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Intellectual Property and Technological Innovation: Comparative Analysis from African Countries

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Abstract: This paper highlights the effects of intellectual property on technological innovation in Africa from 2007-2022. The Driscoll and Kraay estimation approach was employed to overcome cross-sectional dependence, heteroskedasticity and error autocorrelation. The static panel model specification, followed by the estimation technique robust to cross-sectional dependence augmented by country- and year-fixed effects, enabled overcoming cross-sectional dependence, endogeneity, heteroscedasticity, and error autocorrelation. The results indicate that intellectual property positively affects technological innovation in African countries. Comparative analysis reveals that membership in an intellectual property organisation is more beneficial. Furthermore, the results also show that in non-member countries, the rule of law can play a significant role in the relationship between intellectual property and technological innovation. Governments should promote the membership of non-member countries in IP organisations, as such memberships standardise intellectual property protection rules and thus create an environment conducive to innovation.

Keywords: Africa, intellectual property, technological innovation, rule of law

JEL Classification: F14, O34, O32, P48

1. Introduction

Scholars and international organisations have reported that innovation and knowledge protection are the drivers of economic growth, poverty reduction and sustainable development goal (SDG) achievement (Dzhunushalieva & Teuber, 2024; Schot & Steinmueller, 2018; United Nations, 2022). Technological innovation, i.e., the implementation of an idea for a new product or service or the integration of new elements into the production process, is often seen as a key driver in improving firm performance (Azar & Ciabuschi, 2017).

However, it is important to note that technological innovation is an uncertain knowledge process (Chiffi *et al*., 2022; Papageorgiadis & Sharma, 2016; Subramaniam & Loganathan, 2022) influenced by factors such as property rights, research and development (R&D), entry barriers and imitation (Aghion & Howitt, 1990; Arrow, 1962; Arundel & Hollanders, 2008; Pegkas *et al*., 2019). Indeed, the gains from innovation are difficult to appropriate, as are the returns on investment. This uncertainty has a negative effect on innovation activities. Therefore, we argue that intellectual property (IP) can influence technological innovation.

The necessity of protecting IPRs within international, regional and national frameworks has been acknowledged worldwide. Notably, regulations and laws are relatively strict in developed countries, but this is not the case in developing countries (Dutta & Sharma, 2008; Brownbridge & Kirkpatrick, 2000). These regulatory disparities can hinder technology transfer to developing economies. In this context, there is an urgent need to establish a common framework for intellectual property rights to reduce regulatory disparities. The implementation of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) can help address this concern.

Developing countries, especially African countries, significantly responded to the TRIPS agreement by tightening IPR protection regimes. At present, in Africa, two major regional organisations dealing with IP matters exist: the African Regional Industrial Property Organisation (ARIPO) and the *Organisation Africaine de la Propriété Intellectuelle* (OAPI). Membership in these regional organisations has significant implications for their member states. In 2022, ARIPO reported a 26% increase in industrial property applications and a 20% growth in revenue compared with the previous year (ARIPO, 2023). Likewise, these organisations guarantee IP legislation for member states. Moreover, patent, design and trademark applications are faster, more efficient and less costly (Nwauche, 2003).

IPRs are central to both national and international concerns, as they ensure that developed ideas are partly protected. They serve as a central mechanism of the innovation system (Moser, 2013; Woo *et al.*, 2015), an instrument of technological progress and economic growth worldwide. Indeed, when innovators realise that their ideas can be easily stolen, they are discouraged from engaging in productive activities. However, IPRs, which include patents, trademarks, and copyrights, are essential for safeguarding R&D investments (Branstetter *et al.*, 2011; Pegkas *et al.*, 2019) and ensuring a return on investment for firms that engage in value-added activities (Arrow, 1962).

Among the few empirical studies regarding the effects of IPR reinforcement on innovation, at least three different streams of literature exist. A growing body of literature, at first glance, finds a positive correlation between IPR protection and innovation (Amankwah-Amoah & Medase, 2024; Neves *et al.*, 2021; Naghavi & Strozzi, 2015; Kanwar & Evenson, 2003). Others find a negative effect between IPR protection and innovation (Boldrin & Levine, 2009; Gangopadhyay &

Mondal, 2012). Finally, some scholars find no positive relationship between stronger IPR and domestic innovations (Gamba, 2017; Naghavi & Strozzi, 2015; Qian, 2007).

