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Research Article

Strategic Synergies: The Untold Interactions Between Global Competitiveness and Logistics Performance in Sub-Saharan Africa

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The study examines interactive effects among the 12 pillars of the Global Competitiveness Index (GCI) and logistics performance in sub-Saharan Africa. It covers the periods 2007, 2010, 2012, 2014, 2016, and 2018 with regard to consistent data availability for the selected variables and countries within the sub-Saharan region. The study employs innovative approaches, including the Tree-augmented Naïve Bayes Network (TAN-BN), Partial Least Squares Structural Equation Modelling (PLS-SEM), and Importance-Performance Map Analysis (IPMA), to ascertain causal effects, correlations, and the relative importance of the pillars of the GCI to logistics performance for policy decisions and actions within the region. We reveal a significant positive relationship between most of the pillars of the GCI. Also, technological readiness is found to be the only pillar of the GCI that has a significant direct positive relationship with logistics performance. Conversely, higher education and training have a significant indirect relationship with logistics performance. Findings from this study imply that concentration on what drives logistics performance alone may hinder policy decisions due to the existence of linkages among the pillars. It is recommended that governments in sub-Saharan Africa should invest extensively in technology and higher education and training to achieve improvement in logistics performance while observing other pillars of the GCI with caution. Theoretical, practical, and policy implications are provided. Unlike previous global analyses, this study is the first to focus exclusively on Sub-Saharan Africa and further uncovers the indirect pathways among GCI pillars using a combined TAN-BN and PLS-SEM framework to provide regionalised policy recommendations.

1. Introduction

Globalisation and internationalisation have influenced modern logistics[1]. As such, international logistics is related to advancements in global economic integration, and the tendency for businesses to operate globally adds to the development of global logistics systems and supply chains in the market[1][2][3]. The exchange of commodities and services between nations through export and import activities constitutes the global market. On a global scale, there is competition between market participants, or in this case, countries, just like in any market system in line with the new trade theory. The New Trade Theory (NTT), which emphasises increasing returns to scale, network effects, and market imperfections in international trade. Within this framework, logistics performance and competitiveness are not isolated phenomena but are mutually reinforcing. Improvements in infrastructure, human capital, and technological readiness — all core pillars of the GCI — contribute to enhanced logistics capabilities, which in turn support export diversification, regional integration, and global participation for SSA economies. The creation of benchmarking tools like the annual Global Competitiveness Report of the World Economic Forum and the World Competitiveness Yearbook produced by the Institute for Management Development shows that the need for countries to have competitive market positions through global integration has been acknowledged by the international community.

Policy-makers are aware that nations with the capacity to produce items of higher quality at lower costs or to act as handy and affordable transportation corridors for goods will have a clear competitive edge in the global market[3]. International competitiveness is severely lacking in nations with high logistical costs. The high logistical cost is germane to African countries, to which Sub-Saharan Africa is no exception, and is borne with less capacity to ensure lean and agile logistics[4]. The current body of literature demonstrates that the African markets present a continent that is strategically emerging as a significant trading bloc, particularly for Asia and parts of Europe, based on its vast resources, growing wealth, and larger middle class, accompanied by a higher purchasing power (Adewole & Struthers, 2019). Sub-Saharan regional GDP growth of 3.4% in 2021, despite the influence of the COVID-19 pandemic, is evidence that the recently adopted African Continental Free Trade Area (AfCTA) enhances the capacity of the continent.

The Economic Partnership Agreement (EPA) between West African nations and the European Union, which took effect in 2014, is only one example of the growing trade liberalisation and openness that African countries cannot take advantage of without an improvement in logistical efficiency. One of the key factors enabling development is a strong and globally recognised logistics industry[5]. In order to benefit from their efforts, participants in international trade, particularly exporters, must also improve their logistic performance[6][7]. This demands that governments within the Sub-Saharan region evaluate the current region's logistics system to determine its optimisation, development, and creation, through policies and initiatives from the region's global competitiveness level.

To track a country's performance on 12 pillars of competitiveness, the World Economic Forum (WEF) publishes the Global Competitiveness Index (GCI) every year. The GCI evaluates the key elements and organisations that affect a country's ability to grow and compete over the long term. As a result, this indicator tries to aid decision-makers in comprehending the complexity and variety of the development problem. Three sub-indexes—basic pre-requisites, efficiency-improving factors, and innovation and sophistication factors—are created from these pillars.

Under the basic prerequisites, four pillars are considered – Institutions, infrastructure, macroeconomic environment, and health and primary education. Higher education and training, good market efficiency, labour market efficiency, financial market development, technological readiness, and market size form the efficiency-improving factors. On the other hand, business sophistication and innovation make up the key innovation-driven economies. Depending on each economy's stage of development, different weights are assigned to the three sub-indices when calculating the overall index. Hence, the influence of the 12 pillars of GCI on logistics performance might not be the same, which requires empirical investigation for policy decisions. Accordingly, examining the nexus between each of the 12 pillars of GCI and logistics performance is more practicable to decipher the relative importance of the pillars in enhancing LPI[2][3].

Giving credence to each of the 12 pillars opens up a discussion as to whether the pillars of GCI in the sub-Saharan region are connected. The existence of linkages among the pillars in this regard may interrupt policy decisions if there is a concentration on what drives logistics performance alone. It is therefore problematic to investigate the improvement of logistics performance while there could be existing correlations among the 12 pillars themselves. For instance, good health and access to primary education are the foundation of higher education and training[8]. Again, the more people are educated and trained, the more efficient the labour market is[9], and the need for technological readiness[10]. Furthermore, a sound macroeconomic environment contributes to financial market development[11].

From the series of events given, among several others, the pillars of GCI do not operate in isolation but could be integrated. Hence, investigating the interactive effects among the 12 pillars is relevant in providing support for factors of GCI that could accurately capture the dynamics of LPI and would enhance the awareness of policymakers[12][2]. This is supported by the new trade theory, which enhances the globalisation of production and encourages extensive trading among similar nations to warrant global competitiveness among nations. The challenge is therefore how to efficiently move goods and connect manufacturers and consumers with international markets in the case of developing countries. The main objective of this study is to examine the interactive relationships among the pillars of GCI and how they feed into logistics performance in the context of developing and emerging countries.

Research is typically conducted more frequently at the level of micro-logistics than at the level of global logistics, which contributes to the dearth of many significant instruments for measuring country-level logistics efficiency. Although efficient micro-logistics typically lead to a more successful country-level logistics system, it is crucial for governments to assess and contrast their regional logistical and transport systems in order to comprehend current obstacles facing the region. The LPI is frequently used in global logistics research as a benchmarking and comparison tool for nations, as a starting point for the creation of new procedures and instruments, and as a method for assessing the performance of intra-national logistics[1][6].

The fundamental question for this study is therefore the extent to which a territory's (Sub-Saharan Africa) logistics performance can be improved using the pillars of GCI. For this reason, we prioritise the pillars of GCI toward the improvement of logistics performance to heighten the understanding of policymakers about the territory in relation to; (i) the magnitude of effect each pillar has on logistics performance, (ii) important contributing factor(s) of logistics performance, and (iii) the interactive effects among the pillars of GCI.

