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Effects of intellectual property rights on innovation and economic activity: A non-linear perspective from Latin America

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ABSTRACT

Intellectual property rights (IPRs) have a significant impact on facilitating the economic endeavors of countries. Nevertheless, there exists notable disparity among studies concerning the implications of IPRs within developing countries. Therefore, this study examines how stronger IPRs affect economic activity and moderate two important knowledge channels, domestic and foreign innovation activity. Using a sample of 18 Latin American countries from 2007 to 2018, we employed the Driscoll-Kraay robust standard errors, two-stage least squares (2SLS), and Generalized Method of Moments (GMM) to examine the effects of IPRs. Results confirm an inverted U-shaped relationship between IPRs and economic activity. Hence, the majority of Latin countries continue to vary in the factors of production that suport robust IPRs. Conversely, robust IPRs effectively improve the relation between domestic innovation and economic activity. Similarly, this influence holds true for foreign innovation as well. Based on this evidence, the research suggests implementing an optimal IPR policy.

1. Introduction

The endogenous growth and innovation literature highlight intellectual property rights (IPRs) as a fundamental factor for achieving higher economic growth (Arrow, 1962; Branstetter et al., 2006). Over the last two decades, developing countries have begun to tighten IPRs following multilateral and international agreements as policy conditions to attract more capital and foreign direct investment (FDI) inflows, with a special emphasis on increasing domestic innovative capacity (Cho et al., 2015; Maskus, 2015; Klein, 2018; Brandl et al., 2019; Papageorgiadis et al., 2020). Nevertheless, a significant trade-off exists behind increasing IPRs to stimulate economic growth (Hall, 2007; Branstetter and Saggi, 2011). In this context, prior studies have argued that only countries with dynamic efficiency can take advantage of strong patent regimes (Grossman and Lai 2004), while the effect of simply adopting policies from advanced countries is rather controversial in developing countries (Chang, 2002; Parello, 2008; Arza et al., 2023).

While a substantial body of research has broadly explored the relationship between IPRs and economic growth in developing countries, numerous studies present differing viewpoints regarding the elevation of IPRs as a means to boost economic advancement (Yang and Maskus, 2009; Peng et al., 2017; Christopoulou et al., 2021; Neves et al., 2021). In this context, previous studies have revealed that the relationship between IPRs and economic outcomes follows a non-linear pattern, leading to either positive effects (Hudson and Minea, 2013; Papageorgiadis and Sharma, 2016) or negative impacts on innovation and economic growth (Allred and Park, 2007; Furukawa, 2007, 2010). Moreover, recent investigations into the interplay between IPRs and economic growth highligh that robust IPR frameworks might display intricate adverse nonlinear trends in developing countries categorized by income (Kim et al., 2012; Lee et al., 2018; Su et al., 2022) or human development (Arshed et al., 2022).

In particular, scholars have also suggested that strong IPRs could be a significant barrier to domestic innovation (Cui et al., 2022). This is

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because only developing countries with technological advancement can take additional economic benefits from a strong IPR regime (Allred and Park, 2007; Sweet and Maggio, 2015; Steel et al., 2019). Proponents of strong IPRs explain that domestic companies can benefit from FDI inflows (Khoury and Peng, 2011; Lee et al., 2018), which act as a key driver of modern technological spillover and upgrades (Smarzynska--Javorcik, 2004; Krammer, 2015) and introduce more efficient organizational practices to local industries (Wu et al., 2017). Furthermore, overseas enterprises possess the capability to authorize their expertise (Branstetter et al., 2006), thereby impacting the transfer of technology and novel concepts without violating patents (Christopoulou et al., 2021). Nevertheless, prior studies have warned that strong IPRs could reduce the frequency and sophistication of innovations (Brüggemann et al., 2016) or increase tax evasion from innovative activities, thereby decreasing tax revenue and public support for innovation in a country (Uyar et al., 2021).

Despite the earlier efforts to understand the implications of increasing IPR protection, the lack of clarity in the field has resulted in several contradictory conclusions (Cho et al., 2015; Zhang et al., 2015). Recognizing this issue, this study investigates how stronger IPRs affect economic activity and moderate two important knowledge channels: domestic and foreign innovation activity. Drawing upon institutional literature, our theoretical lens focuses on IPRs as a specific legal aspect of a country's institutional framework (North, 1990), which is fundamental to promoting economic development in many countries (Chang, 1994; 2002). Our empirical analysis comprises 18 Latin American and Caribbean countries during the period from 2007 to 2018. By applying this theoretical perspective to this specific empirical background, we assess the effect of IPRs on economic activity. Furthermore, we enhance our understanding of the moderating role of IPRs as a step toward an optimal level of IPR protection (Bogliacino and Ramos, 2008). Using robust estimators, our results suggest a considerable trade-off between strengthening IPRs and the country's economic activity, with both domestic and foreign innovation increasing under strong IPR protection.