Focusing on African countries, it is rare to find empirical studies examining the link between intellectual property and technological innovation. This empirical evidence could yield new policy implications for the region's economic development. Moreover, this study adopts both a global approach (Africa as a whole) and a comparative approach (between African countries belonging to an IP organisation and African countries not belonging to any organisation). To the best of our knowledge, this is the first study to establish a link between intellectual property and technological innovation, with a focus on cross-national comparisons between African countries belonging to an IP organisation and African countries not belonging to any organisation.

The remainder of the article is structured as follows. Section 2 provides a brief literature review. Section 3 presents the empirical model, estimation strategy, and data. Section 4 presents the results and discussion. Conclusions are provided in Section 5.

2. Thematic Review

2.1. Intellectual Property Rights and a Country's Technological Innovation

According to Neves *et al*. (2021) and Adams (2011), the creation and diffusion of innovation have led to the establishment of a structured intellectual property regime designed to stimulate innovation through economic incentives. In this context, IPRs serve as a form of structured monopoly. In line with this, Schumpeter and Fain (1951) argue that the market structure most conducive to innovation is a monopoly, which, in their view, is the only means of providing the incentives for research and development that drive innovation. Indeed, a monopoly grants exclusive rights and is essential for sustained innovation (Sweet and Maggio, 2015; Boldrin and Levine, 2009; Romer, 1990).

Theoretical studies about IPR and innovation have been considered since Robert Solow in 1990) work on endogenous growth theory and Baumol's (1996) research on productive entrepreneurship. For example, Romer (1990) argues that a monopoly is necessary to support innovation, as it ensures a return on investment for firms engaged in innovative activities. The IPR system then appears to be a key factor for innovation since the main purpose is to reward innovators for their creations. The channels through which IPRs influence innovation stem primarily from the hypothesis that IPRs incentivise innovation (Neves *et al.,* 2021; Fang *et al.,* 2017; Sweet and Maggio, 2015). This idea was also advocated by Rikap (2024) and Arrow (1962), who argued that IPR encourages innovation by granting inventors temporary monopoly power over their inventions.

From an empirical point of view, Amankwah-Amoah and Medase (2024) examine the link between IP and innovation performance in sub-Saharan Africa. Based on data from the World Bank Enterprise Survey (WBES) and Innovation Follow-up Survey (IFS), they find a consistent positive effect of IP on innovation. Similarly, Kanwar and Evenson (2003) show that stronger IPR protection can promote technological change across both developing and developed countries. Fang *et al.* (2017) examine the interplay between IPR protection, firm ownership (state-owned versus private), and innovation in China. They find that stronger local IPR protection is positively related to firms' R&D investments and innovation. Moreover, the effects of intellectual property rights also depend on a country's level of economic development. For instance, Chu *et al.* (2014) show that strong IPR protection is correlated with the stage of development. Neves *et al.* (2021) and Sweet and Maggio (2015) reached similar conclusions.

2.1. Intellectual Property Rights and Technological Innovation: the Country's Legal and Institutional Context

Over the past few decades, international agreements have emerged with significant interest in strengthening the legal aspects of IPR to foster innovation and economic growth (Viglioni *et al.,* 2023). In Africa, the two major regional organisations dealing with intellectual property matters, specifically ARIPO (African Regional Industrial Property Organisation) and OAPI (*Organisation Africaine de la Propriété Intellectuelle*), have adopted common legal frameworks and protocols to ensure consistency in the protection of IP across different countries. Some researchers have argued that these agreements increase innovation (Di Vita, 2013) and facilitate the diffusion of knowledge, as inventors are more apt to share their ideas when their ownership rights are protected (Moser, 2011).

In this context, numerous studies have shown that well-defined IPR regulations serve as transparent and equitable mechanisms to support innovation, notably by increasing the number of patent applications (Uyar *et al.,* 2021; Papageorgiadis & Sharma, 2016; Sweet & Maggio, 2015). According to the International Chamber of Commerce (2005), since everyone in society is a user and potential creator of intellectual property, its protection through a system of national and international rules is essential to provide incentives for innovation and knowledge creation. Ang *et al.* (2014) argue that legal protection of IPRs at the national level is necessary to promote investment in R&D. In the same vein, using panel data of 44 developing and developed countries for the period 1981–2000, Kanwar (2007) concludes that the strength of IPR has a strong positive influence on innovation.

