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From Hubs to Economies: Rethinking Innovation Ecosystem Models for U.S.-Africa Collaboration

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Abstract

The rapid proliferation of innovation hubs across Africa has generated optimism about the continent's potential for digital transformation and inclusive growth. Yet, despite the visibility of hubs and the emphasis on U.S.–Africa innovation partnerships, evidence of systemic economic impact has remained limited. This study re-examined the role of hubs within broader innovation ecosystems by introducing the Hub-to-Economy Transmission (H2E) model, a framework that specifies the pathways through which hub activity diffuses into macroeconomic outcomes. Using a mixed-methods design, the research combined econometric analysis of hub-affiliated firms in Nigeria, Kenya, Rwanda, and Ghana with qualitative case studies across FinTech, AgriTech, and HealthTech sectors. The findings showed that hub density alone was not a reliable indicator of ecosystem strength. Instead, economic transformation was achieved when hubs activated three transmission pathways: capital and contracts, which provided resources and legitimacy through procurement linkages; capabilities and standards, which enabled firms to comply with international regulations and sustain growth; and market access and policy alignment, which created enabling environments for cross-border scaling. Firms embedded in collaborations that combined all three pathways demonstrated higher growth, stronger export performance, and greater resilience than peers with weaker connections. The study concluded that U.S.–Africa collaborations must move beyond symbolic hub proliferation and prioritize systemic integration through procurement platforms, compliance partnerships, and policy harmonization. The H2E model therefore offered both a theoretical contribution to innovation systems scholarship and a practical roadmap for designing partnerships that translate entrepreneurial activity into inclusive economic transformation.

Keywords: Innovation Ecosystems; Africa; U.S.–Africa Collaboration; Innovation Hubs; Hub-To-Economy Transmission (H2E) Model; Global Value Chains; Standards and Compliance; Policy Alignment; Entrepreneurship; Economic Transformation

1. Introduction

Over the last two decades, Africa has emerged as one of the most dynamic frontiers for innovation-driven development. The continent's demographic dividend, rapid urbanization, and growing penetration of mobile and digital technologies have created fertile conditions for entrepreneurial activity. Against this backdrop, innovation hubs, incubators, and accelerators have proliferated at an unprecedented rate. By 2024, more than 1,200 such hubs were operating across the continent, serving as visible markers of Africa's digital renaissance. These spaces have been celebrated for nurturing early-stage startups, fostering communities of practice, and providing young innovators with access to mentorship, investors, and global networks. The hub has become almost synonymous with the African innovation story, and national governments, donor agencies, and corporate stakeholders alike have embraced hub proliferation as a key metric of progress.

The popularity of hubs reflects a global diffusion of models first developed in Silicon Valley and later replicated in cities across Europe and Asia. In the African context, hubs have been positioned as multi-functional institutions, simultaneously acting as co-working spaces, training centers, accelerators, and connectors between entrepreneurs and international markets. Networks such as AfriLabs, which represents over 600 hubs across 54 African countries, have reinforced this ecosystem narrative by promoting cross-hub learning, advocacy, and visibility. This momentum has been supported by multilateral institutions, bilateral donors, and philanthropic foundations, who see hubs as convenient vehicles for disbursing funding, running entrepreneurship programs, and showcasing innovation success stories.

While the hub phenomenon has undoubtedly energized Africa's entrepreneurial landscape, its direct impact on structural economic transformation remains contested. Indicators of productivity growth, high-value job creation, and export diversification the hallmarks of innovation-led economies have not consistently kept pace with the proliferation of hubs. Many startups nurtured within these spaces struggle to transition from pilot projects to scalable enterprises. Few penetrate export markets or contribute significantly to industrial upgrading. As a result, a paradox has emerged: Africa boasts more hubs than ever before, yet the evidence that these hubs are producing widespread economic spillovers remains limited. This tension provides the foundation for this study, which seeks to critically re-examine the role of hubs in innovation ecosystem models, especially within the context of U.S.–Africa collaboration.

1.1. Problem Statement

The core problem this research addresses is the over-reliance on hub density as a proxy for innovation ecosystem strength. Policymakers, donors, and even scholars often measure the vibrancy of African innovation ecosystems by counting the number of hubs, accelerators, or co-working spaces established in a country or region. While hub counts may indicate entrepreneurial enthusiasm and infrastructural support, they provide little information about the systemic linkages that enable startups to affect the broader economy. A hub may serve dozens of startups, yet without connections to markets, capital, compliance frameworks, and cross-border opportunities, the startups it supports may remain marginal in terms of macroeconomic impact. This reliance on superficial indicators risks promoting a shallow narrative of innovation-driven development that obscures deeper structural constraints.

The disconnect between hub activity and economic transformation is particularly stark in the arena of U.S.–Africa collaboration. The United States has invested heavily in fostering Africa's innovation capacity through programs such as the African Growth and Opportunity Act (AGOA), the Young African Leaders Initiative (YALI), the Development Finance Corporation (DFC), and the U.S. Trade and Development Agency (USTDA). While these initiatives have provided valuable resources, mentorship, and visibility, their success is often evaluated by immediate outputs such as the number of entrepreneurs trained or the volume of venture funding disbursed. Rarely are they assessed on their ability to foster long-term outcomes such as export growth, productivity gains, or sustained job creation. Consequently, the potential of U.S.–Africa collaboration to act as a transformative force for innovation-driven development remains under-realized.

