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Extracting Innovation Value from Intellectual Property: Evidence from sub-Saharan Africa

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Abstract

Although a sizable body of research concerning innovation and intellectual property (IP) performance exists, there has been limited attention on whether the state of IP strengthens or curtails innovation activity in the global south, specifically among sub-Saharan Africa firms. This article analyzes the direct impacts of IP on innovation performance in sub-Saharan Africa, namely patents, copyrights, industrial designs, and trademarks. The paper responds to firms extracting value from intellectual property strategies through innovation activities and overall performance. Using the World Bank Enterprise Survey (WBES) and Innovation Follow-up Survey (IFS), we find that appropriation channels are essential for transforming innovation pursuits into a competitive advantage. Our results further reinforce that appropriation mechanisms are crucial to innovation and may allow firms to gain returns on their innovation activities. Regardless of the weaknesses and limitations of the patenting strategy in sub-Saharan Africa, the probability of patenting an innovation relates to a process and product innovation while controlling for several other effects. More importantly, we demonstrate how industrial designs and improved or changed trademarks can foster inclusive performance. In addition, we show that beyond perception-based innovations, intellectual property strategies also matter to innovation intensity and sales growth. Consequently, our results indicate that the significance of innovation for competitiveness puts intellectual capital at the critical juncture of knowledge management.

Keywords Copyrights · Industrial designs · Patents · Trademarks · Multivariate Probit

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Introduction

Business and economic research have been driven by innovation for over three decades (Freeman, 1987; Nelson, 1993; Lundvall, 2010). Despite this heterogeneity, organisations innovate, with some firms succeeding and others not (Hollanders, 2009). In addition, intellectual property has become a crucial component of measuring innovation effectiveness. Inevitably, IP protection strategies are designed to reward successful and perhaps impactful innovation, thus stimulating innovation incentives (Bouet, 2015; Grimaldi et al., 2021; Gomes et al., 2022; Lopes et al., 2021). While Intellectual Property (IP) remains crucial for innovation (Amdaoud & Bas, 2021), the United Nations and Economic Commission for Africa (2012) (hereafter, UNECA) document that Africa's global share of knowledge generation and ownership is small. Therefore, the promotion of innovation has become a top agenda for corporate organisations and regional bodies like ECA, the African Union (AU), the New Partnership Africa's Development (NEPAD) and governments in sub-Saharan Africa (hereafter SSA). This is due to its ability to bring about growth and development (Schumpeter, 1942). Innovation is one of the significant determinants of firms' and economies' competitiveness (Amankwah-Amoah, 2021; ECA, 2013; Montresor & Vezzani, 2020; ILO, 2020). While advancement in basic and applied research has contributed to more inclusive and sustainable innovation in Europe and amongst most OECD countries, SSA remains a laggard region in this respect. Most countries and firms in SSA are unable to harness technological benefits compared to Europe and OECD member countries partly due to their distance from technological frontiers. Ineffectiveness of policymaking in advancing and initiating strategies that could project the continent's innovativeness and the hypotheses of exclusive political and economic institutions can be attributed to most African countries' backwardness to leverage technological advancement to spur growth and development via innovation.

However, the SSA region remains a brewing zone for indigenous and international innovation. As the world increasingly evolves in technology and knowledge, invention and innovation become crucial for development and growth (Goedhuys & Veugelers, 2012). Over the past five decades, many researchers and practitioners have proposed different mechanisms to protect creative ideas and innovative ventures. In general, Intellectual Property (IP) is regarded as entirely essential to induce the originality of invention and innovation (Blind et al., 2006; Fritsch & Wyrwich, 2021; Power & Reid, 2021) in the public interest (Castaldi et al., 2020). Patents are the most used indicators to protect invention and innovation radicalness. However, as the scale of innovativeness widens beyond goods and processes, other IP instruments, including copyrights, industrial designs, and trademarks, emerge as a vital strategic tool to protect the strategic asset of organisations and crucial to protect creative activities. As these indicators evolve through time and space, innovators and entrepreneurs in product and service domains have seen the need to appropriate

returns to their invention or innovation, especially at the early phase of their innovation life cycle (Castaldi et al., 2020).

Several scholars have documented arguments regarding the role of IP in innovation performance. Rylkova and Chobotova (2014) suggest that IP is an essential tool that helps improve firms' competitiveness in the market. On the other hand, Mingaleva and Mirskikh (2013) document that innovativeness relies on the efficiency of intellectual property rights. On the other hand, Squicciarini et al. (2012) find a positive relationship between economic returns and trademarks for innovators compared to imitators. A substantial body of research has suggested that IP, especially patents, hinders competition (Boldrin & Levine, 2002) by eroding the collective and free usage of products produced for the common good. An ongoing debate on eliminating or weakening patent rights in producing COVID-19 vaccines is a good example. Traditionally, trademarks have been regarded as a potential measure to protect innovation in service firms and industries with strong product differentiation (Castaldi et al., 2020). It can help combat possible market failures via two essential channels: reducing transaction costs and incentivising innovators to invest in the quality of products (Economides, 1988).

In addition, some prior studies find a correlation between trademarks and productivity (Greenhalgh & Rogers, 2007). A relationship exists between stock market value (Sandner, 2009; Block et al., 2014), trademarks and innovation (Amara et al., 2008; Schmoch, 2003; Medase & Abdul Basit, 2021). Numerous scholars stress the relevance of trademarks as a core innovation indicator (Malmberg, 2005; Mendonca et al., 2004; Millot, 2009; Schmoch & Gauch, 2009; Castaldi, 2018; Flikkema et al., 2019).

Despite its potential significant economic value in fostering innovation for national and business competitiveness (Pietrobelli & Rabellotti, 2011; Carayannis & Grigoroudis, 2014), there have been noticeably limited insights on whether IP as strategies explored by SSA firms can push the frontier of performance to support innovation activities. This is particularly important in developing economies, where institutional impediments such as weak regulations, a weak rule of law, underinvestment in human capital development and inadequate employee training are prevalent. This institutional fragmentation impedes the functioning of the market and innovation activities of firms (see Khanna & Palepu, 1999). Prior studies on IP usage for incentivising innovation have centred primarily on patents and secrecy in multinational and high-tech firms. However, the importance of trademarks to innovation has also received attention in innovation-IP studies (Arthreye & Fassio, 2020; Castaldi et al., 2020). Perhaps, still very limited in the innovation-IP literature is the empirical role of copyright and industrial designs in fostering inclusive innovation at the firm level. Therefore, using other IP systems and how firms combine them have gained much less attention (Thomä & Bizer, 2013). Similarly, the lack of empirical evidence about IP protection of innovation across firms in sub-Saharan Africa is still prevalent. In closing this gap for innovative firms in sub-Saharan Africa, we employ a combination of enterprise and innovation capability surveys from the World Bank.

As a result, this paper assesses the potential impacts of IP on innovation performance in sub-Saharan Africa. The study is essential for sub-Saharan Africa because of its potential to develop indigenous and tailored innovations. Furthermore, the research is also necessary for SSA firms because most African firms lack

competitiveness on the global stage (Amankwah-Amoah, 2018), and the weakness of governance in enforcing the protection of IP Rights that firms rely on for incentivisation and appropriation further complicates the issue. Also, unlike previous studies that focus primarily on perception-based innovation measures in the innovation-IP analysis, we expand the scope by accounting for the potential effects of IP on the intensity of innovation and sales growth of the focal firms. This is important because it helps managers to identify the scale of their investment in intangible assets and how it may matter to the overall performance of the firms. Notably, we answer the following questions: First, to what extent does IP shape the innovation activities of SSA firms? Second, does IP help innovative firms obtain returns from innovation? Finally, we draw insights from innovation-IP literature to test our hypotheses using a multivariate ProBit approach.

Our study employs a multivariate Probit model consisting of four binary equations. It is important to note that all four IP techniques constitute formal methods used to protect innovative ventures. Furthermore, it is possible to estimate several equations simultaneously using MVP while controlling for mutual correlations between disturbances (Amara et al., 2008; Galia & Legros, 2004; Doran & Ryan, 2014). As a result, a multivariate ProBit estimation method is used to resolve inefficient estimates in individual Probit models (Amara et al., 2008; Doran & Ryan, 2014), which show significant correlations between IP methods. Our results show that appropriation mechanisms are crucial to innovation, and their effects go beyond perception-based performance outcomes.

The rest of the paper follows this structure: the "Theoretical Background: IP Concepts and Empirics" section presents the literature, beginning with operational definitions of Africa's selected IP and IP trends. Also, the section reviews relevant empirics that relate to innovation and IP. The "Data and IP Trend in Africa" section describes the data, including the variables and the econometric set-ups. Finally, the "Results" section presents and discusses the results. It concludes by highlighting a few limitations, drawing implications for innovativeness in sub-Saharan Africa and a stimulant for the potential research area.

Theoretical Background: IP Concepts and Empirics

This study is built on strands of literature about IP and innovation. The review focuses on patents, copyrights, industrial designs, and trademarks. It is hypothesised that the relationship between IP and innovation performance will be contingent on a few key attributes. According to Kalanje (2016), "IPR refers to unique, value-adding creations of the human intellect that result from human ingenuity, creativity, and inventiveness." On the other hand, *trademarks* provide exclusive rights to use a visually unique sign or any combination of signs that enables people to differentiate one organisation's goods or services from another. Therefore, the prerequisite to registering a new trademark relies solely on the novelty of the signs.

Furthermore, copyrights offer exclusive rights to the creator of their literary and artistic works. These include books, dramatic and choreographic works; musical composition; cinematographic works, drawings, and photographic work. In addition,

copyrights encourage originality in the art and creative industry. While this remains crucial for innovation performance, the market failures generated by this intangible asset have remained debatable amongst scholars. Scholars indicate that copyright becomes useful for tracing developments in highly innovative sectors, such as software and creative industries (Towse, 2010; Flew, 2015). Since the right to copyright is granted without registration preconditions, it becomes more challenging to empirically analyse its implications and contributions to economic performance. Landes & Posner (1989) demonstrate in their model that expanding copyright protection increases the number of works created.