3. Methods and Data

3.1. Model

This study uses a panel data approach based on the Driscoll–Kraay robust standard error estimator. The empirical model is estimated as shown in Eq. (1):

$$Y_{it} = X^{'}\beta_{it} + \varepsilon_{it},\ i = 1, 2, 3, \ldots, N \quad t = 1, 2, 3, \tag{1}$$

where Y_{it} is the dependent variable for the country i at time t. Driscoll–Kraay considers a panel and time-specific vector of N cross-sectional units, whereas X represents the matrix of control variables over time T. Driscoll–Kraay standard error estimators are a semiparametric estimation technique used for short- and long-term panels, as well as balanced and unbalanced panels, particularly when there is cross-sectional dependence, heteroskedasticity, and autocorrelation.

The functional form of the basic empirical model is outlined as follows:

$$TI_{it} = \theta_{0i} + \theta_{1i} IPR_{it} + \theta_{2i} IPR_{it}^{2} + \theta_{3i} X_{it} + \alpha_t + \vartheta_{it} \tag{2}$$

where the dependent variable is TI and i and t denote the individual (country) and time dimensions, respectively. The intercept parameter is denoted by θ_{0i}. IPR_{it} is the intellectual property variable. X is a vector of control variables. α_t denotes year fixed effects. Finally, ϑ_{it} is the error term assumed to be cross-sectionally and temporally correlated.

Another hypothesis we cannot dismiss is that the IP index is correlated with other measures of the quality of a country's legal and institutional context, which have nothing to do with the quality of its IPR protection regime, so its effect may depend on them. For verification, it may be useful to interact the IP with the rule of law to demonstrate whether the importance of IP on technological innovation depends on stronger IP protection.

$$TI_{it} = \theta_{0i} + \theta_{1i} IPR_{it} + \theta_{2i} RLAW + \delta_i (IPR_{it} \times RLAW) + \theta_{2i} X_{it} + \alpha_t + \vartheta_{it} \tag{3}$$

$IPR_{it} \times Inst_{it}$ represents an interaction term between intellectual property and the rule of law δ is the coefficient to be estimated, and makes it possible to appreciate how the rule of law influences the effects of intellectual property on technological innovation.

3.2. Data and Variables

The study relies on secondary data. We collected data from a variety of sources, including the data provided by the International Property Rights Index (IPRI) report, the Global Innovation Index database for technological innovation, and the World Development Indicators (WDI) for control variables (Table 1).

3.2.1. Dependent Variables

The dependent variable measures technological innovation (TI) and its two subindices. We adopted the global innovation index as a proxy for technological innovation (Brás, 2023; Fernandes *et al.*, 2022; Huarng & Yu, 2022). The global innovation index (GII) takes into account all the dimensions and aspects of technological innovation, which is not the case for indicators such as R&D expenditures or technological imports. The GII consists of a structure of variables. The index is computed by taking a simple average of the scores in two subindices, the innovation input index and the innovation output index.

3.2.2. Interest Predictor Variables: Intellectual Property Rights and Rule of Law

Rapp and Rozek (1990) and Ginarte and Park (1997) developed several indicators of IP protection in the literature. One of the most frequently used indices is the GP index, developed by Ginarte and Park (1997) and updated by Park and Lippoldt (2008). Various scholars have used these indices to measure IP protection (Ivus, 2010; Kashcheeva, 2013; Kim *et al.*, 2012; Park, 2012; Sweet & Maggio, 2015). Although widely used in many studies, the GP index has become obsolete, and the annual data needed for our study were unavailable. Thus, we used the "intellectual property rights" indicator on the basis of data provided by the International Property Rights Index. This indicator is available from 2007 and provides a detailed analysis of 10 variables, including three indicators that reflect the degree of intellectual and physical property rights.