Existing studies on GCI and LPI have concentrated on comparative and/or country-specific analyses[2][1][13][14][6]. However, studies that consider the interactive effects among GCI and LPI in the unique context of a particular region are missing. It must be noted that for businesses and regions, including continents, countries, regions, and districts, including urban/metropolitan areas, logistics has shown to be a competitive advantage[3]. A territory lacking effective supply logistics, such as infrastructure networks, might gravely jeopardise its economic development in an increasingly globalised world[3]. A more integrated living and working environment can be achieved by planning and designing the physical territory to function as a single context infrastructure that is both appealing and well-balanced. The idea of competition has expanded due to globalization: Territories are impacted by competition, which is referred to as the operational systems that foster local economic and social development, promote small enterprises, and draw in new entrepreneurs.

Following the above, prior studies do not consider interactive effects among GCI and their influence on LPI with much emphasis on a given territory. The closest study in this regard is that of Ekici et al.[2] but concentrated on several countries with no particular concentration, and employed the Tree-augmented Naïve Bayes and the Partial Least Square approaches. Sergi et al.[3] on the other hand, laid emphasis on both descriptive and inferential statistics for three clusters of GCI – infrastructure, human factor, and institutions – and LPI for regions including Africa, Asia, and the European Union, employing the ANOVA method.

We address important gaps through the use of data, scope, methods, and insights. Ekici et al.[2] applied a hybrid approach of TAN-BN and PLS-SEM to evaluate the influence of GCI pillars on global logistics performance. However, their analysis did not specifically highlight the region-specific policy gaps or the indirect inter-pillar effects. Our study advances their work by: (1) focusing exclusively on Sub-Saharan Africa, (2) using an extended dataset up to 2018, (3) exploring both direct and indirect causal pathways among GCI pillars, and (4) mapping policy relevance using an IPMA tailored to SSA priorities. We especially highlight the indirect influence of higher education and training (Pillar 5) on logistics through technological readiness and innovation—an effect not dissected in the earlier work. The focus on SSA countries only enable the study to obtain more bespoke findings to inform policy and implementation. Again, the choice of Sub-Saharan Africa (SSA) is informed by the region's unique logistics challenges—ranging from infrastructural deficits and institutional weaknesses to limited technological diffusion and skill gaps. Despite these constraints, SSA is undergoing trade liberalisation and regional integration efforts (e.g., AfCFTA), which make it critical to understand how competitiveness indicators interact to influence logistics outcomes. Studying SSA provides an opportunity to generate context-specific insights and policy directions where resource optimisation is paramount.

Further, in order to be apt in our contribution to the debate on the interactive effects of the pillars of GCI in the unique context of a territory rather than relying on a single country, as revealed in the study of Ekici et al. [2], we recognise the indirect relation between the 12 pillars of GCI and LPI. The Tree-augmented Naïve Bayes (TAN-BN) and the Partial Least Square Structural Equation Modelling (PLS-SEM) approaches, as suggested by Ekici et al.[2], are employed.

As a first step, the TAN-BN technique makes it easier to analyse the causal connections between the sub-Saharan African countries' GCI and LPI indicator values. The choice to precede PLS-SEM with TAN-BN is particularly useful in exploratory settings where causal directions are not predetermined. The PLS-SEM, a structural equation model that maximises the explained variation among several variables, is an additional step that uses the outcomes of this model as inputs. The main goal of employing the Bayesian network before the PLS is to cut down on the number of potential causal relationships between different variables. We assert that in addition to the direct impacts resulting from the pillar scores, the indirect effects resulting from the causal interactions between the pillar scores also have an influence on the overall LPI scores, as surmised by Ekici et al.[2].

Policy-makers within the Sub-Saharan region will be able to effectively utilise their limited resources to raise the logistical competitiveness of their nations by taking these connections into account and focusing on the most crucial competitiveness pillars. Additionally, using this method will allow policymakers to determine which GCI pillars are more important than others in terms of influencing the final LPI score when deciding where to allocate the limited resources needed to improve a nation's logistics performance within the region. Categorically, these approaches are essential to inform policy actions that are directed towards either direct, indirect, or complementary effects of GCI on logistics performance.

We make four unique contributions to the existing literature on the nexus between GCI and logistics performance. First, we ascertain the interactive effects of the 12 pillars of GCI in Sub-Saharan Africa as a territory or region rather than through a comparative study within the region. This is necessary for the formulation of single policies for the regional bloc on important pillars due to the increasing removal of barriers and liberalisation policies by governments that have facilitated international trade and integration. Second, we reveal important pillars that contribute to logistics performance while at the same time recognising pillars that might have indirect effects on logistics performance. In this manner, the improvement of indirect pillars within the Sub-Saharan region may feed into other pillars which may have a substantial direct impact on logistics performance. Third, we provide policy directions and harness the awareness of policymakers in the region with regard to the interactive effects among the 12 pillars of GCI as well as their influence on logistics performance. Fourth, innovative approaches (TAN-BN and PLS-SEM) are applied in stages to address the research problem in the Sub-Saharan Africa context.

The results of this investigation revealed that most of the GCI Pillars have a significant, positive relationship with one another. Additionally, it was discovered that the only GCI Pillar that significantly and directly positively correlates with logistics performance was technology readiness. On the other hand, a significant indirect association between logistics performance and higher education and training was found.

The remaining sections of the essay are as follows: The methodology is presented in section 2, and then section 3 shows a preliminary analysis of the results, analysis, and discussion of the findings. Theoretical, practical, and policy implications of the findings are contained in section 4, whereas the concluding part is contained in section 5.

2. Methodology

The methodology employed by this study was adopted from Spillan and Ramsey[15] and augmented to follow a two-step approach by first employing a Bayesian network (BN) to show the probabilistic nexus among the pillars of GCI and the effect of GCI on LPI and then Partial Least Squares Structural Equation Modelling (PLS-SEM) for the causal explanation of the relationships. This was preceded by an examination of the data span, data sources, and data measurements. While the general framework mirrors that of Ekici et al. (2019), our application introduces two key modifications: (a) explicit modelling of indirect effects among GCI pillars to reflect complex interdependencies in SSA, and (b) contextual calibration of the IPMA output to prioritise regionally constrained policy decisions.

2.1. Empirical Data

The study covers a total of 27 Sub-Saharan African countries, based on the availability of consistent data for the years 2007, 2010, 2012, 2014, 2016, and 2018 for

GCI and LPI. Due to occasional gaps in data for some years, an unbalanced panel was used. While the unbalanced data poses some limitation, this was necessary to balance the need to ensure broader regional representation as against challenge of data availability across years and countries in Sub-Saharan contexts. The LPI employed in this study comprises six elements: Customs, international shipment, infrastructure, logistics services, timeliness, and track and trace. The elements of LPI were measured on a scale of 1-5. Following Ekici et al.[2], we formed a composite index of LPI using averaged scores from the six elements for the TAN-BN model. Conversely, LPI is identified and measured as a latent variable using the six indicators for the IPMA and PLS-SEM models. Logistic performance is considered a latent variable because, by its construction, the elements are selected based on theoretical, empirical, and practical research as well as the practical expertise of logistics experts engaged in international freight forwarding[2]. The six LPI indicators are divided into two main groups: supply chain performance outcomes that correspond to the LPI time and reliability indicators (timeliness, international shipments, and tracking and tracing), and areas for policy regulation, representing key inputs to the supply chain (logistics services, customs, and infrastructure). While standard statistical methods are used by the LPI to combine the data into a single indicator, in this study, we keep all the dimensions as they are in understanding the influence of the pillars of GCI on them at the national level.