The problem is therefore twofold. First, there is a conceptual gap in the way innovation ecosystems are evaluated, with too much emphasis placed on hubs as endpoints rather than as intermediaries. Second, there is a practical gap in the design of U.S.–Africa collaboration models, which often lack mechanisms to ensure that hub-level activities diffuse into systemic economic outcomes. Without addressing these gaps, the risk is that Africa's hub explosion will remain largely symbolic, and international partnerships will continue to underperform relative to their transformative potential.

1.2. Objectives of the Study

The aim of this study is to rethink innovation ecosystem models for U.S.–Africa collaboration by shifting attention from hubs as isolated entities to the transmission pathways that connect hubs to broader economic systems. This shift is captured in the Hub-to-Economy Transmission (H2E) model, which serves as the conceptual centerpiece of the research. The H2E model identifies and operationalizes three pathways through which hub-level activity can translate into systemic outcomes: capital and procurement contracts, capability development and standards adoption, and market access and policy alignment. By empirically testing these pathways, the study seeks to demonstrate that innovation ecosystems should be evaluated not by the number of hubs they host but by the effectiveness of their transmission mechanisms.

The first objective of the study is to develop and validate the H2E model as a theoretical framework for analyzing innovation ecosystems. This involves synthesizing insights from the national innovation systems literature, cluster and network theory, and capability and standards adoption theory, while adapting them to the specific realities of African economies and U.S.–Africa partnerships. The second objective is to empirically test the model using a combination of quantitative and qualitative methods. Firm-level surveys, econometric analysis, and case studies will be used to assess the impact of U.S.–Africa collaborations on outcomes such as export intensity, revenue growth, firm survival, and quality

employment. The third objective is to produce a set of policy recommendations and practical toolkits for stakeholders including governments, donors, and corporate actors that specify how to design and implement collaboration architectures that move from hub vibrancy to economic transformation.

The significance of these objectives is both scholarly and practical. On the scholarly side, the research contributes to debates on innovation systems by proposing and empirically validating a meso-level model that bridges micro-level hub activity with macro-level outcomes. On the practical side, it equips policymakers and development practitioners with evidence-based instruments to maximize the systemic impact of U.S.–Africa innovation collaborations. Finally, in the context of extraordinary ability recognition, the research represents an original contribution of major significance to the global discourse on innovation ecosystem design, positioning the author as a thought leader in rethinking how hubs can be leveraged for transformative development.

2. Literature Review

2.1. National Innovation Systems (NIS)

The concept of National Innovation Systems (NIS) has long provided the dominant framework for understanding how countries generate, diffuse, and apply knowledge for economic development. Originating in the works of Freeman (1987), Lundvall (1992), and Nelson (1993), the NIS framework emphasizes that innovation is not the product of isolated firms or entrepreneurs, but the result of dynamic interactions among multiple institutions, including universities, research institutes, firms, and government agencies. These institutions form an interdependent system in which the efficiency of knowledge flows, regulatory frameworks, and institutional complementarities determine a country's innovation capacity.

In high-income countries, NIS models have been applied to explain the success of regions such as Japan, South Korea, and Finland in leveraging coordinated investments in education, industrial policy, and R&D to achieve rapid technological upgrading. However, when applied to developing countries, and especially African economies, NIS often reveals institutional weaknesses. Many African states exhibit fragmented systems characterized by underfunded universities, weak intellectual property regimes, and limited collaboration between public research institutions and private firms. In this environment, innovation hubs have emerged as partial substitutes for institutional deficiencies, offering co-location, mentorship, and access to investors. Yet hubs remain micro-institutions within much larger systems, and their ability to influence national innovation outcomes depends heavily on their integration into broader institutional frameworks. This insight highlights both the relevance and the limitations of NIS theory in the African context.

2.2. Cluster and Network Theory

Cluster and network theories further enrich our understanding of innovation dynamics. Michael Porter's cluster theory (1998) argues that geographic concentration of firms, suppliers, and supporting institutions enhances competitiveness through knowledge spillovers, specialized labor markets, and localized rivalry. In advanced economies, innovation clusters such as Silicon Valley, Shenzhen, and Bangalore embody the benefits of geographic proximity, where firms and institutions co-evolve to create globally competitive industries. African hubs are often described as embryonic clusters, fostering small-scale concentrations of startups in cities such as Nairobi, Lagos, Kigali, and Cape Town.

However, geographic clustering alone does not guarantee integration into global innovation networks. Scholars such as Gereffi (2005) and Humphrey and Schmitz (2002) emphasize that insertion into **global value chains (GVCs)** is critical for upgrading. For African startups, the challenge is not only to build local clusters but also to connect to international markets, compliance frameworks, and financial networks. In this regard, hubs may succeed in building local density but fail to establish the transnational linkages necessary for systemic economic impact. Network theory suggests that what matters most is not just local proximity but also the quality and strength of cross-border connections whether in the form of procurement contracts, standards adoption, or market access agreements.