A country's legal framework is perhaps unambiguously shaped by its various political and historical contingencies. Hao *et al.* (2024) show that the rule of law significantly promotes the growth of firm performance. The rule of law index (RLAW) highlights "perceptions of the extent to which agents trust and respect the rules of society, particularly the quality of contract enforcement, property rights, police, and courts, as well as the likelihood of crime and violence."

3.2.3. Control Variables

For the analysis, several control variables likely to influence technological innovation were included. First, to account for the effect of education, we introduced the population's education level index (EDUC). This variable is identified in the literature as an indicator of technology and knowledge accumulation (Zhu & Li, 2017). Indeed, adequate human capital is essential for technology transfer and innovation (Fonseca *et al*., 2019; Sweet & Maggio, 2015; Dakhli & De Clercq, 2004). The mean years of schooling, sourced from UNDP data, were used to measure the education level. Moreover, the economic development level is frequently incorporated in analyses of the determinants of technological innovation and was therefore included in this study (Ulku, 2004). An increase in per capita income enables high-income economies to outperform low-income economies in technological innovation (Brás, 2023). Income growth plays a crucial role in fostering technological advances, particularly in economies where growth enables the investments essential to sustaining innovation systems.

Table 1: Description and Source of Variables

Variables	*Description*	*Sources*
TI	Global innovation index	WIPO
IPR	International Property Rights Index	PPA
RLAW	Rule of Law	WGI
EDUC	The mean years of schooling	UNDP
GDPPC	GDP per capita	WDI
GFCF	Gross fixed capital formation	WDI
CREDIT	Credit to the economy by the financial sector	WDI
FDI_inflows	FDI inflows (% of GDP)	WDI
IPR*RLAW	Interaction between intellectual property and the rule of law	Computed

Notes: WIPO means World Intellectual Property Organisation; PPA means Property Rights Alliance; WGI means World Governance Indicators; WDI means World Development Indicators.

Table 2: Summary Table

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
TI	320	25.399	5.677	6	40.9
IPR	369	4.495	.966	1.2	7.6
RLAW	528	-.608	.571	-1.88	1.024
EDUC	528	10.72	2.233	5.231	15.488
GDPPC	528	1.886	9.468	-58.85	150.431
GFCF	469	22.526	7.565	3.286	43.387
CREDIT	485	25.889	26.223	.004	142.422
FDI_inflows	528	3.531	4.964	-11.192	41.98
IPR*RLAW	320	25.399	5.677	6	40.9

Foreign direct investment is repeatedly cited in the literature on the determinants of technological innovation (Meka'a *et al.*, 2024; Chen *et al.*, 2022). By attracting FDI, countries can bridge gaps created by relative shortages of capital, technology, and knowledge. Regarding access to credit, which is also included as a control variable, empirical studies indicate that access to credit further incentivises firms to innovate. We captured this variable through credit to the economy by the financial sector (CREDIT). Finally, we measured the physical capital stock using gross fixed capital formation (GFCF). Countries were selected based on data availability for the variables considered. Tables 1 and 2 provide details on the variables, their measures, sources, and descriptive statistics. The list of countries included is provided in the appendix.

3.3. Estimation Strategy

Given the relatively short time panel dimension used in this research, a series of tests were performed to identify common econometric issues associated with macroeconomic variables across different countries. These issues include cross-sectional dependence, serial correlation, and heteroscedasticity. Thus, cross-sectional dependence was diagnosed using the general Pesaran (2015, 2021). This test is important, particularly when countries from the same region experience economic and social shocks that can impact one another. The results, following the implementation of this test, confirm the presence of cross-sectional dependence, as the probabilities (P-values) for all variables were less than 5% (see appendix). The CD statistics suggest that our estimates require an appropriate technique to address cross-sectional dependency and prevent biased estimates.