Theoretical and empirical contributions to the existing body of knowledge are outlined as follows. Initially, our investigation illuminates the connection between IPRs and economic activity within Latin American countries. Prior research has suggested that the effect of IPRs can vary significantly in developing countries (Lee et al., 2018; Papageorgiadis and Sharma, 2016; Arshed et al., 2022; Su et al., 2022). We argue that non-linear effects could be significantly influenced by the heterogeneity of countries and their geographical locations. To address these challenges, we continue the investigation by focusing on a prosperous yet underexplored region – Latin America (e.g., Khoury and Peng, 2011; Khoury et al., 2014), combining emergent topics on technological change and intellectual property (IP) (Rossetto et al., 2018). Secondly, and to the utmost extent of our comprehension, this study represents the initial endeavor to expand upon the scholarly endeavors of Khoury and Peng (2011) by incorporating an innovative indicator for the assessment of foreign engagements within a given country. While prior research examined FDI inflows in Latin countries after the TRIPS agreement, we explore an unexplored dilemma of how stronger IPRs affect two knowledge channels in developing countries: foreign and domestic innovation activity. Together, this analysis presents an original approach to enhancing our understanding of the moderating effect of strong IPR protection in developing countries. Our findings may offer additional information for policymakers to comprehend and establish the most suitable level and applicability of IPRs in developing countries.

The remainder of the paper is structured as follows. Section 2 presents the literature review and hypotheses. Section 3 describes the methodology. Section 4 outlines the empirical results. Section 5 discusses the findings and provides relevant policy recommendations, discusses research limitations, and highlights future research directions. Finally, Section 6 concludes with a summary of the main findings.

2. Literature review

2.1. Institutional economics of intellectual property rights

Modern institutional economics originated from the idea that a country's institutional framework influences and regulates business and economic activities in multiple ways (North, 1990). In this sense, the economic literature inherently acknowledges that a range of institutions contributes to success and economic welfare (Chang, 1994). Supporting this notion, a country's formal and informal institutional framework has the ability to promote and shape how companies conduct their activities by reducing market imperfections (Cuervo-Cazurra et al., 2019). More specifically, patents represent a legal institutional safeguard that generally ensures knowledge protection and an exclusive right for inventors for a limited period (Hall, 2007), enhancing their innovative activities and returns from innovations (Kafouros et al., 2015).

Beyond being effective solely in motivating local innovation (Arshed et al., 2022), FDI inflows to developing countries are associated with significant IPR reforms (Klein, 2018). In this context, strong IPRs decrease the likelihood of copying and imitation (Tebaldi and Elmslie, 2013), enabling foreign companies to invest abroad with reduced uncertainty of knowledge expropriation to local industries (Peng et al., 2017). This is because weak IP protection in developing countries allows unauthorised access for local companies to merely copy innovations without permission and legal enforcement (Lorenczik and Newiak, 2012). Against this market failure, strong IPRs play a crucial role in assisting foreign companies to gain returns from their innovative activities in host countries without knowledge infringement (Christopoulou et al., 2021).

Over the past decades, international agreements have emerged with significant interest in strengthening the legal aspects of IPRs to foster innovation and economic growth (Cui et al., 2022). Globally, IP mechanisms have been established as an evolutionary process influenced by the world trade organization (WTO) in coordination with the world intellectual property organization (WIPO) to address IPR issues (Papageorgiadis and McDonald, 2019). Specifically, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) plays a crucial role in supporting knowledge trade, innovation, and creativity, as well as resolving IP disputes between countries (Brandl et al., 2019). In this context, IPR policy becomes a key component of formal regulatory institutions governed by laws and contract enforcement that facilitate proper business conduct (Cuervo-Cazurra et al., 2019).

To reinforce IPR regulations, governmental authorities (e.g., United States trade representative – USTR) have developed trade policies, namely "special issues" to issue alerts and sanctions in cases of misconduct or violations related to trading-associated IPR activities (Smarzynska-Javorcik, 2004). As an informal legal institution (i.e., based on ethics, traditions, and values) (Cuervo-Cazurra et al., 2019), the USTR annually publishes the "Special 301 report", which is a global advisory report that assesses countries' IP practices and categorizes judged acts and potential trade violations into the "Watch List" or "Priority Watch List" (Arza et al., 2023). In essence, the USTR (i.e., Law in practice) focuses on complementing formal institutions (i.e., Law on the books, like TRIPS), aiming to prevent possible misconduct in trade agreement compliance (Papageorgiadis and McDonald, 2019).

In this context, numerous studies investigating the implications of IPRs in developing countries suggest that strong patent protection is imperative for firm innovation activities and spurring economic growth (e.g., Khoury and Peng, 2011; Khoury et al., 2014; Peng et al., 2017; Christopoulou et al., 2021; Uyar et al., 2021). On the other hand, another group of researchers argues that a stronger IP regime is unfavorable for several developing countries (Hudson and Minea, 2013; Kim et al., 2012; Arshed et al., 2022; Su et al., 2022). Part of this debate arises from the observation that applying strong IPR policies from advanced countries may not yield the same effects in developing countries (Chang, 2002; Arza et al., 2023). Specifically, an excess of rigid rules and regulations (e.g., property rights and contract laws) hampers the smooth and effective operation of markets (Chang, 1994), potentially inhibiting innovative activities (Brüggemann et al., 2016).

Despite the attention that the effects of IPR policy have garnered in recent decades, the current empirical literature still presents conflicting and inconclusive views regarding the benefits of stronger IPR regimes (Hall, 2007; Neves et al., 2021). To contribute to this debate and enhance our understanding of increasing IPR protection in developing countries, it is crucial to advance this discussion. Furthermore, exploring the effects of increasing IPRs on two types of knowledge sources – domestic and foreign innovation – to achieve higher economic activity is essential. Therefore, we initiate the discussion with a primary focus on the effects of IPRs on economic activity.

