Effects of Innovation and Economic Freedom on Female Economic Inclusion

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Abstract

The Sustainable Development Goal 5 emphasises the need to achieve gender parity in economic participation. Perusing the extant scholarship on female economic inclusion in Africa, we identify two pressing gaps. First, we find that previous studies have not explored how innovation affects female economic inclusion (FEI). Second, we note that prior studies have not examined the interactive effect of innovation and economic freedom on FEI. This study addresses these gaps by using macro data from 1995-2022 for a sample of 51 African countries. Findings from the two-step system GMM estimator reveal the following: (1) innovation reduces FEI, whereas economic freedom increases it, and (2) economic freedom moderates innovation to promote FEI. Further, we find that this positive total effect of innovation on FEI is remarkable at higher thresholds of economic freedom. We conclude that for innovation to promote FEI in Africa, investments in promoting economic freedom are critical.

Keywords: Africa; Innovation; Economic freedom; Female economic inclusion, GMM.

JEL Code: O31; O55; E24; J16; J21

1. Introduction

Goal 1 of Aspiration 6 of the African Agenda 2063 and Sustainable Development Goal 5 stress the need for female economic inclusion (African Union, 2015).[1] Inclusive economic growth is one that provides fairer opportunities for both men and women. Enhancing female economic inclusion is particularly crucial in Africa, considering the strong linkages between unemployment and the gender development gap (United Nations Development Programme, 2022). The 2022 Gender Gap Report pegs the overall gender gap in Africa at 67.9%, suggesting that women have lower quality of life, privileges and economic opportunities when compared to men (World Economic Freedom, 2020). The high female involvement in informal economic activities in Africa exacerbates this concern. For instance, the inclusion of women in precarious informal activities such as subsistence farming, and petty trading is high in Africa (FAO, 2011). More concerning is the evidence in Asongu and Odhiambo (2019), which suggests that low female participation in formal economic activities reduces Africa's annual output by approximately US$ 28 trillion.

One pathway that has the potential to promote female economic inclusion, especially in developing countries, due to the extensive margin for adoption, is innovation (United Nations Conference on Trade and Development, 2023; Zameer et al., 2020; Malerba, 2002). For instance, anecdotal evidence indicates that innovation facilitates entrepreneurship and creates employment opportunities for economic agents, including women (Medase & Wyrwich, 2022; Okumu et al., 2019). Further, innovation adoption can enhance female economic inclusion by ensuring that women become active stakeholders in the development of new ideas, technologies, and access to new market opportunities (Carrasco, 2014). Moreover, innovations and breakthroughs in remote work technologies and flexible scheduling work arrangements can provide opportunities for women to balance work and family responsibilities more effectively. This form of flexibility can go a long way to benefit women who lack social mobility or face difficulties shifting jobs.

This study also argues that empirical analysis concerning innovation and female economic inclusion should also take into consideration the degree of economic freedom in the countries in question. Our main reason for considering economic freedom is ingrained in the argument that freer economies have robust legal frameworks, openness

[1] https://au.int/agenda2063/aspirations

and regulatory efficiency that create a conducive environment for economic agents (including women) to participate meaningfully in the labour market (Miller et al. 2010) For instance, freer economies empower women by enhancing the flexibility to experiment with new ideas and technologies, which can enhance their labour market participation prospects (Adnane, 2015). Further, in countries with high economic freedom, business regulations are less burdensome, allowing for easier entry into markets and more diverse business models, which can include those that are more inclusive of women (McMullen et al., 2008). Additionally, economic freedom fosters competition, which can drive innovation in industries traditionally dominated by men, thus creating more opportunities for women to participate in labour markets (Sarpong-Kumankoma et al., 2018). Besides, in freer economies, governments (i) support women in securing startup capital at low cost, (ii) forge a strong collaboration with the private sector in adopting, mastering, and adopting technologies, and (iii) quickly incentivise foreign investors into their fold (Ofori et al., 2023).

The above intuitive linkages between economic freedom, innovation, and female economic inclusion call for rigorous empirical scrutiny that establishes or refutes such relationships to guide policymaking. However, a careful review of the labour market literature shows that researchers have not taken up this challenge, especially in the context of Africa. Accordingly, this study seeks to address the following questions.

1. Does innovation promote female economic inclusion?
2. Does economic freedom increase female economic inclusion?
3. Does economic freedom moderate innovation to promote female economic inclusion?

This study fills this gap by employing macro data for a sample of 51 African countries from 1995-2022. This study makes clear contributions to the literature. Foremost, regarding the approximation of innovation, we employ a comprehensive index capturing patents, trademarks, and grant applications. In doing so, we build on previous studies (e.g., Medase & Wyrwich, 2022; Gyeke-Dako et al., 2016; Cirera & Sabetti, 2019) that use variables such as total factor productivity, research and development (R&D), patent publications, and licenses to proxy for innovation. Empirical evidence in this direction is

also imperative for policy formulations concerning the effectiveness or otherwise of innovation in spurring female economic inclusion in predominantly informal economies. Second, we investigate how economic freedom affects female economic inclusion. Although this study is not the first to explore this effect, we employ a more comprehensive economic freedom indicator composed of market openness, the rule of law, regulatory efficiency, and government size (Miller et al., 2010). Empirical evidence in this regard is also policy-relevant because it brings to the fore the extent to which the economic architecture of the sampled countries promotes or stifles female economic inclusion. Third, we examine the interactive effect of innovation and economic freedom on female economic inclusion. To the best of our knowledge, this study is the first to contribute to knowledge by exploring this nexus. The result from this contingency analysis will inform policy as to whether investments for promoting innovation adoption and economic freedom will be worthwhile for female economic inclusion. Finally, we concentrate on Africa, where female economic inclusion is low, most economies are repressed/unfree, and innovation (measured by patent application, trademark application and R&D) remains low.

The rest of the paper is organised as follows: Section 2 presents the theoretical and empirical literature linking innovation and economic freedom to female economic inclusion; Section 3 presents the data and methods for the analysis; and Section 4 deals with the presentation and discussion of the findings. The study concludes with some policy recommendations in Section 5.

2. Literature review

2.1. Theoretical link between innovation and labour market participation

The theoretical link between innovation and employment is anchored in the Schumpeterian, skill-biased technological change, and innovation systems theories, as proposed by Schumpeter (1934), Nelson and Phelps (1966), and Dosi et al. (1988), respectively. First, Schumpeter's theory of creative destruction, introduced in 1934, emphasises the critical role of innovation and entrepreneurial activities in determining market dynamics, employment, and economic growth. By fostering a culture of innovation, societies can create new industries and demand new skills, leading to job creation. For example, the invention of information technology has led to job creation in

IT services, software development, and cybersecurity. The author further highlights that technological progress often creates employment opportunities because higher productivity leads to economic growth and job creation. Schumpeter (1942) further elaborates on creative destruction, describing how new innovations replace old technologies, leading to industrial transformation and economic development. Even though this transformation fosters technological progress and productivity improvements, it can also result in job displacement. For instance, automation and robotics have replaced many manual jobs in manufacturing, illustrating both the disruptive and productive aspects of innovation.

