposes be linked with a reporting framework rather than the current pre-approval model. This would make it easier for digital technology start-ups to access global markets and attract investment [13].
Talent	Access to Talent	Barriers and bureaucratic red tape that hinder access to skilled talent should be removed. Access to talent is essential for digital technology start-ups to grow and scale. Therefore, it is recommended that the government create a framework that allows for more flexible employment regimes, allowing digital technology start-ups to hire and terminate employees without facing negative consequences. The Unemployment Insurance Fund (UIF) should also provide financial guarantees for digital technology start-ups in case they decide to terminate employment contracts. Additionally, special visas (start-up visas) should be made available for talent from outside of South Africa, making it an attractive destination for global talent to participate in the South African digital technology start-up ecosystem [13].

In addition to the interventions identified, the study also identified seven models or theories that measure a start-up ecosystem. These models/theories also link back to the challengers and start-up ecosystem elements. Limitations exist with these models and theories in terms of their applicability to developmental start-up ecosystems such as South Africa. For example, these theories/models do not consider inequality and gender issues, a lack of digital access and inclusion, or the role of the public sector in the digital transformation process [48]. These are factors that play a role in the development of a digital start-up ecosystem [55]. (Tables A1–A4) note these factors. It is recommended that developmental start-up ecosystems such as South Africa benefit from the adapted view identified through this study on these models and theories and thus further apply local attributes to enhance their ecosystems' development [18]. The study also identified the following policy and practitioner implications (Table 5):

Table 5. Policy and Practitioner Implications. Author original creative with reference from [56–58].

Startup Ecosystem Element	Hindering Factor	Policy Implication	Practitioner Implication
Government (Regulation: Funding: Investors	Tax/Access to financial Capital	Section 12J of the Income Tax Act was introduced on 1 July 2009 by the South African government, creating an incentive for taxpayers to invest in qualifying venture capital companies (VCCs) in return for an income tax deduction equal to the amount invested. The introduction of this act led to the inflow of funds into South Africa's start-up ecosystem by venture capital companies [56]. With access to funding being a hindering factor [13], the introduction of this policy had a positive impact on the South African start-up ecosystem. The 12J Income Tax Act was placed into sunset by the South African government, ending effectively on 31 July 2021. This then negatively impacted access to funding for South African start-ups [56].	Section 12J of the Income Tax Act had a positive impact on start-up practitioners such as venture capital companies. Venture capital companies had the ability to attract funding from high-net-worth individuals, who were then incentivised to invest with venture capitalists as they would receive tax breaks [56].
Government (Regulation: Talent	Talent	The introduction of a Start-up Act, as introduced by other developing and developed start-up ecosystems globally, has the ability to attract talent into the start-up ecosystem [57]. This has not been the case for South Africa, as a similar act has not been implemented. This must, however, be balanced with the implications of high unemployment in South Africa, and thus a good combination might be to have incentives in place to train up local talent while still having access to a global talent pool.	The delay in the implementation of the South African Start-up Act is making it challenging for start-up practitioners and ecosystem stakeholders such as start-up founders to attract the best talent for their start-up from the global talent pool [58].

5. Summary and Conclusions

This study explored the relationship between the proliferation of digital technology and the expansion and growth of digital start-up enterprises in various parts of the world, focusing on South Africa [49]. The findings reveal that digitalisation remains a catalyst for the growth of digital start-ups as it transforms entrepreneurial and business models [59]. The study also stressed the importance of digital start-up ecosystems, described as environments in which all-essential parties participate in creating and developing new technology enterprises [60].

South Africa is home to the most established start-up ecosystem in Africa, with a strong fintech sector [61]. Most of the start-up activities centred on Cape Town and Johannesburg, respectively [62]. Furthermore, digital start-ups in South Africa have created job opportunities, significantly contributing to the country's economic growth [63].

For South Africa's start-up ecosystem to develop further, its stakeholders must prioritise the adoption of digitalisation plans aligned to the ecosystem's specific needs, combined with putting intervention plans in place to address the hindering factors [13]. The intervention measures could include increasing investment in resources (i.e., financial funding, talent, and digital economic infrastructure [51]), support and acceleration programmes that are inclusive [37], and the creation of an environment favourable to the growth of digital start-ups (i.e., a favourable legal and regulatory framework) [13]. These measures align with the United Nations Sustainable Development Goals (SDGs) 4, 5, 8, 9, and 10, as noted under the discussion section of the paper, as they all contribute to the development

of the digital economies and start-up ecosystems of the Global South. The Global South comprises start-up ecosystems from Africa, Asia, and Central and South America. These developmental start-up ecosystems have attributes similar to South Africa's, such as a deficient digital infrastructure that exists due to low levels of low-cost and reliable access to the internet, especially amongst its low-income demographic population. Attributes such as these are key to growing an inclusive digital economy as start-ups develop solutions used by these users, and should users lack the means to access these services, then the growth of these start-ups might be impacted [10].

