

Exploring the Interplay Between Civil Liberty, Technological Innovation, and Human Capital

Samuel Amponsah Odei and Ivan Soukal

Department of Economics, University of Hradec Králové, Hradec Králové, Czech Republic

ppodei@yahoo.co.uk

Abstract: While existing research has focused on analysing the relationship between democracy and innovation, they fall short on the conditions under which the effect works. We draw insights from the institutional and human capital theories to develop and test a simple theoretical model to examine the conditions under which civil liberty impacts technological innovation. Our empirical model based on a sample of 47 sub-Saharan African countries for the period 1990–2022 using the conditional fixed effect Poisson regression. The empirical results revealed that civil liberty positively influences technological innovation. We further found that human capital negatively influences technological innovation. Finally, we found that the effect of civil liberty on technological innovation conditional on human capital is higher for low values of human capital and diminishes for high values of human capital. The results are robust when we include additional control variables. The study has important implications for technological innovation in sub-Saharan African countries in the context of civil liberty and human capital development.

Keywords: Civil liberty, Technological innovation, Human capital, Institutional theory, Sub-Sahara Africa

1. Introduction

Technological innovation serves as a catalyst for change, driving advancements across various spheres of human endeavour, from communication and healthcare to transportation and beyond. Technological innovation is influenced by micro- or firm-level factors such as engaging in research and development and macro-level factors such as institutional-related conditions and policies (Riaz & Cantner, 2020). Micro-level and macro-level factors have been examined independently (Skare & Porada-Rochon, 2022), but innovation performance cannot be fully explained by micro-level or macro-level factors alone since innovation is a complex and multilayered notion in which the interaction of events occurring both inside and outside of a firm's borders is important (Odei, 2024). Civil liberty, encompassing fundamental freedoms such as freedom of speech, expression, and assembly, forms the bedrock of democratic societies, empowering individuals to voice their opinions, challenge existing norms, and shape the course of collective action. At its core, civil liberty provides the fertile ground upon which technological innovation thrives, fostering an environment of openness, transparency, and accountability conducive to the free exchange of ideas, collaboration, and experimentation. Sub-Saharan African countries are known to have weaker democracy and institutions (Gossel, 2018), which could affect the continent's drive for technological innovation.

Few existing studies have focused on analysing the direct relationship between democracy and innovation (see Forson et al., 2021). A study by Najam et al. (2023) concluded that civil liberties enhance innovations. However, the mechanism through which democracy (civil liberty) works to impact innovation has received less scholarly attention. We focus on civil liberty as a component of democracy to analyse its impact on technological innovation. We also examine the contingent effect of human capital on the relationship. The moderation effect of human capital suggests that the direct association between civil liberty and technological innovation could vary depending on the level of human capital. Higher levels of human capital could amplify the positive effects of civil liberties on innovation by enabling individuals to fully use their freedoms through education, skills, and knowledge. In environments where human capital is high, civil liberties are likely to have a stronger positive impact on technological innovation. Individuals with higher levels of education, skills, and knowledge will therefore be better equipped to capitalise on civil liberties (freedom of speech, access to information, and intellectual property rights) to innovate. This study contributes to the literature by drawing intuitions from the institutional and human capital theories to analyse the relationship. Our main findings demonstrate that human capital diminishes the positive effect of civil liberty on technological innovation. Policymakers in sub-Saharan African countries should prioritise investments in education and training programmes to improve human capital; this could amplify the positive impact of civil liberties on technological innovation.

The research is structured as follows: The ensuing section focuses on the methodology and data. Section 3 describes the results in relation to existing studies. The final section concludes the paper.