A closely related theory is skill-biased technological change, which suggests that technological advancement, often characterised by process innovation, leads to a higher demand for skilled labour and a workforce proficient in new technologies. This type of innovation typically replaces tasks traditionally performed by low-skilled workers with new tasks that require highly skilled workers, resulting in job losses for unskilled workers (Acemoglu, 2002; Vivarelli, 2012).

Within the remit of innovation systems theory, the role of collaboration in promoting employment is not just significant but paramount. This theory highlights that collaboration enhances the development and diffusion of new technologies. A collaborative environment, where various actors in an innovation system work together, fosters job creation by accelerating the commercialisation of innovations. Additionally, policies and institutions that support innovation, such as intellectual property rights, funding for R&D, and innovation clusters, significantly impact employment by creating a conducive environment for entrepreneurial activities.

2.2. Empirical literature on innovation and labour market participation

In a study involving three Latin American countries (Chile, Argentina, and Uruguay) from 1998-2007, Zuniga and Crespi (2013) apply the ordinary least squares (OLS) estimation strategy to explore the impact of innovation on employment growth. The authors find that innovation, measured as external R&D, promotes employment. Similarly, Cirera and Sabetti (2019) investigate the effect of innovation on employment in 53 developing countries from 2013-2015. Using a pooled simple OLS and instrumental variable (IV) estimation, they find that product innovation stimulates employment by increasing sales

in the short run, but process innovation does not significantly impact employment. Additionally, Gyeke-Dako et al. (2016) use linear and non-linear regression approaches to examine the impact of product and process innovation on employment in Ghana. Their study shows that product innovation is positively related to employment levels, whereas no significant relationship is found between process innovation and employment.

Aggarwal (2021) also contributes to the discourse by using macro data from 1995-2019 to investigate the effect of innovation measured by patents on female labour participation rates in India. Evidence from the Vector Autoregression (VAR) model and Granger causality test reveals that innovation positively enhances the female labour force participation rate. Moreover, Medase and Wyrwich (2022) explore the effect of innovation on employment in Nigeria for the period 2005-2010. Evidence from the OLS and quantile regression indicates that product innovation promotes employment growth.

Conversely, several empirical works have confirmed the negative effect of innovation on employment in developing societies, for instance, in South America (Aboal et al., 2015) and Latin America (Crespi & Tacsir, 2013). However, some previous studies do not find any significant impact of innovation on employment, for example, in Europe (Bogliacino & Pianta, 2010) and OECD countries (Pianta et al., 1996). These empirical findings are summarised in Table 1.

Table 1: Summary of empirical studies on the effect of innovation on employment

Author(s)	Sampled countries	Period	Predictor	Methodology	Results
Zuniga and Crespi (2013)	Chile, Argentina, and Uruguay	1998-2007	R&D	OLS	Positive
Cirera and Sabetti (2019)	53 developing countries	2013-2015	Product (process)	Pooled OLS and IV	Positive (negative)
Gyeke-Dako et al. (2016)	Ghana	2013-2015	Product (process)	Linear and non-linear model	Positive (no impact)
Aggarwal (2021)	India	1995-2019	Patent	VAR and Granger causality test	Positive
Medase and Wyrwich (2022)	Nigeria	2005-2010.	Product	OLS and quantile regression	Positive
Aboal et al. (2015)	South America	1998–2009	Process	OLS and IV regression	negative
Crespi and Tacsir (2013)	Chile, Argentina, Costa Rica, and Uruguay	1998-2009	R&D	OLS and IV regression	Negative
Bogliacino and Pianta (2010)	Eight European countries.	1994–2004	R&D expenditure	OLS	No impact
Pianta et al. (1996)	OECD countries	1993-1995	Product (Process)	OLS	No impact

Note: Authors' construct, 2024

2.3. Theoretical link between economic freedom and labour market participation

The link between economic freedom and employment is rooted in economic liberalism and neo-classical economic theory. The former is a foundational theory that emphasises limited government intervention, free markets, and personal liberty in the economy. The theory advocates for the market's self-regulating nature to allocate resources efficiently and promote economic growth. This significantly impacts employment through its influence on free trade, education, labour market flexibility, and entrepreneurship, which can translate to overall economic performance (Sturm & De Haan, 2001). Additionally, reducing government intervention and regulations in the labour market can lead to fairer hiring practices, better job matching, and improved labour market conditions for women (Berggren & Jordahl, 2006; Berggren, 2003).

The latter concept relates to Adam Smith's idea of the invisible hand, which suggests that when individuals are free to pursue their economic interests, they contribute to the overall economic well-being, leading to job creation and efficient markets. Free markets are seen as the most efficient way to allocate resources, including labour. In a free market, wages and employment levels adjust to match the supply and demand for labour. Moreover, the theory assumes that institutional factors like unions, minimum wage laws, and government regulations can contribute to market marginalisation, which influences employment trajectories (Bertola et al., 2007).

The empirical literature on economic freedom and employment is now gaining attention in Africa. A study by Asaleye and Strydom (2024), for instance, explores a comparative analysis of gender diversity in labour economic participation and growth. The study uses data from 48 sub-Saharan African (SSA) countries from 1996-2021. The authors employ the pooled ordinary least squares (POLS), fixed effects (FE), random effects (RE), and the GMM estimators for the estimation. Compelling evidence shows that institutional quality significantly increases male labour force economic participation. However, the effect is statistically insignificant when female labour force participation is considered.

A recent contribution by Ofori et al. (2023) also explore the impact of governance on female economic inclusion in 42 SSA countries. The attendant findings, which are based on macro data from 42 SSA countries over the period 1996-2020, reveal that political, economic, and institutional governance stimulates female economic inclusion in SSA countries.

Moreover, Angulo-Guerrero et al. (2017) employ a panel dataset for 33 OECD countries from 2001-2012 to analyse the effect of economic freedom on entrepreneurial opportunity. Employing the one-step GMM system, the study finds that economic freedom increases job creation. In addition, Dieckhoff et al. (2015) investigate the effect of institutional changes on labour market outcomes for males and females in 18 countries from 1992-2007. The study uses the fixed effect estimator to show that men benefit more from institutional changes compared to their female counterparts. The authors further find that stronger institutional unions bridge the employment gap.

The literature review above reveals some pertinent gaps. First, most previous studies explore the innovation-employment nexus using shallow proxies such as patent, R&D, process and product innovation as innovation. Second, prior studies have not explored the effect of innovation and economic freedom on female economic inclusion in the context of Africa. Moreover, the previous studies did not explore the moderation effect of economic freedom in the relationship between innovation and female economic inclusion in Africa. This study addresses these gaps in the extant scholarship by drawing on the data and methods provided in the next section.

3. Methodology and data

3.1 Data and sources

This study employs a balanced macro dataset from 1995-2022 for a panel of 51 African countries for the analysis. Table A1 provide the sample countries used. According to data from several sources, namely the World Development Indicators, the World Intellectual Property Organization (WIPO), International labour Organization (ILO) and the Heritage Foundation.

