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Bottlenecks and Innovation Performance

An investigation of the low performance in the National Innovation System of Kenya: the emergence and origins of potential system impediments.

Oskar Skorge

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Supervisor: Josef Taalbi

Examiner: Prince Young Aboagye

Words: 11894

Email: oskar.skorge@gmail.com

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Abstract

This thesis investigates the stagnant performance of Kenya's National Innovation System (NIS), utilising a mixed-methods functionalist approach to ascertain weakest-link and potential bottlenecks within the innovation system. Through conducting a comparative benchmarking our findings revealed low performance in Human Capital and Research, particularly in tertiary education and R&D investment, with low tertiary enrolment rates and a low proportion of STEM graduates. A further contextual analysis of Kenya's Vision 2030 policy framework reveals that strategic priorities have heavily focused on primary and secondary education, leaving tertiary education under-prioritised. The study concludes that Kenya's innovation stagnation is primarily due to misaligned policy priorities and inadequate investment in higher education and research. Addressing these issues requires a realignment of policy focus and increased investment in tertiary education and R&D to strengthen Kenya's innovation ecosystem, given its centrality and correlation to other key elements of the NIS and as a foundational driver of innovation output.

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Abbreviations

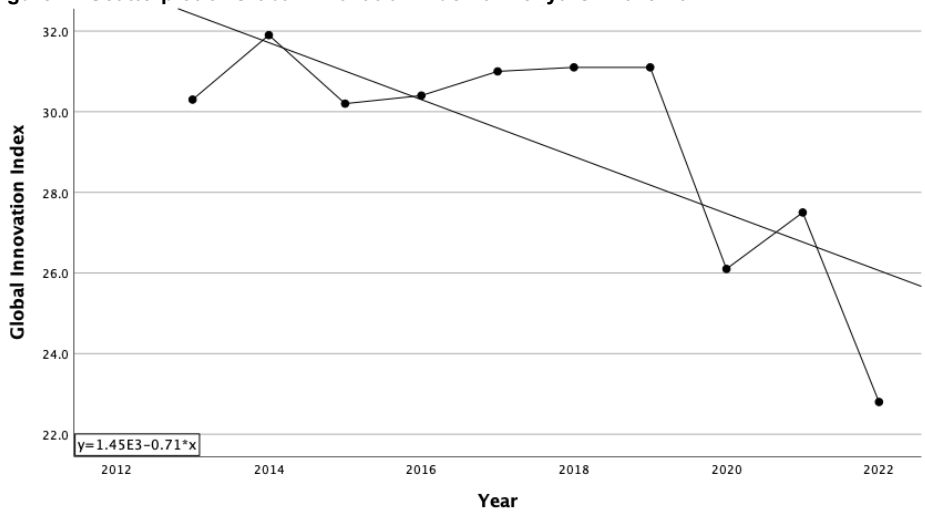
ANIS	Analysis of National Innovation Systems
ASTII	African Science Technology and Innovation Agenda
AU	African Union
ER	Efficiency Ratio
FY	Fiscal Year
GII	Global Innovation Index
GoK	Government of Kenya
IS	Innovation System
KIPPRA	Kenyan Institute for Public Policy Research and Analysis
KNBS	Kenyan National Bureau of Statistics
KNIS	Kenyan National Innovation Survey
KPI	Key Performance Indicators
LMIC	Low Middle-Income Countries
TVET	Technical and Vocational Education and Training
NIS	National Innovation Systems
OECD	The Organization for Economic Co-operation and Development
R&D	Research and Development
ROI	Returns of Investment
SSA	Sub-Saharan Africa
STEM	Science Technology, Engineering and Mathematics
STI	Science Technology and Innovation
STISA	AU Science Technology and Innovation Strategy for Africa 2024
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
WDI	World Development Indicators
WIPO	World Intellectual Property Organisation

1. Introduction

In an age with transformative technologies such as artificial intelligence and 5G innovation, fostering an environment conducive to further advancements of innovation has become a key element of national development policies to unlock the limitless potential of a knowledge-based economy. The trend of using innovation to drive long-term development in Africa is evident today. Initiatives such as the Agenda2063 aspirations of the African Union Development Agency (AUDA-NEPAD) and the Science Technology and Innovation Strategy for Africa 2024 (STISA) have highlighted the transformative power of innovation in achieving the Sustainable Development Goals (SDGs) in critical sectors (AU, 2014). Similarly, Kenya's Vision2030 underscores the strategic role of science, technology, and innovation (STI) as key drivers to transform Kenya into an industrialised, middle-income country, with high quality of life for all citizens (GoK, 2007). Innovation, therefore, has become a critical aspiration for the Kenyan government in terms of improving socio-economic development.

Despite these efforts, innovation performance, as measured by the Global Innovation Index (GII), a composite index of country-level capacities and innovation success, has remained stagnant and has gradually declined, with a 27.5%-point reduction post-2019 (Figure 1). Furthermore, despite being one of the highest performers of innovation in Africa, innovation efficiency is a ratio between innovation outputs such as patent creation and innovation inputs, which refer to key elements conducive to innovation prospects in Kenya, has decreased by 37.5% between 2013 and 2020 (WIPO, 2023). So, albeit the acknowledgement of innovation as a key driver of development trajectories and large policy agendas in place to foster its improvements, a consideration lies in interpreting the gradual decline of innovation performance in Kenya and subsequent large decreases in the returns of investment (ROI) for innovation inputs in the nation.

Figure 1. Scatterplot of Global Innovation Index of Kenya GII 2013-2022



Data source: WIPO (2023).

Understanding innovation performance in Kenya requires an appreciation of both the unique opportunities and the complex challenges its status as an emerging economy presents. One effective way to appreciate these unique challenges is through an exploration of Kenya's national innovation system (NIS), which refers to the synergetic interplay, interactions and collaborations between various entities involved in creating and utilising innovation (Freeman, 1982; Lundvall, 1985). This concept may assist us in apprehending central players and identifying constraints that may impede the prospects of innovation.

1.1 Research Problem and Literature Gap

In light of Agenda 2063 and alignment with the AUDA-NEPAD STII agenda, member states now recognise STIs as critical enablers for achieving the SDGs and fostering long-term economic growth (UNESCO, 2023). Nevertheless, given the prevalence of a big push towards STI advances among emerging African markets, why does Innovation remain stagnant in one of Africa's highest innovation performers, Kenya? This research problem posits a critical need for research to explore why innovation performance is in gradual decline in Kenya.

Current literature on key impediments to the Kenyan NIS (KNIS) suggests that limited performance may be due to systemic issues, such as low organisational capital for advancing assets and skills necessary for fundamental advancements in innovation prospects (UNIDO, 2015). While regional and national policy frameworks aim to harness technology and innovation for development, there remains a gap in research evaluating the rise and emergence of bottlenecks in the prospects for innovation, particularly in Kenya, referring to systematic impediments which may impair the prospects of innovation within a nation (Zofio et al., 2023).

These impediments, or bottlenecks, are usually attributed among scholars as the weakest elements or system failures, determined as structural constraints for innovation performance (Edquist, 2011; Acs et al., 2014). As of 2024, there are limited contemporary studies utilising this approach.

Addressing this research gap is crucial for refining strategies and ensuring that the envisioned benefits of innovation and technology are fully realised. A consideration of previous work on historical case studies of innovation and economic development also has had a considerable emphasis on rich countries and the West, such as the work of Gerschenkron (2015/1962) and Abramowitz (1993). Nonetheless, there has been a focus on catching newly industrialising Asian nations post-1970s (Kim, 1997; Amsden, 1989; Johnson, 1982) concerning innovation and know-how as central to the Asian industrialisation model.

There is, however, a discernible research gap in the study of emerging NISs: fragmented systems still in formation, missing key linkages and within developing economies (Weerasinghe et al., 2023). This points to a need for more empirical research to assess the effectiveness of policy frameworks like Kenya's Vision 2030 and the broader AUDA-NEPAD’s STI agenda in fostering innovation and technological advancement, which will advance the prospects of a knowledge-based economy in the rise of the fourth industrial revolution (AU, 2015).

Despite the significant scholarly interest in innovation systems, much of the existing literature is predominantly theoretical and conceptual. This proliferation of reviews and theoretical frameworks (Chataway et al., 2013) has not adequately addressed the scarcity of empirical research. Consequently, empirical studies are needed to thoroughly understand the complex processes involved in innovation creation and diffusion and reveal its potential impediments (Heeks et al., 2013).

1.2 Aim and Scope

The thesis aims, therefore, to bridge the research gap aforementioned by providing a comprehensive systems analysis of Kenya's national innovation system to elucidate the potential bottlenecks for facilitating the stagnant innovation trajectory within Kenya. Therefore, our analysis will, in light of the NIS framework, conduct a functionalist analysis of key elements of Kenya's national innovation system (KNIS) to facilitate a greater conceptual understanding of potential structural constraints within the system through comparative benchmarking and contextual analysis of the current policy and socio-cultural environment for which may have led to bottlenecks, referring to binding constraints that hinder system performance (Zofio et al., 2023). Given this, the research question at hand is:

> What are the key impediments to innovation performance indicators within the Kenyan National Innovation System? If present, how did these barriers emerge?

The research question will be investigated by conducting a mixed-method case study divided into two sections: quantitative and qualitative. First, it involves identifying key performance indicators (KPIs) and low-performance elements of the GII in a comparative benchmarking between Kenya, Sub-Saharan Africa (SSA), and Low Middle-Income Countries (LMIC), as well as our comparison group: Tanzania, Uganda, South Africa, and Botswana.

Secondly, our assessment strategy will involve a contextual study to systematically study the policy framework and prioritisations that led to this bottleneck and prioritisation within the public policy sphere utilising a content analysis. The content analysis will be enriched with the triangulation of further data points on an identified element for efficient triangulation of data sources to understand the intricacies beyond comprehensive policy papers to a greater extent.

For instance, an integral part of NISs are not only elements but relationships (Edquist, 2010); hence, a correlate analysis will also be conducted to apprehend relationships and associations between elements and also identify element and innovation output to further attribute our findings to a comprehension of a bottleneck to innovation performance.

The identification strategy and contextual analysis allow us to apprehend the development and change of potential impediments to the flow and generation of knowledge with real-world policy considerations for Kenya. This analysis is critical in identifying the areas within the NIS where innovation is most constrained. The thesis aims to delineate this intricate interplay between existing policies, institutional capacities, and the socio-economic factors contributing to these impediments by focusing on bottlenecks.

Studying bottlenecks in the flow and generation of knowledge and innovation within the Kenyan context is not merely an academic exercise but a critical endeavour with significant implications for the country's future economic and social trajectory. Technological catch-up is potentially lucrative, yet as Gerschenkron (2015/1962) demonstrates, it is a challenging endeavour and by no means a free ride. This paper will thereby seek to foster a meaningful understanding of potential impediments to a factor that bears critical transformative power for social and economic improvements in Kenya: innovation.

The scope of this thesis centres on a comparative case study of the Kenyan National Innovation System (NIS), examining the unique characteristics and complexities within this system compared to similar economies in Sub-Saharan Africa, including Botswana, Tanzania, South Africa, and Uganda. In this context, a case study refers to a comprehensive analysis to understand the dynamics, structures, and functionalities of the Kenyan NIS in depth.

This method allows for a comprehensive exploration of specific development blocks and bottlenecks, providing insights into country-specific conditions which may not be apparent in broad conceptual studies. Rather than attempting to formulate a grand theory applicable across multiple systems, this thesis focuses on the intricacies of a single system, thereby offering a detailed portrayal of system imbalances within the Kenyan context.

The thesis acknowledges the limitation in generalisation utilising this approach; the research findings are not intended to be extrapolated to explain phenomena on a macro scale or outside the boundaries of Kenya. Instead, they are intended to shed light on specific elements and fragmentation within emerging NIS, which could serve as exemplars for identifying and understanding similar bottlenecks in comparable contexts, much like the benchmarking. The study employs a mixed-methods strategy, combining comparative benchmarking and contextual analysis to identify low-performing indicators within the Kenyan NIS and situate these findings within the broader socio-political environment of Kenya.

This contextualisation is vital as it enhances the understanding of how external and internal factors influence the generation and flow of knowledge and, subsequently, innovation performance within the nation. By examining the NIS at national and regional levels, the thesis aims to provide actionable insights into the structural and procedural reforms necessary to overcome the identified impediments and foster a more dynamic and effective innovation system in Kenya.

There could be various reasons for the decrease in outputs compared to inputs in Kenya. However, to ensure an ROI, it is important to systematically analyse the possible bottlenecks within the system, referring to a functionalist approach for apprehending low-performing elements that may restrain the performance of an innovation system (IS) (Acs et al., 2014). Understanding the intricacies of this intricate system is paramount. Therefore, the analysis of the KNIS is crucial for shaping effective innovation policies for creating an environment conducive to driving innovation performance and fostering further socio-economic development, particularly given gap in empirical research on NISs in developing economies (Weerasinghe et al., 2023).

1.3 Outline of Thesis and Relevance

This thesis investigates the low performance of the National Innovation System (NIS) in Kenya, focusing on the origins and emergence of system imbalances. The literature review explores the theoretical foundations of innovation and development, focusing on empirical research conducted on NIS and, specifically, bottlenecks in Africa. Secondly, the theoretical framework delves into National Innovation Systems, techno-economic paradigms, evolutionary economics, endogenous growth theory, social network theory, and fragmented innovation systems, which guide the analysis of bottlenecks. The research strategy employs a mixed-methods approach, combining quantitative comparative benchmarking and qualitative contextual analysis. The methodology section details the data sources, operationalisation, comparative benchmarking process, and contextual analysis of policy frameworks. The empirical findings present the results of benchmarking and content analysis, identifying key impediments within the Kenyan NIS. Finally, the discussion interprets the results, compares them with previous research, and suggests areas for future study. At the same time, the conclusion summarises the main findings and their implications for policy and practice.