2.2. Intellectual property rights and the country's economic activity

IPR has become a major institutional pillar for supporting technological progress and achieving higher economic development. Overall, patent enforcement can directly influence the economic growth of both developed and developing countries (Zhang et al., 2015; Alexiou et al., 2016). In this context, previous research has stated that IPR regulations function as transparent and fair tools to sustain innovation, particularly by increasing the rate of patent applications (Papageorgiadis and Sharma, 2016). More explicitly, legal IP regulations motivate the development of innovation and confer additional returns to incumbents engaged in knowledge activities (Bogliacino and Ramos, 2008; Cui et al., 2022).

However, another perspective argues that rigorous IPR protection does not always guarantee higher economic growth in transition and developing countries (Krammer, 2015; Liu, 2016). For instance, stringent IPRs may not lead to promising economic growth when the knowledge base is underdeveloped (Kim et al., 2012; Sweet and Eterovic, 2019). In this sense, a minimum level of knowledge capacity is a prerequisite for determining economic growth (Stel et al., 2019). This is confirmed by Sweet and Maggio (2015), who demonstrated that only countries with an initially above-average level of development can enhance economic complexity through strong IPR regulations. Thus, strong IPR protection can be detrimental when the knowledge structure is weak, manifesting in copying and imitative behavior (Lorenczik and Newiak, 2012). Importantly, the opposing view regarding IPR protection in developing countries stems from its ability to reduce illegal imitation (Lee et al., 2018).

In particular, an increasing cohort of researchers have commenced observing the non-linear impact of IPRs, indicating a relationship that takes the form of an inverted U, connecting IPRs and economic growth in developing countries (e.g., Allred and Park, 2007; Stel et al., 2019). This negative non-linear effect implies that, subsequent to reaching the turning point of the inverted U shape, robust IPRs reduce economic growth (Furukawa, 2007; 2010). Specifically, IPRs might exhibit varying curvilinear patterns based on their stages of economic development (Peng et al., 2017). When examining a sample of 62 countries, Hudson and Minea (2013) identified a positive connection between robust IPRs and innovation output, showing a U-shaped pattern.Nevertheless, their conclusion implies that IPRs assume a multifaceted role, as countries must possess an initial threshold of IP and GDP to foster growth. Subsequently, Su et al. (2022) put forth a comparative analysis to examine the connection between IPRs and productivity across 87 countries. The outcomes indicated that the least-developed countries do not experience advantages from stringent IPRs (inverted U-shaped pattern). This discovery aligns with the findings of Kim et al. (2012), who deduced that robust IPRs might not necessarily correlate with heightened economic growth in countries at early stages of development. Similarly, Arshed et al. (2022) recently unearthed substantial evidence of an inverted U-shaped relationship between legal institutions and a country's innovation. They arrived at the determination that the adverse curvilinear pattern persists even within countries at distinct stages of human development.

In summary, we propose that the current literature offers mixed evidence regarding the relationship between increasing IPRs and economic growth in developing countries. Despite the debates surrounding the strengthening of IPRs, we believe that, on the whole, developing countries within the Latin America and Caribbean region have notably advanced their economic development over time, thus substantiating the need for extended patent protection. Hence, considering the concept of non-linear effects, it is plausible to posit that there exists a positive non-linear relationship between IPRs and economic activity, indicating a U-shaped pattern. Therefore, we formulate the subsequent hypothesis:

Hypothesis 1. There is a U-shaped relationship between intellectual property rights protection and economic activity.

2.3. Moderating effects of IPR on country's economic activity

As previously mentioned, IPR serve as a legal mechanism that facilitates and fosters economic production (Papageorgiadis and Sharma, 2016). However, we argue that it is somewhat arbitrary to draw conclusions on the relationship between IPR protection and economic activity in a relatively uniform manner. Although the connection between IPRs and economic activity appears logical, there are still aspects requiring further comprehension concerning the moderating influences of IPRs on two distinct sources of knowledge within developing countries. In this context, strong IPR protection may exhibit different behaviors for domestic (Liu, 2016; Wu et al., 2017) and foreign innovation activities (Khoury and Peng, 2011; Alexiou et al., 2016). This relationship becomes complex because strong IPR policies benefit foreign companies in safely conducting their innovative activities in host countries (Belderbos et al., 2021; Albino-Pimentel et al., 2022), while strict IPR regimes might hinder domestic innovation (Bogliacino and Ramos, 2008; Cui et al., 2022). This occurs because developing countries still face a multitude of challenges that may involve the lack of technical knowledge as a prerequisite for innovating as well as deficient innovation systems to support a stringent IPR policy (Neves et al., 2021; Viglioni et al., 2020). From this point, we discuss this perspective in a deeper way to examine how the moderating role of IPRs affects both types of knowledge sources and the country's economic activity.

2.3.1. Moderating role of IPR on domestic innovation activity

Domestic innovation plays a vital role in THE potential for economic growth (Arshed et al., 2022). Scholars widely acknowledge patent applications (Gonçalves et al., 2021; Khoury and Peng, 2011), research and development (R&D) (Arrow, 1962; Bogliacino and Pianta, 2013), and quality education (Varsakelis, 2006). Moreover, the proportion of scientific and academic self-citations (Kafouros et al., 2015; Wu et al., 2017) is crucial for increasing domestic innovation. For example, Coe et al. (2009) demonstrated that countries with high-quality educational systems benefit from their R&D efforts. Their findings align with those of Varsakelis (2001), who showed that countries with strong patent protection are willing to invest more in R&D. In a separate study, Wang (2010) ascertained that tertiary education and scientific research yield favorable impacts on R&D intensity across 26 OECD countries. Utilizing a dataset encompassing 29 countries, Varsakelis (2006) similarly demonstrated that superior education fosters innovation outcomes, notably patent activity. Employing a detailed index to gage domestic innovation in Latin countries, Khoury and Peng (2011) deduced that indigenous scientific publications and patent applications enhance local innovation.