3.1.1 Dependent variables

The main outcome variable in this study is female economic inclusion (FEI). We capture FEI as the female labour force participation rate. The choice of this measure is motivated by labour force participation-centric literature (e.g., Asongu et al., 2020; Efobi et al., 2018; Signorelli et al., 2012). According to Asongu et al. (2020), FEI is appropriate for economic inclusion analysis because it provides a broader perspective on an individual's involvement in formal economic society and incorporates both the employed and unemployed. For

robustness checks, the study employs female employment to the population as an alternative outcome variable (see, e.g., Anyanwu & Augustine, 2013). These outcome variables are taken from the World Development Indicators (World Bank, 2024).

3.1.2 Main predictor variable

The main predictor variable in this study is innovation. The innovation variable in this study is an index computed using the principal component analysis (PCA). We employ three indicators precisely: trademark applications, grants, and patent applications for the computation. This approach has been employed in recent studies (e.g., Asamoah et al., 2021; Sinha & Alvarado, 2020). All the innovation variables are drawn from the World Intellectual Property Organization (2024).

3.1.3 Moderating variable

The study employs economic freedom as the moderating variable in the innovation-FEI relationship. According to Miller et al. (2023), economic freedom is an index capturing the (i) rule of law, (ii) the size of government, (iii) regulatory efficiency, and (iv) market openness. The index ranges from 0%-100%, where 0% represents a totally unfree/repressed economic system and 100% denotes an absolutely free economic architecture. The economic freedom series is obtained from the Heritage Foundation Data Centre (Miller et al., 2023).

3.4 Control Variables

The study also controls for covariates such as remittances, economic growth, foreign direct investment, internet access, education, and political stability to address the problem of omitted variable bias and allow for robust estimates. First, we consider remittances consistent with the argument that it is one of Africa's primary sources of private finance. We measure remittances as personal remittances received as a percentage of GDP (World Bank, 2024). Recent studies show that remittances drive both formal and informal participation of women in the labour market (Rodriguez & Tiongson, 2001; Asiedu & Chimbar, 2020).

Also, we take into account the role of education, proxied by secondary school enrolment in terms of gross gender parity index, in female economic inclusion. Education

is critical in labour market analysis because it equips women with the knowledge, skills and ingenuity required to set up their own businesses or secure decent jobs (Mitra & Singh, 2006; Lincove, 2008). Moreover, economic growth, which we capture as gross domestic product per capita growth rate, is imperative in female labour market outcomes because persistent expansion in the economy promotes infrastructural development and supportive programmes and job opportunities for women (see, e.g., González & Virdis, 2022; Tsani et al., 2013).

Additionally, we consider political stability measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. Political stability is an estimate ranging from -2.5 to 2.5. We pay attention to political stability because it offers a secure and predictable setting where initiatives and policies for empowering women can be implemented consistently and effectively. More importantly, political stability provides peace and social trust for all, including women, to access employment opportunities or pursue their entrepreneurial agendas (Ofori et al., 2023).

The essence of internet access as control stems from recent evidence that the digital economy provides a level playing field for all to participate fully in labour markets by facilitating access to information, quality education, broader markets, financial services, and job opportunities (Ramos & Prieto, 2014; Asongu et al., 2021). The study proxies Internet access by fixed broadband subscriptions per 100 people in the population. Finally, the study controls for foreign direct investment, measured as net inflows as a percentage of GDP in the conditioning information set.

Foreign direct investment is important because evidence has shown that foreign investors contribute to industrialisation, private sector growth and revenue mobilisation, and consequently, employment opportunities for both males and females in their host countries (see e.g., Fang et al., 2019; Ouedraogo & Marlet, 2018). Data for all the control variables are retrieved from the WDI (World Bank, 2024). Table 3 presents a detailed description and symbols for these variables. The attendant summary statistics and correlation matrix are reported in Table A2 (see Appendices).

Table 2: Variables names and description

Variables	Symbols	Definitions of variables	Sources
Predicted Variable			
Female economic inclusion	FEI	Labour force participation rate, female (15-64)	ILO Statistics
Predictor variables			
Innovation	INNO	Principal component that embodies patents, trademarks, and grants.	The authors
Economic freedom	EF	It is made up of 12 components, which are subdivided into four key aspects of economic and entrepreneurial nature over which government policies are made and calculated on a scale of 0 to 100.	Heritage Foundation
Control variables			
Remittances	REM	Remittances as a percentage of GDP	WDI
Economic growth	GDPPC	Gross domestic product (GDP) per capita growth (annual %)	WDI
Political stability	PS	The Absence of Violence/Terrorism measures perceptions of how likely political instability and/or politically motivated violence, including terrorism.	WGI
Internet access	ICT	Fixed Broadband subscription (per 100 people)	WDI
Foreign direct investment	FDI	Direct investment equity flows as a percentage of GDP	WDI
Education	EDUC	School enrolment, secondary (gross), gender parity index (GPI)	WDI
Innovation variables			
Patent	PAT	The number of patent applications (direct and PCT national phase entries)	WIPO
Trademark	TRA	The number of trademark applications (direct and through the Madrid system	WIPO
Grant	GRA	Total grants for direct applications (U.S. dollars)	WIPO

Note: WDI: World Development Indicators of the World Bank. ILO: International Labour Organization. WGI: World Governance Indicators of the World Bank. WIPO: World International Patent Organization.

3.2 Construction of innovation index

This study employs the principal component analysis (PCA) to construct the innovation index. Following Jolliffe (2002) and Kaiser (1974), this study specifies a PCA model of the form:

$$INNO_{it} = \varphi_{0\text{it}} + \varphi_{1\text{itPAT}_{\text{it}}} + \varphi_{2\text{itTRA}_{\text{it}}} + \varphi_{3\text{itGRA}_{\text{it}}} + \varepsilon_{\text{it}}, \quad (1)$$

where φ is the parameter; $inno$ is innovation; PAT is the total patent applications; TRA is the total number of trademark applications; GRA is the total grants for direct application; ε is the uncontrolled or nuisance variable; i is the number of countries in the sample; and t is the study period. The appropriateness of the innovation index can be seen from the Bartlett correlation and Kaiser–Meyer–Olkin (KMO) sample adequacy tests (see Table A3). The index generated is accurate and relevant since it replicates an increasing trend observed in the evolution of patents, trademarks, and grant applications (see Figure A1). In addition, the index can be visualised as per the eigenvalues provided in Figure A2. All missing values in any variables were replaced with preceding values to prevent the PCA from generating missing scores.