The scores of sub-Saharan countries in the 12 pillars were employed to denote competitiveness. The 12 pillars can be categorised into three sub-indexes—basic pre-requisites, efficiency-improving factors, and innovation and sophistication factors. Under the basic pre-requisites, four pillars are considered – Institutions, infrastructure, macroeconomic environment, and health and primary education. Higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, and market size form the efficiency-improving factors. Additionally, business sophistication and innovation make up the key innovation-driven economies. The 12 pillars of GCI are each measured on a scale of 1-7. The data on GCI were directly used for the estimations with no specific differences in data in the case of indicators for the TAN-BN and latent variables for the IPMA and PLS-SEM models. In other words, the latent variables were represented by the pillars of GCI. Table 1 shows the pillar numbers of GCI and corresponding explanations.

Number	Explanations
Pillar 1	Institutions
Pillar 2	Infrastructure
Pillar 3	Macroeconomic environment
Pillar 4	Health and primary education
Pillar 5	Higher education and training
Pillar 6	Goods market efficiency
Pillar 7	Labour market efficiency
Pillar 8	Financial market development
Pillar 9	Technological readiness
Pillar 10	Market size
Pillar 11	Business Sophistication
Pillar 12	Innovation

Table 1. Pillars of GCI and their explanations

2.2. Tree-augmented Naïve Bayes

We initially show the probabilistic nexus among the pillars of GCI and the effect of GCI on LPI using the Bayesian network (BN). The fundamental merit of a BN is the less or no requirement for robust statistical assumptions concerning the conditional independence constraints among variables and their corresponding conditional probability distributions[2]. The BN, therefore, demonstrates the causal directions among variables acting as a directed graph (Lauria & Duchessi, 2007). Accordingly, a BN is ideal for the following reasoning; diagnostic, predictive, and inter-causal within a well-classificatory system[2]. Moreover, the BN is robust even when multicollinearity, autocorrelation, and endogeneity issues arise[16].

The BN displays a set of conditional independence constraints among a certain number of variables and their associated conditional probability distributions as a directed acyclic graph. The strength of these linkages is indicated in terms of conditional probabilities, and the arcs show that there are direct causal relationships between the linked variables. As opposed to this, TAN-BN models do away with the naïve Bayes assumption that all attributes are independent[17]. In other words, TAN-BN models (Korb and Nicholson, 2011) permit a tree structure between the variables regardless of their direct correlations with the class variable. Where variables are interrelated, this relaxation is especially crucial because TAN-BN models perform better than naïve Bayes models in these circumstances. The current study employs the TAN-BN model whose algorithm can be located in the study of Friedman, Geiger, and Goldszmidt[18].

2.3. Partial Least Squares Structural Equation Modelling (PLS-SEM)

The PLS-SEM is based on maximizing the variance among the constructs that may be described, and this method makes the fewest assumptions possible about the statistical distribution of the datasets. With a limited sample size, the PLS-SEM can still be effective (Wu et al., 2012). The PLS-SEM path model is typically employed to illustrate the variance of dependent variables, with a focus on causal explanation, in order to construct theories. The PLS path model analyzes the effects of individual scores rather than claiming equal weights for each category score. The PLS-SEM path model breaks down the total effect into direct and indirect effects in addition to estimating the overall influence of each category score on the overall score.

However, a significant flaw in the PLS-SEM approach is that, due to a lack of background information or prior theoretical support, it can occasionally be challenging to determine the causal directions among constructs. To do a causal analysis, Wu[17] suggested using a Bayesian network first before using the PLS path model. To conduct the causal analysis in this work, we have additionally connected the TAN-BN model with the PLS path model. Prior to estimating the PLS path model, the causal directions of a preliminary causal diagram created by the TAN-BN should be inverted[12]. To estimate the PLS path model and determine whether the proposed causal linkages produced by BNTAN data mining are statistically significant, SmartPLS software is employed.

Particularly, following a sequential methodology, a first-stage causal diagram, known as the TAN-BN, is used as a basis for building the PLS-SEM. The model fit and coefficient of determination values of the model are evaluated to ensure the robustness of the estimates. In line with Smart PLS version 4.0, the normed fit index (NFI) should be more than 0.9, and the standardised root mean square residual (SRMR) should be less than 0.08. In a well-fitting model, the (R2) of the variables is anticipated to be more than 0.75. The inconsequential relationships in the diagram are removed if these conditions are not met, and the PLS model is then run again. This process is continued until a model with good fit is attained. It is concluded that there are no important set of relationships in the given system of variables if a good-fitting model cannot be found.

2.4. Importance-Performance Map Analysis (IPMA)

As an extension to the PLS-SEM, the IPMA estimates are provided to examine the performance of the pillars of GCI and LPI. The performance is evaluated by checking the most pertinent pillars of GCI influencing LPI. Constructs are therefore assessed by the IPMA through the importance –total effect within the PLS-SEM, and the performance–averaged values of standardised scores, to arrange the variables in order of primacy. The performance scores are calculated by converting the individual category scores to an index value between 0 and 100. A score is normalised by removing the category's minimum score from it and dividing the result by the difference between the category's maximum and minimum values[12]. The resultant value is multiplied by 100.

Based on the overall score (the importance to performance ratio) calculated by dividing performance by total effects, the elements are ordered. The components with lower overall scores are more important since the main goal is to enhance the constructs with relatively high importance but low performance. In accordance with their overall scores, the factors are sorted in ascending order.

3. Results and Discussion

3.1. Analysis with the Tree-augmented Naïve Bayes

Figure 1 shows the TAN-BN model on the interactive effects among the 12 pillars of GCI and logistics performance. A causal-effect graph is noticeable in Figure 1, in which Pillar 9 is treated as the only parent node of logistics performance, coupled with major interactions among the pillars of GCI relevant for policy decisions and actions. Pillar 1 is seen not to be connected with any other variable. For interactions among the 12 Pillars of GCI, for instance, Pillar 3 and Pillar 8 have a causal effect on Pillar 4. Pillar 5 and Pillar 11 are treated as the greatest parent nodes of all the remaining pillars. Pillar 6 has a causal effect on Pillar 8 and Pillar 10. Also, Pillar 8 causes Pillar 7, whereas Pillar 9 has a causal effect on Pillar 2 and Pillar 7. Furthermore, Pillar 12 causes Pillar 3, Pillar 4, and Pillar 9. Off particular concern in the identified relationship is the indirect relationship between innovation (Pillar 12) and logistic performance but reveals possible nascent innovation capacity in SSA or not directly translated into logistics services due to structural barriers (weak infrastructure, energy issues, etc.). It can be observed that Pillar 2, Pillar 4, Pillar 7, and Pillar 10 are only on the receiving end, whereas Pillar 5 and Pillar 11 are persisting transmitters. The remaining Pillars have a causal effect and are also caused by other Pillars, which requires further investigation for policy decisions. The outcome presented in Figure 1 provides a foundation upon which hypotheses in the case of the PLS-SEM model can be proposed.