On the other hand, industrial design, which encourages creativity, protects the ornamental or aesthetic aspect of an article or concept. Therefore, it must be new or original to offer such protection. (https://www.innovationpolicyplatform.org). Similarly, while there have been growing debates regarding patent usefulness, which has been the most researched of all other IP, studies about appropriation indicators document little about copyrights, industrial designs, and trademarks in SSA. These other IPs are essential because of the increased activities in sectors that utilise them. For instance, there is a growing trend of activities in the entertainment industry in sub-Saharan Africa, for instance, Nigeria, Kenya, DR Congo, and others, that warrants the need for the enforcement of copyrights to mitigate excessive piracy, which has been a concern for the industry in recent times.

Evidence on the Nexus Between IP and Innovation

This study focuses on three knowledge indicators that clarify the relationship between innovation and IP. First, different scholars have argued for or against the need for knowledge protection. The dynamic capabilities of firms allow them to devise different strategies for sustaining their competitive edge. IP will enable firms to leverage this exclusive knowledge creation and protection rights. Second, knowledge creation is vital for organisational performance and sustaining innovativeness. No matter how essential an organisation is, it either produces knowledge or relies on others to produce it while devising avenues to exploit such a knowledge bank. While organisations may need to spend on knowledge creation either via R&D or through supply chain channels (i.e., customers, suppliers, and competitors), organisations must learn how to exploit existing knowledge to achieve a successful innovation outcome. Third, IP provides the holders with many advantages that foster a fruitful innovation execution.

Hence, technological progress is at the centre of development (Blind et al., 2006). However, the innovation processes underlying technological progress in developing or emerging economies, like SSA, have distinct qualities from developed economies (Cirera & Muzi, 2020). Innovation in developing economies occurs predominantly through absorption, adaptation, and adeptness of previously developed technologies in other countries instead of developing completely novel technologies. Considering the developmental challenge of most firms in SSA and the increasing importance of innovation to growth and development, our study investigates the channels of appropriability that may allow firms to gain from their innovative ventures. One of the

primary appropriation indicators is patent. However, scholars contend that using patents as an innovation indicator has several pros and cons (Griliches, 1990; Nagaoka et al., 2010; Fritsch & Wyrwich, 2021). To extract value from patents, scholars indicate that firms must have enhanced managerial slack (Leyva-de la Hiz et al., 2019), more managerial experience and skills (Kim et al., 2018) and financial capabilities (Hottenrott et al., 2016). Even though we know this might not be the case for some firms operating in SSA, especially private-domestic firms, we still believe firms in this region can strive to extract value from their investment in IP.

Hypotheses Development

Patent, Innovation, and Firm Performance

Patents are the applications filed with a national patent office for absolute and sole invention rights. An invention can be a product or a process that offers new approaches to doing things or provides new technological and specialised panaceas to a problem. Patents protect inventions from the owners of the patents for a specified time, usually 20 years (Azomahou & Diene (2012).

Many economists believe that patent protection favours smaller firms over bigger ones (Mansfield et al., 1981; Torrisi et al., 2016; Power & Reid, 2021). However, while this proposition appears rational, the prevailing evidence is weak and, at times, inconsistent. To contend with this argument, we use firm-level data of SSA firms, with close to 99% being SMEs, to estimate the effect of patent applications on the likelihood of innovation. To protect against imitation, firms patent their inventions and creative activities (Blind et al., 2006; Power & Reid, 2021; Amdaoud & Bas, 2021). Protectively, firms patent to thwart competitors outstripping them. Patents are also foundations of accrediting revenue, beneficial for global growth, and boost firms' technological or industrial reputations (Blind & Thumm, 2004). However, Mansfield et al. (1981) also show no evidence that patent protection is more likely to be essential for innovations implemented by smaller firms than bigger ones. On the other hand, Azomahou & Diene (2012) find growth in non-resident patents as an innovation indicator to matter for income polarisation. The study emphasises the importance of technological innovation to economic growth.

Innovation can be identified as transforming technological or non-technological inventions, ideas, and knowledge into new products, services, and processes to produce economic returns. Patents can serve as input and output in the innovation process. Furthermore, patent indicators provide clearer views on innovation developments, including spillover of knowledge and research partnerships (Nagaoka et al., 2010). Finally, a patent is an input that explains firms' performance, including productivity (Griliches, 1990) and innovation (Mansfield, 1986; Griliches, 1990; Nagaoka et al., 2010; Fritsch & Wyrwich, 2021).

Patents are the most used IP (Brem et al., 2017). However, smaller firms have been disadvantaged in applying for and using patents (Thomä & Bizer, 2013; Brem et al., 2017; Amdaoud & Bas, 2021). If we follow the argument of entrepreneurship and innovation projects, patents could benefit smaller firms at the initial stage of

their innovative-entrepreneurial processes. Studies show that patents impact performance positively, notably in the commercialisation phase of innovation (Andries & Faems, 2013). Igami and Subrahmanyam (2019) find patents to associate positively with innovation in the hard disk drive industry. Ernst (2001) shows a positive link between patenting and organisational performance. However, scholars also indicate that possessing various patents does not inevitably lead to superior sales performance (Agostini et al., 2015).

On the contrary, Power and Reid (2021) find patenting to decline the likelihood of enterprises being high performers, especially start-up firms. Correspondingly, studies show that small and medium enterprises (SMEs) have a superior rate of patenting, but more prominent (large) firms produce more patents per company (Hanel, 2006; Brem et al., 2017). On the contrary, Torrisi et al. (2016) find that SMEs are less likely to patent. Scholars also show that SMEs and large firms can increase turnover through patenting (Andries & Faems, 2013). The study finds that patenting improves SMEs' innovation and financial performance even though they patent less than larger firms. These results indicate that SMEs and large firms need to employ distinct strategies for patenting, which is consistent with Spithovenet al. (2013), showing that SMEs diverge from large firms in their patenting activities since they patent only the innovations that are possible to be successful. Given the scale of resources and financial slack of large firms, including the pool of personnel, they can patent all their innovations. SMEs, however, face financial and managerial difficulties, which inhibit efficient patenting. Kalanje (2006) argues that dearness impediment and resource deficiency are probable reasons SMEs patent less than large firms and that the patenting process can hamper innovation. Still, when employed appropriately, it can impact firms' revenue stream and thus influence overall performance. Eppinger and Vladova assert that SMEs' resource deficiencies and dearth of IP management systems are potential obstacles. In a recent study of 19 Latin America and the Caribbean countries, Amdaoud et al. (2022) find that patents increase the likelihood of radical innovation in new processes and products to firms and their markets. When we relate these arguments to firms in SSA, considering that the region is a potential brewing zone for innovation, we thus affirm that firms in SSA can extract value from patents. Hence, we hypothesise that

H1: Patenting activities of firms may impact different shades of performance positively among firms in SSA, especially innovation

The Evidence-Based Relationship Between Copyrights and Innovation

The pioneer studies on the impacts of digitisation on the creative industries address mainly the influence of illicit copying (piracy) on firms' capability to invest in novel products (Landes & Posner, 1989; Watt, 2000). One of the growing industries in SSA is creative/entertainment. Over the years, piracy has impeded the ability of the industry to appropriate returns. Several efforts made by respective governments in the regions have not helped the industry. The contesting assertions for the link between copyright and the creative industries have continued to grow globally (Carrier, 2012; Flew, 2015). The role of IP in creative industries diverges from other

industries in several fundamental aspects (Erickson, 2018). A crucial difference is that copyrights relate instinctively to a piece of work as soon as it is created in an established form. In the case of patents and trademarks, initial registration is not essential. However, copyrights inevitably belong to the individual who initially creates such pieces of work. Global account narratives of the copyright industries indicate that solid IP rights strengthen creative firms (Carrier, 2012; Flew, 2015).

Nevertheless, growing evidence from video game production and 3-D printing suggests that business models established on open IP are beneficial (Carrier, 2012). First, other users would require approval from the copyright proprietor to develop beyond a copyrighted piece of work. This could include the cost of any license and search involved in tracing the right holders, which raises the price of utilising copyrighted information (Baldia, 2013). Second, the protection provided by copyrights is lengthier than other IP rights (WIPO, 2013). For instance, in Europe and the USA, copyright protection mostly lasts for 70 years from the year of the originator's death. Third, firms in the creative industry deal primarily in intangible products that are more vulnerable to information spillover than physical products, thereby decreasing firms' ability to appropriate return from such innovation (Teece, 2010). This problem is observable in digital media, where it can be more challenging to capture value from innovative products and services (Hesmondhalgh, 2007; Teece, 2018). Accordingly, we propose this question:

H2: Copyrights positively support focal firms' innovative efforts with the right mix of internal and external resources.

The Evidence-Based Relationship Between Industrial Designs and Innovation

Roy and Riedel (1997) document that product development projects that are commercially successful are connected to a specific approach to designs by firms instead of an easy focus on factors such as investment. Therefore, various fields of the usefulness of design have been identified, including the interpretation of customers' needs, the organisational design of the firm structure, the construction of the firms' strategy, and its prototypical value creation (Montresor & Vezzani, 2017).

The role of designs has transcended its earlier relevance on price and non-price competition. The significance of design in shaping organisational performance appears to be increasingly relevant to innovation management. It spreads over a wide range of products and functionality within a firm. Its significant impact on objective performance indicators such as market shares, profitability, sales and turnover (Roy & Riedel, 1997; Hertenstein et al., 2005; Chiva & Alegre, 2007; Gerlitz, 2016) remains crucial as well. Montresor and Vezanni (2017) argue that design activities align more with new production engineering and product ingenuity in that it contributes to a firm's ability to stimulate higher innovativeness.