3.3 Estimation strategy

This study examines how innovation and economic freedom impact FEI in Africa. We first specify in Equation (2) to respond to Questions 1 and 2.

$$FEI_{it} = \emptyset_0 + \theta_1 FEI_{it-1} + \beta_1 INNO_{it} + \beta_2 EF_{it} + \sum_1^5 \gamma_k \pi_{kit-\tau} + \mathcal{J}_i + \mu_t + \varepsilon_{it} \quad (2)$$

Finally, to respond to Question 2, Equation (2) is modified to obtain Equation (3) by introducing an interaction term for innovation and economic freedom.

$$FEI_{it} = \emptyset_0 + \theta_1 FEI_{it-1} + \beta_1 INNO_{it} + \beta_2 EF_{it} + \beta_3 (INNO \times EF)_{it} + \sum_1^5 \gamma_k \pi_{kit-\tau} + \rho_i + \mu_t + \varepsilon_{it} \quad (3)$$

We compute the corresponding total effect of innovation on female economic inclusion as follows:

$$\frac{\partial(FEI_{it})}{\partial(INNO_{it})} = \beta_1 + \beta_3\overline{EF} \quad (4)$$

where FEI is a measure of female economic inclusion; $INNO$ is an index for innovation; EF is economic freedom. Furthermore, $(INNO \times EF)$ is the interaction term for innovation and economic freedom; π is the vector of control variables, namely foreign direct investment (FDI); economic growth (GDPPC); political stability (PC); education (*EDUC*); internet access (ICT); REM is remittances, and $\overline{EF}$ represents the average of economic freedom. Additionally, $\emptyset_0$ is intercept, *i* is countries; and t is time in years. Finally, ρ_i is the country-specific effect, μ_t is the time-fixed effect, and ε is the idiosyncratic error term that measures the nuisance. For a priori signs, we expect $\beta_1, \beta_2, \beta_3$ to be positive, meaning the innovation and economic freedom, as well as their interaction term, should increase FEI. Similarly, in line with Section 3.4, $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5$ are expected to have a positive impact on FEI.

The study estimates the models by employing the ordinary least square (OLS), fixed effect (FE), and random effect (RE). However, these techniques produce inconsistent and biased estimates in a dynamic context due to econometric issues such as endogeneity, heteroscedasticity, measurement error, and autocorrelation (Nickell,1981). To solve these problems, we use the Roodman (2009) dynamic two-step system generalised method of moments (Sys-GMM) estimator. According to Roodman (2009), the Sys-GMM estimator should satisfy some major requirements.

First, Roodman's Sys-GMM estimator is dynamic, enabling us to assess the effect of past female economic inclusion values on current performance. Second, the sample size (N) used in the paper must be greater than the number of years (T) in each cross-section. We fulfil this requirement as well since N=51>T=27. Third, due to some potential bias, the predictor variables may be endogenous, and idiosyncratic noise may exhibit individual country-specific patterns of heteroskedasticity and serial correlation.

The Roodman (2009) two-step Sys-GMM estimator uses both internal and external instruments to address the endogeneity problem. Precisely, we use the first lagged

difference levels of female economic inclusion, which is the predetermined variable, as our internal instrument. Also, we implemented the Windmeijer (2005) correction to obtain consistent and efficient estimates of parameters. We use innovation, economic freedom, and control variables as external instruments to account for simultaneity bias. Therefore, good and ideal instrumental variables should have no correlation with error terms but a high correlation with the relevant predictor variables (Roodman, 2009). In so doing, we treat the lagged predicted variable as predetermined and not correlated with the error term. Also, Roodman (2009) limits the proliferation of instruments and cross-country dependencies to avoid overfitting.

We assess the appropriateness of our results on several fronts. First, we assess whether we pass the overidentification restriction. Accordingly, we apply the Hansen (1982) test of over-identification. The test requires that the attendant p-values be insignificant. Second, we check for any second-order serial correlations in the residuals. This means that the test for no autocorrelation in the residuals must not be rejected. Third, we analyse whether the instruments used in the GMM are relevant for estimating innovation and economic freedom. In other words, they should be correlated with endogenous variables in the model. Further, we assess the overall fit of models using the F-statistics test. Hence, the ordinary least squares, fixed effects and random effects are not enough to cater to the above problems.

4. Results and discussion

4.1 Summary statistics

Table A4 presents the descriptive statistics for all the variables. We observe that the average value of female economic inclusion is 55.4%. As expected, innovation has a mean of 0 and a standard deviation of 1, as it is standardised. Additionally, the moderating variable, economic freedom, has an average value of 53% with a standard deviation of 8%.

4.2 Preliminary results

Table A2 demonstrates a statistically significant negative correlation between innovation and female economic inclusion. Moreover, innovation shows a positive correlation with

economic freedom, although statistically insignificant. But for foreign direct investment, all the control variables exhibit negative correlations with female economic inclusion.

We turn to the overview of female economic inclusion and economic freedom, as shown in Figure 3. We observe that most African countries have relatively low female economic inclusion. However, countries such as Mozambique, Madagascar, and Tanzania appear to have high levels of female economic inclusion. Figure 3 further reveals that Mauritius, Botswana, South Africa, Uganda, and Morocco are the freest economies in Africa when compared to their counterparts. Notably, Eritrea, Angola, and Zimbabwe have the repressed/unfree economic systems in Africa.