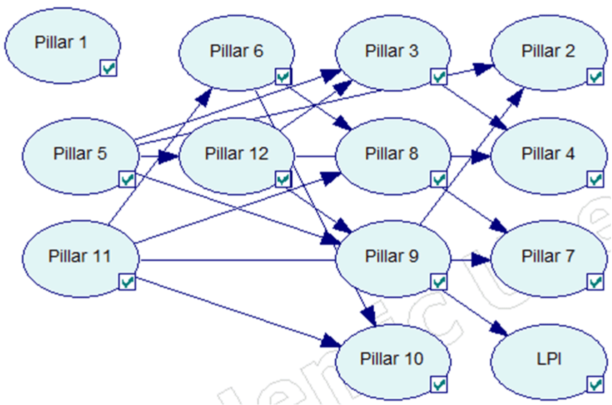

Figure 1. Tree-augmented Naïve Bayes for the pillars of GCI and LPI

3.2. Analysis with PLS-SEM

From the outcome of the TAN-BN, we formulate the following hypotheses for the PLS-SEM approach:

- H_1: The macroeconomic environment has a significant relationship with health and primary education (Pillar 3 → Pillar 4).
- H_2: Higher education and training have a significant relationship with infrastructure (Pillar 5 → Pillar 2).
- H_3: Higher education and training have a significant relationship with the macroeconomic environment (Pillar 5 → Pillar 3).
- H_4: Higher education and training have a significant relationship with health and primary education (Pillar 5 → Pillar 4).
- H_5: Higher education and training have a significant relationship with technological readiness (Pillar 5 → Pillar 9).
- H_6: Higher education and training have a significant relationship with innovation (Pillar 5 → Pillar 12).
- H_7: Goods market efficiency has a significant relationship with financial market development (Pillar 6 → Pillar 8).
- H_8: Goods market efficiency has a significant relationship with market size (Pillar 6 → Pillar 10).
- H_9: Financial market development has a significant relationship with labour market efficiency (Pillar 8 → Pillar 7).
- H_{10}: Technological readiness has a significant relationship with logistics performance (Pillar 9 → LPI).
- H_{11}: Technological readiness has a significant relationship with infrastructure (Pillar 9 → Pillar 2).
- H_{12}: Business sophistication has a significant relationship with goods market efficiency (Pillar 11 → Pillar 6).
- H_{13}: Business sophistication has a significant relationship with labour market efficiency (Pillar 11 → Pillar 7).
- H_{14}: Business sophistication has a significant relationship with financial market development (Pillar 11 → Pillar 8).
- H_{15}: Business sophistication has a significant relationship with market size (Pillar 11 → Pillar 10).
- H_{16}: Business sophistication has a significant relationship with innovation (Pillar 11 → Pillar 12).
- H_{17}: Innovation has a significant relationship with the macroeconomic environment (Pillar 12 → Pillar 3).
- H_{18}: Innovation has a significant relationship with health and primary education (Pillar 12 → Pillar 4).
- H_{19}: Innovation has a significant relationship with technological readiness (Pillar 12 → Pillar 9).

It is important to assess constructs' internal consistency and convergent validity for reliable and robust estimation in line with the application of the PLS-SEM following our methodological procedures. As shown in Table 2, the Cronbach's Alpha and Composite Reliability values above 0.7 are indicative that internal consistency has been adhered to[19] in our PLS-SEM model. Additionally, the average variance extracted (AVE), indicating the average variance shared between individual indicators and the construct, has a threshold of at least 0.5[20] as presented in Table 2. Specifically, for Logistics performance, an AVE above 0.5 suggests that there is convergent validity between the construct and the indicators measuring it. The pillars are each treated as a single-item construct, hence no internal variance and therefore AVE of 1.00. Discriminant validity of the constructs, measuring the degree to which a construct is different from the rest of the constructs in the structural model, is attached as an appendix with a clear indication of ensuring discriminant validity as per the Fornell-Larcker criterion.

	Cronbach's Alpha	Composite Reliability	AVE
Logistics Performance	0.942	0.954	0.775
Pillar 2	1.000	1.000	1.000
Pillar 3	1.000	1.000	1.000
Pillar 4	1.000	1.000	1.000
Pillar 5	1.000	1.000	1.000
Pillar 6	1.000	1.000	1.000
Pillar 7	1.000	1.000	1.000
Pillar 8	1.000	1.000	1.000
Pillar 9	1.000	1.000	1.000
Pillar 10	1.000	1.000	1.000
Pillar 11	1.000	1.000	1.000
Pillar 12	1.000	1.000	1.000

Table 2. Internal consistency and convergent validity

We proceed to examine the interactive relationships among the pillars of GCI and logistics performance, as shown in Figure 2 for the structural model assessment. The relationships in line with the research hypotheses can be found in Figure 2. The path diagram shown in Figure 2 reveals the magnitude and direction of the path coefficients depicting the relational dimension among GCI and LPI. Constructs are measured as latent variables rather than as a mere averaged composite index for the purpose of the PLS-SEM approach. A glance at the indicator loadings, depicting values above 0.7, indicates that the items loaded well, ensuring the reliability of the indicators[20].

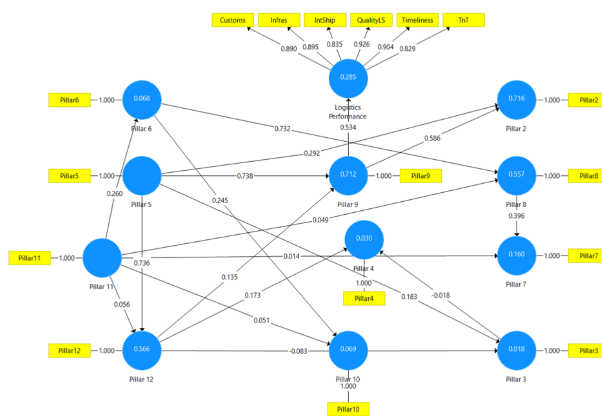

Figure 2. PLS algorithm showing interactive effects among the pillars of GCI and logistics performance

Furthermore, Table 3's Standardised Root Mean Square Residual (SRMR) values of 0.027 and 0.042 are below 0.08, which indicates a good model fit with few deviations from expected and observed correlations. Additionally, the NFI value is greater than the threshold of 0.8; as a result, the model is considered to have marginal fit. The model's estimated Chi-Square, which is calculated by dividing the degrees of freedom (number of observations minus number of independent variables) by the estimated value of the Chi-Square,

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should be less than 3[21]. The model's Chi-Square evaluation is roughly 0.692 (i.e., 94.833/137), which is lower than the benchmark of 3, indicating that the model has a decent fit.