Moreover, empirical studies document designs as drivers of overall firm performance (e.g., Hertenstein et al., 2005; Candi, 2006; Chiva & Alegre, 2007; Candi & Saemundsson, 2011; Filippetti, 2011; Fernández-Mesa et al., 2013), indicating that designs are not limited to appropriation but create value for the focal firms. In addition, Moultrie and Livesey (2014) reveal that developing innovation capacity

affects investment in designs positively. Also, Borja de Mozota and Clipson (1990) empirically show that companies that invest in industrial designs reveal more profitable products. There is a higher likelihood of increased innovativeness for firms' structure planned around an effectual development design with coordination mechanism across their distinct organisational branches (Bruce et al., 1995; Roper et al., 2016). Walch (1996) also shows that assigning financial and non-financial resources to design activities allows firms to gain knowledge, permitting them to master the possible industrial engineering challenges that could create novel or significantly improved innovative products or processes.

Furthermore, von Hippel (1989) surmises that investment in designs could allow firms to be more responsive to market demands or opportunities and open them to integrate new technological development easily. A strand of country-specific studies has documented investment in designs as immaterial inputs that stimulate innovation (Awano et al., 2010). There is also evidence of country studies focusing on a firm-level analysis (Montresor & Vezzani, 2016). If it holds that industrial designs contribute to firm performance, we argue that a firm's ability to innovate should relate positively and significantly to industrial designs. Hence:

H3: Firms that file design rights can extract value from innovation capability; hence, design relates positively to focal firms' innovation propensity in SSA.

The Evidence-Based Relationship Between Trademarks and Innovation

Castaldi et al. (2020) identify three motives that prompt the trademarking choice of firms. They include capturing market position, appropriation of rent and resource attraction and valorisation. According to the authors, these three distinct motives are linked to three research and literature domains: industrial organisation, innovation, and entrepreneurship. While our study addresses the innovation domain, we also believe that the study connects strongly to the entrepreneurship and industrial organisation domains that shape management choices to trademark. The entrepreneurship domain signifies that start-ups may want to file for trademarks to maintain a stronger incentive in the first phase of their innovation process. According to Power and Reid (2021), trademarks increase the likelihood of start-ups being superior performers. However, the innovation domain allows firms to appropriate returns emerging from their inventive activities, which is also strongly linked to the industrial domain that highlights significant private returns to firms (Schautschick & Greenhalgh, 2016; Castaldi et al., 2020). Earlier studies have seen trademarks not only as a protective mechanism but as an instrument that offers firms the opportunity to capture the introduction of innovation (Mendonca et al., 2004), for product differentiation (Davis, 2009) and as an opportunity to invest in valuable assets (Sandner & Block, 2011; Zhou et al., 2016).

Furthermore, Hipp and Grupp (2005) recommend that trademarks can be an especially valuable indicator for the future phases of innovation. The study of Flikkema et al. (2010) also confirms this to hold in the survey of 660 companies. The study shows that 60% of registered Benelux trademarks relate directly to a wide range of innovative activities. While trademark counts have been empirically documented

to contribute positively to innovative capabilities at the firm level (Schautschick & Greenhalgh, 2016), evidence shows that trademarks connect to innovation (Flikkema et al., 2014). For over a decade, Mendonça et al. (2004) have shown the relationship between trademarks and innovation. As the authors assert, trademarks are tools for companies to signal new products in the marketplace. While trademarks capture non-technological innovation as marketing and organisational, patents tend to focus more on technology. Therefore, trademarks allow service innovation and manufacturing (Schmoch, 2003) and technologically inefficient countries to join the innovative venture and become efficient (Millot, 2009).

Based on a country-level study in the USA, Daizadeh (2009) shows a positive link between trademark intensity and R&D intensity. In addition, Jensen and Webster (2009), using a survey of Australian firms, find a positive association between trademarks and R&D intensity. The findings indicate that trademark intensity is more significant in the service sector than manufacturing. Furthermore, the results also empirically document that trademark application has a more significant association with product and marketing innovation. Finally, in a more heterogeneous study, Azomahou and Diene (2012) find a growth in non-resident/resident trademarks to matter for income polarisation.

Furthermore, Schmoch (2003) finds the nexus between trademark use and innovation to be more significant in knowledge-intensive services, whereas patents reveal less relation to innovation. Block et al. (2015) finds a positive association between economic incentives and trademarks for innovators than imitators' motivation. Studies have also documented the overarching effect of trademarks on companies' market valuation (Sandner & Block, 2011; Zhou et al., 2016; Dosso & Vezzani, 2020). Malmberg (2005) finds sectoral variation most influential in explaining trademark strategies. While a product model plays a central role in high-tech manufacturing, e.g., automobile, its name focuses on another (e.g., low-tech service sectors). Hypothesising the innovation process to be systemic and strategic and relying on firms' ability to strategise based on management effective decision-making in knowledge management practice, we expect a positive association with trademarks and innovation performance. Accordingly, hypothesise that:

H4: Firms that file for or improve existing trademarks show a higher tendency to innovate (Fig. 1)

Data and IP Trend in Africa

The Research Context: IP in Africa

Based on the United Nations Conference on Trade and Development (UNCTAD), the Economic Commission for Africa documents many multilateral IPR treaties signed by African countries. The calculations show that fifty-three (53) African countries are members of the World Intellectual Property Association (WIPO). In addition, the report indicates Egypt has signed the most IP treaties (15), while South

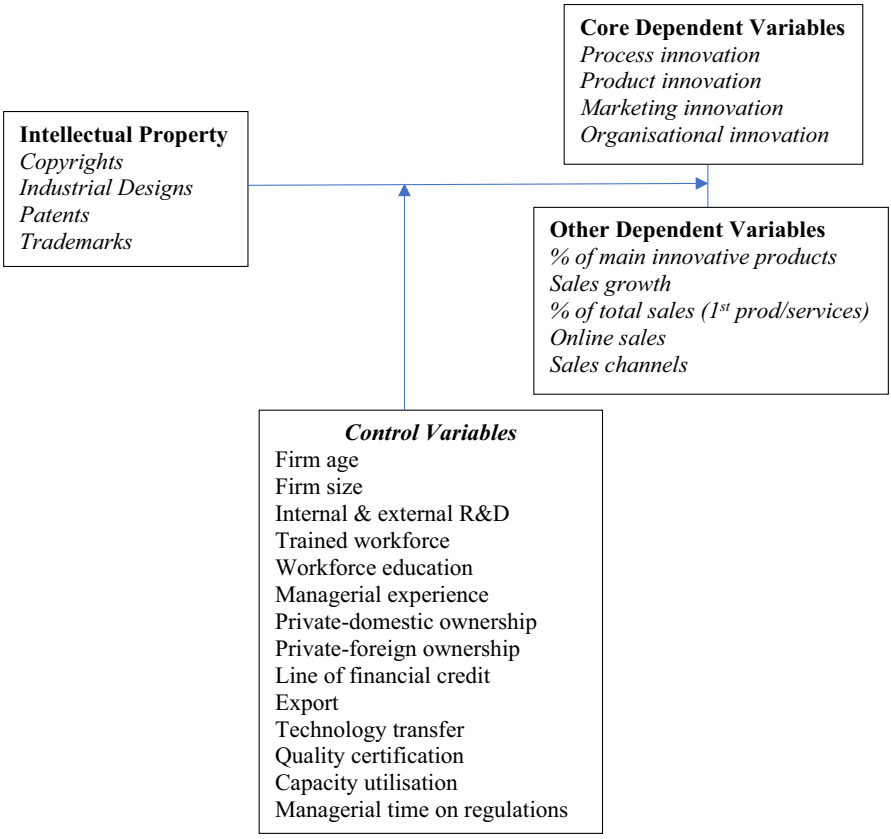


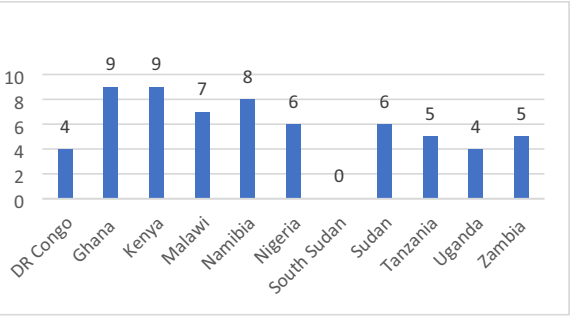
Fig. 1 Conceptual model

Sudan has signed none. Based on the countries of interest in this study, Fig. 2 shows the treaties signed.

The association between IP and innovation has been a topic of several debates. Firms in developing nations like SSA countries that desire to learn and perhaps catch up with advanced economies regarding innovativeness may see IPRs as a limiting factor to their explorativeness. While this remains crucial in most developing countries, academia is not left out in the IP debate (Fig. 2).

A report on the IPR trends in Africa shows that the number of non-resident grantees grows significantly in resident and non-resident applications than the resident grantees. The trends show that granting and sustaining IPR is not a favourable linear progression. Amongst the countries documented, South Africa has the highest applications. In 1990, the report documents that South Africa received 5,429 patents, but this declined to 1,468 in 2010. While for Morocco, between 1990 and 2010, the patent increased from 302 to 915. In Egypt, patent applications increase almost 2.5 times, and the number granted hugely remained constant from 1990 to 2003. Other countries include Ethiopia; Madagascar, Mauritania; Morocco; and Seychelles.