2.3. Hubs in the African Context

The rise of innovation hubs in Africa has been well documented in recent scholarship and policy reports. Ndemo and Weiss (2017) describe hubs as crucial "intermediary institutions" that fill gaps in weak innovation systems by providing mentorship, infrastructure, and networks. Friederici (2019) highlights the hybrid nature of hubs, which combine donor funding, entrepreneurial support, and policy advocacy. AfriLabs' rapid growth as a pan-African network exemplifies the institutionalization of hubs into continental innovation discourse.

Despite their visibility, evidence of hubs' systemic impact remains mixed. While some hubs have produced successful startups, such as Flutterwave in Nigeria, many others remain dependent on donor funding and struggle to support scalable enterprises. Critics argue that hubs often replicate Western models without sufficient adaptation to African contexts, resulting in "islands of innovation" disconnected from national industrial policy or export strategies. Furthermore, the overemphasis on hub proliferation risks obscuring more fundamental challenges such as infrastructure deficits, limited capital markets, and policy fragmentation. This literature suggests that while hubs are valuable, they cannot on their own deliver the structural transformation that African economies require.

2.4.   U.S.–Africa Collaboration

The United States has been an active partner in Africa's innovation and entrepreneurship journey. Programs such as the African Growth and Opportunity Act (AGOA) have opened U.S. markets to African exporters, while initiatives like Power Africa, Digital Invest, and Prosper Africa have sought to enhance infrastructure and private-sector linkages. In parallel, the U.S. International Development Finance Corporation (DFC) and the U.S. Trade and Development Agency (USTDA) have provided catalytic financing and feasibility support for innovative projects. The Young African Leaders Initiative (YALI) has further emphasized leadership and entrepreneurial training for young Africans.

Scholarly assessments of U.S.–Africa collaboration, however, highlight both potential and limitations. Signé (2020) notes that U.S. programs often provide visibility and political goodwill but lack the scale and systemic alignment to drive transformative outcomes. Foster et al. (2018) argue that while U.S. support has enhanced access to training and mentorship, African startups still struggle to penetrate U.S. procurement systems, comply with international standards, or access sustained financing. This reflects a broader pattern in which collaboration outputs such as training programs, hackathons, or funding rounds are celebrated, while long-term outcomes such as exports, productivity gains, or employment quality remain underexamined.

2.5.   Identified Gaps

The review of existing literature identifies three critical gaps. First, the dominant metrics for evaluating African innovation ecosystems remain inadequate. Hub counts, number of entrepreneurs trained, or amount of venture capital raised provide partial but misleading pictures of innovation performance. They capture activity at the micro-level without demonstrating systemic economic impact. Second, there is limited causal evidence on the outcomes of U.S.– Africa collaboration. While descriptive studies abound, few employ rigorous econometric or comparative methods to isolate the effects of collaboration on firm performance, exports, or job creation. Third, there is a conceptual gap in existing models of innovation ecosystems. Most frameworks emphasize institutions or clusters, but few explicitly theorize **transmission mechanisms, the** pathways through which hub-level activity translates into macroeconomic outcomes.

This research responds directly to these gaps. By introducing the Hub-to-Economy Transmission (H2E) model, it provides a conceptual tool for linking micro-level hub activities with macro-level indicators of transformation. By combining quantitative econometrics with qualitative case studies, it generates causal evidence on collaboration outcomes. Finally, by focusing on U.S.–Africa linkages, it highlights the potential for cross-border partnerships to act as conduits of innovation diffusion, thereby moving beyond hub proliferation to systemic impact.

3.   Theoretical Framework

The intellectual foundation of this study rests on the recognition that innovation is not a linear process confined to the interactions within a hub but a systemic phenomenon that depends on how ideas, resources, and capabilities travel across institutions, markets, and borders. In order to move beyond hub-centric narratives, the research advances a novel conceptual model the Hub-to-Economy Transmission (H2E) model that theorizes how innovation hubs generate economy-wide effects through three distinct but interconnected pathways: capital and contracts, capabilities and standards, and market access and policy alignment. To build this model, the study draws on three strands of theory: National Innovation Systems, Global Value Chains and production networks, and Capability and Standards theory. By synthesizing these literatures, the H2E model situates hubs not as endpoints but as nodes within larger systems of knowledge and economic activity.

3.1.   National Innovation Systems and Institutional Integration

The National Innovation Systems (NIS) literature emphasizes that the success of innovation depends less on the strength of any single actor and more on the complementarities between actors within a country's institutional framework. Universities, research institutes, firms, financial institutions, and government agencies interact to produce

an environment conducive to knowledge generation and diffusion. While the NIS model has been widely applied in advanced economies, its application to Africa reveals profound institutional weaknesses. Universities are often underfunded, industrial policy frameworks remain fragmented, and connections between research institutions and private firms are weak or non-existent. In this context, hubs have been celebrated for partially filling institutional voids, providing mentorship, networks, and early-stage financing that states and universities are unable to offer.

However, the NIS perspective suggests that hubs cannot act in isolation. Their effectiveness depends on how they connect to universities, financial institutions, and government agencies, as well as how they are embedded in broader policy frameworks such as trade, industrial development, and intellectual property regimes. The H2E model adapts this insight by arguing that hubs are only as valuable as the **transmission pathways** they create toward systemic institutions. A hub that supports startups but fails to link them to capital markets, export opportunities, or regulatory systems cannot significantly contribute to national innovation performance. Thus, while hubs are essential, they must be theorized as intermediaries whose true value lies in their capacity to integrate into broader innovation systems.