	Saturated Model	Estimated Model
SRMR	0.027	0.042
d_ULS	0.108	0.453
d_G	0.109	0.733
Chi-Square	90.366	94.833
NFI	0.961	0.840

Table 3. Model Fit Summary

As presented in Table 4, the R Square Adjusted values of the latent variables are explained by other variables in the interactive relationships among the 12 pillars of GCI and logistics performance. For instance, logistics performance is explained to about 28% by technological readiness (Pillar 9). Innovation (Pillar 12) is explained by business sophistication (Pillar 11) and higher education and training (Pillar 5) at about 56%. Also, variations in infrastructure (Pillar 2), financial market development (Pillar 8), and technological readiness (Pillar 9) are determined to a degree of about 71%, 55%, and 71% respectively. The remaining endogenous variables are explained by less than 15%. Comparatively, infrastructure (Pillar 2) and technological readiness (Pillar 9) have the greatest explanatory power in our PLS-SEM model. This is followed by financial market development (Pillar 8) and innovation (Pillar 12).

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Endogenous Variables	R Square Adjusted
Logistics Performance	0.281
Pillar 2	0.712
Pillar 3	0.004
Pillar 4	0.017
Pillar 6	0.061
Pillar 7	0.148
Pillar 8	0.551
Pillar 9	0.708
Pillar 10	0.056
Pillar 12	0.560

Table 4. Coefficient of determination (R Square Adjusted) of the endogenous variables

A bootstrapping analysis was performed to assess the significance of the hypothesised associations using the PLS-SEM approach. The outcomes of path coefficients, indirect effects, total effects, and t-statistics are presented in Table 5. In addition, the variance inflation factor (VIF), relevant for multicollinearity assessment, and the decision on the developed hypotheses are shown. The VIF values closer to 3 suggest the absence of multicollinearity, which might have biased the regression outcome[20].

The results in Table 5 show that out of 19 hypotheses, 13 of them were supported. The 13 supported hypotheses illustrate positive associations between related pairs. Particularly, the hypothesis on the significant relationship between higher education and training and infrastructure (Pillar 5 → Pillar 2) was supported by a positive and significant path coefficient (β = 0.292, t-statistics =3.332). Also, higher education (Pillar 5) related significantly with the following Pillars; Pillar 4 (β = 0.738, t-statistics =11.458), Pillar 9 (β = 0.245, t-statistics = 2.932), and Pillar 12 (β = 0.736, t-statistics =17.833). There was a significant connection between goods market efficiency (Pillar 6) and Pillars such as; Pillar 8 (β = 0.732, t-statistics = 18.684), and Pillar 10 (β = 0.245, t-statistics = 2.932). The ninth hypothesis was supported by a positive and significant path coefficient (β = 0.396, t-statistics = 5.435) between financial market development (Pillar 8) and labour market efficiency (Pillar 7). Moreover, technological readiness (Pillar 9) is related significantly to logistics performance (β = 0.534, t-statistics = 7.622) and infrastructure (Pillar 2) (β = 0.586, t-statistics = 7.211). Business sophistication (Pillar 11) is positively associated with Pillar 6 (β = 0.260, t-statistics = 5.967) and Pillar 12 (β = 0.056, t-statistics = 2.085). To end with, the eighteenth and nineteenth hypotheses were supported by positive and significant path coefficients between innovation (Pillar 12) and Pillar 4 (β = 0.173, t-statistics = 4.025), as well as between Pillar 12 and Pillar 9 (β = 0.135, t-statistics = 1.978).

As revealed, there is no significant relationship from the four pillars representing basic prerequisites (institutions, infrastructure, macroeconomic environment, and health and primary education); they are rather influenced by other subindexes including efficiency-improving factors and innovation-driven aspects. The efficiency-improving factors are dominant in relating positively to the Pillars of GCI and logistics performance. Hence, it is important for policymakers in the region to pay particular attention to the efficiency-improving factors such as higher education and training (Pillar 5), goods market efficiency (Pillar 6), financial market development (Pillar 8), and technological readiness (Pillar 9). This is followed by the innovation-driven measures including business sophistication (Pillar 11) and innovation (Pillar 12).

It must be noted that factors contributing significantly to logistics performance both directly and indirectly should be given much attention by policymakers. Such measures include technological readiness (Pillar 9) and higher education and training (Pillar 5), which respectively have direct and indirect significant relationships with logistics performance. It is also pertinent to observe factors that feed into these Pillars in enhancing logistics performance to warrant a sustained improvement in logistics performance in the Sub-Saharan African region. Accordingly, for technological readiness (Pillar 9), credence should be given to influencers including higher education and training (Pillar 5) and innovation (Pillar 12). On the other hand, for higher education and training (Pillar 5), it is crucial for particular attention to be paid to developing the Pillar itself and other possible external shocks since it has no direct or indirect contributing factor(s). Unlike Ekici et al.[2], where several GCI pillars exhibited direct influence on logistics, our analysis for SSA reveals that only technological readiness has a significant direct effect. Higher education and training exerts strong indirect influence, primarily through technological readiness and innovation, showing a cascade effect. This insight highlights a hidden leverage point for policy intervention, particularly under constrained budgets.

It is recommended that a more concerted effort be taken by policymakers and governments to revamp insignificant enhancers such as developing the need for higher education and training, which can be well captured within the macroeconomic environment. The region should welcome more innovative activities to improve other important areas such as labour market efficiency, financial market development, and market size. It is important to restore a positive balance between the macroeconomic environment and health and primary education for the years ahead. This is because the macroeconomic environment in the region is touted to be susceptible to external shocks, including economic policy uncertainty[22][23][24][25], and other shocks[26][27][28][29][30]. Furthermore, the scope of innovation should be widened to welcome improvement in the macroeconomic environment.