Fig. 2 No. of signed IP treaties



Source: UNECA, 2017

Even with many applications, the low grantees' reason is partly due to the patent offices' limited capacity to meet the increasing demands of the appropriation indicator. While the number of Africans that receive patents from the United States Patent and Trademark Office (USPTO) remained unchanged at 140 yearly from 1997 to 2009, only four additional countries registered above ten (10) over 12 years. These countries are Morroco, Nigeria, Tunisia, and Zimbabwe.

The World Economic Forum on Africa in 2015 reports seven of the continent's design trends. These are art spillover, fast "localised" food; fashion surge; starchitecture; digital design drumbeat; creepy-crawly superfoods, and off-grid objects. Similarly, in 2017, Bizcommunity also reports four significant African design trends at the centre stage of African design in 2017 and 2018. They are Nocture, Earthed Together, Youth Tonic, and Kinship. The trends in industrial designs and trademarks follow a different pattern than patents. World Intellectual Property Organization (WIPO) documents that the leading innovative countries in Africa, Ghana, Kenya, Nigeria, South Africa, and Zimbabwe, have not recorded industrial designs and trademarks in the last decade. Unlike patents, where the applications and sustainability remain inversely related, industrial design, as the report documents for resident and non-resident applications and those that eventually got registered, grew progressively to a significant proportion from 2000 to 2010 for six countries: Egypt, Ethiopia, Madagascar, Mauritania; Morocco; and Seychelles. In 2010, the office received 3,300 applications, and 2,600 became grantees. In a different report, Kenya filed 1392 applications on industrial designs between 1991 and April 2014. 51.3%, about 714 of those filed in applications, received the grant during this period. While the growth rate nose-dived significantly, the filed applications fluctuated between 1993 and 2014.

On the trends of trademarks, the growth in trademarks is more significant than in other IP strategies. The trends for Egypt; Ethiopia; Madagascar, Mauritania; Morocco; and Seychelles, as documented by ECA between 1990 and 2010, grow significantly more positively for resident applicants than non-residents; the same trend applies to residents with significant growth as compared to non-resident registration. Overall, the trademark trend suggests an increasing interest in owning IP in Africa compared to patents. Since efficacious innovation comprises taking a new product to market, other innovation indicators become essential. Trademarks and

industrial designs play an indispensable role in the marketing process. While industrial designs and trademarks remain relevant to services and products, an evidence-based account documented for copyrights, which primarily connects to creative knowledge production, is sparse.

Data

We use the World Bank (2019) Enterprise Survey (ES) and Innovation Follow-up Survey (IFS) to test our hypotheses. Since both datasets consist of the same firms, we merge WBES and the IFS for each country using firms' specific identifiers and combine them for the eleven countries to form a single dataset. This merger enhances the robustness of our dataset for useful analysis. The two datasets are firm-level, covering 2012-2015 for these countries: DR Congo, Ghana, Kenya, Malawi, Namibia, Nigeria, South Sudan, Sudan, Tanzania, Uganda, and Zambia. It is important to mention that our interests in these countries stem from the fact that they have information in the innovation and enterprise surveys and converge over the years, making our results highly comparable. In addition, WBES data contains institution-related variables, including political stability, corruption, business qualities, and performance metrics. The World Bank, since 1990, has been reliable in collecting firm survey data to permit country-specific assessment. However, as the world remains interconnected and interdependent, in 2005, the World Bank started conducting a firm-level survey to give room for relative and comparable analysis across nations.

The World Bank considers the importance of firms' activities in stimulating the economy, hence collecting innovation datasets. The IFS was initiated in 2011 to compile data on innovation and innovation-related activities specific to firms' internal operations. The initiative for IFS started in 2011 to concentrate on innovation and interrelated activities within firms. The surveys cover retail, services, and manufacturing. WBES is a typical sample of firms in the formal non-agricultural sector. ES is grouped based on sectoral compositions, firm size, and geographical locations of the sampled firms. Top managers and Business owners constituted WBES and IFS respondents. After merging the datasets, we represent each country and sector in Table 1 (www.enterprisesurvey.org).

Dependent Variables: Process, Product, Marketing, and Organisational Innovation

This paper explores the connection between innovations and IP. The survey asked firms if they introduced new or significantly improved goods and services in the last three years, indicating product innovation. In addition, respondents were asked if their organisations had produced new or significantly improved marketing methods over the previous three years for marketing innovation. Organisational innovation means a new or significantly improved organisational structure introduced in the last three years. Moreover, the survey asked respondents if firms launched innovative approaches to manufacturing products or offering services, representing process innovation. Our

Table 1 Tabulation of sector by country

Country Code	Questionnaire			
	Manufacturing	Retail	Other services	Total
Nigeria	1103	549	978	2630
Namibia	156	188	222	566
South Sudan	90	390	258	738
Sudan	97	138	418	653
Ghana	369	115	228	712
DR Congo	242	136	150	528
Malawi	159	144	203	506
Tanzania	417	121	251	789
Uganda	361	165	215	741
Zambia	363	123	229	715
Kenya	408	166	201	775
Total	3765	2235	3353	9353

measurement of innovations complies with the Community Innovation Survey (CIS) and the Oslo Manual, where firms report introducing new or significantly improved forms of innovation in the last three years. The four innovation types are operationalised as dummy variables. It takes "1" if the firms had introduced or significantly improved each innovation type and "0" otherwise. These are innovation measurements closely related to the following studies: Amara et al. (2008), Thomä and Bizer (2013), Barasa et al. (2017) and Knoben et al. (2022). However, these subjective-based measures of innovation are appropriate in the context of research in emerging markets (Cirera & Muzi, 2020).

Independent Variables: Patents, Copyrights; Industrial Designs; Trademarks

We used four innovation indicators as a measure of our independent variable. They are patents, copyrights, industrial designs, and trademarks. IFS asked respondents if establishments applied for patents, trademarks and copyrights or filed registrations for industrial designs. If the establishments applied or registered for any of these indicators, it takes "1" and "0" otherwise. In the innovation follow-up surveys, respondents were further asked if their organisations improved or changed existing logos/trademarks, taking 1 if firms did and 0 otherwise. Our independent variables share common measurements with, e.g., Amara et al. (2008), Thomä and Bizer (2013), and Veugelers and Schneider (2018).

R&D Activity

More R&D-concentrated firms are also more likely to widely utilise IP (Hall et al., 2014). The survey asked establishment representatives if they conducted internal

R&D. It is a dummy variable. Scholars show that internal R&D strengthens firms' absorptive capacity, making complementarity effects more realistic (Cassiman & Veugeler, 2006; Savin & Egbetokun, 2016). *External R&D.* Zobel et al. (2016) show that internal and external information sources are vital for innovation but stress that external sources are crucial to success. So, we argue that external R&D can inhibit a firm's ability to generate innovation, especially if it does not have staff that could match such knowledge flow or contingent on resource constraints. Again, it is measured as a dummy variable.

Formal Training

Organisational human capital is essential for absorptive capacity either as a specific or general skill (Robson et al., 2012). WBES asked respondents if firms provided formal training to employees from 2011 to 2013. It is a dummy variable. Apart from managerial experience and employees' qualifications, organisations providing training for employees gain returns to their innovation activities (Fonseca, 2019).

Staff Academic Aghion and Jaravel (2015) suggest that different academic achievements are vital for leapfrogging economies that want to catch up with technologically superior economies. The variable is the percentage of full-time workers with high school certificates.

Managerial Experience Managerial experience mainly indirectly (Balsmeier & Czarnitzki, 2014) and directly (Kelley et al., 2011) affects innovation performance, providing knowledge on handling institutional setbacks. The ES asked organisations for the years of working experience of top managers in the establishment. We measured this as a dummy variable. It is coded "1" if the top manager had working experience greater than 20 years and "0" otherwise. Our choice of 20 years is not arbitrary because it takes several years for top managers to impact a firm's overall performance, from human resource management to performance output.

Control Variables

Firm Size: Full-time Employees

Prior research emphasised the importance of firm size to innovation and appropriation mechanisms. We used full-time permanent workers as a measure of size. It was log-transformed to uphold the assumption of normality. Several studies used this measure (e.g., Barasa et al., 2017; Zobel et al., 2017; Knoben et al., 2022). *Firm Age: a*ge is considered essential for innovation and entrepreneurship (Anderson & Yoshihiro, 2013; Soluk et al., 2021) or boosts overall performance (Lopez Rodriguez & Orellana, 2020). However, empirical studies are inconclusive on the role of age in the IP-innovation nexus. We measured age by subtracting the year firms started operation from the survey year; then, the outcome was log-transformed for normality.

External Financing

WEBS asked top managers of the establishments if they had a credit line from any financial institutions. Zhu et al. (2020) found financial resources consequential for firm performance. Therefore, our study attaches importance to an external financing source because it could complement firm-level resources to further innovation activities and foster the filing of IP.

Sector, Industry, and Country Dummies Lastly, we included in our analysis a set sector, year, and industry dummies (24 at the 2-digit industry level) as the necessity for IP mechanisms may vary across industries and years (Hall et al., 2014).

Descriptive Statistics

Table 2 reports the pairwise correlations between variables, while Table 3 contains the descriptive statistics. On average, 36% of the firms belong to manufacturing, 26% to retail, and 38% to services. More importantly, we observe that for the four IPRs put together, 20% of the firms apply or register for them. Patent (4%), copyrights (5%); industrial designs (6%); trademark application (5%); trademark improved or changed (14%). Also, 19% of the managerial team has management experience (Table 3). While 54.3% of the workforce completed high school and 27% received formal training. Furthermore, considering the different innovation types introduced by firms, we observe that 54% of the firms introduced product innovation, 47% process innovation, 51% marketing innovation, and 39% organisational innovation. These values are representative and promising for African firms regarding their innovativeness level, although they may not explain innovations' intensity.