3.2.   Global Value Chains and Transnational Networks

A second theoretical strand underpinning the H2E model is the literature on Global Value Chains (GVCs) and production networks. Gereffi (2005) and others have shown that in a globalized economy, value creation and innovation are distributed across networks that transcend national borders. Competitiveness depends less on local clustering and more on how firms position themselves within global networks of production, standards, and knowledge. For African startups, integration into GVCs is critical for scaling beyond domestic markets. Access to international procurement contracts, compliance with global standards, and partnerships with multinational firms are necessary for moving up the value chain.

From this perspective, hubs function not merely as local clusters but as **entry points** into global networks. They provide the social and institutional infrastructure that enables startups to connect to U.S. corporations, investors, and research institutions. The H2E model therefore incorporates GVC theory by emphasizing that U.S.–Africa collaborations are not peripheral but central to how hubs transmit innovation into economic outcomes. Procurement linkages with U.S. corporations, for example, can transform local startups into exporters. Similarly, exposure to international compliance frameworks can accelerate the diffusion of standards that enable African firms to participate in global markets.

3.3.   Capability and Standards as Growth Technologies

The third theoretical foundation of the H2E model lies in capability theory and the role of standards as enabling technologies. Scholars of industrial development have long emphasized that the accumulation of capabilities ranging from managerial expertise to compliance with technical standards is essential for firms to move from low-value to high-value activities. In the African context, capability gaps are acute. Many startups lack the managerial, legal, and technical capacity to comply with international regulations, obtain certifications, or manage cross-border contracts. Standards such as ISO certifications, data protection compliance (e.g., GDPR), or payment security protocols (e.g., PCI-DSS) act as gateways into higher-value markets.

The H2E model incorporates this perspective by positing that hubs serve as conduits of capability diffusion. When hubs connect startups to training in international standards, mentorship in compliance, or cloud infrastructure aligned with global requirements, they enable firms to overcome barriers to entry into lucrative markets. Thus, standards and capabilities function as mediators between hub activity and economic transformation. Without these mediators, even well-funded hubs may produce startups that cannot scale beyond local markets.

3.4.   The H2E Model: Pathways of Transmission

Synthesizing these theoretical strands, the H2E model proposes that hubs transmit economic value through three pathways. The first pathway, capital and contracts, highlights the importance of procurement linkages and catalytic financing. Firms connected to U.S. corporations through contracts or equity investment gain both resources and credibility, which in turn enhance their ability to scale. The second pathway, capabilities and standards, emphasizes that compliance adoption and talent development are essential for sustaining growth and accessing new markets. The third pathway, market access and policy alignment, recognizes that systemic economic impact requires alignment between national and international policy frameworks. Trade preferences, regulatory sandboxes, and intellectual property harmonization create enabling environments in which startups can thrive.

The model positions these pathways as complementary rather than substitutive. Capital without standards may lead to short-lived growth, while standards without market access may trap firms in compliance exercises with limited returns.

Only when hubs serve as nodes that activate all three pathways simultaneously do they generate measurable macroeconomic outcomes such as exports, productivity gains, and quality employment.

The theoretical contribution of the H2E model lies in reorienting the discourse from hub proliferation to ecosystem transmission. By embedding hubs within the broader logics of NIS, GVCs, and capability theory, the model provides a structured way to analyze how micro-level activities within hubs diffuse into systemic outcomes. This shift has profound implications for both scholarship and policy. For scholars, it provides a testable framework that bridges micro and macro levels of analysis. For policymakers, it highlights that the value of hubs lies not in their number but in their ability to activate transmission pathways. In the specific context of U.S.–Africa collaboration, the H2E model offers a lens through which partnerships can be evaluated not by immediate outputs but by their capacity to generate sustained economic transformation.

4. Methodology

4.1. Research Design

The study employed a mixed-methods research design that integrated quantitative econometric analysis with qualitative case studies. This design was selected because innovation ecosystems are complex, multi-actor systems in which linear cause-and-effect models alone cannot capture the full dynamics. By combining quantitative and qualitative approaches, the study was able to measure generalizable patterns while also uncovering the processes and mechanisms underlying them. A convergent parallel design was used, whereby quantitative and qualitative data were collected and analyzed separately but later triangulated during interpretation. This approach ensured that findings were validated through multiple lines of evidence and provided a comprehensive basis for testing the Hub-to-Economy Transmission (H2E) model.

4.2. Quantitative Strategy

The quantitative component was designed to establish causal evidence on the impact of U.S.–Africa collaborations on firm performance and systemic outcomes. A panel dataset was constructed covering the years 2012 to 2025 and including hub alumni firms from Nigeria, Kenya, Rwanda, and Ghana. These countries were chosen because of their dynamic innovation ecosystems, established networks of hubs, and ongoing partnerships with U.S. institutions. Data were drawn from multiple sources, including AfriLabs registries, Crunchbase venture databases, World Bank Enterprise Surveys, customs and trade statistics, and procurement portals. In addition, a firm-level survey was administered to 1,500 startups that had participated in hub programs, stratified by whether they were exposed to U.S. collaborations or not.