2. Literature Review

2.1 Innovation and Development

Although a comprehensively studied phenomenon, innovation is a concept that bears little consensus on definition (Stenberg, 2017). The general conceptualisation within modern policy frameworks ascertained by the Oslo Manual of the OECD (2018) states:

> "An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" – OECD/EUROSTAT (2018).

The Oslo Manual highlights the importance of advancements in products and processes, much like Schumpeter's technical progress in production (1934). This understanding of innovation as improvements in production and products sets the stage for further research into innovations' broader role in economic development.

Early research on innovation in economic development suggested comprehensive changes at the product level, technological transitions, and systemic changes in the market (Lange, 1943). Additionally, the involvement and alignment of central stakeholders (Rosenberg, 1969) are essential for facilitating growth and structural change.

Despite the early focus on product and process in the perennial research on innovation of the 1930s-40s, which can still be seen in the framework of the OECD (2018), a consideration of the early research in innovation studies is the focus on systemic and technological changes (Schumpeter, 1934; Maclaurin, 1950). Secondly, a consideration lies in the apprehension of various elements and their respective relationships for structural change, as ascertained by Rosenberg (1969).

The analysis of systems of innovation over time has, particularly post-1970, seen a discernible recognition of the relational interaction between various stakeholders within a nation as conceptualisations have gone towards an interactive model and a broader nature beyond product and process.

2.2 Innovation in the Global South

The return on innovation investments in emerging markets often differs significantly from that in developed countries. The challenges include varying absorptive capacity, infrastructure deficiencies, and differing regulatory environments which may produce structural constraints to advancing innovation prospects (Pellegrino & Savona, 2017). Nevertheless, the proportional output returns per unit investment of R&D are generally higher than the farther a nation is away from the technological frontier of a nation (Goni & Maloney, 2017), which again posits the focus of AU and GoK on the importance of innovation.

Despite the push towards agendas of innovation performance within Africa, a paradox emerges as developing countries encourage less innovation than advanced economies (Cirera & Maloney, 2017). Albeit the assertions of the works of the World Bank on the innovation paradox of developing economies at a general level, it is clear through our assertion of innovation efficiency ratios that inputs in the KNIS are increasing; the ROI of these inputs are decreasing, albeit the big push for innovation in the nation.

The big push for innovation is clear, as spillover effects of Innovation in emerging markets often lead to improved healthcare, agriculture, and energy solutions, which are critical for improving quality of life (Li & Shapiro, 2019). The existing literature has mainly discussed the absence of support for innovation; however, an inundation of current research has primarily concentrated on the systemic failures of information systems to explain lower output rates within developing and emerging economies (Holidin, 2023).

2.3 Previous Research on NIS and Bottlenecks

The assertion of the limited ROI on advancements in innovation expenditures in emerging economies has led to an inundation of a push for innovation prospects in developing economies. It has also led to the emergence of literature trying to systematically analyse bottlenecks and system failures as a functionalist approach to NIS (Edquist, 2011; Hekkert et al., 2007; Kashani & Roshani, 2019; Rakas & Hain, 2019; Zofio et al., 2023; Bergek et al., 2008: Wolthuis et al., 2005).

This functionalist approach has led to the emergence of empirical case studies of innovation performance within Africa, given its means to systematise a broad appreciative and conceptual framework like NIS. For instance, a cluster analysis of 30 African countries utilising the Global Competitiveness Report identified structural barriers such as inadequate governmental policy, poor infrastructure and institutional frameworks for IP protection and lack of human capital advancements at a higher level (Garcia et al., 2012). However, this broad-scaled benchmarking-based benchmarking does not assess country-level conditions. Similar issues of weak innovation policy within policy frameworks have also been attributed to Africa's fragmented nature of emergent innovation systems (Gachie & Govender, 2017).

A case study of Ghana identifies structural barriers, such as a lack of technical ICT knowledge and unsophisticated market structures, as hindrances to the performance of skills and know-how (Bartels et al., 2016). Within the same research, a comparative case study between Ghana and Kenya highlights human capital and financial systems as significant determinants of the NIS output efficiency. The focus on skills and know-how can be further attributed to Garcia's (2012) findings regarding Africa's lack of human capital advancements. UNIDO (2015) also identified excessive economic risks, insufficient and poor-quality market demand, inadequate skills formation and rigid, low-resolution regulatory standards as impediments for an innovation-driven economy as aspired by Vision 2030.

The empirical research on bottlenecks has focused on elements that meaningfully impact innovation performance, yet how and why these impediments have occurred has not been extensively covered. Methods such as factor analysis (Bartels et al., 2016), cluster analysis (Garcia et al., 2012), and process and sequence analysis (Hekkert et al., 2007) use predominantly quantitative means to map the innovation landscape in Africa. To some extent, these empirical studies on NIS performance follow the weakest-link method mentioned in the introduction. However, the essence of the NIS concept emphasises the importance of understanding systems as dynamic and ever-changing. The empirical literature has only covered to a minor extent how and why these impediments have occurred, albeit the focus and scope of subsequent analysis have been on mapping what bottlenecks can be found in respective nations and regions.

Recent literature has begun to address this gap by employing mixed-method approaches that integrate qualitative and quantitative analyses to provide a more nuanced understanding of the dynamic nature of National Innovation Systems (NIS) in Africa. For instance, the acknowledgement of wider contextual structures, such as sectoral, geographical and political influences on innovation processes (Bergek et al., 2015), which has been generally overlooked in the empirical work described earlier. Furthermore, the literature on STI research, particularly policies, lacks the contextual specificity of NIS and often neglects the socioeconomic and political context of the IS (Chaminade & Perez, 2014).

By combining quantitative and qualitative methods, studies offer deeper insights into the underlying causes of innovation bottlenecks and the interactions between various NIS actors. While quantitative methods remain crucial for mapping and measuring innovation systems, integrating qualitative perspectives is essential for a holistic understanding of innovation performance. It ensures the findings align with the broader conceptual complexity of NIS, which will be explored and operationalised in the subsequent theory section.

3. Theory

3.1 National Innovation Systems

National Innovation Systems (NIS) emphasises innovation as an interactive process where various forms of knowledge are shared and utilised between agents connected through relational linkages (Edquist, 2010). This approach highlights the critical role of knowledge creation, diffusion, and utilisation in market applications and addressing socio-economic challenges. Originally introduced by Freeman (1982) in an unpublished paper and later expanded by Lundvall (1985), the NIS framework explores the significance of the connections between industry and universities in the effective use of knowledge (Chaminade et al., 2018, p. 3). Freeman's early work highlighted how Japanese firms' competitive advantage in the global market was significantly boosted by systematic government support and effective linkages with research institutions (1982). This observation suggested that innovation success results from a cohesive system where various elements such as policy, corporate strategy, and education are aligned towards common goals.

The NIS's holistic view of the innovation ecosystem is significant. It recognises the importance of interaction among the various components of the system, suggesting that the flow of knowledge is not linear but cyclical and iterative, involving feedback loops between creation, diffusion, and utilisation of knowledge (Woolthuis et al., 2005). This interconnected approach is instrumental in understanding how innovations can drive economic development and address broader socio-economic challenges of system failures. Focusing on the interdependencies within the innovation system, the NIS framework helps explain the mechanisms through which innovation influences economic patterns and outcomes (Freeman, 1991). It shows how robust linkages between universities and industries, supported by conducive policies and a collaborative culture, can enhance economic performance and competitiveness.

NIS advocates for accumulating knowledge as a collaborative and systemic activity: a system of cooperation and interactive learning (Lundvall, 1992). The system consists of a web of interconnected elements and relationships that facilitate the creation and diffusion of knowledge within a national economy (Chaminade, 2018, p. 69).

The National Innovation System (NIS) framework underscores the significance of interconnectedness and interdependence among various economic elements, drawing from developmental theories by economists such as Stewart (1997) and Hirschman (1958). Stewart's work emphasises the role of intellectual capital and know-how as a critical driver for technical advancements and structural change in developing countries, arguing that building local capabilities and fostering innovation within developing economies can lead to sustained economic growth. Secondly, Hirschman's (1958) linkage theory adds depth to this perspective by highlighting the significance of interconnected economic sectors, or in our case: innovation elements.

NIS, Conceptual Complexity and Triple Helix

The National Innovation System (NIS) offers a comprehensive framework for grasping innovation compared to the readily utilised Triple Helix model, which mainly focuses on the interactions among universities, industry and government. Unlike the Triple Helix, which limits its focus to three actors, NIS encompasses a spectrum of stakeholders: non-governmental organisations, technology transfer intermediaries, venture capitalists, financial institutions, and policy and regulatory bodies. Moreover, NIS incorporates social aspects into its framework by emphasising how cultural values, social norms, and historical contexts impact innovation and technological integration capabilities. This dimension introduces complexity by acknowledging that innovation is not solely an institutional result but also shaped by the socio-environment in which it unfolds.

Key elements, like strategies, political steadiness, regulations and legal settings, shape innovation endeavours. This holistic perspective enables NIS to tackle the intricacies of the innovation landscape in a manner not typically covered by the Triple Helix model. Moreover, NIS underscores the interplay within the innovation system, including feedback loops where the outcomes of innovation processes can impact the elements of the system.

This viewpoint underscores how innovation ecosystems evolve and possess the ability to adjust and evolve with time. By understanding the various factors influencing innovation, NIS lays a stronger groundwork for policy development. It aids policymakers in crafting strategies considering various influences, enhancing national innovation capabilities more efficiently. NIS's detailed and interconnected nature makes it a valuable instrument for examining and promoting innovation across landscapes like Kenya, where institutional, cultural and economic factors significantly shape the nuances of innovation endeavours.

3.2 Grand Theoretical Influences

Given NIS's broad conceptualisation as a framework encompassing various functions, activities, and practices, linking it to a theoretical framework is challenging as a practical application in analysing ISs (Edquist, 2010). Given this, a comprehension of the theories that have guided and inspired the NIS concept will be conducted to provide a greater apprehension of a theoretical framework for analysing bottlenecks in the KNIS.

The Techno-Economic Paradigms

From Schumpeter's perennial work (1934) on the centrality of entrepreneurship and evolutionary processes, innovation has become integral to the analysis and prospects for long-term economic development and structural change.

With waves of emerging endogenous innovations, economies change in tandem with cyclical investments and growth patterns over time (Grossman & Helpmann, 1994). As such, the Schumpeterian school has set a conceptual groundwork for a specific emphasis on innovation in examining technical change and the evolution of economic systems within economic history and innovation studies (Mokyr, 2010). The analysis of innovations' role in economic development can be further attributed to the techno-economic paradigm, which represents a synthesis of economic theories prominently championed by influential figures such as Freeman (1991) and Perez (2010) within the Schumpeterian school.

The paradigm delves into the profound impact of technological revolutions on economic structures, elucidating how these revolutions trigger phases of rapid growth and structural transformation within economies seeking to catch up, overtake, and ensure they do not fall behind (Chaminade et al., 2018, p.32). Its relevance for analysing the KNIS is a critical analytical tool for comprehending the intricate interplay between the factors influencing innovation performance.

Furthermore, by examining historical patterns of technological change and their repercussions on economic systems, the thesis will discern the emergence of distinct techno-economic paradigms characterised by dominant technologies, organisational structures, and innovation patterns within our research's scope. Within the NIS framework, techno-economic paradigms provide valuable insights into the systemic interactions between government, industry, academia, and other stakeholders in shaping innovation ecosystems and driving long-term economic progress, which acts as a proponent for cross-tabulation and correlates on key variables' interconnection and relevance for innovation output.

Evolutionary Economics

In the neo-Schumpeterian schools of thought, evolutionary economics stands out for its focus on change and transformation. This focus is not merely a superficial observation but a fundamental tenet that aligns closely with the core principles of ISs (Chaminade et al., 2018, p. 32).

At its essence, evolutionary economics delves deep into the dynamic nature of economic systems, recognising that they are in a perpetual state of flux. It challenges the conventional notion of static equilibrium and rational decision-making epitomised by the 'homo economicus' model. Instead, it embraces limited rationality, disequilibrium, and complexity, acknowledging the inherent unpredictability and non-linear dynamics characterising real-world economic phenomena (Nelson & Winter, 1982). Both NIS and evolutionary economics converge in recognising the pivotal role of uncertainty and disruptions in catalysing innovation.

Evolutionary economics provides a rich analytical lens to examine the intricate interplay between technological change, institutional dynamics, and economic development. It emphasises the inherently uncertain and turbulent environment in which economic actors operate.

Evolutionary economics provides insights into how new technologies and practices come about to spread and eventually replace existing paradigms. It illuminates the process of evolution that drives development showing how innovation and creative destruction continuously reshape economic frameworks and systems. By recognising the changing nature of economic progress, evolutionary economics offers a foundation for comprehending and adapting to the intricacies of modern economic environments and shifts in factors within the KNIS, which presents an appreciation for longitudinal assessment of changes in elements and relationships over time as an implicit, integral part of empirical studies (Chaminade et al., 2018, p. 33).

Endogenous Growth Theory

Endogenous Growth theories represent a significant departure from traditional neoclassical economics by placing innovation and knowledge at the centre of long-term economic development. Pioneered by economists such as Lucas (1988), Romer (1986), and Aghion and Howitt (1992), these theories underscore the intrinsic link between innovation and sustained economic growth.