On firms' R&D, we observe that 11% conducted internal R&D while only 4% conducted external R&D. Considering the importance of finance, we observe that 15% had lines of credit from financial institutions. Worthy of note, this variable is positively and statistically significant across all regressions for the four innovation types (Tables 4 and 5). This further accentuates the salient role of external financing in innovation performance in sub-Saharan Africa.

Empirical Model

In this paper, we examine the impactive role of IP on innovation in selected countries in sub-Saharan. We employ three econometric approaches to test the hypotheses due to the operationalisation of our dependent variables. We use Ordinary Least Squares (OLS), Probit and multivariate Probit (simultaneous regression) estimation strategies[1]. We cluster the standard errors at the country and industry levels in the multivariate Probit model, controlling for the year-specific-effect, country, and sector dummies, respectively. Second, given that our dependent variables

[1] In the main text, we present the estimation results from the multivariate ProBit regression while we document as supplementary results emerging from ProBit and Ordinary Least Squares (OLS) regressions, respectively.

Table 2 Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Product	1																		
Process	0.550***	1																	
Marketing	0.447***	0.492***	1																
Organisational	0.389***	0.448***	0.511***	1															
Main prod/ser[1]	0.176***	0.102***	0.094***	0.075***	1														
ln_sales[2]	0.101***	0.107***	0.089***	0.103***	0.032***	1													
% 1st prod/serv.[3]	0.012	0.036***	0.030***	0.020*	0.024**	0.174***	1												
Online sales[4]	0.088***	0.097***	0.124***	0.089***	0.199***	0.069***	0.042***	1											
Sales channels[5]	0.056***	0.104***	0.080***	0.094***	0.107***	0.132***	0.038***	0.238***	1										
Patent	0.069***	0.088***	0.092***	0.065***	0.226***	0.011	0.008	0.197***	0.091***	1									
Copyright	0.052***	0.089***	0.080***	0.086***	0.206***	0.000	-0.004	0.186***	0.105***	0.407***	1								
Industrial design	0.067***	0.091***	0.093***	0.071***	0.223***	0.019*	0.020*	0.187***	0.102***	0.517***	0.567***	1							
Trademark[6]	0.052***	0.084***	0.078***	0.076***	0.228***	0.008	0.007	0.216***	0.134***	0.426***	0.704***	0.592***	1						
Trademark[7]	0.110***	0.106***	0.140***	0.105***	0.282***	0.025**	0.028***	0.288***	0.127***	0.280***	0.250***	0.294***	0.285***	1					
Internal R&D	0.099***	0.115***	0.119***	0.116***	0.230***	0.061***	0.017*	0.330***	0.229***	0.174***	0.142***	0.166***	0.186***	0.289***	1				
External R&D	0.066***	0.069***	0.062***	0.073***	0.171***	0.017*	-0.007	0.219***	0.147***	0.157***	0.128***	0.143***	0.170***	0.202***	0.409***	1			
Staff trained	0.210***	0.237***	0.223***	0.261***	0.044***	0.112***	0.044***	0.123***	0.094***	0.008	0.028***	0.030***	0.032***	0.050***	0.104***	0.056***	1		
Manager exp.	0.025**	0.027***	-0.002	0.029***	0.005	0.080***	0.013	0.048***	0.041***	-0.006	-0.003	-0.008	0.003	0.001	0.055***	0.023**	0.062***	1	
Staff education	0.082***	0.053***	0.074***	0.053***	0.026**	0.148***	0.191***	0.118***	0.082***	0.003	0.020*	0.013	0.031***	0.035***	0.039***	0.023**	0.140***	0.014	1

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

[1] Percentage of the main innovative product or service
[2] The Establishment Sales in 2009.
[3] First Product/Service, Percent of Total Annual Sales
[4] Online sales and order fulfillment.
[5] Introduced/Significantly changed: Sales channels or sales points.
[6] Did firm: Apply for a trademark.
[7] Introduced/Significantly changed: Branding, logo, name, or trademark.

Table 3 Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
Product Innovation	9353	.533	.499	0	1	-.132	1.017
Process Innovation	9353	.468	.499	0	1	.127	1.016
Marketing innovation	9353	.5	.5	0	1	0	1
Organisational innovation	9353	.387	.487	0	1	.464	1.216
% of main innovative prod/services	9353	7.294	18.868	0	100	3.07	12.358
Annual firms' total sales (logged)	9353	9.324	8.478	0	30.029	.017	1.366
First product/service (% of total sales)	9328	76.514	28.997	0	100	–1.51	4.84
Online sales and order fulfillment	9353	.135	.342	0	1	2.136	5.562
Introduced/changed: sales channels	9353	.089	.284	0	1	2.892	9.366
Patent	9353	.042	.2	0	1	4.579	21.964
Copyrights	9353	.046	.209	0	1	4.353	19.952
Industrial design	9353	.056	.23	0	1	3.852	15.841
Trademark(filed)	9353	.054	.226	0	1	3.956	16.651
Trademark (changed or improved)	9353	.14	.347	0	1	2.079	5.324
Firm size (logged workforce)	9353	2.183	1.401	0	9.105	.46	3.602
Firm age (logged)	9353	2.555	1.433	0	7.612	1.625	7.814
Internal R&D	9353	.109	.312	0	1	2.508	7.292
External R&D	9353	.039	.194	0	1	4.761	23.665
Trained workforce	9353	.266	.442	0	1	1.057	2.118
Manager experience	9353	.178	.382	0	1	1.684	3.837
Workforce education	9353	53.311	38.284	0	100	-.162	1.476
Private-domestic	9353	73.872	41.284	0	100	–1.072	2.29
Private-foreign	9353	10.097	27.482	0	100	2.651	8.471
Line of financial credits	9123	.151	.358	0	1	1.954	4.817
Export	9353	4.364	15.62	0	100	4.395	23.315
Technology transfer	9353	.064	.245	0	1	3.55	13.605
Quality certification	9353	.126	.332	0	1	2.256	6.09
Capacity utilisation	9353	21.725	35.737	0	100	1.204	2.712
Managerial time on regulation	9353	7.558	17.279	-0	100	3.349	15.058

are dichotomised and highly correlated, indicating whether a firm had introduced or improved the innovation types in the last three years, we use a non-linear multivariate Probit approach. Considering the four traditional types of innovation, it is probable that individual heterogeneity, which is not captured by the explanatory variables, could influence the likelihood of firms engaging in several forms of innovation concurrently. As a result, innovation likelihood will be correlated across two regression equations due to an upswing/downswing bias, such as in a bivariate Probit model. This may bias our estimates. As a result, we account for this potential bias by estimating a multivariate Probit model that assesses the four equations simultaneously, accounting for possible correlation across the error terms (Cappellari & Jenkins, 2006; Amara et al., 2008; Doran & Ryan, 2014). The Multivariate Probit

(MVP) model also estimates the variance-covariance matrix of the disturbances of the equations (Amara et al., 2008; Greene, 2004) that will deduce the presence of either substitution or complementary effects in the choice of the diverse IP strategies. We include industry and country dummies in the Probit and OLS estimations. Also, we obtain the predictive rate to dispel concerns regarding the significance of all the appropriation indicators. We express the functional forms of the estimation equations below. Equation (1) tests the impact of IPRs on innovation.

$$\begin{aligned} DV_i = & \alpha_0 + \sum \beta_1 (IPR_i) + \beta_2 (Firm\ Size_i) + \beta_3 (Firm\ Age_i) + \beta_4 (HC_i) \\ & + \beta_5 (R\&D\ activities_i) + \beta_6 (Ownership) + \beta_7 (Year\ Dummy_i) \\ & + \sum \beta_8 (other\ controls_i) + e_i \end{aligned} \tag{1}$$

DV represents dependent variables, capturing the four innovation types and other constructs used for the robustness checks. They include % of the main innovation products/services, sales growth, percentage of sales from the first innovative products/services, online sales, and improved sales channels/points. IP represents patents, copyrights, industrial designs, and trademarks. HC captures the human capital variables that include a trained workforce, education of the workforce, and managerial experience. The ability of firms to innovate and explore these appropriation mechanisms can rely on firms' level of absorptive capacity. Finally, R&D activities indicate if firms engage in intra and extramural R&D activities, an essential component that shapes firms' innovation intensity. In the list of controls, we include the line of credit available to firms from financial institutions, private-domestic and private-foreign ownership, technology transfer, quality certification, export, management time in dealing with government regulations, country, industry, and sector dummies, respectively.

Results

This paper examines the impacts of four notable IP instruments on innovation performance in sub-Saharan Africa. Our multivariate output and the first two sets of robustness checks from a Probit approach are in Tables 4, 5, and 6. Correspondingly, we obtain the predictive rates of all IP indicators. The marginal effects allow us to infer how IP strategies affect innovation and other performance constructs. The marginal effect coefficients are in Tables A1, A2, and A3. Also, in the appendix, we report the Probit estimation that includes country and industry dummies and the third set of robustness checks (Table A4) based on Ordinary Least Squares (OLS).