2. Theoretical Review and Hypotheses Development

We used the institutional theory to explain how the democratic environment in sub-Saharan Africa function within structured environments to influence technological innovation. According to North (1990) institutions can be defined as rules, norms, and structures that influence social behaviour as well as organisational practices. This theoretical frame emphasises how institutions which could be both formal (laws, regulations, policies) and informal (norms, cultural practices, social expectations) impact economic and social development. The institutional theory suggests that rules, norms, and structures influence how societies adopt and adapt to changes, including technological progress and human capital development. They provide frameworks that guide human interactions and shape decision-making. Organisations and economic agents are inclined to conform to prevailing institutional expectations to gain legitimacy. From the institutional theory perspective, we anticipate that strong civil liberties could provide the foundation for technological innovation. Civil liberties in the form of freedom of expression, access to information, privacy rights, and the rule of law (Balkin, 2017; Czuryk, 2022), can create an enabling environment that promotes innovation, creativity, and the development of new technologies. Open societies that allow unrestricted exchange of ideas, could create knowledge diversity which fuels R&D activities which is vital for innovation. When citizens are able to contribute to knowledge-sharing and global collaboration enhanced by open internet policies could result in technological advancements. We summarise the understanding that civil liberties can contribute to technological innovation by fostering an environment where knowledge sharing and protection can thrive. Based on the aforementioned analysis, we propose our first hypothesis as.

Hypothesis 1: Civil liberty has a significant positive influence on technological innovation

2.1 Moderating Role of Human Capital

In our second hypothesis we predict that human capital will strengthen the positive relationship between civil liberty and technological innovation. We draw insights from the human capital theory which posits that investment in individuals' education and skills enhances their productivity and economic value (Sweetland, 1996). This framework considers human knowledge, skills, experience and capabilities as a form of capital, akin to physical or financial capital, that can be utilised to contribute to individual and economic growth as well as development. Education advances critical thinking and political awareness, resulting in stronger calls for democracy, freedom of expression, and digital rights. Human capital plays a moderating role in the relation between civil liberties and technological innovation by improving the absorptive capacity. Countries with high human capital resources are better positioned to capitalise in institutional support for innovation, which is frequently stronger in democracies that uphold civil liberties (Kwan & Chiu, 2015). This suggests that the effectiveness of civil liberties in promoting technological innovation is contingent upon the existing level of human capital present in a country. When individuals possess the requisite skills and knowledge, they stand a lofty chance of utilising the freedoms provided by civil liberties to carry out innovation and its associated activities, thereby amplifying the positive effects of civil liberties on technological innovation. Based on this discussion we anticipate that human capital will play an essential role in reinforcing the relationship between civil liberty and technological innovation which aligns with the human capital theory. We provide our second hypothesis as.

Hypothesis 2: human capital strengthens the relationship between civil liberty and technological innovation.

3. Data and Methodological Approach

Table 1 below provides the sources of data for the empirical estimations spanning the period 1990–2022. For the methodological approach, we used the conditional fixed-effects Poisson regression. This statistical method models count data, specifically outcome variables that are non-negative integers, while addressing unobserved heterogeneity based on the conditional likelihood estimation (Correia et al., 2020). This statistical technique was used because our dependent variable thus patent is count by nature as well as has panel or longitudinal data structure (Verdier, 2018). We provide the formula for the conditional fixed effects Poisson model as.

$$E(Y_{it} | X_{it}, \alpha_i) = \exp(X_{it} \beta) \alpha_i \quad [1]$$

Where.

Y_{it} = represents the count-dependent variable (thus number of patents)

X_{it} = denotes the vector of independent variable namely civil liberty

β = represents the coefficient' vector

α_i = is the fixed effect (removed via conditioning)