At the heart of Endogenous Growth theories lies the recognition that economic progress is not solely dependent on exogenous factors such as capital accumulation or technological shocks. Instead, these theories emphasise the pivotal role of endogenous factors, particularly innovation, in driving long-term economic dynamism. By integrating innovation as a core growth mechanism, Endogenous Growth theories depart from the traditional assumption of diminishing returns to capital, positing that investments in knowledge and human capital can yield increasing returns and foster sustained growth over time (Romer, 1989; Kefala, 2010). Drawing inspiration from Schumpeter's seminal work in 1934, Endogenous Growth theories offer a nuanced understanding of the innovation process within the National Innovation Systems (NIS) context. They contend that innovation serves not only to enhance firms' competitive advantage but also as a fundamental catalyst for sustainable economic advancement at the national level.

Nations have the potential to boost their economy in the run and improve their standing by creating a supportive atmosphere for innovation. The application of endogenous growth to our NIS analysis will, therefore, emphasise the relevance of producing an environment conducive to advancing innovation and knowledge, given its centrality in economic development. Additionally, Endogenous Growth theories provide insights into how innovation spillovers take place and their impact on productivity and economic well-being. These theories highlight the interconnectedness of players and stress the significance of sharing knowledge and transferring technology across different sectors and geographic areas.

Endogenous Growth provides a comprehensive framework for understanding the complex interplay between innovation, human capital accumulation, and economic development, in our case, innovation output. By recognising the central role of innovation in shaping long-term growth trajectories, policymakers can formulate strategies to nurture innovation ecosystems and foster sustainable prosperity in an increasingly dynamic global economy.

Social Constructivism and Innovation

In alignment with the NIS concepts focus on innovation as an interactive process (Lundvall et al., 1988), social network theory underscores the importance of networks and relationships among different actors within the innovation system. This theory provides tools to analyse how relationships affect knowledge transfer and the creation of ideas (Kolleck, 2013), emphasising that the strength and character of relational linkages can significantly impact the system's effectiveness. In the NIS framework, this perspective helps to understand how socio-cultural factors influence technological development and innovation practices. It posits that innovation is not merely a technological advancement but also a socially constructed phenomenon that reflects its creators' collective cognitive and social processes.

3.3 Emergent Innovation Systems

In exploring the application of National Innovation Systems (NIS) within emerging economies, it becomes essential to adapt the framework to reflect the unique conditions and developmental stages of these contexts. Emergent Innovation Systems are particularly relevant to countries like Kenya, where economic structures and institutional frameworks rapidly evolve to support knowledge creation, diffusion, and utilisation in distinctive ways. Emergent Innovation Systems in developing countries are marked by the formation of early-stage institutional development of both key elements and respective relationships (Chaminade et al., 2018, p. 74).

Institutions supporting innovation in these economies are often not fully established or are undergoing significant transformation. The key characteristics are, then, a supposition of some key components of the national innovation system, a degree of informality of the market, poor infrastructure, human capital advancements, and poor inter-element collaboration (Lundvall et al., 2009).

The combinations of emergent elements, relationships, and the respective socio-economic environment in which this system takes place may lead to flexibility and instability, potentially impairing knowledge and technology flows in an ever-changing dynamic system. Further exacerbated by resource constraints form another significant challenge, with emerging economies frequently grappling with limited financial, human, and infrastructural capacities. These limitations can hinder the development of robust innovation systems and further impede the prospect of advancements in innovation performance within emergent economies.

Moreover, emerging economies like Kenya often emphasise strategic international linkages to bolster their domestic capabilities. These include foreign direct investments, international research collaborations, and technology transfers, which are crucial for enhancing local innovation capacities.

Fragmented Innovation Systems and Bottlenecks

Certain components often underperform or are missing in emerging national innovation systems (NIS), leading to fragmentation and inefficiency. These weak components typically include insufficient institutional coordination, lack of effective governance, and inadequate policy frameworks (Chaminade et al., 2018, p. 74). Additionally, emerging NIS often lacks connectivity between research institutions and industry, resulting in failure to translate research into marketable innovations and producing conditions referred to as bottlenecks (Johnson, 2001). The bottleneck concept involves identifying and analysing system attributes that may hinder the development of technology and innovation (Zofio et al., 2023).

Identifying bottlenecks is crucial for targeting effective interventions that enhance connections between research and industry and improve the innovation ecosystem. The shortcomings within fragmented emerging NIS have significant consequences for the innovation system's overall performance and, by extension, economic growth. When key elements such as policy coherence, institutional alignment, and effective governance are lacking, it can lead to inefficiencies that stifle innovation outputs. The absence of robust coordination and governance mechanisms in emerging economies like those in the Maghreb region can result in stagnant economic environments where innovation is not effectively fostered or utilised to drive economic progress (Slimane & Ramadan, 2017)

3.4 Theoretical Framework

With the broad categorisation of innovation systems as an interlinked system of agents and relationships, fragmented and emerging NIS becomes a framework to understand and analyse this complex system to foster an inclusive system by identifying bottlenecks and complementarities that may impede innovation potential (Johnson, 2008). The framework is particularly relevant in explaining countries' differentiated performance regarding elemental interactions and policies in shaping a nation's innovative capabilities (Watkins et al, 2015; Nasierowski, 2009). As dysfunctions within an NIS can significantly impede a country's innovation capabilities, the emergent and weakest link theories of NIS become an integral part of our analysis in apprehending setbacks to innovation performance, a part of the broader functionalist school of IS (Edquist, 2011; Hekkert et al., 2007; Bergek et al., 2008: Wolthuis et al., 2005). With the acknowledgement of the centrality of innovation as an interactive process (Lundvall, 1985) and in constant change, as ascertained by the evolutionary economics school, the theoretical framework also sets a framework for apprehending both changes of elements and relationships over time, as innovation as a collaborative process, the relationship between elements is of considerable importance.

4. Methods and Data

4.1 Research Strategy

The research strategy for identifying potential bottlenecks within the Kenyan NIS employs a mixed-method, sequential explanatory design organised into two distinct phases: quantitative and qualitative. The research strategy is grounded in an inductive approach, which seeks to identify and contextualise empirical findings to construct general-level assertions about potential impediments within the KNIS, utilising an upward logical hierarchy. To further assert general conclusions of low performance within innovation metrics in Kenya, the qualitative section seeks to add depth and context to quantitative findings, allowing for a more comprehensive analysis and understanding of emerging results (Punch, 2014, p. 586).

The sequential explanatory research design is based on the ANIS reporting approach, an indicator-based analysis of national innovation systems intended for emerging innovation systems in developing countries (Seidel et al., 2013). The reporting system involves benchmarking KPIs of innovation systems in similar regions and local economies. Secondly, the policy framework within the respective innovation system is evaluated to produce an analysis embedded in the country's current conditions and provides actionable insights into the NIS studied. Using a mixed methods strategy enables us to comprehensively tackle the complexity of our case by integrating both quantitative and qualitative approaches offering a more profound understanding of the processes and outcomes of a case study (Robson & McCartan, 2016, p. 179). Furthermore, it allows us to compensate for outdated datasets with a triangulation of information from policy documents and primary and secondary sourced data. This functionalist approach enables us to systematically recognise and evaluate bottlenecks within NIS, consistent with the theoretical framework of Lundvall et al.'s (2011) fragmented and emerging innovation system concept.

4.3 Methodology

4.3.1 Phase 1: Quantitative Analysis: Comparative Benchmarking

Our quantitative section aims to dissect the components of the Global Innovation Index (GII) to evaluate and benchmark the performance of Kenya's NIS against strategically chosen comparison groups. This comparison highlights relative standings and pivotal trends in crafting strategies to enhance Kenya's position in the global innovation ecosystem. By doing so, the research addresses critical gaps and harnesses strengths identified through empirical evidence. Furthermore, the analysis is integral in identifying areas for improvement within Kenya's innovation landscape, contributing to a robust understanding of low-performing elements of the NIS.

4.3.1a Data Source: WIPO GII Index

The Global Innovation Index (GII) is a comprehensive metric that measures trends in the innovation ecosystem performance of 132 countries over 2012-2023 (WIPO, 2023). While linear metrics of innovation, such as those based on the Frascati Manual, predominantly utilise input/output metrics such as R&D expenditures or patent applications (Chaminade et al., 2018, p. 55), the GII offers a comprehensive measure that seeks to reflect the complex realities of national innovation systems. The GII considers aspects beyond technological outputs, including factor variables on Institutions, Infrastructure, Human Capital and research, and Business Sophistication and Market Sophistication (Appendix Table 2). The GII delves into the quality of institutions that form the backbone of innovation ecosystems, the effectiveness of government policies, the regulatory environment, and the overall business atmosphere are all scrutinised to understand how they support or hinder innovation activities.

The data asserts not only levels and quality of elements but also relationships, a key consideration for studying innovation systems. This approach is particularly aligned with the theoretical framework of the National Innovation System (NIS), which emphasises the interconnections and synergies among various actors and elements within the innovation landscape.

Within the GII, the effectiveness of government policies, regulatory environment, and overall business atmosphere are all scrutinised to understand how they support or hinder innovation activities in a data set that asserts not only levels and quality of elements but also relationships, a key consideration for the study of innovation systems (Meissner et al., 2016).

The GII's conceptual underpinning is based upon a broader definition of innovation. Innovation is generally defined through the conceptualisation originally developed for the *Oslo Manual*, emphasising improvements in products and processes, similar to technical progress in the production function ascertained by Schumpeter (1934). The GII does not offer a definition of its conception of innovation.

However, it offers a broader systems-based approach to the assertion that innovation is a process of producing innovation as an interactive process between actors and their respective environment, which is the conceptual underpinning of the NIS framework (Lundvall, 1985). The GII provides a structured way to assess and compare countries' innovation ecosystems by breaking complex constructs into understandable metrics and identifying strengths and weaknesses within national innovation systems. This is essential for developing targeted means of analysing KNIS bottlenecks, which are both highly quality and replicable.

4.3.1b Data Limitations

While the GII is considered high in data quality, it contains gaps, particularly in survey data from African nations. The research acknowledges these limitations and notes the African Union's ongoing efforts to improve STI indicators. Most GII data is not collected by the World Intellectual Property Organization (WIPO) but is acquired directly from member states. Nonetheless, the GII team identified missing and outdated data in their country representation briefs (WIPO, 2023). The thesis will also report Identified and missing data to represent findings clearly.

4.3.1c Operationalization of the Global Innovation Index (GII)

The initial quantitative analysis phase involves creating boxplots for overarching variables from the Global Innovation Index (GII). This visual assessment method allows for the preliminary comparison of performance levels across Kenya and its selected benchmark countries and regions. Boxplots highlight the distribution and range of innovation scores, facilitating the identification of outliers, median trends, and quartile distributions. Performance categorisation is conducted through quartile analysis, where innovation scores are segmented as follows:

In evaluating the performance of the National Innovation System (NIS), good performance is indicated by scores that exceed the regional median, signifying that a particular region is performing well compared to others. Conversely, poor performance is suggested by scores below the regional median, highlighting areas in need of improvement. Anomalies are identified when scores fall outside the 25th to 75th percentile range, indicating exceptionally high or disappointingly low performance levels compared to peers, warranting further investigation.

This categorisation provides a structured approach to benchmarking Kenya's innovation capabilities, highlighting strengths and pinpointing weaknesses within its NIS. Overarching variables under poor performance, especially anomalies, will signify merit for further exploration.

Following the visualisation, a longitudinal analysis is conducted from 2013 to 2022. This in-depth investigation tracks the evolution of identified low and anomaly performance, enabling the study to capture dynamic changes and trends in innovation performance over time. By adopting this iterative approach, we gain insights into the consistency and fluctuations in the innovation, which are critical for assessing progress or identifying periods of stagnation.

To delve deeper into the constituents of innovation performance, the GII is disaggregated to ascertain further areas for which, within the overarching variable, can be explained by sections variable and the respective included variables (Appendix Table 2). Each category is analysed to determine its impact on the overall innovation score and contribution to Kenya's innovation landscape changes. Iterative data processing is employed to examine data by disaggregation, allowing for a nuanced analysis of specific elements influencing poor to anomaly-level overarching variables.

4.3.1d Comparison Group & Comparative Benchmarking

The operationalised GII's comparative benchmarking involves a nuanced analysis of Kenya’s innovation system against country and regional benchmarks. The selected countries include Kenya itself, alongside Tanzania, Uganda, Botswana, and South Africa, supplemented by broader regional comparisons with Sub-Saharan Africa (SSA) and Lower Middle-Income Countries (LMIC). Botswana and South Africa are included due to their distinguished innovation performances. They were the two highest-performing nations of the SSA for 2023 (WIPO, 2023). These countries further represent a means of peer comparison, aligning with Kenya's aspirations to enhance its own innovation system and elevate its status to that of an upper-middle-income country (GoK, 2007). Their inclusion provides a comparative standard that can offer insights into performance levels compared to the highest performers of the SSA.

Tanzania and Uganda are chosen based on their geographical proximity and socio-cultural ties to Kenya. These countries share similar economic and regional contexts, making them particularly relevant for understanding how comparable environments impact innovation performance. The analysis aims to uncover regional trends, challenges, and opportunities by including these nations, providing a clearer picture of Kenya's innovation landscape. This selection strategy ensures a comprehensive examination across varying levels of innovation success, from regional peers to global leaders in innovation. By studying these diverse groups, the research highlights potential pathways for Kenya to boost innovation capabilities by learning from similar and more advanced systems. The comparative analysis seeks to extract actionable insights into fostering a robust innovation ecosystem, aiming to inform and refine Kenya's innovation policies and practices.