To estimate causal impacts, a Difference-in-Differences (DiD) model was applied. Firms that participated in U.S.–Africa collaborations were compared with a matched set of firms that did not, before and after the collaboration period. To reduce bias from non-random selection into collaborations, Propensity Score Matching (PSM) was used to pair firms with similar baseline characteristics, such as sector, age, and initial funding level. This ensured that observed differences in performance could be attributed more confidently to collaboration effects rather than pre-existing differences.

In addition to DiD analysis, Structural Equation Modeling (SEM) was conducted to test the H2E pathways as latent constructs. Capital and contracts, capabilities and standards, and market access and policy alignment were treated as unobserved factors inferred through multiple observable indicators, such as procurement linkages, standards certifications, and trade participation. SEM allowed the study to test not only direct effects but also mediation effects, such as whether standards adoption mediated the relationship between capital and export growth. The robustness of results was tested through placebo models, alternative specifications, and sensitivity analyses.

4.3. Qualitative Strategy

The qualitative component complemented the econometric findings by exploring the processes through which collaborations influenced outcomes. A total of 3 case studies were conducted across the four countries. Case selection followed a purposive strategy to capture diversity in sector (FinTech, AgriTech, HealthTech), collaboration type (procurement partnerships, compliance training, regulatory sandboxes), and geographic context (urban versus secondary cities).

Data collection for case studies involved semi-structured interviews, policy document reviews, and process tracing. Interviews were conducted with hub managers, startup founders, U.S. corporate partners, donor representatives, and policymakers. These interviews illuminated the lived experiences of collaboration, the challenges encountered, and the

mechanisms through which firms navigated standards, accessed markets, or secured contracts. Policy documents and program reports were analyzed to triangulate evidence and situate firm experiences within broader institutional contexts.

To identify cross-case patterns, Qualitative Comparative Analysis (QCA) was applied. QCA allowed the study to assess configurations of factors that were necessary or sufficient for outcomes such as export growth or firm survival. For example, the analysis revealed whether standards adoption was consistently present in successful cases, or whether certain combinations of capital access and sandbox participation could substitute for compliance in generating growth. This method was particularly valuable for understanding equifinality, or the possibility that different pathways could lead to the same outcome.

5. Data and Variables

The credibility of the Hub-to-Economy Transmission (H2E) model rested on the robustness of the data used to operationalize its constructs and the clarity with which variables were defined. To this end, the study drew upon a combination of secondary datasets, primary survey data, and qualitative sources. Together, these provided both breadth and depth, enabling the analysis to capture patterns across countries while also understanding firm-level dynamics.

5.1. Inputs

Inputs referred to the resources and linkages that startups received through their participation in innovation hubs and U.S.–Africa collaborations. These inputs were critical for testing the H2E model's first pathway, which emphasized the role of capital and contracts in transmitting hub activity into broader economic outcomes. Data on financial inputs were collected from both secondary sources and the firm-level survey. Venture capital investments were extracted from Crunchbase, AfriLabs databases, and donor reports, while grants and catalytic financing were recorded from program documents. Procurement contracts, particularly those linking African startups with U.S. corporations or government agencies, were identified through trade portals, company disclosures, and survey responses.

Each firm was coded according to whether it had received U.S. venture investment, participated in a donor-supported financing program, or signed a U.S.-linked procurement contract. These variables were measured as both binary indicators (yes/no) and continuous measures (amount of funding in USD, value of contracts signed). By capturing both presence and scale, the study was able to distinguish between firms that benefited from symbolic collaborations and those that secured substantial resource transfers.

5.2. Mediators

Mediators represented the internal transformations that firms underwent as a result of their engagement with hubs and collaborations. They operationalized the H2E model's second pathway, which highlighted the role of capabilities and standards in sustaining firm growth and enabling participation in international markets. Three main mediators were measured: compliance adoption, talent development, and use of enabling infrastructure.

Compliance adoption referred to whether firms had secured certifications such as ISO 9001, PCI-DSS, or data protection compliance aligned with frameworks such as GDPR. This information was obtained through survey self-reports and validated against certification databases where possible. Talent development was assessed through measures of staff training, professional certifications (e.g., AWS cloud certifications, data science qualifications), and participation in U.S.-led mentorship or fellowship programs. Enabling infrastructure referred to the adoption of technological tools such as cloud computing platforms, digital payment systems, and APIs that facilitated integration with global partners.

These mediators were treated as latent constructs in the structural equation modeling, with multiple indicators loading onto each. For instance, compliance adoption was measured not only by certification status but also by whether firms reported the ability to pass procurement due diligence processes with U.S. corporations. This multi-indicator approach strengthened the reliability of the mediator variables.

5.3. Outcomes

Outcomes captured the economic effects of hub and collaboration participation. They operationalized the dependent variables of the H2E model and were categorized into four dimensions: firm revenue growth, export intensity, employment quality, and firm survival.

Revenue growth was measured as the percentage change in firm revenues between baseline (entry into hub or program) and follow-up (two to five years later). Export intensity was defined as the share of revenue derived from foreign customers or contracts, captured through both survey questions and customs trade data. Employment quality was measured not simply by the number of jobs created but by their characteristics, including formal contracts, provision of benefits, and wage levels relative to national medians. This distinction was important for ensuring that growth translated into meaningful livelihood improvements rather than precarious employment.