Regarding the effects of IPRs on domestic innovation, patent protection is an essential factor in protecting and fostering the creation of knowledge (Papageorgiadis and Sharma, 2016). As an illustration, Cho et al. (2015) documented that IPR protection yields positive outcomes for South Korean R&D-intensive companies that exhibit robust innovation capability and submit patent applications. Similarly, Lee et al.

(2018) found that stronger IPRs enable countries to capture more of the benefits of their R&D activities. Analyzing the Chinese subnational regions, Kafouros et al. (2015) prominently concluded that stronger IPRs stimulate local academic collaborations. Furthermore, Wu et al. (2017) discovered that strong IPRs have a positive effect in leading innovator countries. However, specific studies demonstrated a detrimental impact of IPRs on indigenous innovation. For example, previous research emphasizes that many developing countries do not have a sufficient knowledge structure to develop their own technology and invest in highly innovative products (Sweet and Maggio, 2015; Stel et al., 2019). In this sense, Wu et al. (2017) explain that too much IPR protection may hinder international patenting activities among emerging innovators. This is why, among other reasons, Lorenczik and Newiak (2012) reinforce that only countries with efficient R&D activities and high labor quality can take advantage of strong IPRs.

Among the group of developing countries, Latin American countries have started to invest in innovation and improve their economic conditions in recent decades (Crespi et al., 2014; Viglioni et al., 2020). Simultaneously, several institutional reforms (e.g., IPRs) have been implemented as well (Khoury et al., 2011, 2014). This leads us to challenge the idea that a strict IPR regime, that is, increasing IPR protection from low to high levels, will positively moderate the relationship between domestic innovation and the country's economic activity. Therefore, we propose the following hypothesis:

Hypothesis 2. The strengthening of intellectual property rights protection in developing countries positively moderates the relationship between domestic innovation and the economic activity of the country.

2.3.2. *Moderating role of IPR on foreign innovation activity*

From the perspective of foreign activity, studies typically assert that the technical effects associated with FDI inflows profoundly shape economic growth in developing countries, reflecting the knowledge and technological spillovers to local industries (Smarzynska-Javorcik, 2004). Essentially, foreign companies provide capital and introduce advanced knowledge embedded in high-technology products (Khoury and Peng, 2011). Additionally, FDI facilitates the interchange of specialized know-how (Cui et al., 2022) and new managerial and marketing skills (Kafouros et al., 2015). In particular, FDI inflows increase local competition (Kim et al., 2012; Krammer, 2015). In such cases, foreign competition helps domestic producers improve the quality standards of their products and reduce managerial inefficiencies (Cho et al., 2015; Gonçalves et al., 2021).

Governments in developing countries have sought ways to improve IPR regulations to attract more FDI inflows to stimulate the local economy and economic growth (Alexiou et al., 2016; Lee et al., 2018). As such, prior studies reinforce the view that IPRs are fundamental mechanisms for relatively increasing FDI inflows into developing countries (Khoury et al., 2011). As an illustration, employing data concerning outward FDI from the USA directed towards 42 host countries, Papageorgiadis et al. (2020) underscored that both formal and informal IP institutions facilitate FDI inflows. Recently, Albino-Pimentel et al. (2022) concluded that strong IPR regimes facilitate foreign R&D location choices. Investigating 103 countries during 1970–2009, Kashcheeva (2013) concluded that better IPRs facilitate FDI inflows to increase economic growth in developing countries. Nevertheless, the author arrived at the conclusion that strong IPR mitigates the growth effect of FDI when the local knowledge structure is insufficient. Lastly, in an exploration involving a sample of Western and Eastern countries, Kramer (2015) revealed that Western countries with a robust IPR framework favorably moderate the connection between consistent FDI inflows and domestic productivity. However, for Eastern economies, they observed a negative effect.

Considering the aforementioned discussion, we expect that a strong IPR regime is positive for foreign innovation activity, potentially increasing economic activity in developing countries. In such settings, we argue that foreign innovators have the legitimacy to operate their overseas investments in "strange waters," that is, without or with less risk of knowledge expropriation due to low IPR protection. Consequently, we expect that increasing IPR protection from low to high levels will positively moderate the relationship between foreign innovation and economic activity. Thus, we propose the following hypothesis:

Hypothesis 3. The strengthening of intellectual property rights protection in developing countries favorably moderates the relationship between local foreign innovation and the economic activity of the country.

3. Methodology

3.1. *Data*

We chose Latin America as the scope of research for several reasons. Constraining the examination to Latin countries aids in managing regional variability (Khoury and Peng, 2011). Regarding economic aspects, the United Nations conference on trade and development (UNCTAD) report showed that after East Asian countries, the Latin region became the largest recipient of FDI from 2013 to 2018 (UNCTAD, 2020). Throughout the past few decades, Latin America has consistently augmented its endeavors in R&D and innovation (Bogliacino and Ramos, 2008; Crespi et al., 2014). As outlined in the official report by *La Red de Indicadores de Ciencia y Tecnología-Iberoamericana e Interamericana* – RICYT (2019), the Latin region observed noteworthy investments in R&D, escalating from over US$43 billion in 2008 to approximately US $63 billion in 2017. Concerning the specifics of the IPRs, Latin countries experience weak and strong patent protection (Arza et al., 2023). For example, Chile is ranked among the top-tier IPR policies (Lee et al., 2018), while the Bolivarian Republic of Venezuela is bottom-ranked with an extremely low IPR profile (Papageorgiadis et al., 2013). Additionally, Brazil and Mexico have spearheaded a series of legal reforms over the past few decades (Maskus, 2015). Hence, the Latin region presents an exceptional empirical setting characterized by a blend of diverse levels of IPR within a shared economic context.