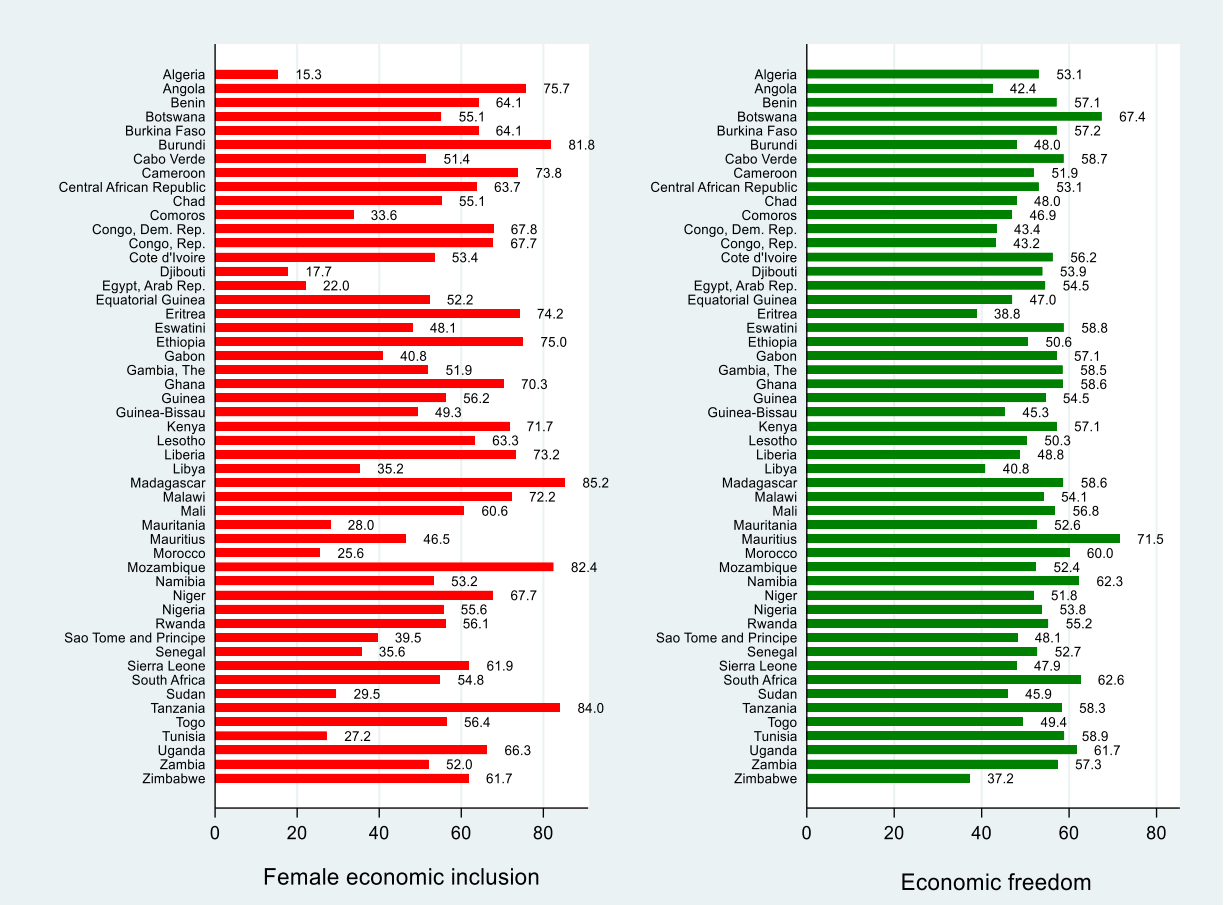

Figure 3: In-country average female economic inclusion and economic freedom, 1995-2022

4.3 Unconditional effect of innovation on female economic inclusion

Table 3 presents the findings for the direct effect of innovation on female economic inclusion based on the OLS, FE, RE and Sys-GMM estimators. We find that a unit increase in the score of innovation reduces female economic inclusion by 0.107% (Column 4). This

result is statistically significant at the 1% significance level and is contrary to our a priori expectation. This estimate is conspicuously lower than the corresponding estimates from the OLS, FE, and RE estimators, meaning that failure to address the endogeneity problem could have biased the effect of innovation upward.

Table 3: Unconditional effects of Innovation on female economic inclusion

Variables	OLS	FE	RE	Sys-GMM
Female economic inclusion (-1)	–	–	–	0.9574***
				(0.0083)
Education	-2.912***	-2.870***	-2.912***	-1.3703***
	(0.531)	(0.530)	(0.531)	(0.2080)
Foreign direct investment	-0.0196*	-0.0198**	-0.0196*	0.0006
	(0.0101)	(0.0101)	(0.0101)	(0.0021)
Economic growth	-0.00903	-0.00897	-0.00903	0.0020
	(0.0113)	(0.0113)	(0.0113)	(0.0017)
Internet access	0.572***	0.578***	0.572***	-0.0516***
	(0.0505)	(0.0505)	(0.0505)	(0.0136)
Remittances	0.107***	0.107***	0.107***	0.0145***
	(0.0191)	(0.0191)	(0.0191)	(0.0042)
Political stability	-0.0593	-0.0487	-0.0593	0.0381
	(0.166)	(0.165)	(0.166)	(0.0596)
Innovation	-0.414***	-0.407***	-0.414***	-0.1077***
	(0.137)	(0.137)	(0.137)	(0.0288)
Economic freedom	0.0382**	0.0390**	0.0382**	0.0086*
	(0.0183)	(0.0183)	(0.0183)	(0.0044)
Constant	55.68***	55.62***	55.68***	2.9845***
	(2.641)	(1.074)	(2.641)	(0.5292)
Time fixed effect	Yes	Yes	Yes	No
Observations	1,428	1,428	1,428	1,377
Wald Chi/F-stats.	307.64***	8.87***	307.64***	1.04e+06 ***
Countries	51	51	51	51
Instruments	–	–	–	48
Hansen P-Value	–	–	–	0.326
AR(1)	–	–	–	0.003
AR(2)	–	–	–	0.128

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

We explain this unexpected result in the following. First, in developing countries such as Africa, technological change can lead to job displacement. This is because rapid adoption

of innovation by firms and companies can lead to job losses or labour market shifts due to skillset mismatch. Additionally, the innovation ecosystem, including adoption, startups, and adaption, requires huge capital. However, in Africa, where women are the most financially excluded, innovation can work to the advantage of men. Moreover, adoption of innovation and mastery require specialised science, technology, engineering, and mathematics (STEM) skills. However, in Africa, where most women lack access to quality STEM education and digital connectivity, innovation could fail to promote female economic inclusion. This finding provides empirical evidence for World Economic Freedom (2020) and Crespi & Tacsir (2013) but contradicts the evidence in Cil and Guzey (2024), and Aggarwal (2021).

For Question 2, we examine the direct effect of economic freedom on female economic inclusion. The evidence in Column 4 shows that economic freedom increases female economic inclusion, consistent with our expectations. Precisely, we find that a 1% increase in economic freedom increases female economic inclusion by 0.008%. This evidence is statistically significant at the 10% significant level. The result confirms the argument that freer economic systems promote female economic inclusion. This can manifest in several ways. First, economic freedom can promote entrepreneurship by eliminating burdensome business regulations and obnoxious tax codes. This can facilitate entrepreneurship and job opportunities for women across various sectors, including those traditionally dominated by men.

Further, in freer economies, financial institutions are robust, property rights are secure, and investment freedom is enhanced. This can facilitate private sector competition and market efficiency, which can increase female economic inclusion. For example, in Botswana, South Africa, Mauritius, and Namibia, where the ease of doing business is high, women entrepreneurs are able to transition from unpaid to meaningful employment. Moreover, in freer economic systems, small- and medium-scale businesses expand dues to friendly tax codes and government support for the private sector (e.g., lower energy costs and research collaborations). This concurs with recent contributions in the literature (see, e.g., Fike, 2018; Ruseski & Maresova, 2014; Anyanwu & Augustine, 2013).

4.3.2 Conditional effect of innovation on female economic inclusion

Table 4 presents the results for Question 3. The coefficient of innovation and economic freedom on female economic inclusion is positive regardless of the type of estimator applied. This suggests that economic freedom complements innovation to promote female economic inclusion. In other words, economic freedom forms a synergy with innovation to increase female economic inclusion.