The study also identified the importance of the coming together of all ecosystem stakeholders in both the public and private sectors as a collective to address the developmental factors identified in the study [64]. This collective effort will assist the South African start-up ecosystem in developing and growing in an inclusive manner.

Theoretical Implications of the Study: The study identified a literature gap that existed with existing research on the study of start-up ecosystems. Existing literature does not necessarily include elements that impact developmental start-up ecosystems, and thus, through this research study, a holistic model has been developed that includes elements that impact both developed and developmental start-up ecosystems. Researchers can now, for future studies, refer to or cite this model and build on it for further research studies on start-up ecosystems.

Practical Implications of the Study: The research study provides South Africa's start-up ecosystem stakeholders with a guide on how to address key hindering factors impacting South Africa's start-up ecosystem. And if addressed, it could help South Africa's start-up ecosystem grow. The study also serves as a practical guide for other developmental start-up ecosystems globally on start-up elements and factors that require consideration in order to grow.

6. Research Limitations

While the research conducted on the relationship between digital technology proliferation and the growth of digital start-up enterprises in South Africa provides valuable insights, it is essential to acknowledge certain limitations that may affect the interpretation and generalisation of the findings. Here are some research limitations for this study:

Time Constraints: Research is often constrained by time limitations. The study's data may not fully capture the long-term effects of digital technology proliferation on digital start-up ecosystems, as technological trends and ecosystem dynamics can change rapidly [19].

Language and Cultural Barriers: The study may have overlooked language and cultural barriers that could affect the development and growth of digital start-ups, both in South Africa and other regions. This could be explored for future research [65].

Overemphasis on Positive Outcomes: The research appears to focus primarily on positive aspects of digitalization for start-up ecosystems. It may not fully address the potential negative consequences or unintended effects of technological proliferation [66].

Bias in Theoretical Model Development: The theoretical model developed in the study might be influenced by the authors' biases or assumptions. It is essential to be critical of any preconceived notions that may have shaped the model [67].

Dynamic Nature of Ecosystems: Start-up ecosystems are constantly evolving and influenced by various external factors, economic conditions, and government policies. The study may not capture all the complexities and changes in the ecosystem over time [68].

Limited Scope of Sustainable Development Goals (SDGs): While the study aligns the intervention measures with specific SDGs, it might not consider the full spectrum of sustainable development goals that could have implications for start-up ecosystems [69].

Lack of Comparative Analysis: The study does not compare South Africa's start-up ecosystem with other countries or regions, which could provide valuable insights into best practises and potential areas for improvement [70].

Despite these limitations, the research study offers valuable contributions to the understanding of digital start-up ecosystems in South Africa and can serve as a foundation for future research in this area. Researchers and stakeholders should consider these limitations while interpreting the findings and using them to inform practical interventions.

7. Future Research

As noted under the theoretical implications of the study, the research study examined academic literature on start-up environments. The findings revealed a scarcity of academic literature on developmental start-up ecosystems and models or theories that account for developmental characteristics. The research identified developmental and impedimental elements that can now be evaluated, adding to the existing global body of knowledge on studying start-up ecosystems. This new information improves our understanding of the start-up ecosystem domain and can be utilised to assist in building start-up ecosystems. The study identified seven theories, models, or approaches (Figure 6). Most of these theories present some drawbacks. For example, the social capital theory does not consider gender inequality, a pervasive problem in South Africa [42].