To test the hypotheses, we combined various data sources. First, we collected comprehensive data from the world development indicators (WDI) published by the World Bank (www.worldbank.org). The second dataset was provided by the RYCIT (http://www.ricyt.org) and the third comes from the Fraser Institute's Economic Freedom of the World 2015 dataset (https://www.fraserinstitute.org). The fourth was selected from the Penn World Table project database (PWT version 10.01) (https://www.rug.nl). The sample consists of 18 countries from Latin America, encompassing South America, Central America, and Caribbean regions (namely Argentina, Barbados, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and the Bolivarian Republic of Venezuela). The observation spans a period of 12 years, spanning from 2007 to 2018. Finally, it is necessary to mention that the choice of the period of analysis and the selection of countries are conditioned by the availability of data.

3.2. *Variables*

3.2.1. *Dependent variable*

The dependent variable measures economic activity. We adopted total factor productivity (TFP) as a proxy for economic activity (Coad and Vezzanic, 2019; Gonçalves et al., 2021; Su et al., 2022; Sweet and Eterovic, 2019). The TFP is directly computed from the penn world table (PWT) version 10.01 (for more comprehensive information, kindly refer to Feenstra et al., 2015, PWT 10.01). In line with Su et al. (2022), we adopted the CTFP (in current PPPs, USA = 1). We selected the CTFP (in current PPPs, USA = 1) instead of RTFP (in constant purchasing power parity or PPP, 2017 = 1) to measure the effects of economic activity as a form of productivity. In this case, the CTFP (in current PPPs, USA = 1) is advised for cross-country productivity comparisons, while the latter method is better suited for examining alterations in productivity over time (Coad and Vezzanic, 2019).

3.2.2. Independent variables

We examined two variables within the realms of country innovation. Initially, we adhered to the methodology endorsed by Khoury and Peng (2011, p. 340) to formulate the indicator of indigenous innovation. For the creation of this proxy variable, we employed the natural logarithm of the count of patent applications from local proprietors and the natural logarithm of scientific publications originating from within the country. Acknowledging the substantial correlation between these two variables, Khoury and Peng (2011) introduced an index that resolves this matter through the application of principal component analysis (PCA) on both underlying components. Adopting a similar technique, we executed a factor extraction and then conducted a varimax rotation (orthogonal) grounded in a squared loading matrix of each indicator. This resulted in the derivation of the "domestic innovation index," featuring a composite reliability score of 0.680, which closely approaches the recommended threshold of 0.7 (Hair et al., 2010). The second approach consists of foreign innovation activity, constructed based on two technologically related variables. We first selected the natural log of foreign patent applications in a given country, as high patent intensity from foreign applicants indicates better IPRs within the patent recipient country (Khoury et al., 2014). We chose the natural log of FDI inflows (billion USD) to capture the ability of a country to attract foreign capital and increase economic growth through technology transfer (Smarzynska-Javorcik, 2004; Hudson and Minea, 2013; Lee et al., 2018). Thus, a new proxy was created using the natural log sum of FDI inflows plus the natural log of foreign patent applications. Complementing the previous literature (i.e., Khoury and Peng, 2011) and applying the PCA method, we developed the foreign innovation index", with a composite reliability score of 0.92.

3.2.3. Moderating variable

Our moderating variable is a composite index that measures IPR protection. Su et al. (2022) recommend using several items from the "Institutional Pillar" provided by the global competitiveness report (GCR). Likewise, we exclusively considered the "Intellectual Property Protection, Index"sourced from the World Economic Forum (WEF, 2018). This index employs a reflective seven-point scale, ranging from 1 (least favorable) to 7 (most favorable), based on a survey evaluation of property rights protection (Uyar et al., 2021). Additionally, Yang and Maskus (2009) and Dussaux et al. (2022) suggested multiplying this index with the composite value constructed using several institutional elements from the Fraser Institute's Economic Freedom. This approach is similar to Park and Belderbos (2022), where the authors multiplied the well-known ginarte-park (GP) index with a measure of the enforcement of patent laws, the "Legal System & Property Rights Index". It is important to note that the "Intellectual Property Protection Index" from WEF shows gaps for all countries in the year 2010. To avoid losing data, we calculated the mean value using the subsequent and preceding values. In accordance with the recommendation of Dussax et al. (2022), we constructed the initial segment of the index relying on diverse constituents extracted from the Fraser Institute's legal system assessment, encompassing factors such as contracts, judicial independence, impartial courts, and the integrity of the legal system. This portion of the index exhibits a composite reliability score of 0.83. Then, we multiplied the "Intellectual Property Protection Index" from WEF with the prior composite measure to obtain the IPRs index.