Table 4: Conditional effect of innovation on female economic inclusion

Variables	OLS	FE	RE	Sys-GMM
Female economic inclusion (-1)	–	–	–	0.9634***
	–	–	–	(0.0086)
Education	-3.071***	-3.031***	-3.071***	-1.5463***
	(0.526)	(0.526)	(0.526)	(0.2661)
Foreign direct investment	-0.0201**	-0.0203**	-0.0201**	-0.0008
	(0.00997)	(0.00996)	(0.00997)	(0.0025)
Economic growth	-0.0101	-0.0100	-0.0101	0.0009
	(0.0112)	(0.0112)	(0.0112)	(0.0019)
Internet access	0.600***	0.605***	0.600***	-0.0270*
	(0.0503)	(0.0502)	(0.0503)	(0.0137)
Remittances	0.109***	0.109***	0.109***	0.0151***
	(0.0189)	(0.0189)	(0.0189)	(0.0035)
Political stability	-0.0242	-0.0141	-0.0242	0.0460
	(0.164)	(0.164)	(0.164)	(0.0563)
Innovation	-7.828***	-7.825***	-7.828***	-5.1739***
	(1.409)	(1.407)	(1.409)	(0.8249)
Economic freedom	0.0558***	0.0565***	0.0558***	0.0308***
	(0.0184)	(0.0184)	(0.0184)	(0.0055)
Innovation × Economic freedom	0.137***	0.137***	0.137***	0.0927***
	(0.0258)	(0.0258)	(0.0258)	(0.0154)
Constant	54.87***	54.81***	54.87***	1.5658**
	(2.663)	(1.074)	(2.663)	(0.7139)
Time fixed effect	Yes	Yes	Yes	No
Observations	1,428	1,428	1,428	1,377
Wald Chi/F-stats.	342.03***	1038.24***	342.12***	720729.6***
Countries	51	51	51	51
Instrument	–	–	–	48
Hansen P-Value	–	–	–	0.312
AR(1)	–	–	–	0.00328
AR(2)	–	–	–	0.190

Note: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

This becomes clear when we compute the total effect of the innovation and economic freedom interaction on female economic inclusion. These total effects are based on the minimum, mean, and maximum values of economic freedom. We show that at the minimum (21.4) and mean (53.1) of economic freedom, innovation reduces/mitigates the negative impact on female economic inclusion from -5.173% to -3.189% and -0.245%, respectively. More importantly, when we consider the maximum value (77) of economic freedom, the effect of innovation on female economic inclusion becomes positive 1.967%.

This evidence suggests that economic freedom effectively conditions innovation to enhance female economic inclusion at higher thresholds (i.e., Mostly free bracket). This is revealing because, according to Miller et al. (2010), economic freedom values of 21.4 and 53.1 signify repressed and unfree economic architecture. Such settings may be ineffective for innovation and economic freedom to facilitate greater female economic inclusion. This can be explained by the fact that in the presence of economic freedom, economic agents find it easy to adopt, master, and adapt innovation in their businesses. This can boost economic activity and contribute to job creation. Furthermore, economic freedom reduces investment risks and safeguards property rights, which can enable firms to leverage open innovation to enhance production efficiency and productivity, including employment opportunities for women. Besides, economic freedom deepens access to both domestic and international market data, trends, and opportunities, which can enable women to have access to wider markets and collaborate for effective labour market participation. Additionally, economic freedom attracts foreign investors. In Africa, where grounds are fertile for market- and resource-seeking foreign investors (Ofori et al., 2023), economic freedom can be an incentive to foreign investors. Their investment and contribution to growth in host countries can create more opportunities for females to become gainfully employed.

For our control variables, the study finds that education and internet access reduce female economic inclusion in Africa. The magnitude of the coefficient indicates that an additional year of secondary schooling statistically reduces female economic inclusion by 2.671%. The negative effect of education can be attributed to the fact that high school graduates may lack sufficient employable skills to enter the labour market. Also, restrictive gender norms in developing societies like Africa may hinder the full participation of women in the labour market. Our finding is in line with the argument of Kattan and Khan (2023).

Similarly, an increase in broadband connectivity impedes female economic inclusion by 0.1221%. Internet access can also hinder female economic inclusion because of high internet costs, poor connectivity, and the highly informal sector of Africa. This result is consistent with Asongu and Odhiambo (2023). The study also reveals that a percentage increase in remittance inflow increases female economic inclusion by 0.014%. This is plausible because remittances may serve as seed capital for women looking to establish or expand small-scale businesses. This can stimulate economic growth and provide more prospects for women. The finding corroborates Amuedo-Dorantes and Pozo (2006).

Table 5: Conditional effects of innovation at various economic freedom values

Total effect	**OLS**	**FE**	**RE**	**Sys-GMM**
At Minimum	-4.910***	-4.903***	-4.905	-3.189***
	(0.860)	(0.858)	(0.860)	(0.495)
At Mean	-0.459***	-.452***	-.459***	-0.2451***
	(0.136)	(.136)	(0.136)	(0.0303)
At Maximum	2.693***	2.700***	2.689***	1.967***
	(0.602)	(0 .601)	(0.602)	(0.365)

Note: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

From several studies that use the Sys-GMM estimation technique, the results should satisfy the post-diagnostic information criteria to determine the validity of the estimators and the models used for the analysis. The insignificance of the AR (1) and AR (2) p-values suggests the absence of first and second-order serial correlation with the idiosyncratic error term of the first differenced Equation. Furthermore, the non-significant p-value of the Hansen test indicates that the instruments employed in the model are valid and reliable in addressing the endogeneity problem. Additionally, the number of instruments is less than the number of countries, providing clear evidence of the validity of our instruments.

4.4 Robustness checks

As a robustness check, we utilise female employment to population as an alternative measure of female economic inclusion. Consistent with the main results in Tables 3 and 4, The results in Table 6 indicate that innovation has different conditional and

unconditional impacts on female economic inclusion. First, Table 6 shows a negative and statistically significant effect of innovation on female economic inclusion. Specifically, a point increase in innovation reduces female economic inclusion by 0.515%. This evidence is statistically significant at the 1% significance level and confirms the evidence in Table 3. This evidence is consistent across all the estimators and contradicts our expectation of innovation increasing female economic inclusion.

Table 6: Unconditional effect of Innovation on female economic inclusion

Variables	OLS	RE	FE	Sys-GMM
Female economic inclusion (-1)	–	–	–	0.9818***
	–	–	–	(0.0031)
Education	-2.449***	-2.449***	-2.392***	-0.1814
	(0.524)	(0.524)	(0.522)	(0.1373)
Foreign direct investment	-0.0206**	-0.0206**	-0.0208**	-0.0029**
	(0.00994)	(0.00994)	(0.00991)	(0.0014)
Economic growth	-0.00144	-0.00144	-0.00137	0.0108***
	(0.0112)	(0.0112)	(0.0111)	(0.0021)
Internet access	0.430***	0.430***	0.436***	0.0083
	(0.0499)	(0.0499)	(0.0497)	(0.0059)
Remittances	0.113***	0.113***	0.113***	-0.0013
	(0.0189)	(0.0189)	(0.0188)	(0.0027)
Political stability	0.122	0.122	0.138	-0.0706**
	(0.163)	(0.163)	(0.163)	(0.0310)
Innovation	**-0.235***	**-0.235***	**-0.229***	-0.5153***
	(0.136)	**(0.136)**	**(0.135)**	(0.0498)
Economic freedom	**0.0489*****	**0.0489*****	**0.0498*****	0.0075***
	(0.0180)	**(0.0180)**	**(0.0180)**	(0.0022)
Constant	48.73***	48.73***	48.65***	0.5220**
	(2.682)	(2.682)	(1.058)	(0.2123)
Time fixed effect	Yes	Yes	Yes	No
Wald Chi/F-stats.	266.31***	266.31***	7.70***	1.45e+06***
Observations	1,428	1,428	1,428	1,377
Countries	51	51	51	51
Instruments	–	–	–	49
Hansen P-Value	–	–	–	0.149
AR(1)	–	–	–	0.004
AR(2)	–	–	–	0.485