4.2.2 Phase 2: Contextual Analysis

In this qualitative phase, the study extends beyond the quantitative assessments previously conducted with the Global Innovation Index (GII) to incorporate a deeper, more nuanced understanding of the Kenyan National Innovation System (KNIS). The objective of this phase are to provide depth and context to the quantitative findings and explore the socio-economic and policy environments that influence KNIS performance due to the embedded nature of institutions and innovation systems (Balzat & Hanusch, 2004).

The qualitative research will thoroughly analyse the policy frameworks that govern innovation, particularly focusing on areas identified as underperforming in the quantitative phase of Vision2030 (GoK, 2007) and KIPPRA (2022). This involves an extensive review of regulatory documents, innovation policies, government support mechanisms and overall priorities that are crucial for fostering the immersion of the low performance identified in Phase 1. Further primary and secondary datasets will be utilised post-analysis for further contextual appraisal.

A thematic analysis will be performed on the collected data, identifying recurring themes significant to understanding the barriers to and facilitators of innovation within KNIS. The thematic exploration will allow us to distil key patterns and trends from qualitative data, which are essential for interpreting the broader implications of our findings and contextualising them in the historical socio-economic and political specificities that may have given rise to their emergence (Chaminade et al., 2018, p. 43). Through this qualitative phase, the study aims to move beyond mere statistical analysis, offering a layered, in-depth exploration of the factors that drive innovation in Kenya. By bridging the gap between numerical data and the actual conditions on the ground, this phase is instrumental in formulating recommendations that are not only data-driven but also contextually informed and strategically viable. This approach ensures that the insights generated are robust and capable of guiding targeted interventions to enhance the efficacy of KNIS.

The choice of policy documents is directly related to the GII variables: the overarching section and included indicators. Grand conceptual policy frameworks in Kenya are provided in the Vision2030 development plan spanning from 2008-2030, which aligns with the timeframe of the GII dataset. The development plan includes all overarching policy priorities, which will be further explored and identified utilising our thematic coding. Based on the findings from my quantitative analysis, the coding strategy involves categorising themes based on the overarching variable determined to be considered low-performing or anomalies. These areas, including the section and included variables, will, therefore, guide the focus of the policy analysis. This implies that the nature of the argumentation asserts the overarching variable as the point of investigation, with the sub-indices as sections of the thematic analysis that will be undergone inductively but based upon the overarching variable. Furthermore, the GII variables will also be coded in the context of prioritisation to determine the scope of intervention and choices of improvements that have been chosen in Kenya.

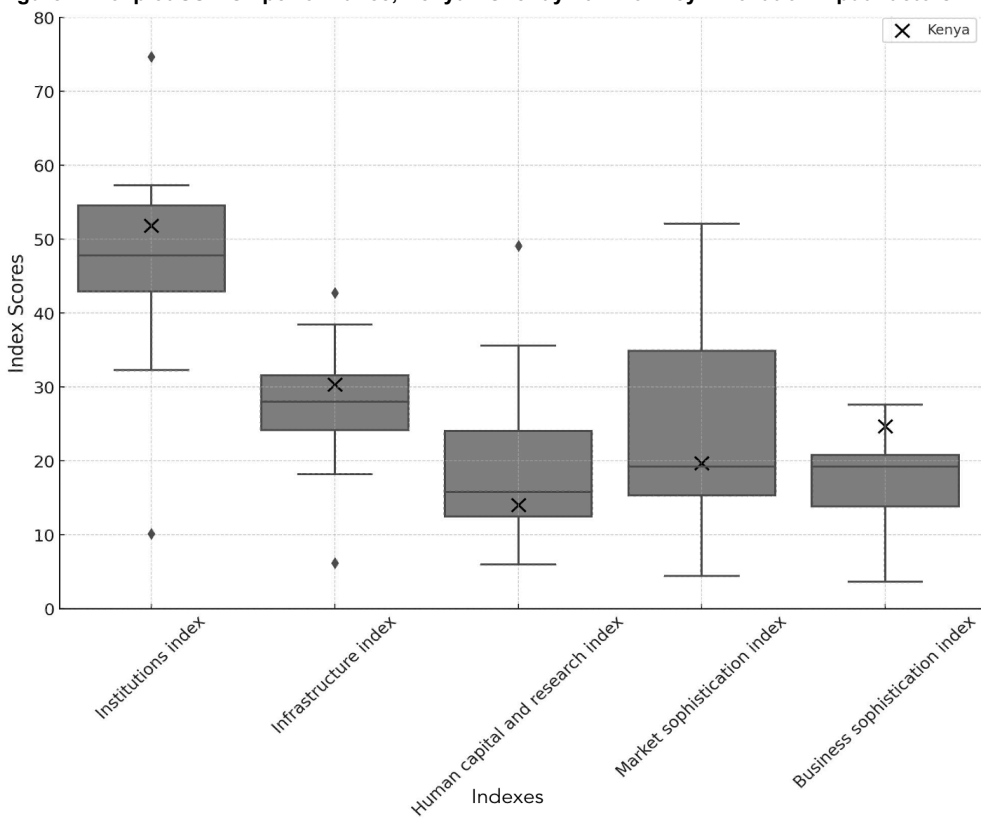
5. Empirical Findings

5.1 Benchmarking results

5.1.1 Overarching Indicators

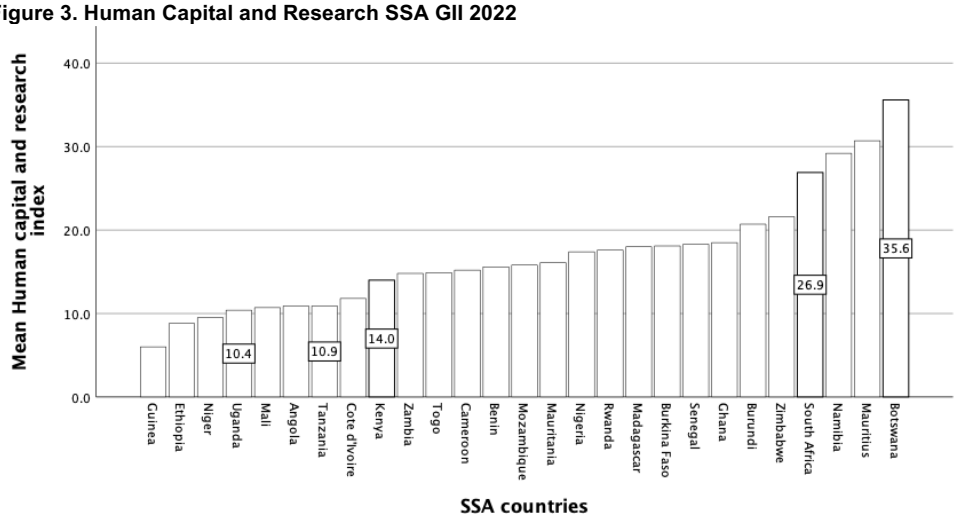
Overarching variables, the factors that represent the dimensions of the GII, with data from the latest WIPO (2023) report, have been utilised for comparative benchmarking between Kenya, the SSA, and LMICs for 2022. Based on the World Bank definition FY2024, there were 48 countries in the SSA and 56 LMICs in 2022, with our data containing N of 27 and 36, respectively, for that year.

Figure 2. Boxplot SSA GII performance, Kenyan Overlay 2022 for Key Innovation Input Factors



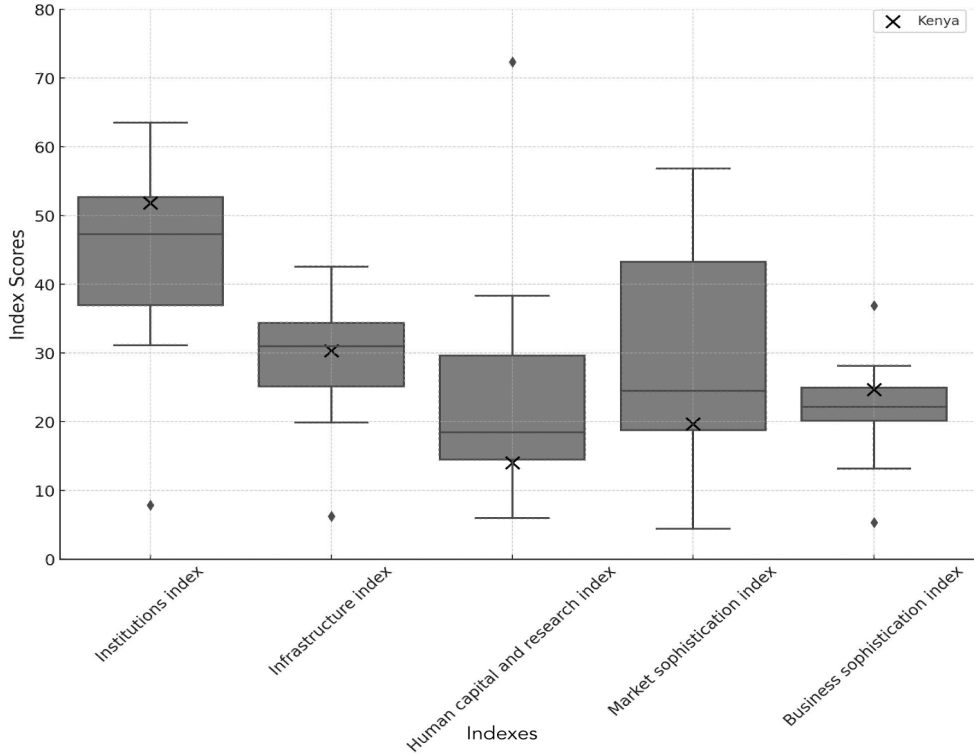
Kenya exhibits commendable performance in several key indexes within the 2022 GII compared to other SSA countries in input-related innovation indicators (Figure 2). For 2022, Kenya scored almost all factors above median levels, with business sophistication (27.7) among the top 25th percentile (25.2). Conversely, Kenya faces challenges in Human Capital and Research (14.0), where its performance lags behind the SSA median (16.9). In the comparison group, Kenya performs higher than Tanzania and Uganda but considerably behind South Africa (35.6) and Botswana (26.9) (Figure 3).

Figure 3. Human Capital and Research SSA GII 2022



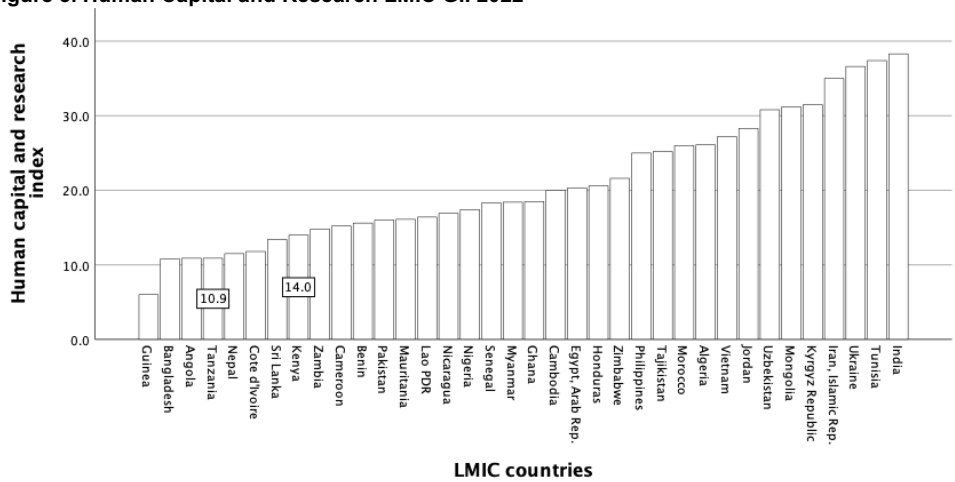
The lower Human Capital and Research Index score indicates potential weaknesses in education quality, research and development investment, and the availability of skilled researchers and scientists. This suggests a need for further investigation in our weakest-link analysis to determine its potential impact on the innovation output sub-index. However, the findings here are from a geographical region of the SSA containing multiple income groups, with 21 countries missing from our sample (Appendix Table 7). Furthermore, the N 27 sample represents only 45.45% of LI, 65% of LMI, and 57% of UMI, which entails only 56% of SSA has been represented in our benchmarking due to poor statistical availability.

Figure 4. Boxplot LMIC GII performance, Kenyan Overlay (2022) for Key Innovation Input Factors



Due to the SSA's limited statistical capacity in 2022, we have incorporated income group LMIC benchmarking to assess performance more accurately. We can better understand performance factors beyond the SSA's regional scope by analysing a larger sample size based on income groups. Benchmarking by income group reveals that Kenyan performance is lower than performance levels within our SSA sample (refer to Figure 4). Despite the above-median performance in institutions and business sophistication, Kenya shows areas of underperformance, notably in the Human Capital and Research Index (14.0), which is among the lowest 25th percentile (14.9) compared to other LMICs and is considered an anomaly. Notably, market sophistication is also below median levels, 19.7 compared to the 24.717 median for the income group, along with infrastructure (30.3) to LMIC median (31.0).