Autocorrelation and groupwise heteroscedasticity were examined using the Wooldridge test (Wooldridge, 2010) and the modified Wald test (Baum *et al.*, 2003), respectively. Both tests showed highly significant statistical values for autocorrelation (F-statistic = 23.21, $p < 0.01$) and heteroscedasticity ($\chi^2 = 292.59$, $p < 0.01$). These results indicate potential issues of serial correlation and unequal variances across groups, which can lead to biased standard errors and unreliable coefficient estimates if not properly addressed. To address these issues, the analysis employed the Driscoll–Kraay robust standard error method (Driscoll & Kraay, 1998), which is robust enough to account for heteroskedasticity, autocorrelation and any form of cross-sectional and temporal dependence (Hoechle, 2007). In addition, for the robustness check, the basic model was also re-estimated using the robust two-stage least squares (2SLS) with an instrumental variable (IV) (Baum *et al.*, 2015; Bogliacino & Pianta, 2013) to address endogeneity and serial correlation issues within countries (Piteli *et al.*, 2021).

4. Results and Discussion

4.1. Baseline Results

We present our baseline results using the Driscoll–Kraay robust standard error method to address cross-sectional dependence, autocorrelation, and heteroscedasticity. The results show that intellectual property rights promote technological innovation in African countries. The preliminary discussions indicate that the baseline results in Table 3 are not affected by multicollinearity and are significant overall. Table A3 presents the pairwise correlations among the explanatory variables. Despite the coefficients between pairs not showing close correlation and not exceeding the threshold of 0.50, the variance inflation factor (VIF) test was also conducted to address concerns of multicollinearity in the raw data. All values were less than 10, indicating no significant presence of multicollinearity among these variables.

Following a brief presentation of result reliability, the discussion on the contribution of individual variables begins with intellectual property. Consequently, the results presented in Table 3 examine the effects of intellectual property on technological innovation. In most cases, the coefficients linked to intellectual property are positive and significant at the 1% or 5% level (see columns 1, 3 and 5). For instance, taken as a whole, the results indicate that a 1-point increase in IP leads to a 1.541-point increase in TI.

This result underlines the importance of intellectual property as an important determinant of technological innovation in African countries. First, we can state that the sign of the IP coefficients is perfectly logical and consistent with findings in the literature. This indicates that the estimates generally yield reasonable results. In addition, the coefficients associated with the IP-squared term are significant and positive in all three estimates. These results show that there is no inverse U-shaped relationship between IP and TI. Amankwah-Amoah and Medase (2024) and Kanwar and Evenson (2003) reported similar results.

The comparative analysis reveals a significant variation in the effect of IP on TI. Indeed, a one-unit increase in IP leads to an increase in TI of approximately 3.072 points for countries that are members of an IPR organisation versus 0.898 points for other African countries. This difference underlines the magnitude of the impact of IPR organisation membership. Indeed, OAPI and ARIPO member countries often benefit from harmonised legal frameworks and more consolidated intellectual property standards. ARIPO and OAPI have adopted common legal frameworks and protocols to ensure consistency in the protection of IP across different countries (Kongolo, 2000). This protects investors and firms, reducing the risk of intellectual property infringement. In other words, these countries can leverage their innovations without fearing a loss of control over their creations.

Table 3: Effect of Intellectual Property on TTechnological Innovation in Africa

	African Countries		*OAPI and ARIPO*		*Other African Countries*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
IPR	1.541***	0.832*	3.072**	1.346**	0.898**	0.165
	(0.324)	(0.755)	(1.268)	(1.194)	(0.213)	(0.316)
IPR square	0.057**		0.502**		0.221***	
	(0.028)		(0.138)		(0.090)	
RLAW		6.380		3.895		9.838***
		(4.451)		(6.705)		(2.142)
IPR*RLAW		0.815*		-0.297		1.312**
		(0.888)		(1.190)		(0.495)
EDUC	0.341***	0.423***	0.357**	0.380***	0.192*	0.168**
	(0.077)	(0.052)	(0.138)	(0.086)	(0.103)	(0.075)
GDPPC	0.169*	0.166*	0.195**	0.208*	0.046	-0.008
	(0.083)	(0.089)	(0.065)	(0.096)	(0.080)	(0.091)
GFCF	-0.074**	0.098*	-0.117	-0.133	0.039	0.020
	(0.033)	(0.049)	(0.069)	(0.095)	(0.025)	(0.031)
CREDIT	0.059***	0.065***	0.069***	0.062**	0.065***	0.074***
	(0.006)	(0.006)	(0.018)	(0.021)	(0.010)	(0.010)
FDI	0.130	0.138	-0.036	-0.027	0.500***	0.477***
	(0.168)	(0.161)	(0.202)	(0.192)	(0.072)	(0.089)
Constant	14.512***	17.588**	14.622*	16.817	13.574***	20.939***
	(3.802)	(5.819)	(7.061)	(10.511)	(1.651)	(3.166)
Observations	230	222	150	130	98	88
F-Stat	2000.42	1393.54	123.40	40.75	805.33	380.23
F-Prob	0.000	0.000	0.000	0.000	0.000	0.000
Country-FE	YES	YES	YES	YES	YES	YES