4. Results and Discussion

Table 1 presents the summary statistics, the average patents applied is about 118. After standardisation, the difference GDP per capital is large, indicating that there are huge variations across the sampled countries in terms of economic growth. The mean for human capital is 8.457 which is low. The mean for civil liberty is 4.210, there are huge variations between and across the sample. The mean for ICT penetration is 79.100. Also, the result in Table 2 shows the correlations of the variables which are very low indicating that there are no issues of multicollinearity. The results of the moderated analyses are shown in Table 3. In Model 2, we see that there is a positive and statistically significant association between civil liberty and technological innovation ($\beta = 0.390, P < 0.001$). This results means that any increase in civil liberty increases the likelihood of technological innovation, suggesting that societies with stronger civil liberties provide a conducive environment for innovation to thrive by fostering creativity, risk-taking, and entrepreneurship. This result contradicts with the findings of previous studies in developing countries that found an insignificant association Ahmed et al. (2024), and Najam et al. (2023) who found a negative relationship. The result also shows that the direct relationship between human capital and technological innovation is negative ($\beta = -0.043, P < 0.001$), indicating that any increase in human capital reduces the likelihood of technological innovation. This result could be possibly explained as the educational systems may not necessarily equip students with the practical knowledge and skills needed for successful innovation (Habiyaemye et al., 2022), particularly in fields like STEM (Science, Technology, Engineering, and Mathematics). This skillset mismatch could therefore play a key role in hindering the development of a workforce with the skills necessary for high-level needed for innovation. This result contradicts the finding of a related study in sub-Saharan African countries by Danquah & Amankwah-Amoah (2017) who found an insignificant relationship. However, studies in developed countries found that human capital has a positive influence on radical innovation (Delgado-Verde et al., 2016).

Table 1: Descriptive Statistics and variables sources

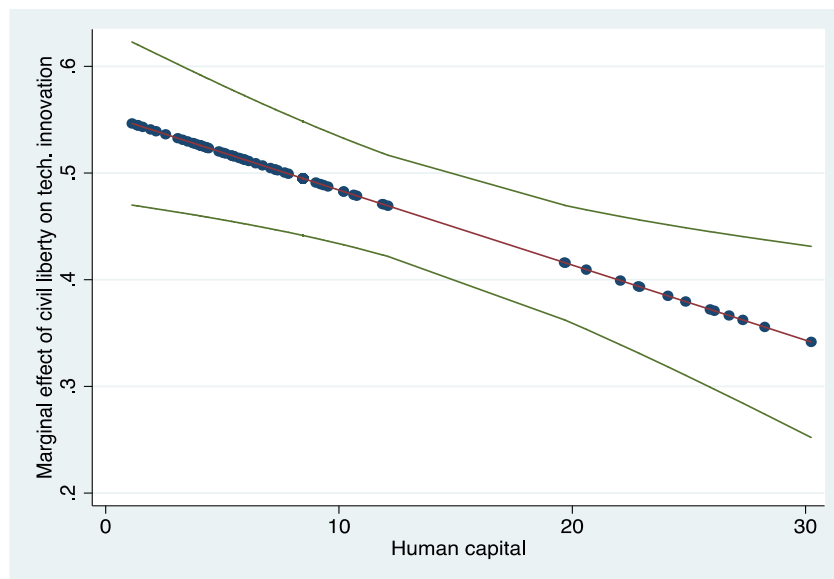
Variable		Mean	Std. Dev.	Min	Max	Sources
Patents	overall	117.873	245.740	1	1003	World Intellectual Property Organization
	between		162.420	1	800	
	within		74.605	-140.127	360.373	
GDP per capita	overall	7.120	0.954	5.542	9.748	World Bank
	between		0.948	5.676	9.515	
	within		0.1651	6.311	7.723	
Political stability	overall	-0.557	0.917	-3.310	1.280	World Bank
	between		0.849	-2.681	1.023	
	within		0.369	-2.075	0.752	
Regulatory quality	overall	-0.713	0.638	-2.550	45323,00	World Bank
	between		0.617	-2.198	0.794	
	within		0.185	-1.736	0.119	
ICT	overall	79.100	211.233	1	1706	International Telecommunication Union
	between		136.271	1	849.2	
	within		143.610	-767.101	986.394	
Property rights	overall	35.986	15.070	5	90	Heritage Foundation
	between		12.080	15.130	67.957	
	within		8.479	7.160	91.160	
Civil liberty	overall	4.210	1.542	1	7	Freedom House
	between		1.176	1.905	6.545	