Figure 5. Human Capital and Research LMIC GII 2022

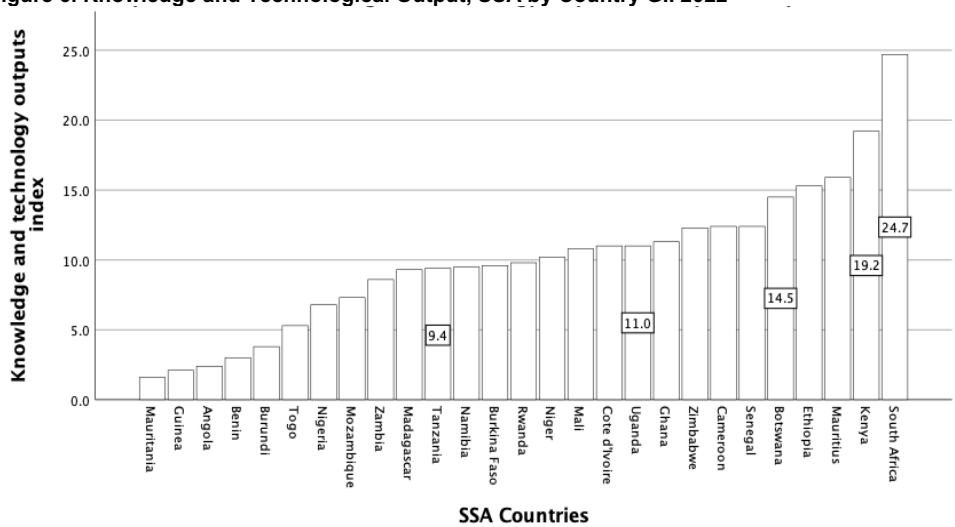


A comparison among LMICs (GNI $1,136 to $4,465) further ascertains low global performance, with the latter being far behind northern African and *c*entral*,* southern Asian countries*,* albeit outperforming Tanzania (Figure 5). In sum, regarding elements of innovation inputs of the GII, Human Capital and Research appears to be a low-performing sector for the innovation input-sub index. Despite Kenya's generally high performance in the GII's KPI, our initial operationalisation has deduced that Human Capital and research is a factor for which it is performing at both a regional and income-based level, lagging behind peers such as Botswana, South Africa, Asia, and North Africa at large.

Although the low performance of some key input elements of innovation performance is underperforming on an international scale, the empirical findings suggest an above-median score in innovation output sub-index factors such as Knowledge and Technology and Creative Output, considered the fruits of the system's labour, elements, and relationships in the KNIS (WIPO,2023). Kenya's performance in the "Creative Outputs" category is impressive when evaluated within both the Sub-Saharan Africa (SSA) and Lower-Middle-Income Countries (LMIC) groups (Appendix Tables 3-5).

Kenya's score (15.6) is considerably higher than the SSA (5.4), placing Kenya at the top of the 25th percentile (11.1) and top 4 in the region, behind Ghana and South Africa. Within the LMIC group, Kenya's score exceeds the median (10.5), though it falls below the 75th percentile (19.2). This positioning shows that Kenya performs exceptionally well within the SSA context, ranking among the top performers and having an above-median position within the broader LMIC group.

Figure 6. Knowledge and Technological Output, SSA by Country GII 2022

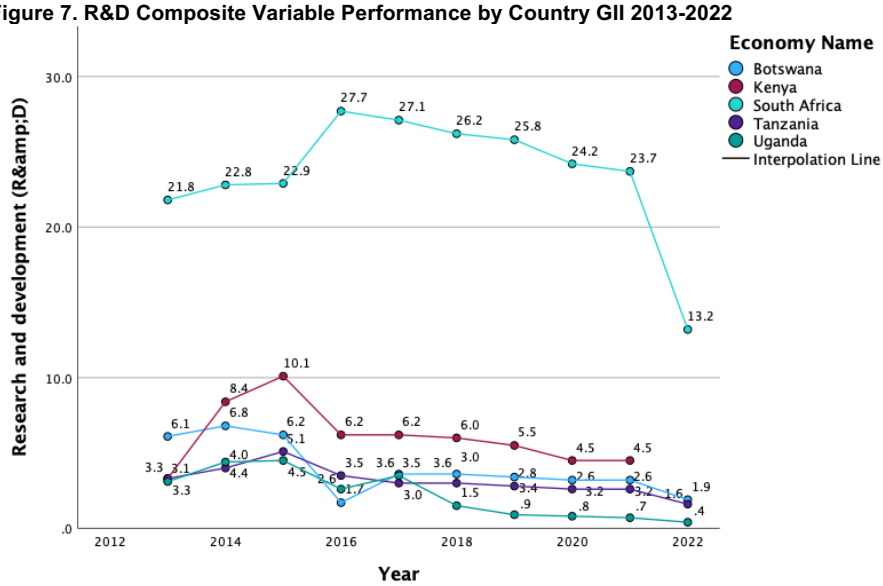


The same can be said for Knowledge and Technology output (Figure 6), with Kenya (19.200) exceeding the median in both SSA (9.800) and LMIC (12.400) and being the second-highest performer in Africa behind South Africa (24.7). A consideration here, however, lies in deducing that despite high innovation outputs in Kenya, overall GII and innovation efficiency ratios have declined.

5.1.2 Section Variables

Section variables are investigated within the overarching factors contributing to low performance in our benchmarking of Kenya, SSA, and LMICs. This section will, therefore, investigate sub-indicators of human capital and research: education, tertiary education, and R&D to see trends and compare standings to our comparison group to further ascertain our weakest link investigation to poor innovation performance. This will help us identify the weakest link impediments to innovation prospects within the KNIS and move beyond the static nature of our previous findings.

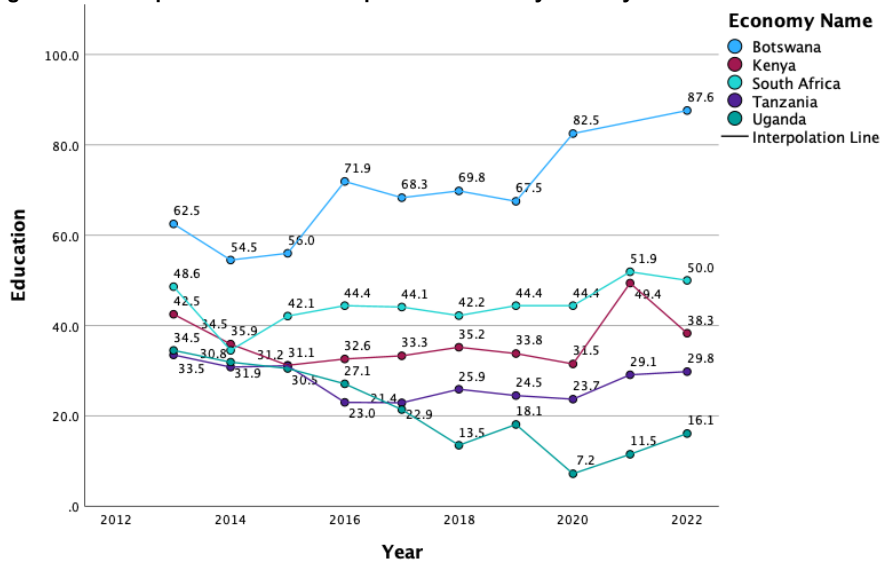
Figure 7. R&D Composite Variable Performance by Country GII 2013-2022



NOTE: Kenya's score for 2022 has been left out due to poor statistical coverage (.0).

R&D levels among the comparison group are similar, with South Africa (13.2) as a key outlier in terms of the R&D composite indicator. However, most nations are seeing a gradual decline in the composite index, which includes gross expenditure on R&D and researchers' FTE/mn pop. Kenya's 55.45% decrease from 2015 to 2021 is the largest, followed by Botswana, Tanzania, and Uganda (Figure 7).

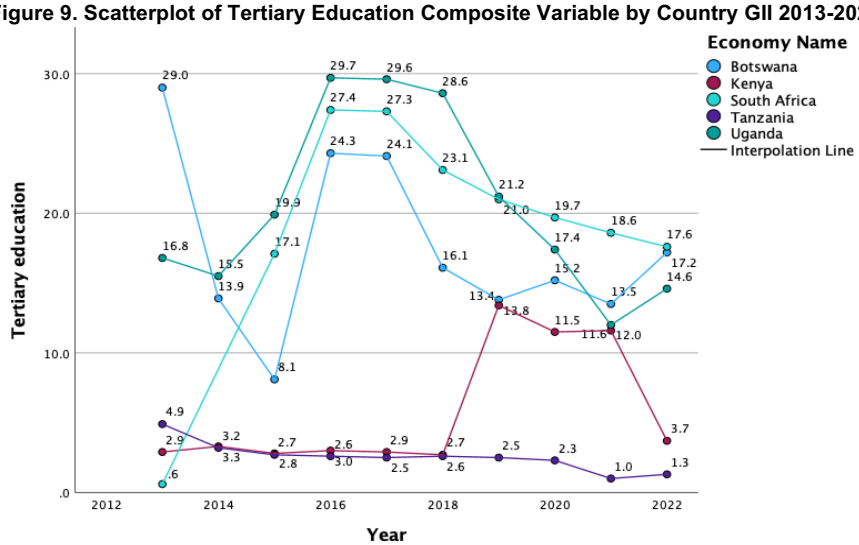
Figure 8. Scatterplot: Education Composite Variable by Country GII 2013-2022



Note: Botswana's score for 2022 has been left out due to poor statistical coverage (.0).

Kenya's education trend, on the other hand, has remained stagnant since 2013 but shows a slight upward trajectory post-2020 (21.59%). It is in the middle of the comparison group but performs below South Africa and Botswana (Figure 8).

Figure 9. Scatterplot of Tertiary Education Composite Variable by Country GII 2013-2022



Kenya's tertiary education index remained stable from 2012 until around 2018 (avg. 2.82). In 2018, the index experienced a notable surge, reaching a peak of 2.7 in 2018 to 13.8 in 2019 before declining again (Figure 9). Kenya's performance is thus considerably low, with post-2018 splitting away from Tanzania. However, it is still lagging behind its peers, with a 10.9 point difference from its next competitor, Uganda (14.6), to 3.7 for Kenya in 2022. Exploring further the included variable of tertiary education asserts a low average tertiary school enrolment (4.62%) in Kenya compared to its peers like Botswana (16.41%) between 2013-2022, indicating a low tertiary educational attainment within the nation (Appendix Figure 14).

To further assert low performance in tertiary education of the percentage of graduates in science and engineering in 2021 reveals that Kenya has only 20.2% of its graduates in these fields, considerably lower than its peers in Botswana (30.5%) and South Africa (29.9%) for 2022 (Appendix Figure 15). This indicates a potential gap in Kenya's focus on developing critical skills and know-how for fostering innovation and technological advancement.

Our last included variable is tertiary inbound mobility; students from abroad are the lowest-performing indicator within the subset of tertiary education, averaging 3.275% between 2019 and 2022 for Kenya, but not too far behind Botswana (5.8%), South Africa (9.2) with Uganda as a top performer (28.6%), albeit all countries seeing a declining trend post-2018 (Appendix Figure 16)

The combined insight from these trends points to a need for a deeper contextual analysis of Kenya's education policies and economic factors affecting tertiary education and human capital and research at large. Such analysis would help understand the barriers to higher education enrolment and the low proportion of science and engineering graduates. Addressing these issues through targeted policy interventions could enhance the skill base necessary for innovation.

5.2 Content Analysis

5.2.1 Coding Framework

The coding strategy is designed around the thematic areas in our KPIs identified during our comparative benchmarking of the GII, which posits further research. This is to contextualise the empirical findings within the broader political framework of Vision 2030 to ascertain the rise and emergence origins of these potential impediments to innovation prospects. Secondly, the content analysis of Vision2030 addresses the concern of data availability on educational statistics, for instance, post-2015, to provide a more nuanced picture of the potential issue at hand: educational attainment and human capital. The coding scheme is provided below (Table 1).

Table 1. Coding Strategy Content Analysis

Code	Theme	Description	Indicators (Examples)
P1	Political Priorities	What areas are prioritized within Vision 2030	References to specific areas within education as of strategic importance.
P2	Educational Level Frameworks	Formulation of Education Level Policies (Primary, Secondary & Tertiary)	Specific policies targeting each level addressing key political priorities.
P3	Situational Analysis	Reasoning for policies within the educational sector	Elements of consideration for the imposition of P2 to addressing P1 macro level issues in Kenya.

Note: See Appendix Table 8 for coding.

The coding table for content analysis regarding Kenya's Vision 2030 is designed to explore specific aspects of Political Priorities (P1), Strategies for PI (P2) and Situational foundations for the reason of P1 and P2 (P3). These codes offer a lens to view the strategic intent and implementation efforts within Kenya's Vision 2030, particularly in enhancing human capital through educational and political initiatives. The coding is provided in Appendix Table 8 to assert transparency and replicability of our findings.

5.2.2 Findings

In the third pillar of Vision2030, Equity and Poverty Reduction, key political priorities to alleviate rising regional inequality have introduced regional programmes to ensure no one is left behind in the development process (GoK, 2007, p.3) for which equitable access to education is prioritised (p.101). A report by KIPPRA (2022) also asserts that national education priorities include ensuring universal, inclusive, quality and relevant education and training accessible to all (p. 84).

Our coding has identified two main areas of strategic importance in prioritised areas (P1): P1A, which focuses on equitable access to education and its availability to marginalised and rural communities (GoK, 2007, p.101), and P1B, which focuses on improving the quality and relevance of educational programs, particularly to meet market demands (p.94). These are the guiding overarching goals for the Vision2030 educational and training sector for the social pillar of the agenda.

Policy frameworks (P2) identified are predominantly within the sphere of P1A (6) and P1B (2) of our 8 total strategies identified in the education and training sector. P2A strategies have a considerable bottom-up approach to educational attainment, including free universal primary education post-2003 (p.3), construction of 560 secondary schools post-2012, and mobile boarding schools for primary and secondary school availability of pastoral nomadic communities (p. 101).