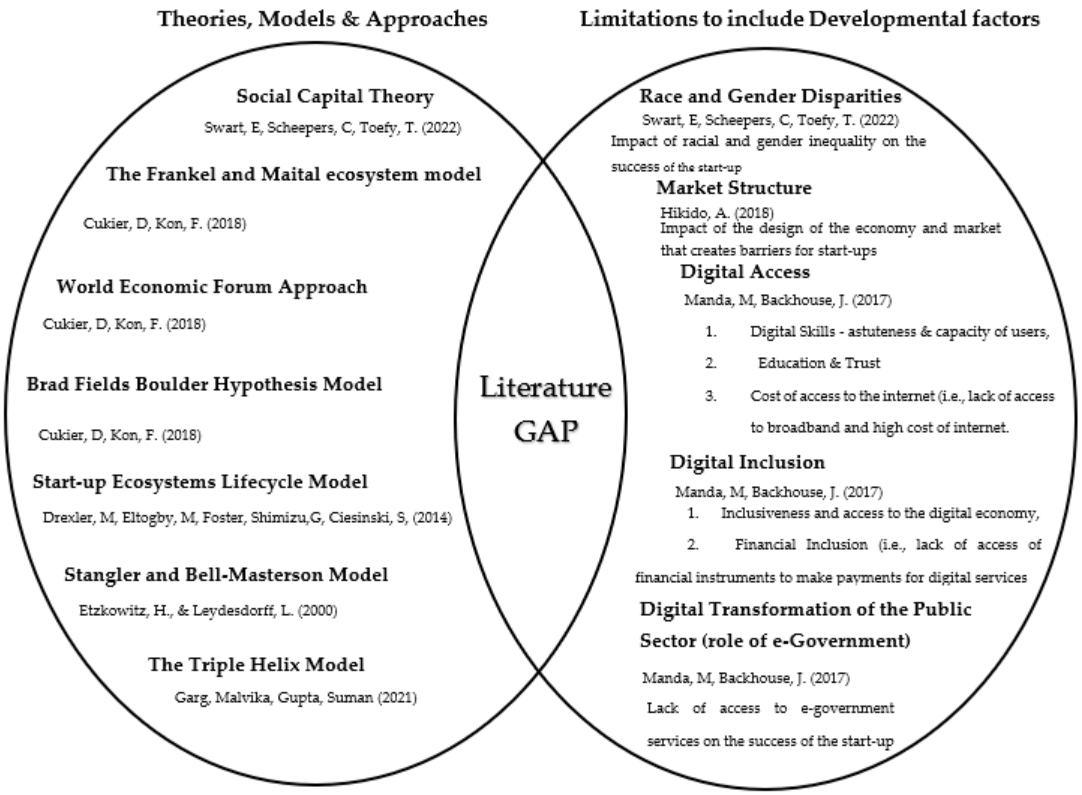

Figure 6. Holistic Model with Developmental Factors Included. Author original creative with reference from [16,26,32,51,52].

Therefore, future research should focus on developing a model that will consider common challenges faced by other developmental start-up ecosystems on the African continent and beyond (the Global South). In addition, expanding on the gaps identified and presented by existing models, theories, and approaches (Figure 6) will be another research area of interest. The development of a holistic model that considers developmental factors (i.e., race and gender, market structure, and digital access) that impede the growth and scaling-up of start-up firms will also be a research area of interest. Details of the major components to be considered in the holistic model are presented in Figure 6.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su151612513/s1.

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Appendix A

Table A1. Summary of key attributes and limitations of the Social Capital Theory and Frankel and Maital ecosystem model.

Models	Context	Key Attributes	Limitations and Areas for Improvement
Social Capital Theory	It states that the start-up's survival includes the availability and utilisation of social capital, including having access to social networks or relationships that can assist the start-up in unlocking growth opportunities [64].	Factors in the theory include [64]: Availability of social capital; Utilisation of social capital; Start-up survival.	Lack of factors such as race and gender will form part of the availability of social capital factors. The SA start-up ecosystem faces challenges due to a lack of social capital [61], which should be considered in the conceptual framework to be developed.
The Frankel and Maital ecosystem model	The model refers to 20 key attributes and foundational elements for a start-up ecosystem. The model segments these key attributes into L1, L2, and L3 [64]. The larger the number of start-ups in an ecosystem, the more they can engage with each other and other actors within the ecosystem, thus improving their chance of success. As these start-ups grow and become scale-ups, their reliance on other start-ups and the key attribute in the model diminish [64].	Factors in the model include [64]: Exit strategies; global market; Universities; # of start-ups; access to funding; mentoring; bureaucracy; tax burden; incubators; accelerators' quality; High-Tech Companies Presence; Established Companies Influence; Human Capital Quality; Cultural values for Entrepreneurship; Technology Transfer Process; Methodologies Knowledge; Specialised Media Players; Ecosystem Data and Research; Ecosystem Generations.	Lacks digital access: Digital Skills; astuteness and capacity of users; Education and Trust; Cost of access to the internet (i.e., lack of access to broadband and high cost of mobile data]; Lacks digital inclusion: Inclusiveness and access to the digital economy; Financial Inclusion (i.e., lack of access to financial instruments to make payments for digital services) Lacks digital transformation of the Public Sector *(role of e-Government)*: i.e., access to e-government services to get online and digital services (i.e., Digital identity).

Table A2. Summary of key attributes and limitations of the World Economic Forum Approach and Brad Fields Boulder Hypothesis model.