Our findings support in entirety the hypotheses, indicating a positive effect of patent (H1), copyright (*H2*), industrial design (*H3*), and trademark (*H4*) on innovation introduced or improved by firms, which are not considered trivial, considering the combinations of approaches. For trademark, we use two constructs: whether firms filed for trademark registration and whether firms changed or improved on the existing trademarks. The findings show that patents and copyrights, as appropriation mechanisms, impact all four innovations positively and significantly at the

Table 4 Relationship between patent, copyrights, industrial design, trademark, and innovation (Multivariate probit estimation)

	(Model 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)	(Model 7)	(Model 8)
VARIABLES	Product	Process	Marketing	Organisation	Product	Process	Marketing	Organisation
Patents	0.250**	0.429***	0.412***	0.314***				
	(0.099)	(0.087)	(0.082)	(0.086)				
Copyrights					0.179**	0.443***	0.383***	0.443***
					(0.076)	(0.080)	(0.079)	(0.083)
Firm size	0.091***	0.078***	0.083***	0.093***	0.091***	0.078***	0.084***	0.093***
	(0.012)	(0.015)	(0.014)	(0.014)	(0.012)	(0.015)	(0.014)	(0.014)
Firm age	-0.025**	-0.030**	-0.032***	-0.008	-0.025**	-0.028**	-0.031***	-0.006
	(0.010)	(0.012)	(0.009)	(0.010)	(0.010)	(0.012)	(0.009)	(0.010)
Internal R&D	0.251***	0.301***	0.343***	0.267***	0.261***	0.313***	0.353***	0.265***
	(0.057)	(0.058)	(0.052)	(0.048)	(0.056)	(0.056)	(0.052)	(0.048)
external R&D	0.147*	0.137	0.022	0.177**	0.152*	0.130	0.024	0.168*
	(0.089)	(0.087)	(0.096)	(0.088)	(0.090)	(0.088)	(0.096)	(0.089)
trained staff	0.512***	0.561***	0.542***	0.586***	0.510***	0.557***	0.539***	0.583***
	(0.045)	(0.044)	(0.039)	(0.041)	(0.045)	(0.044)	(0.039)	(0.041)
Manager experience	-0.026	-0.043	-0.112***	-0.028	-0.027	-0.047	-0.114***	-0.030
	(0.034)	(0.039)	(0.037)	(0.039)	(0.034)	(0.040)	(0.037)	(0.039)
Staff education	0.001**	0.000	0.001**	-0.000	0.001**	0.000	0.001**	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
Constant	-0.775***	-1.113***	-0.847***	-1.102***	-0.770***	-1.102***	-0.837***	-1.090***
	(0.097)	(0.115)	(0.112)	(0.121)	(0.098)	(0.114)	(0.112)	(0.121)
atrho21		0.954***		0.856***		0.956***		0.855***
		(0.033)		(0.024)		(0.033)		(0.024)
Likelihood ratio test of rho21 = 0		2431.2***		1948.2***		2435.8***		1942.3***
Log pseudolikelihood		-10407.3		-10382.6		-10404.3		-10374.7
Wald chi2(48)		1980.0***		1517.7***		2317.9***		1634.9***
rho21		0.742***		0.694***		0.742***		0.693***
		(0.015)		(0.013)		(0.015)		(0.013)
Observations	9,353	9,353	9,353	9,353	9,353	9,353	9,353	9,353

Table 4 (continued)

	(Model 9)	(Model 10)	(Model 11)	(Model 12)	(Model 13)	(Model 14)	(Model 15)	(Model 16)	(Model 17)	(Model 18)	(Model 19)	(Model 20)
VARIABLES	Product	Process	Marketing	Organisation	Product	Process	Marketing	Organisation	Product	Process	Marketing	Organisation
Industrial designs	0.211***	0.323***	0.320***	0.259***								
	(0.080)	(0.078)	(0.071)	(0.076)								
Trademark(filed)					0.134*	0.324***	0.292***	0.304***				
					(0.070)	(0.074)	(0.075)	(0.080)				
Trademark (changed/improved)									0.266***	0.262***	0.380***	0.296***
									(0.048)	(0.046)	(0.065)	(0.054)
Firm size	0.091***	0.078***	0.084***	0.094***	0.092***	0.079***	0.084***	0.094***	0.091***	0.078***	0.084***	0.094***
	(0.012)	(0.015)	(0.014)	(0.014)	(0.012)	(0.015)	(0.014)	(0.014)	(0.012)	(0.015)	(0.014)	(0.014)
Firm age	-0.025**	-0.029**	-0.031***	-0.008	-0.025**	-0.029**	-0.031***	-0.007	-0.023**	-0.028**	-0.029***	-0.006
	(0.010)	(0.012)	(0.009)	(0.010)	(0.010)	(0.012)	(0.009)	(0.010)	(0.010)	(0.012)	(0.009)	(0.010)
Internal R&D	0.253***	0.309***	0.350***	0.270***	0.260***	0.310***	0.351***	0.265***	0.204***	0.270***	0.279***	0.216***
	(0.056)	(0.057)	(0.053)	(0.049)	(0.056)	(0.057)	(0.052)	(0.049)	(0.060)	(0.055)	(0.052)	(0.049)
external R&D	0.149*	0.141	0.025	0.180**	0.149*	0.127	0.019	0.167*	0.129	0.129	0.002	0.164*
	(0.089)	(0.088)	(0.097)	(0.089)	(0.090)	(0.089)	(0.097)	(0.090)	(0.090)	(0.090)	(0.097)	(0.091)
trained staff	0.510***	0.557***	0.538***	0.583***	0.511***	0.558***	0.540***	0.584***	0.507***	0.554***	0.536***	0.581***
	(0.045)	(0.044)	(0.039)	(0.041)	(0.045)	(0.044)	(0.039)	(0.040)	(0.045)	(0.044)	(0.039)	(0.041)
Manager experience	-0.025	-0.043	-0.111***	-0.027	-0.027	-0.046	-0.113***	-0.029	-0.029	-0.049	-0.117***	-0.031
	(0.034)	(0.040)	(0.037)	(0.039)	(0.034)	(0.039)	(0.037)	(0.039)	(0.034)	(0.040)	(0.037)	(0.039)
Private-foreign	0.001	0.000	0.000	0.000	0.001	0.000	-0.000	0.000	0.001	0.000	-0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	-0.770***	-1.104***	-0.838***	-1.093***	-0.772***	-1.107***	-0.841***	-1.095***	-0.245**	-0.369***	0.022	-0.766***
	(0.098)	(0.114)	(0.112)	(0.121)	(0.098)	(0.114)	(0.112)	(0.120)	(0.114)	(0.102)	(0.154)	(0.128)
atrho21		0.954***		0.856***		0.956***		0.856***		0.951***		0.852***
		(0.033)		(0.024)		(0.033)		(0.024)		(0.033)		(0.025)
Likelihood ratio test of rho21 = 0		2432.6***		1950.9***		2438.9***		1953.1***		2414.2***		1928.9***
Log pseudolikelihood		-10411.8		-10385.6		-10412.0		-10385.1		-10400.1		-10356.6
Wald chi2(48)		2136.8***		1567.7***		2165.0***		1613.5***		2005.8***		1567.1***
rho21		0.742***		0.694***		0.742***		0.694***		0.740***		0.692***
		(0.015)		(0.013)		(0.015)		(0.013)		(0.015)		(0.013)
Observations	9,353	9,353	9,353	9,353	9,353	9,353	9,353	9,353	9,353	9,353	9,353	9,353

Estimations include private-domestic, private-foreign, line of financial credits, export, technology transfer, quality certification, capacity utilisation, managerial time on regulation, country, and sector dummies. Robust standard errors in parentheses and adjusted at the level of country and industry, respectively *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5. Relationship between patent, copyrights, industrial design, trademark, and firm performance (Robustness I: Probit estimation)

	(Model 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)	(Model 7)	(Model 8)	(Model 9)	(Model 10)
VARIABLES (probit)	**Online sales and order fulfillment**					**Introduced/Significantly changed: Sales channels or sales points**				
Patents	0.717***					0.818***				
	(0.095)					(0.118)				
Copyrights		0.736***					0.743***			
		(0.090)					(0.107)			
Industrial Design			0.590***					0.673***		
			(0.086)					(0.106)		
Trademark				0.762***					0.854***	
				(0.093)					(0.086)	
Trademark					0.725***					0.697***
					(0.055)					(0.073)
Firm size	0.092***	0.093***	0.093***	0.096***	0.094***	0.055***	0.057***	0.056***	0.057***	0.053***
	(0.017)	(0.016)	(0.017)	(0.017)	(0.018)	(0.019)	(0.018)	(0.018)	(0.018)	(0.019)
Firm age	-0.032*	-0.029*	-0.031*	-0.027	-0.023	-0.045*	-0.048**	-0.046**	-0.045**	-0.045**
	(0.017)	(0.016)	(0.017)	(0.017)	(0.016)	(0.023)	(0.023)	(0.023)	(0.022)	(0.023)
Internal R&D	0.955***	0.970***	0.964***	0.950***	0.847***	0.821***	0.840***	0.831***	0.825***	0.778***
	(0.064)	(0.064)	(0.065)	(0.066)	(0.066)	(0.069)	(0.067)	(0.068)	(0.067)	(0.069)
external R&D	0.384***	0.383***	0.392***	0.350***	0.350***	0.535***	0.526***	0.541***	0.513***	0.521***
	(0.094)	(0.095)	(0.094)	(0.092)	(0.097)	(0.089)	(0.090)	(0.089)	(0.093)	(0.089)
trained staff	0.192***	0.184***	0.184***	0.190***	0.175***	0.092	0.088	0.078	0.096	0.058
	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.059)	(0.059)	(0.060)	(0.060)	(0.059)
Manager experience	-0.015	-0.024	-0.012	-0.017	-0.029	-0.004	-0.005	-0.002	-0.002	-0.003
	(0.054)	(0.054)	(0.054)	(0.053)	(0.055)	(0.059)	(0.058)	(0.059)	(0.058)	(0.059)
Staff education	0.003***	0.003***	0.003***	0.003***	0.003***	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	-1.171***	-1.189***	-1.166***	-1.210***	-1.195***	-1.455***	-1.426***	-1.421***	-1.491***	-1.360***
	(0.172)	(0.178)	(0.171)	(0.173)	(0.176)	(0.218)	(0.213)	(0.217)	(0.212)	(0.204)
Pseudo R^2	0.232	0.234	0.23	0.237	0.251	0.153	0.153	0.153	0.16	0.167
Chi^2	1673.8***	1501.5***	1570.4***	1514.6***	1754.0***	975.3***	847.4***	859.0***	946.9***	883.7***
ll	-2754.6	-2748.4	-2761.3	-2735.8	-2686.8	-1777.7	-1777.1	-1777.5	-1762.1	-1749.3
Observations	9,353	9,353	9,353	9,353	9,353	4,257	4,257	4,257	4,257	4,257