These identified key strategies focus on primary and secondary schooling availability and access, but Agenda2030 only minorly addresses the attainment of tertiary education. Of the 6 P1A strategies found, 1 has been identified as a means for advancements to improve educational attainment at the university level, including open and distance learning programmes to alleviate individuals' geographical and financial constraints for further studies (p. 101) which attests to one of our key P3 findings, a key structural constraint to tertiary education in Kenya lies in poor equitable access, quality and relevant education (p.94).

P1B strategies involve incorporating STI and STEM coursework in tertiary education programmes (p. 102) and a comprehensive educational reform for quality improvement and transition rates in early education and primary and secondary schooling (p. 96 & 97). To comprehend the reasoning for strategic policies, one must acknowledge the situational findings identified in the coding.

Out of the 6 P3 identified in our coding, many contextual underpinnings to the strategies and agendas attributed in Vision2030 align closely with our quantitative findings in our comparative benchmarking. STI and STEM coursework stems from an acknowledgement of the poor relevant education in Kenya (p.94), but also a shortage in capacities at the university level (p.96) and a misalignment with market needs of know-how of current educational programmes (p.98). Another consideration has been the financial constraints at the individual and construction levels, despite the availability of schools (p. 96), albeit technical and tertiary education enrolment being attributed to as an “acute” issue (p.97).

5.2.3 Educational Sector

The Vision2030 grand development strategy was written in 2007, and despite aspirations to improve several sectors we acknowledged as underperforming in our benchmarking analysis, the issues are still present in 2022, which posits further contextual study into the trends between these years.

Figure 10. Government expenditure on education, (%) GDP Kenya GII 2013-2022

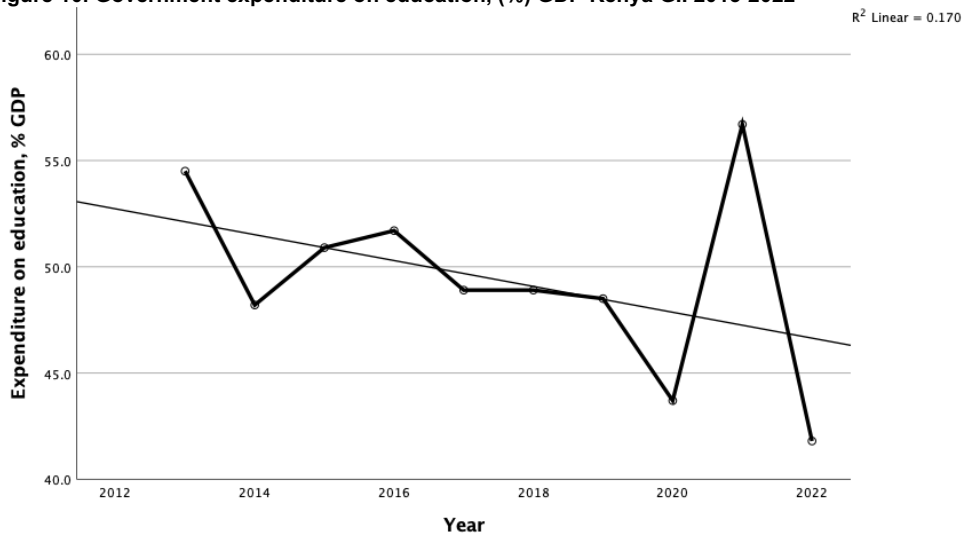
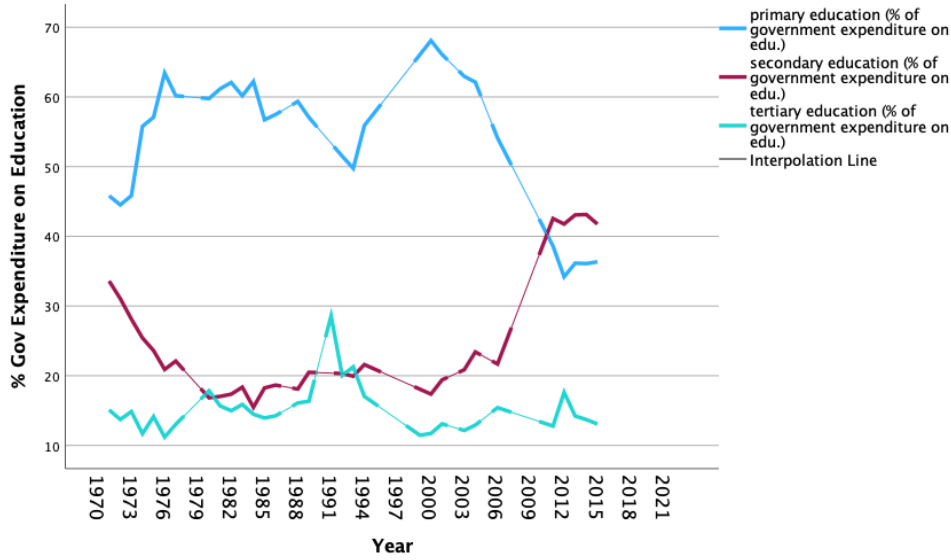


Figure 10 illustrates a general trend of declining educational expenditure as a percentage of Kenya's GDP from 2012 onwards, with a notable dip occurring after 2016 and reaching a low point in 2020, despite education being a key strategic area in Vision 2030 (GoK, 2007, p. 7). Nonetheless, the respective decline in expenditures does not align with the surge in tertiary education and enrolment between 2019-2021. Still, the decline in expenditure does not ascertain how that money is spent. KIPRA (2019), however, states that approximately 92% of government expenditure on education is based on recurrent spending, with free primary and secondary schooling (40%) and wages (52%), with estimates of underspending on tertiary allotment by 30% for the fiscal year. We can thereby further deduce the financial and political prioritisation of primary and secondary education within the educational element of the KNIS.

Figure 11 below provides a more detailed breakdown of government expenditures on different levels of education. It reveals that while the percentage of government expenditures on primary education has decreased significantly post 2000 and a subsequent rise of secondary school financing from 2006, allocation for tertiary education starting has remained stagnant.

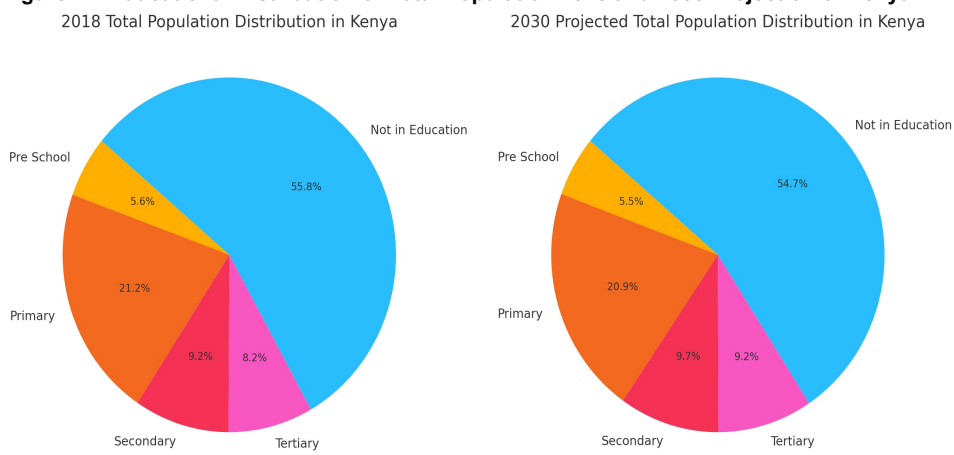
Figure 11. Dis-Aggregated % Government expenditure on education Kenya 1970-2015



Data Source: UNESCO Institute for Statistics (UIS) (2023), Mapping Research and Innovation in the Republic of Kenya. UIS.Stat Bulk. NOTE: gaps in the data set have been interpolated.

Noticeably, the disaggregated government expenditure on education is only accessible until 2015. Still, the data is under the Vision2030 timeframe and aligns with our quantitative benchmarking on low tertiary education scoring and subsequent content analysis with prioritisation of primary and secondary education.

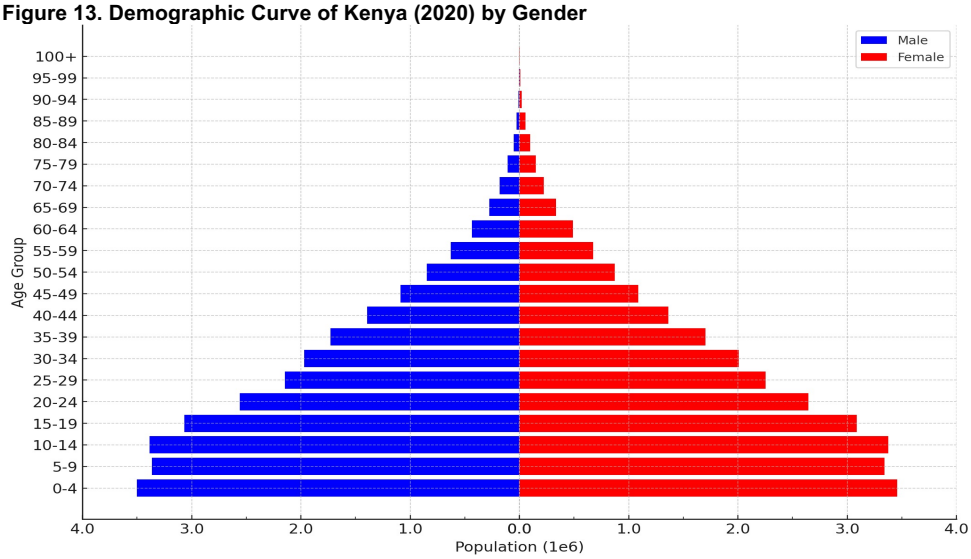
Figure 12. Educational Distribution of Total Population 2018 and 2030 Projection of Kenya



Source: KNBS (2018), Economic Survey

Approximately 46% of Kenyans are within schooling years (4-21) (Figure 12), so schooling has become a central aspiration for overarching long-term development plans like Vision2030 and the National Education Sector Policy (2013), which further ascertains the P3 ambitions of the Nation for bottoms-up educational attainment.

Figure 13. Demographic Curve of Kenya (2020) by Gender



Source: United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022

With a significant proportion of its population at the lower end of the demographic pyramid (Figure 13), Kenya's educational policy makes sense in terms of fostering education, reaching a large section of the population, and ensuring no one is left behind (GoK, 2007, p.3). This strategy is crucial due to the high number of children and young adolescents who require access to basic education as a foundation for their future academic and career opportunities. Focusing on these basic educational levels in Kenya can benefit many young people. However, this may come at the expense of advancements in TVET and tertiary education, which are still lacking as of 2022, 15 years after the launch of the Vision2030 strategy.

5.3 Human Capital and Relationship to NIS Factors

Our findings have ascertained the weakest link elements within human capital and research, particularly tertiary education and a decline in R&D within Kenya. Yet, to ascertain and attribute to our theoretical framework, NIS are subject to a complicated relationship between elements and linkages (Edquist, 2010). Albeit the fragmented nature of emerging IS (Chaminade et al, 2018, p. 74), a correlated analysis has been conducted to ascertain linkages and relationships between various elements within the KNIS innovation inputs and their importance for respective outputs.

A correlation analysis of key factors of NIS in LMIC from 2013 to 2022 reveals that Human Capital and Research have moderate, statistically significant relationships with several key components of the KNIS (Appendix Table 9). Notably, a strong and significant correlation exists between Institutions ($r = 0.728$, $p = .001$) and a moderately strong linkage with Infrastructure ($r = 0.447$, $p = .004$). These relationships underscore the integral role of educational and research development in strengthening institutional frameworks and supporting infrastructure, which is vital for a robust innovation system. Additionally, Human Capital and Research are moderately correlated with Market Sophistication ($r = 0.365$, $p = .021$) and knowledge output ($r = 0.314$, $p = .048$).

The paper acknowledges that correlates assume a linear relationship between factors and do not imply causation but ascertains Human Capital and Research as an integral element for which is associated and has respective relationships between central innovation input elements of the KNIS. These findings assert that human capital and research are correlated and moderately associated with many key areas of NIS among LMICs, highlighting the importance of the performance of human capital as a catalyst for enhancing other significant factors within Kenya's NIS and a key element in furthering innovation output. Secondly, we will test the association between innovation output and Human Capital and Research section variables.

The Knowledge and Technology Outputs Index shows a strong and statistically significant positive correlation with Tertiary Education % pop ($r = .356$, $p < .001$) and Graduates in Science and Engineering ($r = .252$, $p < .001$), indicating that higher levels of tertiary education and a greater proportion of graduates in science and engineering are associated with higher knowledge and technology outputs (Appendix Table 10). Conversely, the correlation between Tertiary Inbound Mobility and Knowledge and Technology Outputs is insignificant ($r = .023$, $p = .349$), suggesting that the percentage of international students does not significantly impact knowledge and technology outputs. The Creative Outputs Index, however, is positively correlated with Tertiary Education ($r = .225$, $p < .001$) and Tertiary Inbound Mobility ($r = .148$, $p = .006$), indicating that higher levels of tertiary education and greater international student presence are associated with increased creative outputs.