Notes: “””, “”, and — denote significance at 1%, 5% and 10%, respectively. *F*-Stat is the statistic for the overall significance of the results. *F*-Prob is the probability associated with Fisher’s statistic.

The coefficients of the interaction variables are positive and significant at the 1% level in columns 1 and 5. On the other hand, the interaction effect between IPR and the rule of law is not significant for OAPI and ARIPO member countries. The insignificant effect may indicate that in these countries, the quality of the IP regime is already sufficiently high and uniform owing to the legal standards set by these organisations. For example, member countries of IP organisations, such as WIPO, adopt stronger protection standards, making the additional impact of the rule of law less obvious or less necessary to reinforce the effects of IP. The significant effect in column 5 demonstrates that the rule of law can play a critical role in the relationship between IP and technological innovation in countries that do not belong to any IP organisation. This finding corroborates the study by Wang *et al*. (2025), which highlights that the judicial protection of IPRs should be increased to provide an institutional environment more conducive to enterprise development in developing countries. In summary, in non-member countries, the rule of law plays a crucial role in the IP, whereas in member countries, this effect is probably cushioned by the protections already established through adherence to the organisation's standards.

The control variables are now examined. Among these, GDP per capita (GDPPC), human capital (EDUC), and credit (CREDIT) have positive and significant coefficients in most cases. This suggests that improvement in these indicators is essential for technological innovation.

4.2. Robustness Check

We undertake further robustness checks to verify the consistency of our benchmark findings regarding robust positive associations between intellectual property and technological innovation. As mentioned above, robust two-stage least squares (2SLS) with instrumental variables is used for the robustness check. The results can be found in Table 4.

The main model was also re-estimated using the robust two-stage least squares (2SLS) with an instrumental variable (IV) (Baum *et al.,* 2007; Bogliacino & Pianta, 2013) to address endogeneity and serial correlation issues within countries (Piteli *et al.,* 2021). However, finding valid external instruments for the model is challenging (Gonçalves *et al.*, 2021). Following the recommendations of prior studies, we included "Protection of property rights" from the Fraser Institute (Viglioni *et al.,* 2023) and political stability from the Worldwide Governance Indicators (Khoury *et al.,* 2015) as instruments for IPRs.

The results of the robustness test account for these two conditions. First, the Sargan and Hansen J-statistics confirm the validity of the selected instruments in several estimations. Second, the Cragg–Donald Wald F-statistic exceeds the 10% tolerance threshold of critical values from Stock–Yogo (2015), suggesting the validity of the instruments.

Regarding the coefficients of the variables, the results indicate that, for both the variables of interest and the control variables, their signs remain consistent with those observed in the baseline results. However, slight differences are observed in the intensity and significance of the coefficients, which, probably due to the specificities of each estimation technique, do not further erase the policy implications drawn from the baseline results.

Table 4: Effect of Intellectual Property on Technological Innovation in Africa (2SLS/IV Regression)