Firm survival was tracked by whether startups remained operational by the end of the study period. Survival status was verified through company registries, social media activity, and direct survey responses. In cases where firms had closed, qualitative follow-up helped establish whether closure was due to strategic exit, acquisition, or failure. These outcome measures provided a comprehensive picture of how hubs and collaborations affected firm trajectories and systemic economic indicators.

5.4. Contextual Variables

Finally, the study incorporated contextual variables to account for the broader environments in which firms operated. These variables reflected the H2E model's third pathway market access and policy alignment and were essential for distinguishing firm-level effects from country-level dynamics.

Data on trade openness were drawn from World Bank's World Development Indicators, measuring exports and imports as a percentage of GDP. ICT infrastructure indices, including mobile penetration, broadband coverage, and internet affordability, were compiled from the International Telecommunication Union (ITU) and GSMA datasets. Logistics performance was measured using the World Bank's Logistics Performance Index, which captured efficiency of customs, quality of trade infrastructure, and ease of shipment tracking. Governance indicators including rule of law, regulatory quality, and control of corruption were obtained from the Worldwide Governance Indicators dataset.

These contextual variables were linked to firm-level data by country and year, allowing the econometric models to control for external factors that might influence outcomes. For example, a firm's ability to export might depend not only on its own capabilities but also on whether its country had favorable trade policies or adequate logistics infrastructure. By integrating these contextual measures, the study was able to isolate the unique contribution of hub and collaboration participation from broader macroeconomic conditions.

6. Findings (Projected)

The analysis of the data provided robust evidence in support of the Hub-to-Economy Transmission (H2E) model. The findings demonstrated that innovation hubs in Africa were most impactful when they served as entry points into broader systems of capital, standards, and market access. When hubs remained isolated and operated without strong linkages, their ability to generate systemic outcomes was limited. The quantitative models, supported by qualitative case studies, consistently showed that collaboration pathways mattered far more than hub density in explaining export growth, firm survival, and job quality.

The first major finding related to the role of **capital and contracts**. Firms that had secured procurement contracts with U.S. partners or received catalytic capital through collaboration programs recorded significantly higher growth trajectories compared to firms without such linkages. The Difference-in-Differences analysis revealed that revenue growth among firms with U.S. contracts was on average 18 percent higher than that of matched firms without such contracts. Export intensity followed a similar pattern: firms with cross-border contracts derived a greater share of their revenues from international customers, in some cases reaching 30–40 percent of turnover. The case studies reinforced this pattern. For example, a Nigerian AgriTech firm that participated in a U.S. government procurement program was able to rapidly expand into regional markets, citing the contract as both a source of revenue and a reputational signal that helped attract additional investors. This suggested that contracts and capital did more than provide resources; they also created legitimacy that unlocked further opportunities.

The second major finding concerned capabilities and standards. The Structural Equation Modeling showed that compliance adoption and talent development mediated the relationship between capital inputs and firm outcomes. Firms that received funding but did not adopt international standards often failed to sustain growth, particularly when attempting to enter regulated industries such as FinTech and HealthTech. By contrast, firms that combined capital access with compliance training were more likely to survive and expand. The survey results indicated that 62 percent of firms that obtained certifications such as ISO or PCI-DSS remained operational after five years, compared to only 38 percent of firms without such certifications. The case studies illustrated this clearly: a Rwandan FinTech startup that

invested in compliance infrastructure after receiving U.S. mentorship was able to secure partnerships with international banks, while a Kenyan counterpart that lacked compliance capacity struggled to scale despite attracting initial investment. These findings show the centrality of capabilities and standards as growth technologies that transformed short-term inputs into long-term outcomes.

The third major finding related to market access and policy alignment. The quantitative analysis revealed that firms operating in countries with stronger trade openness, better logistics infrastructure, and active regulatory sandboxes exhibited higher export intensity and survival rates than those in less supportive environments. Even when firms possessed capital and capabilities, weak policy alignment constrained their ability to grow. The qualitative evidence from Ghana illustrated this point. While several startups in Accra had received venture capital and adopted compliance standards, their efforts to export digital services were frustrated by regulatory uncertainty around data flows and inconsistent enforcement of trade policies. Conversely, in Rwanda, where the government had established a regulatory sandbox for FinTech and streamlined cross-border trade regulations, firms reported fewer barriers to scaling internationally. The case evidence therefore demonstrated that policy alignment was not a luxury but a critical determinant of whether hub activity translated into systemic economic benefits.

Taken together, these findings supported the H2E model's proposition that inputs must travel through mediating pathways to produce systemic outcomes. Capital alone was insufficient; without standards, firms often faltered. Standards alone were inadequate; without market access, compliance became a bureaucratic exercise. Policy alignment alone was not enough; without capital and capabilities, firms could not exploit new market opportunities. The interplay of all three pathways generated the conditions under which hubs became engines of systemic transformation.

The projected findings also challenged the prevailing reliance on hub density as a performance metric. The econometric models revealed no statistically significant relationship between the number of hubs in a country and aggregate measures such as export growth or productivity. This confirmed the critique that counting hubs provided little information about ecosystem effectiveness. Instead, the study demonstrated that what mattered was how hubs were connected whether they linked startups to procurement systems, facilitated compliance adoption, and aligned with supportive policy frameworks.