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Causal Relationship	Path Coeff. Β	t-statistic	Indirect Effect	t-statistic	Total Effect	t-statistic	VIF	Decision
H_1: Pillar 3 → Pillar 4	-0.018	0.383			-0.018	0.383	1.003	Not Supported
H_2: Pillar 5 →Pillar 2	0.292*	3.332	0.491*	7.259	0.783*	18.881	3.381	Supported
H_3: Pillar 5 → Pillar 3	0.183	1.546	-0.061	0.652	0.122	1.572	2.288	Not Supported
H_4: Pillar 5 → Pillar 4	0.738*	11.458	0.125*	4.036	0.125*	4.036	1.003	Supported
H_5: Pillar 5 →Pillar 9	0.245*	2.932	0.099	1.940	0.837*	30.312	2.288	Supported
H_6: Pillar 5 → Pillar 12	0.736*	17.833			0.736*	17.833	1.076	Supported
H_7: Pillar 6 → Pillar 8	0.732*	18.684			0.732*	18.684	1.073	Supported
H_8: Pillar 6 → Pillar 10	0.245*	2.932			0.245*	2.932	1.073	Supported
H_9: Pillar 8 → Pillar 7	0.396*	5.435			0.396*	5.435	1.061	Supported
H_{10}: Pillar 9 → Logistics Performance	0.534*	7.622			0.534*	7.622	1.000	Supported
H_{11}: Pillar 9 → Pillar 2	0.586*	7.211			0.586*	7.211	3.381	Supported
H_{12}: Pillar 11 → Pillar 6	0.260*	5.967			0.260*	5.967	1.000	Supported
H_{13}: Pillar 11 → Pillar 7	0.014	0.374	0.095*	4.762	0.109*	2.657	1.061	Not Supported
H_{14}: Pillar 11 → Pillar 8	0.049	1.831	0.190*	5.587	0.239*	5.281	1.073	Not Supported
H_{15}: Pillar 11 → Pillar 10	0.0507	1.187	0.0637*	2.556	0.114*	2.102	1.073	Not Supported
H_{16}: Pillar 11 → Pillar 12	0.056*	2.085			0.056*	2.085	1.076	Supported
H_{17}: Pillar 12 → Pillar 3	-0.083	0.660			-0.083	0.660	2.288	Not Supported
H_{18}: Pillar 12 → Pillar 4	0.173*	4.025	0.002	0.197	0.175*	4.070	1.003	Supported
H_{19}: Pillar 12 → Pillar 9	0.135*	1.978			0.135*	1.978	2.288	Supported
$ID*_1$: Pillar 5 → Logistics Performance			0.447*	7.317	0.447*	7.317		
$ID*_2$: Pillar 11 → Logistics Performance			0.004	1.113	0.004	1.113		
$ID*_3$: Pillar 11 → Pillar 2			0.004	1.161	0.004	1.161		
$ID*_4$: Pillar 11 → Pillar 3			-0.005	0.586	-0.005	0.586		
$ID*_5$: Pillar 11 → Pillar 4			0.010	1.511	0.010	1.511		
$ID*_6$: Pillar 11 → Pillar 9			0.008	1.198	0.008	1.198		
$ID*_7$: Pillar 12 → Logistics Performance			0.072	1.800	0.072	1.800		

Causal Relationship	Path Coeff. Β	t-statistic	Indirect Effect	t-statistic	Total Effect	t-statistic	VIF	Decision
ID^*_8: Pillar 12 → Pillar 2			0.079	1.917	0.079	1.917s		

Table 5. Summary results of the PLS-SEM path models

Note: VIF shows Variance Inflation Factor. ID denotes indirect relationships that are not hypothesised. * denotes significance at 5%.*

3.3. Analysis with IPMA

In this section, the relative importance of the pillars of GCI to logistics performance is shown in Table 6, with a pictorial representation illustrated in Figure 3. It can be noticed that Pillar 5, Pillar 9, Pillar 11, and Pillar 12 are the variables that either have a direct or indirect relationship with logistics performance. The importance of these indicators is ranked in ascending order of magnitude on their effects on logistics performance. The lowest overall score is much preferred for attention by policymakers. It is crucial for policymakers and governments in the Sub-Saharan region to focus attention on technological readiness (Pillar 9), higher education and training (Pillar 5), innovation (Pillar 12), and business sophistication (Pillar 11) toward enhancing logistics performance. The high-performing but low-importance of Pillar 11 suggest resource reallocation opportunities. Thus, the need to monitor investment in business sophistication if returns to logistics are marginal.

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	Total Effect (E)	Performance (P)	Overall score (P/E)	Importance rank
Pillar 9	0.387*	35.520	91.783	1
Pillar 5	0.288*	40.956	142.208	2
Pillar 12	0.071	52.482	739.183	3
Pillar 11	0.001	64.910	64910	4

Table 6. IPMA results for the logistics performance as the target variable

***** *denotes significance at 5%.*

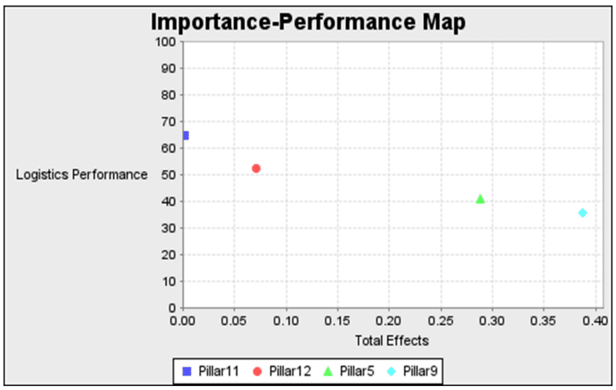

Figure 3. IPMA using logistics performance as the target variable

3.4. Discussion

3.4.1. Technological readiness

Technological readiness (Pillar 9) demonstrated the most important influence on logistics performance, as found by Ekici et al.[2] and Moldabekova et al.[31]. Although technological readiness is directly associated with factors including internet usage, availability of up-to-date technologies, technology transfer, and technology absorption at the firm level. Technology readiness is anticipated to produce competitive advantages in a number of areas, including cost reduction, improved inventory efficiency, production timeliness and order, support for strategic planning, and facilitated firm-to-firm information sharing. Technological readiness at the organisational level denotes the capacity of the organization to adopt and utilise new technological resources[2].

Technological readiness also feeds into infrastructure. This is not surprising because the availability of the latest technology is pertinent in enhancing infrastructural activities such as the quality of overall infrastructure, roads, railroads, port infrastructure, air transport infrastructure, electricity supply, among others[32][33][34].

To enhance logistics performance and infrastructural development, it is pertinent for governments to handle or manage large-scale logistics and infrastructural data. Accordingly, the automation of the entire logistical and infrastructural systems is crucial for improved digitalisation to facilitate logistics and infrastructure development.

3.4.2. Higher education and training

Higher education and training (Pillar 5) was found to be the second most important variable in improving logistics performance, as revealed by Ekici et al.[2]. The higher education and training construct inculcates dimensions such as the quality of the educational system, the quality of math and science education, the quality of management schools, internet access in schools, secondary education, tertiary education, the availability of specialized training services, and the degree of staff training[35][36]. It is important that governments invest extensively in these dimensions for an enhanced improvement in logistics performance. This is not surprising because the current globalization trend demands the nurturing by nations of a pool of well-educated and trained individuals to perform complex assignments and meet the evolving needs of the logistics system[35].

Additionally, higher education and training require improvement in the quality of roads, railroad, port infrastructure, electricity supply, fixed-telephone lines, and mobile-cellular telephone subscriptions, as well as

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the quality of overall infrastructure. In other words, the greater the quality of education and training, the greater the quality of infrastructure in countries. Higher education and training promote the need for health and primary education, technological readiness, and innovation. This implies that investment in higher education and training creates awareness of individuals' health, the availability of the latest technology, and capacity for innovation, the quality of scientific research institutions, the availability of scientists and engineers, and research and development.