3.2.4. Control variables

Several control variables that may influence economic activity were included. Trade openness was operationalized as the ratio of exports and imports over GDP (Hudson and Minea, 2013), as international trade is a significant driver of knowledge exchange between countries (Gonçalves et al., 2021). ICT exports as a percentage of total exports were added to account for a certain degree of technology (Papageorgiadis and Sharma, 2016). Average prices of goods and services were controlled using the annual inflation GDP deflator, and personal remittances received over GDP were considered as a source of household income (Piteli et al., 2021). The labor force, measured as the percentage of individuals in the total population aged between 15 and 64 years, aimed to capture human capital (Su et al., 2022). Health expenditures over GDP were included as a source of wealth and social context (Papageorgiadis et al., 2016). Gross fixed capital formation over GDP was controlled because physical capital is directly related to economic growth (Arshed et al., 2022). GDP growth rates were considered to account for differences in economic development (Kim et al., 2012). Urbanization was accounted for by considering the urban population as a percentage of the total population (Wu et al., 2017). A *de jure* legal protection "Law on the books", represented by TRIPS was selected and assumed a value of 1 based on the year of acceptance in TRIPS (Khoury and Peng, 2011). An informal institution, USTR's Special 301, was included as a measure of *de facto* enforcement "Law in practice" (Papageordiadis et al., 2020), assuming a value of 1 for countries on priority and watch lists (Smarzynska-Javorcik, 2004). According to the World Bank classification, a yearly dummy variable equal to 1 was included for high-income countries to capture income variations (Maskus, 2015). Finally, a dummy variable was added to capture time-specific effects. A summary of all variables, definitions, and sources is provided in Table 1.

Table 1
Definition, measurement and source of variables.

Variables	Acronym	Measurement	Source
Total Factor Productivity	TFP	Economic activity is measured as the total factor productivity (TFP) (Feenstra et al., 2015; PWT 10.0)	PWT
Domestic innovation	DI	The innovation base index (Khoury and Peng, 2011, p. 340)	WDI and RICYT
Foreign innovation	FI	Created using the PCA between (ln FDI inflows + ln foreign patent applications)	WDI and RICYT
IPR	IPR	Measures the country's IPR protection	WDI and Fraser Institute
Trade openness	TR	Exports and imports as% of GDP	WDI
High-tech exports	ICT	ICT exports as a% of total exports	WDI
Inflation	IF	Inflation as consumer price rates	WDI
Remittances	RE	Personal remittances inflow as% of GDP	WDI
Labor force	LF	Labor force participation rate between 15 and 64 years	WDI
Health expenditures	HE	Health expenditures as% of GDP	WDI
Capital	CF	Gross fixed capital formation as% of GDP	WDI
GDP growth	GDP	GDP growth rate	WDI
Urbanization	URB	Urban population as% of the total population	WDI
TRIPS	TRIPS	A dummy variable that assumes the value of 1 based on the year of acceptance on TRIPS agreement; 0 otherwise	WTO
USTR Special 301	USTR	A dummy variable that assumes the value of 1 based country on watch and priority watch list; 0 otherwise	USTR
High income	IC	A yearly dummy variable that assumes the value of 1 for high income (HI) economy = 1 and 0 otherwise	WDI
Time dummy	—	Years dummy variable from 2007 to 2018	—

3.3. Estimation methods

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

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

Where $Y_{i,t}$ is the dependent variable for country i at time t. Driscoll-Kraay considers a panel and time-specific vector of N cross-sectional units, while X represents the matrix of independent variables over time T. Driscoll-Kraay robust standard errors are a non-parametric approach used for short- and long-run panels, as well as balanced and unbalanced panels, to account for heteroscedasticity, serial autocorrelation, and cross-sectional dependence (Driscoll and Kraay, 1998). Initially, the Hausman test is employed to choose the most appropriate specification model between random-effects and fixed-effects. The Hausman test favors the random-effects (RE) specification (Prob>chi2 = 16.75, p-value > 0.2697). The Driscoll-Kraay standard errors by the random-effects estimator are given as follows:

$$Y_{i,t} = \beta_0 + \overline{X}_{i,t}\beta_1 + \left(X_{i,t} - \overline{X}_{i,t}\right)\beta_2 + \beta_n + \varepsilon_{i,t} \quad (2)$$

The random-effects are generated by the weighted matrix average value of an individual X coefficient ($X_{i,t} - \overline{X}_{i,t}$) of N observations in time T between and within estimator regressors (Hoechle, 2007). Accordingly, the random-effect estimates the intercept by the yearly average of the cross-sections of country i at time t, addressing cross-sectional and temporal dependence with more efficiency. Furthermore, the random-effect model is more suitable when the fixed-effect estimator produces inflated standard errors when variables exhibit little variation within units (Kafouros et al., 2015). The functional form of the basic empirical model is outlined as follows:

$$TFP_{i,t} = \beta_0 + \beta_1 DI_{i,t} + \beta_2\ FI_{i,t} + \beta_3 IPR_{i,t} + \beta_4 IPR^2{}_{i,t} + \beta_5\ DI_{i,t} * IPR_{i,t} + \beta_6 FI_{i,t} * IPR_{i,t} + \beta_n K^{'}{}_{i,t} + \gamma_t + \varepsilon_{i,t} \quad (3)$$

Where the dependent variable is TFP_t and $_t$ displays country i at time t. The intercept parameter is denoted by β_0. The independent variables are domestic innovation ($DI_{i,t}$) and foreign innovation activity ($FI_{i,t}$). IPR is represented in linear form ($IPR_{i,t}$) and squared term ($IPR_{i,t}{}^2$) to test non-linearities. Interaction terms are symbolized by domestic innovation and IPR ($DI_{i,t}*IPR_{i,t}$) and foreign innovation and IPR ($FI_{i,t}*IPR_{i,t}$). The parameter $\beta_n K'_{i,t}$ is a vector of control variables. Finally, γ_t denotes time effects, and the ε_{it} refers to the general error term.