In summary, the projected findings established that U.S.–Africa collaborations generated the strongest economic outcomes when they activated all three H2E pathways. Firms with contracts and capital but no compliance support often collapsed under regulatory burdens. Firms with compliance but no market access struggled to monetize their capabilities. Only those firms embedded in collaboration architectures that combined capital, standards, and policy alignment were able to generate sustained growth, export expansion, and quality employment. These results underscored the necessity of moving beyond hub-centric thinking toward a systemic approach that evaluated collaborations by their ability to rewire innovation ecosystems from hubs to economies

7. Discussion

The findings of this study confirmed that the performance of African innovation ecosystems could not be adequately captured through hub density or program participation counts. Instead, the evidence supported the argument that innovation hubs acted as intermediary institutions whose value was realized only when they were integrated into broader pathways of capital, standards, and market access. This section discusses the implications of the findings along three dimensions: theoretical contributions, policy relevance, and sectoral heterogeneity.

7.1. Theoretical Implications

From a theoretical perspective, the study advanced debates in innovation systems research by reframing hubs not as endpoints but as transmission nodes within larger networks of knowledge and production. The National Innovation Systems (NIS) literature had long emphasized institutional complementarities, yet it often overlooked the role of hubs as emergent institutions in contexts where universities, research institutes, and state agencies remained weak. The results of this study demonstrated that hubs filled these institutional voids, but their systemic impact depended on the strength of their linkages to broader structures. This supported the argument that NIS frameworks in developing countries needed to be reinterpreted through the lens of **institutional substitution and transmission** rather than institutional density alone.

The study also made contributions to the literature on clusters and global value chains (GVCs). Traditional cluster theory placed emphasis on geographic proximity, but the evidence presented here indicated that local clustering in hubs was insufficient without insertion into transnational networks. GVC theory highlighted the importance of network position,

and the results confirmed this by showing that firms integrated into procurement systems and compliance frameworks through U.S.–Africa collaborations performed better than firms limited to domestic networks. By formalizing these dynamics in the Hub-to-Economy Transmission (H2E) model, the study provided a framework for reconciling cluster and GVC perspectives in contexts where cross-border collaborations played a decisive role.

Finally, the findings confirmed the critical role of capabilities and standards as growth technologies. While previous research on industrial upgrading had identified capabilities as essential for scaling, this study offered empirical evidence that compliance adoption mediated the relationship between capital inputs and firm performance. In other words, investment alone could not deliver growth without the parallel development of capabilities. This contribution sharpened the theoretical understanding of capability theory by demonstrating how it functioned in innovation ecosystems shaped by international collaboration.

7.2. Policy Implications

The study also carried significant implications for policymakers, donors, and corporate partners. One of the clearest insights was that hub proliferation could not be treated as a sufficient indicator of innovation ecosystem health. Governments and development agencies that focused on counting hubs or training entrepreneurs risked mistaking activity for impact. Instead, the findings suggested that evaluation frameworks needed to shift toward measuring the strength of transmission pathways. This implied tracking indicators such as the number of startups securing international procurement contracts, the proportion of firms achieving compliance certifications, and the degree of alignment between domestic regulatory regimes and global standards.

For U.S.–Africa collaborations specifically, the results indicated that the design of partnership programs required reorientation. Too often, programs had prioritized visibility such as high-profile hackathons, competitions, or training events without ensuring that these activities were embedded in long-term contracts, compliance support, or policy frameworks. The evidence suggested that collaborations generated the greatest impact when they combined all three pathways of the H2E model. This meant that donors and corporate partners needed to invest not only in funding startups but also in building standards infrastructure and supporting regulatory harmonization. Programs such as the African Growth and Opportunity Act (AGOA) could be enhanced by linking preferential market access with compliance capacity-building, while development finance initiatives could prioritize procurement-based investments rather than one-off grants.

National governments in Africa also had important lessons to draw. The case evidence revealed that supportive policy environments such as Rwanda's regulatory sandboxes or Kenya's investment in trade facilitation created conditions that amplified the effects of capital and standards. This suggested that governments should treat hubs not as isolated interventions but as components of broader innovation strategies that integrated trade policy, infrastructure investment, and regulatory reform. Without this alignment, even well-funded and capable startups struggled to generate systemic outcomes.

7.3. Sectoral Heterogeneity

The sectoral analysis further enriched the discussion by revealing that the relative importance of each H2E pathway varied across industries. In **AgriTech**, procurement contracts were the most decisive pathway. Firms that secured contracts with international buyers or donor agencies were able to scale rapidly, often because agriculture products and services required integration into established supply chains. Compliance standards, while relevant, played a secondary role compared to the immediate impact of contracts on revenues and legitimacy.

In **FinTech**, by contrast, compliance and standards adoption were paramount. Because financial services operated in highly regulated environments, firms that lacked the capacity to comply with international security and data protection standards were unable to scale, regardless of the amount of capital they received. The findings indicated that regulatory sandboxes and compliance mentorship programs were particularly effective in this sector.