3.4.3. Financial market development

It must also be noted that the development of the financial market is crucial for labour market efficiency. For instance, the availability and affordability of financial services, ease of access to loans, venture capital availability, soundness of banks, regulation of the securities exchanges, legal rights, and financing through the equity market are relevant in promoting labour market efficiency. Labour market efficiency can be enhanced in diverse ways, such as pay and productivity, a country's capacity to attract and retain talent, reliance on professional management, flexibility of wage determination, and hiring and firing practices, which depend vehemently on the soundness of the financial system[37].

3.4.4. Innovation

Innovation includes factors such as the capacity for innovation, the quality of scientific research institutions, spending by companies on research and development, procurement by governments of advanced technologies, and the availability of scientists and engineers. These dimensions of innovation are relevant to the macroeconomic environment. This is because as countries innovate, governments are able to rectify their budget deficit, enhance gross national savings, correct inflation, plummet government debt, and correct and improve their credit rating in the long term. This is so that the same input can produce more output, thanks to innovation, which can raise productivity. The economy expands as productivity increases because more goods and services are produced. Growth in the economy leads to proper improvements in macroeconomic indicators. Innovation, according to Ahmed and Farah[38], causes co-movement in important macroeconomic variables, such as production, labour hours, consumption, and investment in IT and non-IT industries. Innovation is also seen as a significant contributor to health and primary education, as well as technological readiness.

We, however, found no significant relationship between innovation and logistics performance. The study contradicts the outcomes of Ekici et al.[2], Gabriela-Lucia and Cristian-Gabriel[39], and Moldabekova et al.[31], who found that innovation is significantly related to logistics performance. Innovation plays a critical role in achieving success in a rapidly changing environment and creating a competitive advantage[40][2]. Logistical innovations are underappreciated and receive less attention in Sub-Saharan Africa[36]. However, cutting-edge logistics services can offer fresh approaches to commerce and industry, as well as a base for expansion into new markets[2]. Innovation is no longer just a priority for the most developed economies; it is also crucial for developing nations as well. Innovation capability is the weakest pillar of most economies[36]. The ability to innovate is still severely constrained, highly confined, and/or restricted to a very small number of industries in the great majority of countries. For the majority of economies, an innovation formula is yet unknown. A nation's superior logistics performance is correlated with its strong innovation performance.

Governments should do a better job of promoting funding possibilities at the national and regional levels, especially for small and medium-sized enterprises (SMEs), to foster innovation. To meet the demands of the SMEs engaged in creating and putting into practice innovations, they ought to think about enlarging the scope of funding and tax credits. They ought to think about extending funding and tax incentives to innovative business models and services as well as technology. They ought to stimulate cooperation, awareness of, and the spread of new techniques in addition to fostering tighter international cooperation. Furthermore, it is essential that policymakers support renewable energy with a policy design to address the unintended price effect of supporting renewable energy because the high cost of electricity for SMEs in Sub-Saharan Africa inhibits the innovation decisions and activities of SMEs[41].

3.4.5. Goods market efficiency

Goods market efficiency is significantly related to financial development and market size. The goods market efficiency is responsible for local competition intensity, market dominance, effectiveness of anti-monopoly policy, incentives to invest due to tax, timing of business start-ups, agricultural policy costs, business

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influence of rules on FDI, among others. These factors are necessary in enhancing or driving the need for the availability of financial services, affordability of financial services, and ease of access to loans, and eventually improve financial development. Furthermore, local competition intensity, market dominance, effectiveness of anti-monopoly policy, incentives to invest due to tax, timing of business start-ups, agricultural policy costs, and business influence of rules on FDI intensify the domestic market size, global market size, economic growth, and drive export activities.

Given their specific supply-and-demand dynamics, nations with developed goods markets are in a good position to both produce the ideal mix of goods and services and make sure that these goods can be traded as efficiently as possible[35][36]. Healthy domestic and international market competition is crucial for promoting market efficiency and, consequently, business productivity by ensuring that the most productive businesses, those that produce the goods that the market wants, are those that succeed. Demand factors like buyer sophistication and customer orientation have an impact on how efficiently a market operates. Customers are more demanding in Sub-Saharan African countries due to cultural or historical factors[42]. As a result, companies are forced to be more innovative and customer-focused, which imposes the discipline needed to achieve market efficiency. This can give them a significant competitive advantage, which intensifies access to financial services to meet their demand, with an eventual surge in market size. Sub-Saharan African countries are noted for the supply of the majority of global raw materials, which support exports for improved market size.

3.4.6. Business sophistication

Business sophistication was found to have a significant positive relationship with goods market efficiency and innovation. Business sophistication examines local supplier quantity and quality, the state of cluster development, the nature of competitive advantage, value chain breadth, international distribution control, production process sophistication, degree of marketing, and the zeal to delegate authority. These indicators contribute to intense local competition, degree of market dominance, and degree of customer orientation, to name a few. Also, a well-developed business sophistication strategy is relevant for firms' innovation[43][44][45].

4. Theoretical, Practical and Policy Implications

The results of this investigation revealed that most of the GCI Pillars have a significant, positive relationship with one another, addressing the new trade theory which promotes the globalisation of production, the need for government support such as subsidies for improved industrialisation, and helps local firms to compete with international ones, and ensures trade competition among similar countries. It was also discovered that the only GCI Pillar that significantly and directly positively correlates with logistics performance was technology readiness. It is not surprising that the Pillars of GCI contribute less to logistics performance in Sub-Saharan Africa, given the region's severe lack of global competitiveness. In order to ensure lean and agile logistics, the high logistical cost is crucial to Sub-Saharan Africa and is borne with less capacity[4]. Based on its abundant resources, growing wealth, and expanded middle class, which has a higher purchasing power, the current body of literature shows that the African markets represent a continent that is strategically emerging as a significant trading bloc, particularly for Asia and parts of Europe (Adewole & Struthers, 2019).

By considering these connections and concentrating on the most important competitiveness pillars, such as technological readiness and higher education and training, policymakers in the Sub-Saharan region will be able to utilize their limited resources to raise the logistical competitiveness of their countries. In order to ensure a sustained improvement in logistics performance in the Sub-Saharan African region, it is also important to consider the variables that feed into the pillars that enhance logistics performance. As a result, factors like innovation and higher education and training (Pillar 5) should be given credit for influencing technological readiness (Pillar 9). (Pillar 12). On the other hand, because higher education and training (Pillar 5) do not have any direct or indirect contributing factors, it is crucial that special attention be paid to developing the Pillar itself and other potential external shocks (s).

Governments and policymakers should work harder to improve minor enhancers that can be successfully incorporated into the macroeconomic environment, such as the rising demand for higher education and training. To improve other crucial aspects like market size, financial market development, and labor market effectiveness, more innovative initiatives should be welcomed in the sector. It is critical to strike a good

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balance between the macroeconomic environment, health, and primary education in the upcoming years. Additionally, it is necessary to broaden the scope of innovation to incorporate developments in the macroeconomic environment. Governments in the Sub-Saharan region should invest heavily in technology, higher education, and training in order to improve logistics performance.