The findings from the Knowledge and Technology Outputs Index and the Creative Outputs Index highlight the critical role that education, particularly tertiary education, plays in fostering innovation and creativity output within the KNIS. The strong positive correlation between higher levels of tertiary education and knowledge and technology outputs suggests further that a well-educated population is better equipped to contribute to technological advancements and produce new knowledge (Stewart, 1997). Similarly, a greater proportion of graduates in science and engineering directly translates to increased outputs in these areas, emphasising the importance of specialised education in driving innovation. On the creative front, the positive correlations with both tertiary education and international student presence suggest that a diverse and educated population fosters a richer environment for creative outputs. These relationships underscore the multifaceted impact of higher education on both technological and creative domains, highlighting the need for policies that enhance educational attainment and effectively integrate diverse talents into KNIS for both the creation, but also utilisation of know-how in the market.

6. Discussion

6.1 Human Capital, Research and Innovation

In apprehension of our weakest link approach to analysing key impediments to the innovation performance of the KNIS, a central factor within the IS, Human Capital and Research, is found to be lagging behind both SSA (16.9) and LMIC (18.45) medians and among the bottom 25th percentile for LMIC despite being a top performer in innovation outputs. The acknowledgement of reduced R&D performance, along with the considerably low performance of tertiary education in Kenya, is further asserted in Vision2030's P3 coding considerations, aligning with previous empirical research on poor technical know-how in Kenya (Bartels et al., 2016; UNIDO, 2015) and African structural constraints of technological advancements due to critical lack of human capital (Garcia et al., 2013; Pellegrino & Savona, 2017).

The significance of our findings also aligns with previous empirical research regarding the importance of knowledge creation, such as strong R&D systems to foster innovation output (Bergek et al., 2008). Similarly, Hekkert et al., (2007) further underscores the significance of knowledge creation for improving innovation prospects, suggesting that innovation potential remains stunted without addressing gaps in human capital. Additionally, Liu and White (2001) emphasise the importance of educational advancements and specific technical know-how for fostering sustainable innovation and technological progress. All of these previous works synergetically align with the bottleneck acknowledgement of our empirical findings. Furthermore, with the attribution of correlates between Human Capital and Research for both innovation input and output (Appendix Table 9-10), its improvements can be seen as a critical aspiration for advancing innovation performance by alleviating the bottleneck.

Furthermore, the positive correlation between the number of science and engineering graduates and knowledge and technology outputs further underscores these graduates' vital role in driving technological advancement and innovation. Similarly, the positive link between tertiary education and creative outputs indicates that a strong higher education system fosters technological innovation and enhances creative capacities (Appendix Table 9-10).

Nevertheless, Kenya is still seen as a leading innovator in SSA, but its innovation outputs, such as patents and research publications, lag behind peers like South Africa; further challenges in sectors critical for innovation, such as agriculture and technology transfer, have not fully capitalised in policies (Andrzejczak & Przysiecka, 2016). In terms of improving innovation output, further consideration for human capital as a bottleneck stems from the acknowledgement of innovation efficiency reduction, being the gradual decrease in outputs related to inputs, which posits that it may be an impediment within the KNIS, which can be attributed to some extent, to poor performance in Human Capital and Research.

Despite the Vision2030 agenda for advancing STEM and STI levels in higher education (GoK, 2007, p. 100), our benchmarking suggests these improvements have not been met. The Vision2030 educational strategy has predominantly been intended to offer a basic level of education to the entire population, seeking to address the limited access to education for the general population (GoK, 2007, p. 94). However, it reveals gaps in advancing tertiary-level education that can still be seen in 2022. These elemental constraints also align with our theoretical framework of emergent innovation systems, for which some key NIS components are in place. Yet, quality and linkages are in early-stage construction. This creates a system imbued with poor infrastructure and an endowment of qualified human capital (Chaminade et al., 2018, p. 58), both of which have been attributed as underperforming factors in our comparative benchmarking (Figure 4).

6.2 Implications

Our findings underscore the potential for policymakers to address factors considered the weakest link in attribution to our theoretical framework (Johnson, 2001). Enhancing R&D infrastructure and increasing funding is crucial to bolstering innovation outputs, yet policies come down to endless needs and finite resources. These reforms are essential for addressing the systemic weaknesses in human capital and research that impede the full realisation of Kenya's innovation potential if they seek to achieve the Agenda2063 STI framework. The push for a knowledge-based economy is based on fostering the capacity and know-how of the nation and the individual. Yet, the underperforming tertiary education sector may not only hinder potential improvements in innovation performance but also obstruct long-term prospects for economic development, as ascertained in our grand theories section (Kefala, 2010; Romer, 1986).

Addressing these bottlenecks has profound implications for Kenya's long-term economic growth and technological advancement. By enhancing human capital and research capabilities, Kenya can more effectively position itself as a knowledge-driven economy. This transition is vital for sustainable development, as it will foster a more robust and innovative economic environment capable of supporting long-term growth. While the path to addressing these issues lies with policymakers, our study provides an indication of the areas that require attention to improve innovation performance and foster economic development in Kenya to reach Agenda2063 STI priority area. Poor linkages addressed in emerging innovation systems frameworks can also be attributed to educational misalignment with market needs, posing a divide between these integral elements of KNIS (GoK, 2007, p.98). Furthermore, the results also highlight a potential deficiency in addressing the availability and quality of tertiary education, which are essential for fostering innovation and supporting Kenya's aspirations as a knowledge-driven economy and underscores tertiary education's pivotal role in shaping innovation performance.

7. Conclusion

7.1 Aim and Relevance

This thesis delves into KNIS's underperformance, shedding light on significant bottlenecks through a mixed-methods approach. Our comparison analysis has revealed that Kenya's Human Capital and Research sector in education and R&D investment falls short compared to other countries in SSA and LMICs. Further analysing Kenya's Vision2030 policy framework, it became evident that the strategic priorities have mainly centred on primary and secondary education, which has led to a gap in the advancements for higher education. This discrepancy in policy focus and insufficient investment in education and research may contribute to underperforming capital, which persists even in 2022. By pinpointing the deficiencies in education and R&D, this study emphasises the necessity of aligning policy priorities with the requirements of the innovation ecosystem.

To enhance its innovation outcomes and overall economic progress, resolving these issues is crucial for Kenya. The discoveries from this study add to our comprehension of how developing nations can enhance their emerging and disjointed innovation systems to promote sustainable development. Additionally, this research enriches our understanding of emerging innovation systems by illustrating how barriers like those related to human capital and research hinder the overall performance of NIS in developing countries. In sum, the paper highlights a system imbalance that sheds light on an impediment that may restrict Kenya's innovative capabilities and performance. By tackling the obstacles identified within its Human Capital and Research domains, Kenya has the potential to cultivate a more vibrant National Innovation System and potentially advance its prospects for advancing STIs in pursuit of the AU Agenda 2063.

7.2 Limitations and Further Studies

While this study provides possible insights into the key impediments to the innovation performance of KNIS, it is essential to acknowledge several limitations. Data gaps and quality pose a notable constraint. The analysis is limited by incomplete data for some Sub-Saharan African (SSA) countries, which may affect the accuracy and reliability of our comparative benchmarking. This has been sought to be alleviated by the triangulation of primary, secondary and qualitative data sources, yet it has implications for the statistical depth we can provide. Furthermore, the scope of this study is confined to Kenya, which limits the generalizability of our findings to other contexts. Consequently, the specific challenges and dynamics identified in the Kenyan innovation system may not entirely apply to other countries with different socio-economic and institutional environments. Nonetheless, the GII offers a means to compare trends and performance with other nations but is limited in its apprehension of the conceptual complexity of NIS, as pure scoring can obscure the nuanced interactions and systemic interdependencies that drive innovation within a country.

Several avenues for future research are recommended to build upon this study's findings and address its limitations. Given the limited appraisal of networks, linkages and relationships within the analysis, future research can seek to further analyse the subsequent relationships and complementarities between key elements of the KNIS to ascertain flows, diffusion and creation of knowledge within the system. Secondly, an in-depth evaluation of the effectiveness of policies implemented under Vision2030 and other strategic frameworks is necessary. By assessing these policies, researchers can identify successful interventions and pinpoint areas requiring further improvement, offering actionable insights for policymakers beyond the weakest link apprehension provided in this analysis. With advancements of empricial research beyond this thesis has the means to empower policy makers to cultivate not only a dynamic innovation system, but Kenyas future.

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Appendix

Table 2. Global Innovation Index Input Sub-Index Variables

Overarching Variable	Section Variables	Included Variables
1. Institutions	1.1 Institutional environment	1.1.1 Operational stability for businesses
		1.1.2 Government effectiveness
	1.2 Regulatory environment	1.2.1 Regulatory quality
		1.2.2 Rule of law
		1.2.3 Cost of redundancy dismissal
	1.3 Business environment	1.3.1 Policies for doing business
		1.3.2 Entrepreneurship policies and culture
2. Human Capital & Research	2.1 Education	2.1.1 Expenditure on education, % GDP
		2.1.2 Government funding/pupil, secondary
		2.1.3 School life expectancy
		2.1.4 PISA scales in reading, maths and science
		2.1.5 Pupil-teacher ratio, secondary
	2.2 Tertiary education	2.2.1 Tertiary enrolment, % gross
		2.2.2 Graduates in science and engineering
		2.2.3 Tertiary inbound mobility
	2.3 Research and Development (R&D)	2.3.1 Researchers, FTE/mn pop.
		2.3.2 Gross expenditure on R&D, % GDP
		2.3.3 Global corporate R&D investors, top 3
		2.3.4 QS university ranking, top 3
3. Infrastructure	3.1 Information and Communication Technologies (ICTs)	3.1.1 ICT access
		3.1.2 ICT use
		3.1.3 Government's online service
		3.1.4 E-participation
	3.2 General infrastructure	3.2.1 Electricity output, GWh/mn pop.
		3.2.2 Logistics performance
		3.2.3 Gross capital formation, % GDP
	3.3 Ecological sustainability	3.3.1 GDP/unit of energy use
		3.3.2 Environmental performance
		3.3.3 ISO 14001 environment/bn PPP$ GDP
4. Market Sophistication	4.1 Credit	4.1.1 Finance for startups and scaleups

Overarching Variable	Section Variables	Included Variables
		4.1.2 Domestic credit to private sector, % GDP
		4.1.3 Loans from microfinance institutions
	4.2 Investment	4.2.1 Market capitalization, % GDP
		4.2.2 Venture capital (VC) investors, deals/bn PPP$ GDP
		4.2.3 VC recipients, deals/bn PPP$ GDP
		4.2.4 VC received, value, % GDP
	4.3 Trade, Diversification, and Market Scale	4.3.1 Applied tariff rate, weighted avg., %
		4.3.2 Domestic industry diversification
		4.3.3 Domestic market scale, bn PPP$
5. Business Sophistication	5.1 Knowledge workers	5.1.1 Knowledge-intensive employment, %
		5.1.2 Firms offering formal training, %
		5.1.3 GERD performed by business, % GDP
		5.1.4 GERD financed by business, %
		5.1.5 Females employed with advanced degrees, %
	5.2 Innovation linkages	5.2.1 University-industry R&D collaboration
		5.2.2 State of cluster development
		5.2.3 GERD financed by abroad, % GDP
		5.2.4 Joint venture/strategic alliance deals/bn PPP$ GDP
		5.2.5 Patent families/bn PPP$ GDP
	5.3 Knowledge absorption	5.3.1 Intellectual property payments, % total trade
		5.3.2 High-tech imports, % total trade
		5.3.3 ICT services imports, % total trade
		5.3.4 FDI net inflows, % GDP
		5.3.5 Research talent, % in businesses

Source: WIPO (2023)

Table 3. Innovation Outputs GII

6. Knowledge & Technology Output	6.1 Knowledge creation	6.1.1 Patents by origin/bn PPP$ GDP
		6.1.2 PCT patents by origin/bn PPP$ GDP
		6.1.3 Utility models by origin/bn PPP$ GDP
		6.1.4 Scientific and technical articles/bn PPP$ GDP
		6.1.5 Citable documents H-index
	6.2 Knowledge impact	6.2.1 Labor productivity growth, %
		6.2.2 Unicorn valuation, % GDP
		6.2.3 Software spending, % GDP
		6.2.4 High-tech manufacturing, %
	6.3 Knowledge diffusion	6.3.1 Intellectual property receipts, % total trade
		6.3.2 Production and export complexity
		6.3.3 High-tech exports, % total trade
		6.3.4 ICT services exports, % total trade
		6.3.5 ISO 9001 quality/bn PPP$ GDP
7. Creative Outputs	7.1 Intangible Assets	7.1.1 Trademarks by origin/bn PPP€ GDP
		7.1.2 Industrial Designs by origin PPP€ GDP
		7.1.3 ICT & business model creation
		7.1.4 ICT & organisational model creation
	7.2 Creative Goods and Services	7.2.1 Cultural & creative services exp, % total trade
		7.2.2 National Feature films/mm pop 15-69
		7.2.3 Printing & publishing manufactures %
		7.2.4 Creative goods exports, % total trade
	7.3 Online Creativity	7.3.1 Generic TLD/th pop 15-69
		7.3.2 Country-code TLDs/th pop. 15-69
		7.3.3 Wikipedia monthly edits/mm pop. 15-69
		7.3.4 Video

Source: WIPO (2023).

Table 4. SSA Scores GII 2022

Variable		Institutions	Infrastructure	Human capital and research	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative Outputs
N		27	27	27	27	27	27	27
Missing		21	21	21	21	21	21	21
Mean		50.126	28.533	16.963	19.226	19.800	9.981	7.815
Median		47.800	28.000	15.800	17.800	19.200	9.800	5.400
Std. Deviation		10.1230	6.2000	7.0079	10.2415	3.6032	5.2846	7.6441
Variance		102.476	38.440	49.111	104.887	12.983	27.927	58.433
Range		42.4	24.5	29.6	47.7	14.4	23.1	32.8
Minimum		32.3	18.2	6.0	4.4	13.2	1.6	.3
Maximum		74.7	42.7	35.6	52.1	27.6	24.7	33.1
Percentiles	25	43.500	23.800	10.900	12.800	16.800	6.800	2.100
	50	47.800	28.000	15.800	17.800	19.200	9.800	5.400
	75	57.300	32.800	18.500	22.000	21.800	12.400	11.10

Source: WIPO (2023).