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7: Conditional effect of Innovation on female economic inclusion

Variables	OLS	FE	RE	Sys-GMM
Female economic inclusion (-1)	–	–	–	0.9527***
	–	–	–	(0.0053)
Education	-2.590***	-2.535***	-2.590***	-0.7021***
	(0.520)	(0.519)	(0.520)	(0.1957)
Foreign direct investment	-0.0211**	-0.0213**	-0.0211**	0.0036
	(0.00986)	(0.00983)	(0.00986)	(0.0025)
Economic growth	-0.00239	-0.00233	-0.00239	0.0068**
	(0.0111)	(0.0110)	(0.0111)	(0.0030)
Internet access	0.455***	0.460***	0.455***	-0.0864***
	(0.0497)	(0.0496)	(0.0497)	(0.0105)
Remittances	0.114***	0.114***	0.114***	0.0037
	(0.0187)	(0.0187)	(0.0187)	(0.0044)
Political stability	0.154	0.169	0.154	-0.0868*
	(0.162)	(0.162)	(0.162)	(0.0461)
Innovation	-6.828***	-6.821***	-6.828***	-1.3018*
	(1.392)	(1.389)	(1.392)	(0.7088)
Economic freedom	0.0645***	0.0654***	0.0645***	0.0084*
	(0.0182)	(0.0182)	(0.0182)	(0.0046)
Innovation × Economic freedom	0.121***	0.121***	0.121***	0.0221*
	(0.0255)	(0.0255)	(0.0255)	(0.0130)
Constant	48.01***	47.93***	48.01***	2.3499***
	(2.707)	(1.060)	(2.707)	(0.4451)
Time fixed effect	Yes	Yes	Yes	No
Wald Chi/F-stats.	293.57***	8.24***	293.57***	1.71e+06***
Observations	1,428	1,428	1,428	1,377
Countries	51	51	51	51
Instrument	–	–	–	49
Hansen P-Value	–	–	–	0.147
AR(1)	–	–	–	0.005
AR(2)	–	–	–	0.449

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The contingency analysis in Table 7 also supports our findings in Table 4 that economic freedom is critical for innovation to promote female economic inclusion. This is because the negative sign of innovation on female economic inclusion becomes positive when it interacts with economic freedom. This means that economic freedom forms a synergy

with innovation to induce female economic inclusion. As we found in Table 5, the study finds that at the minimum and mean of economic freedom, innovation mitigates but does not nullify) the negative effect of innovation on female economic inclusion. However, when the maximum value of economic freedom is considered, the total effect of innovation on female economic inclusion becomes positive (0.0402), albeit statistically insignificant (Table 8). These results confirm that innovation enhances female economic participation in economically free economies compared to unfree countries and reinforces the robustness of our main contribution to the literature.

Table 8: Conditional effects of innovation at various economic freedom values

Total effect	**OLS**	**FE**	**RE**	**Sys-GMM**
At Minimum	-4.229***	-4.223***	-4.229***	-0.828*
	(0.850)	(0.848)	(0.850)	(0.430)
At Mean	-0.276**	-.2697***	-0.276**	-0.126***
	(0.135)	(0.134)	(0.135)	(0.035)
At Maximum	2.524***	2.529***	2.524***	0.402
	(0.595)	(0.594)	(0.595)	(0.297)

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5. Conclusion and policy recommendations

This research contributes to the labour market literature by examining the direct and indirect effects of innovation on female economic inclusion in Africa. The study captures female economic inclusion by female labour market participation rate of females aged 15-64. To this end, we employ a panel of 51 African countries with data from 1995 to 2022. The findings are robust to several econometric specifications and techniques, namely the ordinary least squares, the random effect, the fixed effect, and the two-step system generalised method of moments.

The following findings are drawn from the data analysis. First, innovation directly reduces female economic inclusion in Africa. Second, the study finds that economic freedom mitigates (nullifies) the negative effect of innovation on female economic inclusion at lower (higher) thresholds. In other words, economic freedom interacts with innovation to promote female economic freedom. These results remain consistent when

we capture female economic inclusion by female employment to population ratio as a percentage of females aged 15 years and above.

In light of these findings, we offer the following policy recommendations. Firstly, African governments should strive to enhance economic freedom. This can be done by building systems, frameworks, and structures to address corruption and repressive business regulations. Additionally, African governments can improve economic freedom by investing in legal structures, law enforcement systems, and property rights to enable women to innovate and participate in the labour force. Also, the positive effect of innovation on female economic inclusion in the presence of economic freedom calls for investments in science, technology, and training programmes, especially for women to leverage innovation and participate in the labour market via entrepreneurship or employment. Also, policymakers could invest in STEM education for women/girls, implementing flexible work arrangements and supportive policies, combating gender bias and discrimination, and providing financial support for women innovators and entrepreneurs.

Despite the contribution of this study to the labour market scholarship, some limitations can be highlighted. To begin with, the dataset used for analysis included data from 51 instead of 54 African countries. Precisely, data for South Sudan, Djibouti, Somalia, and Seychelles have missing values for significant periods. The analysis can thus be revisited should data become available. As a direction for future research, we encourage other researchers to assess the interplay between economic freedom and innovation on outcomes such as gender inequality.

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Appendices

Table A1: List of Countries

Algeria	Eritrea	Morocco
Angola	Eswatini	Mozambique
Benin	Ethiopia	Namibia
Botswana	Gabon	Niger
Burkina Faso	Gambia, The	Nigeria
Burundi	Ghana	Rwanda
Cabo Verde	Guinea	Sao Tome and Principe
Cameroon	Guinea-Bissau	Senegal
Central African Republic	Kenya	Sierra Leone
Chad	Lesotho	South Africa
Comoros	Liberia	Sudan
Congo, Dem. Rep.	Libya	Tanzania
Congo, Rep.	Madagascar	Togo
Cote d'Ivoire	Malawi	Tunisia
Djibouti	Mali	Uganda
Egypt, Arab Rep.	Mauritania	Zambia
Equatorial Guinea	Mauritius	Zimbabwe

Table A2: Summary statistics of sample data from 1995-2022

Variables	N	Mean	SD	Min	Max
Female economic inclusion	1428	55.408	17.920	12.250	88.602
Innovation	1428	0.000	1.000	-0.251	8.924
Economic freedom	1428	53.145	8.153	21.400	77
Foreign direct investment	1428	3.938	8.676	-17.292	161.824
Economic growth	1428	1.845	7.213	-47.900	140.48
Political Stability	1428	-0.552	0.870	-2.848	1.224
Internet Access	1428	0.665	2.176	0.000	25.726
Remittances	1428	3.477	7.154	0.000	108.403
Education	1428	0.837	0.226	0.000	1.453
PCA variables					
Patent	1428	1397.697	4161.578	0.000	32125
Trademark	1428	32.517	129.375	0.000	1187
Grant	1428	1.317	7.342	0.000	108