Variable		Mean	Std. Dev.	Min	Max	Sources
	within		1.010	0.210	7.305	UNESCO
Human capital	overall	8.457	7.603	0.350	44.39	
	between		5.633	1.504	30.558	
	within		4.330	11.070	22.290	

Note: UNESCO= United Nations Educational, Scientific and Cultural Organization

Table 2: Correlation matrix (1081 obs.)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Patents	1.000							
(2) GDP per capita	0.476	1.000						
(3) Political stability	-0.054	0.481	1.000					
(4) Regulatory quality	0.280	0.430	0.648	1.000				
(5) ICT	0.621	0.206	-0.014	0.197	1.000			
(6) Property rights	0.203	0.429	0.519	0.732	0.224	1.000		
(7) Civil liberties	0.467	-0.015	-0.317	-0.320	0.071	-0.319	1.000	
(8) Human capital	-0.232	0.279	0.217	0.370	0.029	0.208	-0.058	1.000



Source: Own estimation

Figure 1: Effect size of the moderation

Our second hypothesis anticipated that human capital would improve the relationship between civil liberty and technological innovation. The result in Table 3 shows that the simple slope coefficient is significant but negative ($\beta = -0.015$, $P < 0.001$). This result means that we didn't find support for our hypothesis 2. As shown by the descriptive statistics in Table 1, the human capital potential in the sampled countries is low and resonates with the findings of previous research (Ogundari & Awokuse, 2018), hence the possible reason why it has a negative direct influence on technological innovation. This result is contrary to the widely held view that human capital is essential for innovation, in the case of sub-Saharan African countries our result has demonstrated that human capital hinders technological innovation. This result contradicts the findings of a related study in China by (Liu et al., 2017), who found a positive association between human capital and innovation. Since using the simple slope coefficient to interpret a moderation effect is considered not intuitive enough because it does not show the trend of the moderation effects (Meyer et al., 2017). We followed the literature (Meyer et al., 2017) and used the effect size approach. This approach allowed us to estimate the confidence intervals for interaction effects

over the significant range of the independent variable (Meyer et al., 2017). Another important benefit of this approach is that it provides detailed information that allows us to ascertain the magnitude and nature of the contingent effect. The result of the effect size is shown in Figure 1 above. Although the simple slope coefficient revealed a significant moderation effect, the effect of the interaction varies according to the level of human capital. Lower levels of human capital have the highest marginal effect on the relationship between civil liberty and technological innovation. But as human capital increases, the marginal effect of civil liberty on technological innovation decreases. This result means that lower levels of human capital improve the relationship between civil liberty and technological innovation compared to higher levels. This can be explained through the lens of the law of diminishing marginal returns. At lower levels of human capital, marginal improvements in education, skills, or access to knowledge have a disproportionately large impact on technological innovation. As human capital increases, the additional impact of civil liberties on technological innovation decreases because civil liberties create a conducive environment that allows the free flow of new knowledge and ideas, but it is highly skilled capital who turn these ideas into innovations. As a country accumulates or increase their human capital base, the direct impact of civil liberties on technological innovation diminishes, because well-educated workers can drive innovation regardless of political freedom.

Table 3: Results of the moderated analysis

	(1)	(2)	(3)	(4)
	Patents	Patents	Patents	Patents
GDP per capita	1.568***	1.020***	3.069***	3.005***
	(11.20)	(6.97)	(11.77)	(11.41)
Political stability	-0.091	-0.422***	-0.615***	-0.653***
	(-1.77)	(-6.91)	(-6.25)	(-6.53)
Regulatory quality	0.524***	0.287***	-0.179	-0.024
	(7.84)	(3.64)	(-0.82)	(-0.11)
ICT	-0.000***	0.000***	-0.000	-0.000
	(-6.37)	(7.74)	(-1.51)	(-0.58)
Property rights	0.014***	0.014***	0.014***	0.015***
	(10.79)	(10.03)	(5.83)	(6.13)
Civil liberty [CL]		0.390***	0.291***	0.416***
		(16.91)	(4.41)	(5.65)
Human capital [HC]			-0.043***	0.035
			(-5.09)	(1.68)
CL*HC				-0.015***
				(-3.96)
Year-fixed effects	Yes	Yes	Yes	Yes
Country-fixed effects	Yes	Yes	Yes	Yes
N	1081	1081	1081	1081