Table 5. LMIC GII Scores 2022

Variable		Institutions	Infrastructure	Human capital and research	Market sophistication	Business sophistication	Knowledge & technology outputs	Creative Outputs
N		36	36	36	36	36	36	36
Missing		18	18	18	18	18	18	18
Mean		47.453	31.797	20.944	25.717	22.167	14.581	12.333
Median		47.300	31.000	18.450	24.500	21.550	12.400	10.500
Std. Deviation		7.8456	6.2140	8.5061	11.4710	5.3019	8.5515	8.7170
Variance		61.553	38.614	72.355	131.585	28.110	73.128	75.986
Range		32.4	22.6	32.3	52.4	23.7	32.2	31.5
Minimum		31.1	19.9	6.0	4.4	13.2	1.6	.3
Maximum		63.5	42.5	38.3	56.8	36.9	33.8	31.8
Percentiles	25	41.450	27.600	14.900	17.825	18.675	7.925	5.400
	50	47.300	31.000	18.450	24.500	21.550	12.400	10.500
	75	53.525	36.900	26.925	34.125	25.200	19.575	19.200

Source: WIPO (2023)

Table 6. Kenya GII Score 2022

Variable	Institutions	Infrastructure	Human capital and research	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative Outputs
Score	51.800	30.300	14.000	19.700	24.700	19.200	15.6

Source: WIPO (2023)

Table 7. Country Representation in SSA Benchmarking Sample 2022

Income Group	N	Percentage	Countries	Missing Countries
Low Income	10	37.04%	Burundi, Burkina Faso, Ethiopia, Madagascar, Mali, Mozambique, Niger, Rwanda, Togo, Uganda	Chad, Democratic Republic of the Congo, Eritrea, Sierra Leone, Somalia
Lower-Middle Income	13	48.15%	Angola, Benin, Cote d'Ivoire, Cameroon, Ghana, Guinea, Kenya, Mauritania, Nigeria, Senegal, Tanzania, Zambia, Zimbabwe	Egypt, Lesotho, Morocco, Tunisia
Upper-Middle Income	4	14.81%	Botswana, Namibia, South Africa, Mauritius	Gabon, Equatorial Guinea
	27	100%		

World Bank (2023) – with major processing by Our World in Data. Income group categorisation 2022, World Bank Atlas Method. Low-income economies GNI per capita <=$1,135. Lower middle-income =$1,136 and <=$4,465. Upper middle-income economies =$4,466 and <=$13,845. High-income economies >=$13,846.

Figure 14. Scatterplot: Tertiary School Enrolment % Gross by Country GII 2013-2022

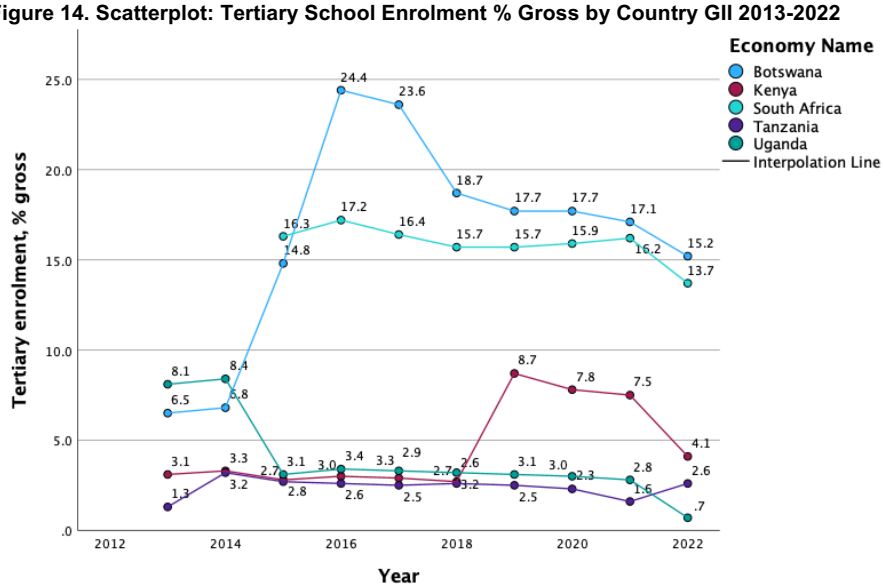
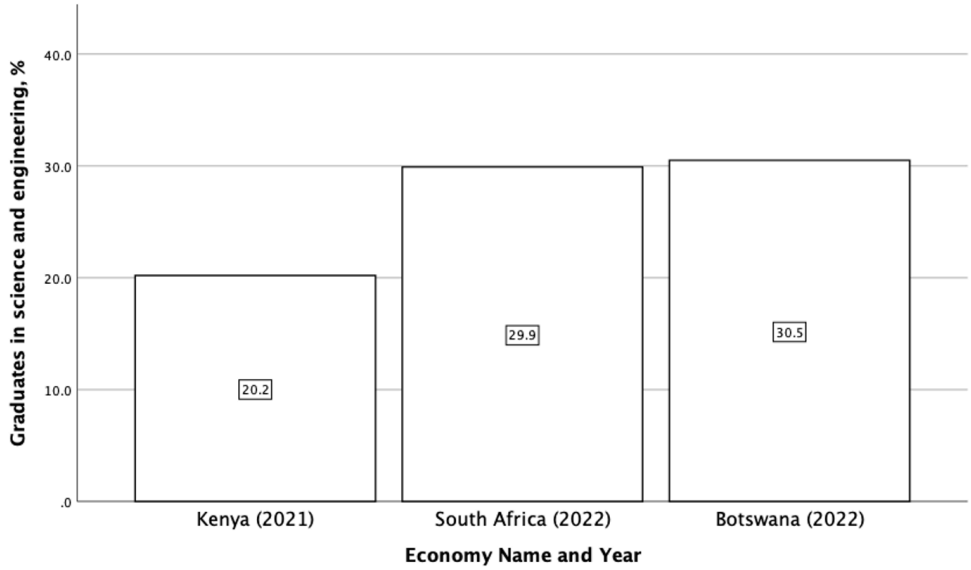


Figure 15. Barchart: STEM Graduates % by Country GII 2021-2022



NOTE: Kenya has no statistical coverage on STEM graduates for 2022.

Figure 16. Scatterplot: Tertiary Inbound Mobility % by Country GII 2013-2022

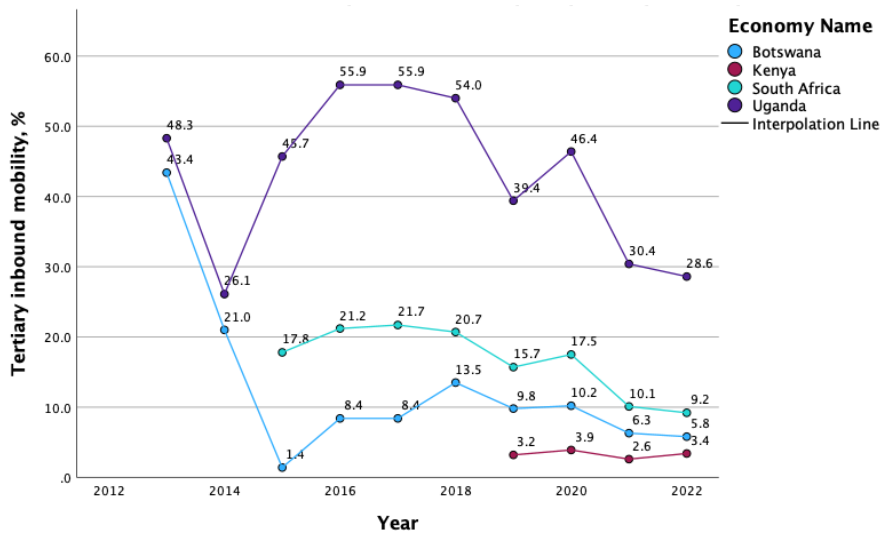


Table 8. Content Analysis, Policy Framework of Vision2030, Kenya

Code	Theme	Description	Indicators (Examples)	Excerpts	Relevance
P1	Political Priorities	What areas are prioritized within Vision 2030?	References to specific areas within education as of strategic importance.	Equitable access to to education that reaches the marginalised and rural comminties (p.101).	Focus has been on advancements of primary and secondary education for the population at large.
				Improving the quality of educational programmes that meets market demand (p.94).	Despite advancements towards access and availability, quality of education is ascertained as low.
P2	Educational Strategies by level	Formulation of Education Level Policies (Primary, Secondary & Tertiary)	Specific policies targeting each level addressing key political priorities.	Free Universal Primary Education post 2003 (p.3).	Alignment with priority A. Bottom up approach to education.
				Improving transition rates between Primary and Secondary Education (p.97).	Focus on moving the population up the educational ladder.
				Early childhood, primary and secondary educational reforms for enhanced quality of programmes (p.96).	Alignment with priority B.
				Construction of 560 secondary schools post 2012 (p.101).	Improving availability and access of secondary education, priority A.
				Supporting the development of private higher education that fulfills the requirements of the Higher Education	Supporting private sector development of tertiary education, priority A.

				Commission of Kenya (p.101).	
				ASAL: Mobile and Boarding Schools to reach rural and pastoral nomadic people (p.101)	Advancements of equitable primary and secondary availability and access, priority A.
				Open and distance learning higher education programmes	Increased tertiary education access through mediating financial constraints and geographical obsticals for tertiary education advancements, priority A.
				Incorporating STI and STEM coursework in tertiary education programmes (p.102)	Seeking to advance STEM higher education within Kenya, priority B.
P3	Situational Analysis	Reasoning for policies within the educational sector	Elements of consideration for the imposition of P2 to addressing P1 macro level issues in Kenya.	Recognition of poor equital access, quality and relevant education (p.94)	Aligns with our STEM and Tertiary Educations findings of the GII.
				Shortance of capacities at the university level (p.96)	Alignment with the quantitative findings of the GII benchmarking. Kenya being lowest 25th percentile in tertiary sector enrollment and expenditure
				Misalignment of market needs of know-how and current higher education programmes (p.98)	Poor relationship with business and market demand. Univeristy industry misalignment.

		Limiting factors for tertiary enrolment stem from both availability of facilities and high costs of attendance (p.96)	Access and availability inhibited by costs both from advancing construction of universities but also the cost of attendence for the population
		Acknowledgment of the need for expansion of teriary and higher education enrolment given the push for primary and secondary education (p.97).	Given priority of primary and secondary education, the government acknowledges the need for funding of tertiary schooling.

Source: GoK, 2007. Kenya Vision 2030: A Globally Competitive and Prosperous Kenya.

Table 9: Correlates between GII / NIS factors – LMIC 2013-2022

		Knowledge and technology outputs	Human capital and research	Institutions	Infrastructure	Market sophistication	Business sophistication
Knowledge and technology outputs	Pearson Correlation	1	.314*	.166	-.129	.581**	.650**
	Sig. (2-tailed)		.048	.305	.428	<.001	<.001
	N	40	40	40	40	40	40
Human capital and research	Pearson Correlation	.314*	1	.728**	.447**	.365*	.228
	Sig. (2-tailed)	.048		<.001	.004	.021	.157
	N	40	40	40	40	40	40
Institutions	Pearson Correlation	.166	.728**	1	.317*	.445**	-.002
	Sig. (2-tailed)	.305	<.001		.046	.004	.989
	N	40	40	40	40	40	40
Infrastructure	Pearson Correlation	-.129	.447**	.317*	1	.095	.224
	Sig. (2-tailed)	.428	.004	.046		.562	.165
	N	40	40	40	40	40	40

Market sophistication	Pearson Correlation	.581**	.365*	.445**	.095	1	.456**
	Sig. (2-tailed)	<.001	.021	.004	.562		.003
	N	40	40	40	40	40	40
Business sophistication	Pearson Correlation	.650**	.228	-.002	.224	.456**	1
	Sig. (2-tailed)	<.001	.157	.989	.165	.003	
	N	40	40	40	40	40	40

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 10. Correlates of Tertiary Education and Innovation Output Sub-indicators

		Knowledge and technology outputs index	Creative outputs index	Tertiary education	Tertiary inbound mobility, %	Graduates in science and engineering, %
Knowledge and technology outputs index	Pearson Correlation	1	.496**	.356**	.023	.252**
	Sig. (1-tailed)		<.001	<.001	.349	<.001
	N	368	368	340	292	236
Creative outputs index	Pearson Correlation	.496**	1	.225**	.148**	.075
	Sig. (1-tailed)	<.001		<.001	.006	.126
	N	368	381	340	292	236
Tertiary education	Pearson Correlation	.356**	.225**	1	.306**	.843**
	Sig. (1-tailed)	<.001	<.001		<.001	<.001
	N	340	340	340	289	236
Tertiary inbound mobility, %	Pearson Correlation	.023	.148**	.306**	1	-.116*
	Sig. (1-tailed)	.349	.006	<.001		.042
	N	292	292	289	292	224
Graduates in science and engineering, %	Pearson Correlation	.252**	.075	.843**	-.116*	1
	Sig. (1-tailed)	<.001	.126	<.001	.042	
	N	236	236	236	224	236

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).