Estimations include private-domestic, private-foreign, line of financial credits, export, technology transfer, quality certification, capacity utilisation, managerial time on regulation, country, and sector dummies. Robust standard errors in parentheses and adjusted at the level of country and industry, respectively *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6 Relationship between patent, copyrights, industrial design, trademark, and firm performance (Robustness II: Probit estimation) innovators only

	(Model 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)	(Model 7)	(Model 8)	(Model 9)	(Model 10)
VARIABLES	**Online sales and order fulfillment**					**Introduced/Significantly changed: Sales channels or sales points**				
Patent	0.721***					0.610***				
	(0.137)					(0.216)				
Copyrights		0.681***					0.781***			
		(0.123)					(0.182)			
Industrial designs			0.550***					0.712***		
			(0.118)					(0.178)		
Trademark filed				0.715***					0.705***	
				(0.122)					(0.177)	
Trademark improved					0.710***					0.707***
					(0.091)					(0.124)
Firm size	0.103***	0.104***	0.102***	0.108***	0.103***	0.118***	0.124***	0.116***	0.123***	0.116***
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.034)	(0.034)	(0.034)	(0.034)	(0.035)
Firm age	0.010	0.013	0.011	0.019	0.015	0.009	0.006	0.011	0.018	-0.001
	(0.031)	(0.030)	(0.030)	(0.030)	(0.030)	(0.041)	(0.041)	(0.041)	(0.040)	(0.041)
Internal R&D	1.034***	1.043***	1.040***	1.022***	0.935***	0.981***	0.972***	0.969***	0.960***	0.913***
	(0.098)	(0.097)	(0.097)	(0.098)	(0.099)	(0.114)	(0.115)	(0.115)	(0.116)	(0.115)
External R&D	0.336**	0.364**	0.352**	0.336**	0.326**	0.322*	0.345*	0.354*	0.353*	0.348*
	(0.149)	(0.147)	(0.146)	(0.148)	(0.146)	(0.193)	(0.195)	(0.191)	(0.193)	(0.194)
Trained Staff	0.142*	0.144*	0.135*	0.145*	0.116	-0.002	-0.001	-0.025	-0.001	-0.049
	(0.080)	(0.080)	(0.079)	(0.080)	(0.081)	(0.097)	(0.097)	(0.097)	(0.097)	(0.098)
Manager experience	0.035	0.025	0.044	0.035	0.076	-0.047	-0.044	-0.043	-0.040	-0.000
	(0.092)	(0.093)	(0.092)	(0.093)	(0.094)	(0.114)	(0.115)	(0.115)	(0.115)	(0.116)
Staff education	0.004***	0.004***	0.004***	0.004***	0.004***	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Pseudo R^2	0.28	0.28	0.275	0.282	0.295	0.192	0.201	0.198	0.199	0.214
Chi^2	427.4***	421.8***	418.2***	423.0***	434.0***	214.2***	235.3***	226.2***	223.2***	238.0***
ll	-731.486	-731.624	-736.32	-728.795	-715.678	-507.013	-501.81	-503.202	-502.692	-493.747
Observations	2,068	2,068	2,068	2,068	2,068	1,066	1,066	1,066	1,066	1,066

Estimations include private-domestic, private-foreign, line of financial credits, export, technology transfer, quality certification, capacity utilisation, managerial time on regulation, country, and sector dummies. Robust standard errors in parentheses and adjusted at the level of country and industry, respectively *** $p<0.01$, ** $p<0.05$, * $p<0.1$

one per cent level. Similarly, industrial design and trademark affect all four innovations positively, with a statistically significant p<0.01. Thus, in general, we find all appropriation mechanisms to support firms' innovation activities in SSA. Using the ProBit strategy, the predictive rates (Table A1) show that patents increase the likelihood of firms introducing the four innovation types by these percentage points (9, 15, 15, & 10). Copyrights also increase firms' probability of product, process, marketing, and organisational innovations in the following percentage points (6, 15, 12, & 13). Industrial designs and trademarks can support firms' innovation activities by the following percentages (ID: 7, 11, 10, & 8); (trademark-filed: no effect on product innovation but process, marketing and organisational—10%, 8%, & 8%). For improved or changed trademark, product, process, and organisational (9%) and marketing at 13%.

Shifting to the robustness analysis, we operationalise six other dependent variables. Two indicate innovation intensity: the percentage of the main innovative products/services and sales from the first innovative products/services. The other independent variables are firms' overall sales growth, online sales, or order fulfilment and significantly improved or changed sales channels or points. We use a linear regression approach for three dependent variables that are in continuous forms. While our results do not diverge utilising the percentage of the main innovative products/services, online sales/order fulfilment and improved sales channels/point, there is a significant divergence with sales and the percentage of sales from the first innovative products and services. This reveals important implications for managers on perception-based and objective-based performance outcomes.

Drawing from Table 6 based on the dependent variable, online sales and improved sales channels, patents, copyrights, industrial designs, and both trademarks (filed and improved) impact firm performance in the following order for online sales (*patent: β=0.72, p<0.01;(copyrights: β=0.68, p<0.01*; *industrial designs: β=0.55, p<0.01*; *trademark filled: β=0.72, p<0.01; trademark improved: β=0.71, p<0.01*. Similarly, when firms improve their sales point, we find IP to impact such change positively (*patent: β=0.61, p<0.01;(copyrights: β=0.78, p<0.01; industrial designs: β=0.71, p<0.01; trademark filled: β=0.71, p<0.01; trademark improved: β=0.71, p<0.01*). We find a similar pattern when we restrict our estimations to innovators in process, product, marketing, and organisational only.

On the predictive rates (see Tables A1, A2 & A3), patents, copyrights, and trademarks increase online sales by 12%, while industrial designs increase online sales by 9%. When firms change their sales points/channels, we find the impact of the four IP strategies as follows: patents (19%), copyrights (17%), industrial designs (15%), and both trademarks (20% & 16%). Still, on these performance outcomes, with a specific interest in innovators only (see Table 6), we find the effect on online sales to be 14% for patents, copyrights, and trademarks. In comparison, industrial designs stand at 11%. Subsequently, relating the impact to change in sales channels/points, patents stand at (16%), copyrights (20%), industrial designs and trademark (application) at 19%, while improved trademark is 18%.

The second set of robustness in Table A4 is based on the dependent variable, *the percentage of the main innovative products/services, establishments' total annual sales and the percentage of total annual sales from first products7services*. We find

patents, *copyrights*, *industrial designs*, and both *trademark* constructs to positively impact innovation intensity in the following order *(*$\beta = 17.9$, $p < 0.01$*;* *(*$\beta = 15.9$, $p < 0.01$; $\beta = 15.6$, $p < 0.01$; $\beta = 15.6$, $p < 0.01$; $\beta = 11.4$, $p < 0.01$). On the contrary, only patents ($\beta = 0.74$, $p < 0.1$) and an improvement in existing trademarks of the focal firms predict a positive impact on sales growth ($\beta = 0.58$, $p < 0.05$). Furthermore, on the percentage of sales from the first products/services, only changed or improved trademark affects this construct positively with ($\beta = 1.78$, $p < 0.05$), which shows the importance of improved existing trademarks on performance.

Involving our control variables, internal R&D, firm size, trained staff, and line of credit from financial institutions, export, technology transfer, quality certification, and management time in dealing with government regulations have significant positive effects on all firm innovation types in Tables 4 and 5. The findings confirm several studies showing the importance of absorptive capacity, firm-level attributes, and financing to innovation performance. Moreover, internal and external R&D activities positively impact the percentage of the main innovative products/services.

Discussion

In this study, we examined the direct impacts of IP strategies on innovation performance in sub-Saharan Africa. We confirm that intellectual property strongly shapes organisational innovation activities. Also, our study demonstrates that even beyond the perception-based innovation outcome, firms can be certain of a potentially positive impact on their objective performance outcomes. The paper contributes to the innovation-IP literature in several ways. First, no study has empirically linked copyrights and industrial designs to the traditional innovation types defined by the Oslo Manual 2018. Second, the trademark construct that indicates if firms changed or significantly improved the existing trademark is rarely used in the IPR-innovation nexus. Third, it is also the first to use the other three innovation types (process, marketing, and organisational innovation). For example, Medase and Abdul Basit (2021) relate the construct to product innovation in a recent publication. However, Brem et al. (2017) employ patents, copyright, industrial design, and trademark to predict firm-level performance in turnover with a particular interest in SMEs, while Zobel et al. (2016) combine copyrights, industrial design, patents, and trademarks as a single construct to predict the impact on radical and incremental innovation. Considering the different advantages that firms may gain from using these appropriation mechanisms independently, our study directly explores the independent impact of patents, copyrights, industrial design, and trademarks on the innovation pursuit of firms in SSA.

While much is known about the link between innovation and patents, the role of our other three IPR constructs linking the traditional innovation types as defined by the Oslo Manual 2018 is still limited in empirical research and, more importantly, in sub-Saharan Africa. Thus, while the region is a future brewing zone for innovation due to its abundant raw material and the potential to industrialise, it becomes more important to draw the attention of managers and practitioners to how essential appropriation mechanisms may encourage innovation intensity.