4. Results

4.1. Diagnostic tests

Given the relatively short time panel dimension used in this research, additional tests were conducted to identify common econometric issues associated with macroeconomic variables across different countries. These issues include cross-sectional dependence, serial correlation, and heteroscedasticity. A test was conducted to analyze the properties of cross-sectionally dependent panel data based on Pesaran's test (2015; 2021). This test aims to detect cross-sectional dependence-related problems, particularly when countries from the same region experience economic and social shocks that can impact one another. The Pesaran CD test results, presented in Table 2, generally reject the null hypothesis of weak cross-sectional dependence (except for the IPRs variable). The CD statistics suggest that our estimates require an appropriate technique to address cross-sectional dependency and prevent biased estimates.

Autocorrelation and group-wise heteroscedasticity were examined using the Wooldridge test (Wooldridge, 2010) and the Modified Wald test (Baum, 2000), respectively. Both tests showed highly significant statistic values for autocorrelation (F-statistic = 65.518, $p \leq 0.01$) and heteroscedasticity ($\chi^2 = 180.77$, $p \leq 0.01$). To address these issues, the analysis employed the Driscoll-Kraay robust standard error method (Driscoll and Kraay, 1998), which is effective in correcting cross-sectional dependence, autocorrelation, and heteroscedasticity in panel data (Hoechle, 2007). To ensure the robustness of the results, the main model was also re-estimated using the robust two-stage least squares (2SLS) with instrumental variable (IV) (Baum et al., 2007; Bogliacino and Pianta, 2013) and the robust two-step Generalized Method of Moments (GMM) to address endogeneity and serial correlation issues within countries (Piteli et al., 2021).

Table 2
Cross-sectional dependence panel test.

Variables	Pesaran (2015, 2021) CD statistic test
TFP	2.90***
DI	11.34***
FI	5.73***
IPR	–0.76
TR	19.31***
ICT	6.80***
IF	9.17***
RE	17.89***
LF	2.48**
HE	6.52***
CF	3.19***
GDP	24.70***
URB	33.27***

Notes: ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$. The CD test LM for IPR is highly significant (256.37, $p \leq 0.01$) for CDw+ with power enhancement from Fan et al. (2015), suggesting that strong cross-section dependence tends appear in a large cross-section number of observations over groups.

4.2. Regression analysis

Table 3 presents the pairwise correlations among explanatory variables. Despite coefficients between pairs not showing close correlation and not exceeding the threshold of 0.70, the Variance Inflation Factor (VIF) test was conducted to address concerns of multicollinearity in the raw data. VIF scores indicated that the highest VIF and average were 4.97 and 2.73, respectively. All values were below the critical threshold of 10 (Hair et al., 2010), confirming the absence of multicollinearity among selected variables.

The results of the main regression estimates are presented in Table 4. Model 1 serves as the baseline model with only control variables. Model 2 examines the linear effect of IPRs. Model 3 tests Hypothesis 1, suggesting a curvilinear relationship between IPRs and countries' economic activity. Model 4 and 5 test Hypotheses 2 and 3, respectively, focusing on the moderating role of IPRs between each source of innovation activity (domestic innovation [Model 4] and foreign innovation [Model 5]) and economic activity.

In Model 3, estimation results show that the linear coefficient of IPR is positive and significant (β = 0.016, $p \leq 0.01$), while the squared term is negative and significant (β = −0.003, $p \leq 0.01$). This outcome indicates a negative and non-linear effect, implying an inverted U-shaped pattern ($\beta_3 > 0$ and $\beta_4 < 0$), which suggests a monotonically negative relationship between IPRs and economic activity. The slope of the curve initially increases until reaching a turning point, after which it declines with increasing IPR protection. Thus, economic activity initially rises with weak IPR institutions and subsequently falls with better IPR protection. This leads us to reject Hypothesis 1.

To confirm the existence of an inverted U-shaped pattern, an additional test was conducted using the "utest" command in STATA 15, as proposed by Lind and Mehlum (2010). This test validates the three-step procedure based on non-linearity significance, the presence of an extreme point, and the turning point positioned between the maximum and minimum values in the data range intervals (Lind and Mehlum, 2010). Fieller's standard error test (Fieller, 1954) at 95% and 99%

Table 3
Pairwise correlations with descriptive statistics.

Variables	Mean	S.D.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) TFP	0.596	0.166	1.000												
(2) DI	0.000	1	0.363***	1.000											
(3) FI	0.000	1	0.369***	0.505***	1.000										
(4) IPR	0.533	3.457	0.238***	0.624***	0.056	1.000									
(5) TR	67.241	28.804	−0.104	−0.240***	−0.448***	−0.074	1.000								
(6) ICT	2.667	5.712	0.233***	0.130*	0.214***	0.108	0.222***	1.000							
(7) IF	7.191	7.776	0.180***	0.135*	0.052	−0.165**	−0.235***	−0.092	1.000						
(8) RE	4.428	5.530	−0.570***	−0.557***	−0.525***	−0.210***	0.460***	−0.177**	−0.151**	1.000					
(9) LF	69.600	4.850	−0.075	0.230***	−0.079	0.342***	−0.129*	−0.288***	−0.182***	−0.337***	1.000				
(10) HE	6.895	1.342	0.279***	0.537***	0.285***	0.182***	−0.133*	−0.101	0.287***	−0.182***	−0.033	1.000			
(11) CF	21.966	4.970	0.105	−0.067	0.060	−0.355***	0.522***	0.199***	−0.213***	0.084	−0.152**	−0.139**	1.000		
(12) GDP	3.268	3.203	0.250***	−0.257***	0.093	−0.206***	0.208***	0.075	−0.166**	−0.079	−0.026	−0.176**	0.359***	1.000	
(13) URB	70.317	16.613	0.371***	0.481***	0.693***	0.008	−0.569***	0.064	0.374***	−0.582***	−0.060	0.249***	0.005	0.122*	1.000