Note: N is observations; Std. Dev is standard deviation; min is minimum, and max is maximum

Table A3: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Female economic inclusion	1											
(2) Innovation	-0.164***	1										
(3) Economic freedom	-0.082**	0.039	1									
(4) Foreign direct investment	0.0357	-0.055*	-0.067*	1								
(5) Economic growth	-0.024	-0.002	0.009	0.211***	1							
(6) Political Stability	-0.112***	-0.116***	0.401***	0.062*	0.076**	1						
(7) Internet Access	-0.234***	0.185***	0.271***	-0.039	-0.014	0.135***	1					
(8) Remittances	-0.040	-0.008	-0.023	0.043	0.013	0.132***	-0.006	1				
(9) Education	-0.185***	0.034	0.251***	-0.023	-0.009	0.244***	0.079**	0.285***	1			
PCA variables												
(10) Patent	-0.179***	0.385***	0.221***	-0.063*	-0.013	-0.033	0.279***	-0.027	0.134***	1		
(11) Trademark	-0.164***	1.000***	0.039	-0.055*	-0.002	-0.116***	0.185***	-0.008	0.034	0.385***	1	
(12) Grant	0.137***	0.058*	0.038	-0.025	0.042	-0.109***	0.018	-0.043	0.112***	0.143***	0.058*	1

Note: N is observations; Std. Dev is standard deviation; min is minimum, and max is maximum; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A4: Tests for appropriateness of innovation index

Variable	KMO
Trademarks	0.509
Patents	0.510
Grant applications	0.580
Overall	**0.514**

Note: Bartlett test of sphericity: Chi-Square statistics = 257.9***

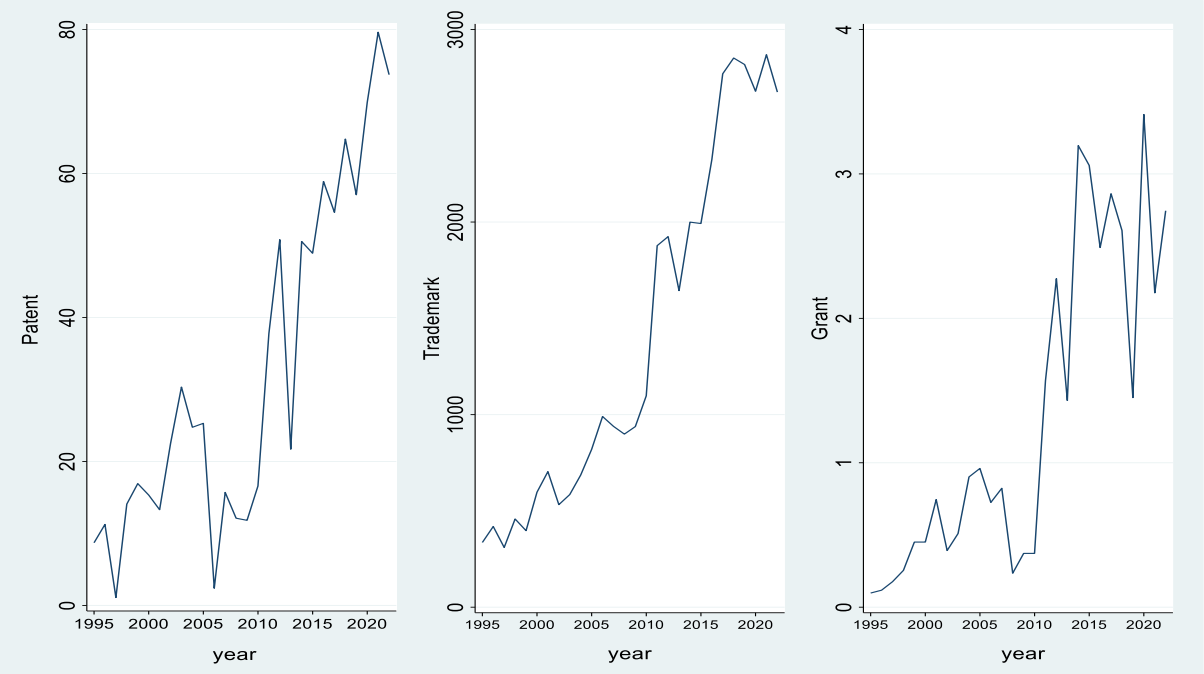

Figure A1: Trends of innovation indicators

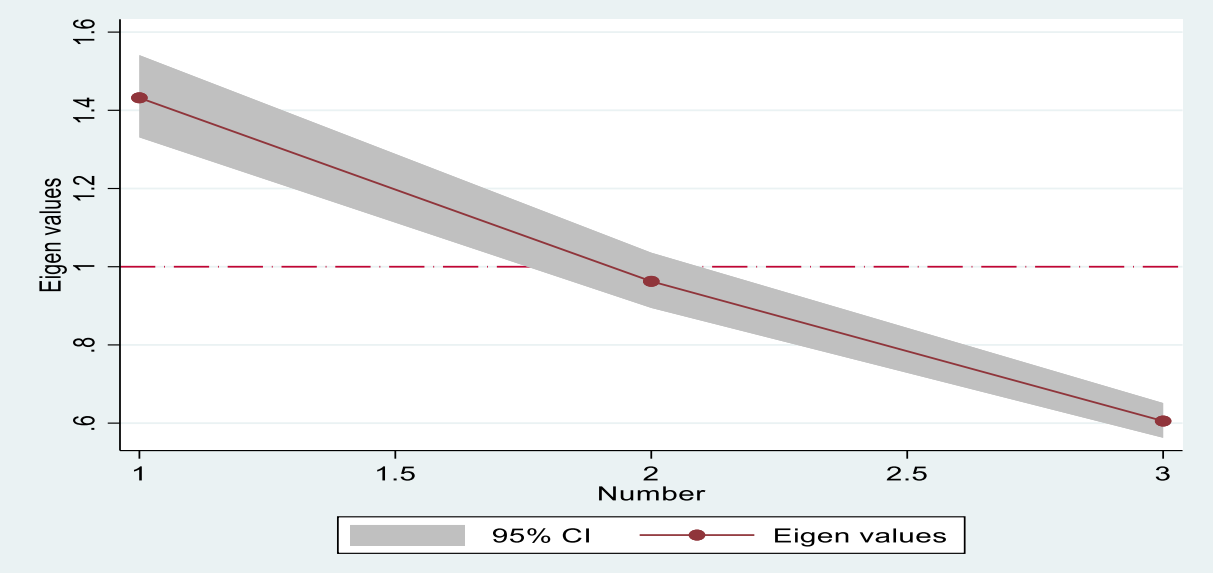

Figure A2: Scree plot of the innovation index