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.1 Further Robustness Test

We reevaluated the model and confirmed the validity of the main research findings using other estimating techniques to examine the robustness of the empirical results mentioned above. We incorporated an alternate set of control variables that have been shown by the innovation literature to influence technological innovation for the model reassessment into the models, in accordance with the literature (see Meyer et al., 2017). We included the new variables namely government effectiveness and voice and accountability. The results of the reassessed models are shown in Table 4. Government effectiveness was shown to positively influence technological innovation ($\beta = 0.913$, $P < 0.001$), while voice and accountability demonstrated to negatively influence technological innovation ($\beta = -0.260$, $P < 0.05$). The results in Models 2, 3, and 4 show that the

directions and significance of the of the variables of interest remain unchanged after including other control variables. Based on these unchanged results, we draw the conclusion that our findings are robust.

Table 4: Robustness test with additional controls

	(1)	(2)	(3)	(4)
	Patents	Patents	Patents	Patents
GDP per capita	1.513***	0.975***	3.724***	4.125***
	(9.44)	(5.83)	(11.27)	(11.74)
Political stability	0.126*	-0.231***	-0.424***	-0.402***
	(2.54)	(-3.60)	(-3.84)	(-3.60)
Government effectiveness	0.913***	1.187***	2.585***	2.707***
	(13.03)	(14.85)	(17.23)	(17.30)
ICT	-0.000***	0.001***	0.001***	0.001***
	(-6.02)	(13.26)	(3.33)	(3.30)
Property rights	0.012***	0.012***	0.005	0.004
	(10.03)	(10.03)	(1.87)	(1.72)
Voice and accountability	-0.260*	-0.081	-0.196	-0.120
	(-2.51)	(-0.69)	(-1.01)	(-0.62)
Civil liberty [CL]		0.418***	0.213**	0.335***
		(17.61)	(2.70)	(4.07)
Human capital [HC]			-0.039***	0.099***
			(-4.25)	(3.93)
CL*HC				-0.024***
				(-5.75)
Year-fixed effects	Yes	Yes	Yes	Yes
Country-fixed effects	Yes	Yes	Yes	Yes
N	1081	1081	1081	1081

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5. Conclusion and Policy Implications

This research investigates the relationship between civil liberty and technological innovation in sub-Saharan African countries, considering the contingent effect of human capital. The empirical results revealed that civil liberty positively influences technological innovation which is in line with the institutional theory. However, human capital demonstrated to have a negative relationship with technological innovation, which aligns with the human capital theory. The result further demonstrated that human capital diminishes the positive impact of civil liberty on technological innovation. However, the result of the effect size estimation revealed that lower levels of human capital strengthen the relationship compared with higher levels. Our results have implications for policy. First, to make sure that people have the skills and knowledge needed to effectively use civil liberties for technological innovation, governments and policymakers need to prioritise investments in education, training, and skill development. Second, the descriptive statistics result shows that human capital in sub-Saharan African countries is low, the possible reason for the negative moderation. Policies should focus on improving and shifting the focus of education to technical and vocational training. Finally, policies should be designed to maximise the impact of civil liberties and human capital investments to accelerate technological innovation. Policy makers should crackdown on internet shutdowns and censorship that impede access to new ideas and knowledge.

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Ethical consideration: Ethical approval was not sought for the present study because the research involves non-human subjects.

AI declaration: This research paper did not use AI tools at any stage of its development. All analyses, writing, and conclusions were done manually by the authors.

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