Models	Context	Key Attributes	Limitations and Areas for Improvement
World Economic Forum Approach	The new model considers key pillars of entrepreneurial ecosystems, specifically available markets, human capital personnel, funding, mentor and advisor support systems, regulatory framework and infrastructure, education/training and cultural support [64].	Factors in the model include [64]: Markets; Human capital personnel; Funding; Mentors and advisors; Regulatory framework; Infrastructure; Education/training and cultural support	Digital Access; Digital Inclusion; Digital Transformation of the Public Sector (role of e-Government)

Table A2. *Cont.*

Models	Context	Key Attributes	Limitations and Areas for Improvement
Brad Fields Boulder Hypothesis Model	Identifies four essential features of a thriving start-up community: It must be directed by entrepreneurs and not by other significant players such as the government, universities, service providers, and corporations. The field mentions that these are feeders with which the leaders (entrepreneurs) must establish a long-term commitment. The start-up ecosystem community must be inclusive and offer high-quality events to engage people, especially acceleration programmes and mentoring sessions [64].	Factors in the model include [64]: The number of entrepreneurs and people working for start-ups or high-growth companies is divided by the adult population.	Factors that the model does not consider are the following [25]: Development start-up ecosystems also include the informal sector. Thus, the number of these entrepreneurs and people working in these informal sectors should also be taken into consideration [25].

Table A3. Summary of key attributes and limitations for the Start-up Ecosystems Life Cycle Model.

Models	Context	Key Attributes	Limitations and Areas for Improvement
Start-up Ecosystems Lifecycle Model	It is premised on a metric attraction score that measures the attractiveness of the ecosystem. The attraction metric then segments start-up ecosystems into four key categories: Emergence, Activation, Integration, and Maturity [64].	The attraction metric includes # of [64]: start-ups and larger tech companies that move their headquarters to the ecosystem; secondary offices opened by investors that are headquartered outside the ecosystem; entrepreneurs who move to the ecosystem before starting a start-up and specifically for this purpose; secondary offices opened by start-ups and larger tech companies that are headquartered outside the ecosystem. Secondly, it offers excellent research insights, including [64]: Prioritisation of foreign markets (scale opportunities) for start-up entrepreneurs; Financial support by the start-up ecosystem to attract new entrepreneurs; Leverage cultural relationships to strengthen the start-up ecosystem (i.e., a Jewish support system that provides support to Jews across different start-up ecosystems); Start-up ecosystem collaborations (local ecosystems supporting each other); Growth Centre of Expertise: Beyond traditional mentorship, the start-up ecosystem requires professional growth services to assist start-ups in its ecosystem; Government investment marching funds: Creation of incentives to match angel funding.	Developmental start-up ecosystems (such as Africa) into consideration. It is key to a holistic depiction of the completeness of the model. Regarding the driving factors to create a start-up ecosystem as articulated in the model [17], these can include [25]: -*Digital Access*: Based on the attraction metric, ecosystem stakeholders must provide start-ups with assurances that policies and measures will be put in place to provide greater digital access to users) [25]. -*Digital Inclusion*: Based on the attraction metric, ecosystem stakeholders must provide start-ups with assurances that policies and measures will be put in place to provide greater digital inclusion [25]. -*Digital Transformation of the Public Sector* (role of e-Government): Based on the attraction metric, ecosystem stakeholders must provide start-ups with assurances that the government will put policies and measures in place to provide access to e-government services to users [25].

Table A4. Summary of key attributes and limitations for the Stangler and Bell Marterson Model and the Triple Helix Model.

Models	Context	Key Attributes	Limitations and Areas for Improvement
Stangler and Bell-Masterson Model	The model is based on key attributes that measure start-up ecosystem vibrancy [64]. They include Density, Fluidity, Connectivity, and Diversity	The model factors include [64]: -Density: Measurement of new start-ups per 1000 people, the share of employment of new start-ups, and sector density; -Fluidity: Measurement of population flux, labour market reallocation, and high-growth start-ups; -Connectivity: Measurement of programme connectivity, spin-off rate, and dealmaker networks; -Diversity: Measurement of multiple economic specialisations, mobility, and immigrants.	Factors do not consider the following: -Density: Developmental start-up ecosystems have an emerging tech sector; thus, this is a key element to be considered for developmental ecosystems. [25] -Diversity: Due to the developmental nature of developing start-up ecosystems, diversity in terms of economic specialisation must be considered. The model should also consider the impact of mobility and immigration on developmental start-up ecosystems [25].
The Triple Helix Model	The model is based on key attributes that link public organisations, companies/industries, and universities [64]. It highlights the importance of these elements in supporting the start-up ecosystem.	The model includes [64]: -Public organisations: These institutions provide policy formation, support, and financing to start-ups; -Companies/Industries: These are organisations that provide product development, service development, and venture development; -Universities: These organisations provide research and development, education, and incubation.	Factors do not consider the following [25]. -Public organisations: The public sector's role in providing digital services is vital in developing start-up ecosystems. Access to digital identities makes access to online services provisioned by start-ups more accessible [49]. -Companies/Industries: The model does not expand on the role of open innovation in bridging the gap between start-ups and corporations [49].

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