Contrary to the views of Kitching and Blackburn (1998), our findings show that formal appropriation mechanisms positively impact innovation performance, but their impacts on objective performance indicators are mixed. After considering the different capabilities that firms may need to leverage appropriation mechanisms and the criticisms regarding their utilisation, the distinct channels for innovation protection matter for product, process, marketing, and organisational innovations. Trademarks play a role in branding strategies targeted at appropriating the rents from innovation. However, there is no one-to-one link between the introduction of innovations and trademark application or its improvement. Whether trademarks play an essential or modest role in firm-level appropriation strategies remains largely debated (Athreye & Fassio, 2020). Earlier studies often based their analysis on trademark applications connected to innovation, which we extended based on changed or improved existing trademarks.

Furthermore, while growing interest has been in developed economies because of their innovation intensity and rapidity, technological and enforcement of legal rights advantages, SSA countries lag in this exploration. Therefore, while we include trademarking through application and its intensity, we determine what diverges between both constructs and their impact on innovation performance. Taking both perspectives is vital for innovation because we establish that while filing for a trademark may matter, its intensity relates more positively to objective and subjective performance measures.

Importantly, businesses are increasingly employing industrial designs to build their competitive advantage, a vital strategy for most firms in SSA. Nevertheless, little empirical evidence is available on how industrial designs support innovation and firms' overall performance. We demonstrate that designs are a fundamental factor in firms' competitiveness. Firms react to new know-how and adjustments in market demands through new product introduction, new organisational structures, new marketing strategies and capabilities and overall new processes along recognised and regulated trajectories of superior performance and reduced cost. Significantly, successful products/processes regularly reveal distinctive qualities beyond normal function, constant superiority, and minimal cost. They are a fusion of technology that appeals to user tastes and preferences. Customers are induced mainly by the forms and efficacy of products. So, products' descriptions and functional efficacy are distinct outcomes of innovation processes considered fundamental to SSA firms. Moreover, the ability of firms to file for industrial designs indicates they have a strong taste and response to customers' needs and preferences. Firms leveraging this advantage stand the chance of gaining from IP utilisation.

With these findings, our paper shed light on the debatable role of IP strategy choice (Veugelers & Schneider, 2018; Sweet & Maggio, 2015; Candelin-Palmqvist et al., 2012), first, on perception-based innovation; second, the scale of innovation and other performance indicators important to firms, including sales growth. While our study confirms the role of IP on innovation, as shown by Amara et al. (2008), Thomä and Bizer (2013), Hall and Sena (2017), Veugelers and Schneider (2018), and Amdaoud et al. (2022), we show in a broader sense how internal capabilities are fundamental to the relationship between innovation and IP strategies. We particularly evince that organisational absorptive capacity, internal capabilities and

attributes are strong drivers in the success of IP strategies. The interesting takeaway from our findings indicates that IP strategies adopted by firms have a significant impact on their performance with the right mix of resources. More importantly, we respond first, to several questions on the role of patents in innovation (Neuhäusler, 2012; Candelin-Palmqvist et al., 2012), especially in developing countries (Amdaoud & Bas, 2021; Amdaoud et al., 2022) and close the research gap on how patents can facilitate innovation and sale performance in SSA. We also close the research gap on the role of industrial design in innovation while responding to the call from Castaldi (2020) on what firms can do with trademarks. In particular, we show that while existing trademarks matter for innovation, improved or filed trademarks can foster inclusive performance at the firm level. Finally, our study confirms the findings of Thomä and Bizer (2013) and Amara et al. (2008) on the importance of patents, industrial designs, trademarks and copyrights as usual appropriation tools in fostering innovation. This highlights that the choice to use any form of IP strategy relies strongly on the firms' level of innovativeness, which we demonstrate in our result on the scale of innovation to measure innovation intensity. In general, our findings imply that the usage of IP strategies by innovative firms relates collectively to other performance measures aside from innovation.

Managerial and Policy Implications

Our findings have significant implications for managers and policymakers in fostering innovation at all levels of firms' activities fundamental to regional economies, particularly SSA. First, the study provided insights for managers of businesses about which mechanism they can employ to appropriate returns on innovation without impeding competition. Importantly, we demonstrate that appropriation channels are crucial instruments for transforming innovation pursuits into a competitive advantage and are, thus, affected by innovation process features and the attributes of firms.

Managers will recognise that when a product conforms to current socio-cultural standards and adopts attributes that appeal to current values and preferences, consumers will most likely recognise the product as relevant. It corresponds to prevailing views of exquisiteness, including developing common words and conveying allowed content. Second, the perspective on the function of innovative design has aftereffects on firms' innovation processes. If great design covers the meaning of products, functions, and customer needs, the design process cannot be isolated due to technological advancement. Creative designers are used to creating specialised, non-exchangeable solutions with results that may be used for more tangible products. In comparison, various designers have embraced a more complicated design viewpoint, where design is incorporated into a considerable array of activities and deeply engaged in strategic business decisions (Brown, 2008).

These findings highlight the importance of formal appropriation indicators such as copyrights, industrial designs, and trademarks providing innovating firms time-restricted rights to utilise their inventions and novel designs. These formal appropriation methods incentivise firms to re-invest in innovations and new know-how and to diffuse new products founded on innovations safeguarded by regulation. Given

the growing strategic significance of IP, this paper has examined the importance of IP to innovation by accounting for other essential firm attributes, including firm age, size, and human capital, allowing them to explore this channel. The idea of innovation indicates that firms use external knowledge more significantly and progressively cooperate with other external allies. As a result, firms search more largely and intensely across distinct knowledge sources. The perceived risk related to such openness rests on the fact that resources and modus operandi are made available to others, especially competitors, to exploit. This could make it more challenging to protect the innovative endeavours of firms and seize gains that ensue from cooperative and mutual innovative efforts. On this premise, firms in SSA that file for either a trademark, industrial design, or copyright can have the ability to protect their resources and knowledge that might be prone to exploitation by competitors.

Limitations and Future Research

As with many empirical studies, our paper has limitations, creating engaging channels for future studies. First, our data is cross-sectional, which impedes us from observing the long-term impacts of IP on innovation. Similarly, causation cannot be inferred from the nature of the data and forms of analysis used. Thus, the paper examines if correlations can be observed between the different constructs of IP and innovations employed in the study. As notably observed, potential endogeneity is imminent in our study. However, we expect this to be minimised but not removed completely, considering that reverse causation looms between innovation and IP. However, this might not be obvious for firms in SSA due to their imitation and indigenous-driven innovation that may not warrant stringent IP regulations. Notwithstanding, we have performed several robustness analyses to mitigate this concern. For instance, we use different approaches and outcome measures and find our results highly stable across the perception-based innovation measures. In addition, our control variables provide some cushion regarding the endogeneity concern.

Second, according to the economic importance of IP, this paper may have contributed to a significant buzz on the economic importance of IP, mainly through innovation and sales channels. However, additional theorising and more robust empirical research are needed to grasp better the nexus between innovation and IP on the one hand and IP and other objective performance indicators. For instance, one could take a specific industry and relate the distinct capabilities required to leverage IP usage.

In addition, the emerging critical issue is to determine whether these findings can be related to other developing countries, even countries within SSA, especially considering that we observe positively significant effects of IP on all perception-based innovation measures. While these results go against the typical views of scholars on the role of IP in innovation in developing countries, especially SSA, examining different channels through which IP can(not) facilitate innovation will be essential. Perhaps, paying particular attention to indigenous and international innovations could shed more light on the veracity of IP, which brings exporting ability into the picture. Another vital area that could reveal the importance of IP to innovation is the endogenisation of local, national, and

international markets in the innovation equations. Finally, while (in)formal institutions matter to the appropriation regime, there is a growing concern regarding how formal institutions impact policies concerning IP rights. So, we have investigated countries with a closely diverged level of institutional quality. To further shed light on the innovation-IP nexus, it will be worthwhile to investigate the formal institutional channels and their effects on formal appropriation mechanisms.

To summarise our study, we offer a starting point for scholars, practitioners, and policymakers seeking to grasp the IP-innovation nexus in SSA countries. Our study focuses on the importance of copyrights, industrial designs, and trademarks on firms' innovation activities in SSA. Furthermore, it contributes to the growing debate on the role of IP in economic performance and broader societal inclusivity. However, several additional channels of the investigation remain for further discussion, and we hope that future studies will build on this foundation.

Conclusion

This paper has assessed the relative impact of IP on innovation in the context of developing countries in sub-Saharan Africa. Specifically, we centre our analysis on the four notable appropriation mechanisms: copyrights, industrial designs, patents, and trademarks. Relatively, these countries have closely diverged institutions that could shape the potential impact of IP on their innovation capabilities. Building on the World Bank Enterprise and Innovation datasets, we demonstrate an overly noticeable consistent positive effect of IP on innovation. We further estimate a split sample by considering only innovators; our results significantly reveal the undeniable impact of IP on innovation. While we potentially observe the scale of consistency in the significance level in the perception-based innovations, we resolve to test the same effect on objective-based innovation measures and sales growth. The results diverge regarding sales; nevertheless, the results on the perception-based innovation measures and intensity converge.

Using the total annual sales of firms as an explained variable, we find a statistically positive outcome for patents with no effect from other IP instruments. Additionally, we observe an interesting dynamism between trademark applications and improved trademarks or logos, including industrial designs that are rarely investigated in IP-innovation studies. In the case of existing trademarks/logos, it mainly suggests that the existence of firms in an established market could signal a crucial continuity effect on their innovation. This is a novelty confirmed in the study. Prior studies have primarily focused on trademark applications neglecting the impact of existing ones. Consequently, we evince statistical links between improved trademarks/logos and the total annual sales from first products/services, sales growth and the proportion of main innovative products and services. Our finding is fundamental to the innovation ecosystem of the region. In particular, we demonstrate that the notion of aggregating IP instruments for analysis can becloud their primary stand-alone effects on the different innovations pursued by firms. We conclude that, undeniably, IP is an important instrument for innovation activities.

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Declarations

Competing Interests The authors declare no competing interests.

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