Even though the African Continental Free Trade Area (AFCTA) exists to enhance intra-African trade, governments should concentrate on signing trade agreements with nations on other continents. For instance, the AFCTA is in charge of ensuring the free flow of people, capital, goods, and services—all of which are essential for furthering economic integration—as well as advancing industrialization, agricultural development, food security, and structural economic transformation. It is evidenced that the recently adopted African Continental Free Trade Area (AfCTA) enhances the capacity of the continent. Free trade agreements will make it possible to lower taxes and duties in this way. Additionally, because there won't be any taxes to pay to the government, trade will become more flexible, and exports and imports will rise.

In fact, as global trade grows, it becomes increasingly important to organize and synchronize flows through an effective logistics system, as well as to improve terminals, regional and long-distance connections, and infrastructure, such as enlarging and modernizing ports and airports, and constructing wider access roads to logistics nodes. Performance in logistics will rise as a result. In actuality, all of these advancements will greatly facilitate the trade of goods and, over time, result in a significant decrease in costs. A nation's international trade will increase if it can gain a competitive edge in terms of logistics performance. This study suggests that policymakers in SSA should adopt an integrated investment approach where indirect influencers such as higher education are supported not only for their intrinsic value but also for their downstream effects on innovation and technological adoption, ultimately enhancing logistics performance. This contrasts with the direct-only emphasis in Ekici et al. (2019), offering a more dynamic strategy for developmental planning.

5. Conclusion

The study investigated interactive effects among the 12 pillars of GCI and logistics performance covering the years 2007, 2010, 2012, 2014, 2016, and 2018 based on consistent data availability. Unbalanced data were used due to missing data for some countries in a particular year. We used innovative approaches including TAN-BN, PLS-SEM, and IPMA. As a first step, the TAN-BN technique makes it easier to analyse the causal connections between the Sub-Saharan countries' GCI and LPI indicator values. The PLS-SEM, a structural equation model that maximises the explained variation among several variables, is an additional step that uses the outcomes of this model as inputs. The main goal of employing the Bayesian network before the PLS is to cut down on the number of potential causal relationships between different variables. The IPMA approach was subsequently used to assess the performance of the 12 pillars of GCI and logistics performance.

Hence, in this study, four unique contributions to prior studies were obtained. To begin with, we investigated the interactive effects of the 12 pillars of GCI in Sub-Saharan Africa as a territory or region in support of policies and concepts relating to international trade and integration. Also, we examined the pertinent pillars that relate to logistics performance while deciphering pillars that have indirect effects on logistics performance. Additionally, we provided suggestions for policy directions that harness the awareness of policymakers in the region with regard to the interactive effects among the 12 pillars of GCI as well as their influence on logistics performance. To end with, innovative approaches (TAN-BN and PLS-SEM) were used in stages to address the research problem in the Sub-Saharan Africa context.

It was revealed that out of 19 hypotheses, 13 were supported, illustrating positive relationships. For instance, the hypothesis on the significant relationship between higher education and training and infrastructure was supported by a positive and significant path coefficient. Also, higher education and training (Pillar 5) related significantly to the following Pillars: health and primary education (Pillar 4), technological readiness (Pillar 9), and innovation (Pillar 12). There was a significant connection between goods market efficiency (Pillar 6) and Pillars such as financial market development (Pillar 8) and market size (Pillar 10). The ninth hypothesis was supported by a positive and significant path coefficient between financial market development (Pillar 8) and labour market efficiency (Pillar 7). Moreover, technological readiness (Pillar 9) is related significantly to logistics performance and infrastructure (Pillar 2). Business sophistication (Pillar 11) was positively associated with goods market efficiency (Pillar 6) and innovation (Pillar 12). To end with, the eighteenth and nineteenth hypotheses were supported by positive and significant path coefficients between innovation (Pillar 12) and health and primary education (Pillar 4), as well as innovation (Pillar 12) and technological readiness (Pillar 9).

It is recommended that governments and policymakers make a more determined effort to overhaul minor enhancers, such as the growing demand for higher education and training, which can be effectively incorporated into the macroeconomic environment. More creative initiatives should be welcomed in the sector to enhance other crucial aspects, including market size, financial market development, and labour market effectiveness. For the upcoming years, it is crucial to achieve a favourable balance between the macroeconomic environment, health, and primary education. Moreover, the reach of innovation needs to be expanded to embrace advancements in the macroeconomic environment. Toward improvement in logistics performance, extensive investment should be made in technology and higher education and training by governments in the Sub-Saharan region.

As a suggestion for further studies, the Pillars of GCI can be categorised based on the three subindexes – basic prerequisites, efficiency-improving factors, and innovation and sophistication factors – due to their homogeneous dynamics in terms of having a significant influence on other Pillars to provide a general idea of the integration of the Pillars of GCI and logistics performance in the Sub-Saharan African region. Also, future studies could incorporate contextual variables—such as institutional quality or infrastructure—as moderators or mediators to better explain variations in the GCI-logistics nexus. The study is limited to the application of a unidirectional relationship; hence, the tendency for a bi-directional nexus between the variables is ignored by the current study. The two-way interaction is important because improvement in logistics performance by the advancement in the Pillars of GCI, and logistics performance can in turn enhance the Pillars of GCI due to the role of logistics performance as a major determinant of growth and development[1][2][3]. Additionally, the two-way interaction between the Pillars of GCI can act as mediators for the improvement of specific Pillars for sustained competitiveness. In this regard, further studies can explore the bi-directional relationship among the Pillars of GCI and logistics performance for further policy decisions and actions. Findings from this study were crucial to the Sub-Saharan region; hence, as a suggestion for further studies, other regional blocs can be investigated to facilitate comparison for global policy decisions. By centring the analysis on SSA and introducing indirect interaction pathways, this study provides novel empirical and policy insights beyond prior work such as Ekici et al.[2], thereby enhancing both methodological depth and regional relevance.

Appendix

	Logistics Performance	Pillar 2	Pillar 3	Pillar 4	Pillar 5	Pillar 6	Pillar 7	Pillar 8	Pillar 9	Pillar 10	Pillar 11	Pillar 12
Logistics Performance	0.880											
Pillar 2	0.378	1.000										
Pillar 3	0.058	0.180	1.000									
Pillar 4	0.332	0.192	-0.008	1.000								
Pillar 5	0.453	0.784	0.121	0.220	1.000							
Pillar 6	0.441	0.705	0.109	0.213	0.831	1.000						
Pillar 7	0.138	0.251	-0.047	0.168	0.275	0.378	1.000					
Pillar 8	0.498	0.710	0.165	0.145	0.751	0.745	0.400	1.000				
Pillar 9	0.534	0.831	0.173	0.192	0.839	0.768	0.219	0.709	1.000			
Pillar 10	0.515	0.130	0.201	-0.015	0.334	0.258	-0.056	0.407	0.472	1.000		
Pillar 11	0.425	0.217	0.018	0.924	0.265	0.260	0.109	0.239	0.244	0.114	1.000	
Pillar 12	0.519	0.541	0.055	0.172	0.750	0.766	0.361	0.647	0.689	0.409	0.250	1.000

Table 7. Discriminant Validity -Fornell-Larcker Criterion

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