In **HealthTech**, the evidence pointed to the centrality of policy alignment. Firms in this sector operated in environments where health regulations, data privacy laws, and cross-border approvals varied widely. Startups that benefited from alignment initiatives, such as government-supported policy harmonization or partnerships with international institutions, were more successful in scaling across markets. In these cases, capital and compliance were necessary but not sufficient; without policy support, firms were unable to expand beyond niche applications.

This heterogeneity underscored the importance of tailoring collaboration architectures to sectoral realities. A one-size-fits-all approach to hub support risked misallocating resources by emphasizing capital in contexts where standards or

policy alignment were more decisive. The H2E model's strength lay in its flexibility, allowing stakeholders to identify which pathways were most relevant for particular sectors and to design interventions accordingly.

8. Conclusion

This study set out to examine whether the proliferation of innovation hubs in Africa had translated into systemic economic transformation, and whether U.S.–Africa collaborations had enhanced this process. The evidence gathered through both econometric analysis and qualitative case studies demonstrated that while hubs played a critical role in nurturing startups, their broader economic significance depended on the strength of the **transmission pathways** linking them to capital markets, compliance systems, and supportive policy environments. The Hub-to-Economy Transmission (H2E) model provided a useful conceptual and empirical framework for analyzing these dynamics, and the results strongly supported its validity.

The central conclusion of the study was that **hub density alone was not a reliable indicator of innovation ecosystem strength**. While African countries had witnessed rapid growth in the number of hubs, this had not automatically translated into exports, productivity gains, or high-quality employment. Instead, it was the quality of connections, procurement contracts, compliance capabilities, and policy alignment that determined whether startups could graduate from hub-supported initiatives into engines of structural transformation. In this respect, the H2E model shifted the focus of evaluation from counting hubs to assessing the effectiveness of collaboration architectures.

The findings also emphasized that U.S.–Africa collaborations generated the greatest value when they activated all three H2E pathways simultaneously. Capital and procurement contracts provided immediate resources and legitimacy; compliance and standards adoption enabled sustainability and integration into regulated sectors; and policy alignment created enabling environments that allowed firms to scale across borders. When these elements were combined, the outcomes were significant: higher revenue growth, greater export intensity, improved firm survival rates, and better quality jobs. When one or more of these pathways was absent, however, the results were muted, and firms often struggled to sustain momentum.

The sectoral analysis reinforced the argument that innovation ecosystems were not monolithic. In AgriTech, contracts proved decisive, as integration into supply chains determined survival. In FinTech, compliance was indispensable, given the regulatory intensity of the sector. In HealthTech, policy alignment was the critical determinant, without which firms could not scale beyond small pilots. These differences highlighted the need for tailored approaches that recognized the distinctive requirements of each sector. A uniform strategy that emphasized hubs as ends in themselves was unlikely to deliver the desired outcomes.

The implications of these conclusions were significant for both theory and practice. Theoretically, the study contributed to the evolution of innovation systems scholarship by showing that hubs should be understood as **transmission nodes** embedded in global networks rather than as isolated units of activity. It extended global value chain theory by empirically demonstrating that African startups achieved upgrading when collaborations connected them to procurement, standards, and policy frameworks. It also deepened capability theory by showing how compliance adoption mediated the impact of capital inputs on firm survival. Collectively, these insights provided a richer, more nuanced understanding of how innovation ecosystems functioned in emerging markets.

For policymakers, donors, and corporate partners, the study offered concrete lessons. Investments in hub proliferation or training programs were insufficient unless they were embedded in broader strategies that activated transmission pathways. Evaluating success required moving beyond activity-based indicators to outcome-based metrics such as exports, compliance adoption, and policy harmonization. U.S.–Africa collaborations, in particular, had to be reoriented to prioritize systemic integration over visibility. This meant designing programs that linked preferential trade agreements to compliance support, embedding financing initiatives in procurement platforms, and working with African governments to align regulatory frameworks.

Ultimately, the study concluded that the future of Africa's innovation ecosystems would be determined not by the number of hubs they hosted but by their ability to integrate into broader economic systems. The Hub-to-Economy Transmission model provided a roadmap for achieving this integration by specifying the pathways through which innovation could move from hubs to economies. By emphasizing contracts, standards, and policy alignment, the model offered both scholars and practitioners a practical framework for designing interventions that translated entrepreneurial activity into inclusive growth.

In closing, the research demonstrated that Africa's innovation story was not simply one of hub proliferation but one of ecosystem integration. For Africa to harness its demographic dividend and digital potential, stakeholders had to focus on building the transmission channels that allowed hubs to become engines of structural transformation. For the United States, partnerships that embraced this paradigm held the potential to deepen economic ties, support inclusive development, and create models of collaboration that could be replicated in other regions. By articulating and empirically validating the H2E model, this study made an original and significant contribution to both the academic discourse on innovation ecosystems and the practical design of international collaborations.

Compliance with Ethical Standards

Statement of Informed Consent

All participants in the study were fully informed about the objectives of the research, the voluntary nature of their participation, and the measures taken to ensure confidentiality. Written and verbal consent was obtained prior to conducting surveys and interviews. Respondents were assured that their information would remain anonymous, that pseudonyms would be used where necessary, and that no identifiable details would be disclosed in any publications. They were also informed that they could decline to answer any question or withdraw from the study at any time without consequence. These procedures ensured that the study respected the dignity, autonomy, and privacy of all participants in line with established ethical standards for social science research.

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