	African Countries		*OAPI and ARIPO*		*Other African Countries*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
IPR	4.003***	1.798	5.083***	4.240**	4.190***	1.507*
	(1.010)	(1.926)	(1.210)	(1.750)	(1.223)	(0.828)
IPR square	1.318**		1.036**		0.946	
	(0.576)		(0.516)		(0.642)	
RLAW		2.510*		5.424*		3.981***
		(1.292)		(2.237)		(1.085)
IPR*RLAW		0.493***		0.320		0.681***
		(0.159)		(0.123)		(0.184)
EDUC	0.869***	0.530***	0.440	0.646*	1.008***	0.110
	(0.227)	(0.191)	(0.283)	(0.348)	(0.377)	(0.377)
GDPPC	0.091	0.122	0.151*	0.154	-0.018	0.011
	(0.100)	(0.081)	(0.084)	(0.118)	(0.135)	(0.103)
GFCF	0.085*	0.085**	0.088**	0.148**	0.002	0.037
	(0.044)	(0.036)	(0.035)	(0.062)	(0.062)	(0.048)
CREDIT	-0.005	0.026	0.049	0.093	0.006	0.068**
	(0.032)	(0.024)	(0.037)	(0.064)	(0.037)	(0.033)
FDI	0.232	0.145	0.138	0.044	0.701***	0.464***
	(0.152)	(0.129)	(0.129)	(0.197)	(0.208)	(0.171)
Constant	4.941***	5.163**	2.211***	5.163**	3.574***	1.103*
	(1.349)	(2.109)	(0.349)	(1.109)	(1.651)	(0.303)
Observations	202	222	202	202	108	108
F-Prob	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.6023	0.764	0.654	0.578	0.650	0.779
C-Donald	30.170	40.354	20.273	22.039	17.075	15.585
Stock-Yogo	19.93	19.93	19.93	19.93	19.93	19.93
Sargent	0.219	0.325	0.225	0.210	0.304	0.106

Authors.

5. Conclusion and Policy Implications

This study analysed the effect of intellectual property on technological innovation in African countries. The study considered 33 African countries, including 21 OAPI and ARIPO member countries and 12 other African countries, over the period 2007-2022. Second-generation tests were employed to diagnose cross-sectional dependence. We used the Driscoll–Kraay robust standard error method to address cross-sectional dependence, autocorrelation, and heteroscedasticity. Robust two-stage least squares (2SLS) with an instrumental variable (IV) is applied for a robustness check. The results indicate that intellectual property positively affects technological innovation in African countries. Comparative analysis shows that belonging to an IP organisation is beneficial for all African countries.

The results on the interaction effect between IP and the rule of law demonstrate that external institutional rules established by international agreements of IP organisations standardise a level of IP protection that limits disparities in effects. The results also show that in non-member countries, the rule of law can reinforce the effect of IP on technological innovation. However, governments should opt for the accession of non-member countries, as membership in organisations such as OAPI and ARIPO standardises IP protection rules, creating an environment conducive to innovation.

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Appendix

Table A1: Cross-sectional Dependence Panel Test

Variables	*Pesaran (2015, 2021) CD statistic test*
TI	.
IPR	31.53
RLAW	15.34
EDUC	43.77
GDPPC	26.80
GFCF	23.55
CREDIT	17.58
FDI_inflows	10.80
IPR*RLAW	18.63

Table A2: Countries List

Algeria	Malawi
Angola	Mali
Benin	Mauritanie
Botswana	Mauritius
Burkina-Faso	Morocco
Burundi	Mozambique
Cameroon	Nigeria
Chad	Rwanda
Congo	Sénégal
Côte d'Ivoire	Sierra Leone
Egypte	South Africa
Ethiopie	Sudan
Eswatini	Tanzanie
Ghana	Tunisie
Kenya	Uganda
Lybie	Zambie
Madagascar	Zimbabwe

Table A3: Correlation Matrix

Variables	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
(1) TI	1.000								
(2) IPR	.562***	1.000							
(3) RLAW	.627***	.538***	1.000						
(4) EDUC	.391***	.168***	.339***	1.000					
(5) GDPPC	.153**	.066	.014	.002	1.000				
(6) GFCF	-.126*	-.032	.131***	-.096*	.023	1.000			
(7) CREDIT	.636***	.592***	.557***	.507***	-.031	-.059	1.000		
(8) FDI	.015	.065	-.001	-.126***	.052	.135***	-.040	1.000	
(9) IPR*RLAW	.486***	.387***	.645***	.280***	.056	.007	.379***	-.018	1.000

Table A4: Variance Inflation Factor

	VIF	*1/VIF*
RLAW	6.448	.155
IPR*RLAW	5.749	.174
IPR	2.925	.342
CREDIT	2.675	.374
EDUC	1.799	.556
GFCF	1.161	.861
FDI	1.132	.883
GDPPC	1.072	.932
Mean VIF	2.870	.