Notes: *** $p \le 0.01$, ** $p \le 0.05$, * $p \le 0.10$.

confidence levels indicates that the curvilinear relationship turns when IPR protection reaches an extreme point (turning point) of 2.548, with 95% Fieller confidence intervals (CI = [1.922, 4.463]) and an overall "utest" (t-value = 3.12; $p \le 0.01$). Additionally, the 99% Fieller confidence intervals for the curve are CI = [1.746, 8.364]. Furthermore, the range of slope at both low-end and upper-end percentiles was significant ($p \le 0.01$) (refer to Table 5). In this scenario, the vertex of the parabola lies within the IPRs interval (CI = [−5.788, 8.547]), and the slope reaches its peak when IPRs hit the maximum turning point of 2.548 (see Fig. 1, red line), indicating the start of a decreasing trend in economic activity. Consequently, this finding supports the alternative hypothesis of an inverted U-shaped relationship between IPR protection and economic activity.

Model 4, which examines the moderating role of IPRs on the relationship between domestic innovation and economic activity, reveals that the interaction of the linear term is negative and significant (β = −0.023, $p \le 0.01$), while the interaction of the square term is positive and significant (β = 0.007, $p \le 0.01$). These results suggest that weak IPR protection reduces domestic innovation, whereas strong IPRs enhance domestic innovation. Interestingly, these results counter the main arguments put forth in Hypothesis 1, allowing us to accept Hypothesis 2.

To provide greater clarity, we examine the marginal effects of both domestic and foreign innovation on economic activity. Fig. 2 and Fig. 3 depict the marginal effects of domestic and foreign innovation on economic activity across various percentiles of IPRs and IPRs squared (Models 4 and 5). To enhance understanding of the estimates (refer to Table 6), we have considered the following percentile intervals: the 10th percentile, 25th percentile, 50th percentile, 75th percentile, and 90th percentile. The marginal effects of domestic innovation on economic activity at different percentile values of IPRs are as follows: −3.083 (10th), −1.335 (25th), 0.161 (50th), 3.299 (75th), and 5.522 (90th). Furthermore, the marginal effects at percentile values of IPRs squared are 0.075 (10th), 0.350 (25th), 3.160 (50th), 18.988 (75th), and 31.017 (90th). Overall, the coefficients for the marginal effects of domestic innovation on economic activity at the percentile values of IPRs and IPRs squared are statistically significant at both the lower and upper percentiles.

In terms of the moderating role of IPRs on the relationship between foreign innovation and economic activity, Model 5 demonstrates that the linear term of IPRs has a negative and significant effect (β = −0.031; $p \le 0.01$), while the squared term is positive (β = 0.004; $p \le 0.01$). This result aligns with our expectations and supports Hypothesis 3. Additional insights are gained from Fig. 3, illustrating the marginal effect of foreign innovation. At percentile values of IPRs, the marginal effect of foreign innovation on economic activity was −3.007 (10th), −1.258 (25th), 0.208 (50th), 4.130 (75th), and 5.762 (90th). Correspondingly, the marginal effect at percentile values of IPRs squared were 0.094 (10th), 0.438 (25th), 3.238 (50th), 20.298 (75th), and 33.507 (90th). Overall, coefficients for the marginal effect of foreign innovation were statistically significant at lower and upper percentile values of IPRs and IPRs squared (refer to Table 6). Additionally, domestic innovation exhibited slightly more variable changes at strong IPRs, whereas foreign innovation demonstrated higher variability at weak IPRs.

Concerning control variables, trade showed significant positive association with economic activity. As expected, GDP growth had a positive impact on the country's economic activity. Conversely, remittance inflows had negative effects, indicating that inflows of money to residents negatively influenced productivity. Importantly, the negative significance of the labor force possibly indicated productive inefficiencies. It's noteworthy that, in general, the impact of TRIPS on economic activity was slight.

4.3. Robustness checks

To assess the robustness of our initial results, we pursued an

Table 4
Driscoll-Kraay Robust Standard Errors Regression Results.

Dependent variable TFP	Model 1	Model 2	Model 3	Model 4	Model 5
DI				–0.058***	
				(0.013)	
FI					–0.004
					(0.025)
IPR		0.011***	0.016***	0.010	–0.003
		(0.002)	(0.002)	(0.008)	(0.005)
IPR squared			–0.003***	–0.003***	–0.000
			(0.001)	(0.000)	(0.000)
DI*IPR				–0.023***	
				(0.006)	
DI*IPR squared				0.007***	
				(0.002)	
FI*IPR					–0.031***
					(0.003)
FI*IPR squared					0.004***
					(0.001)
TR	0.002**	0.001	0.001*	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ICT	–0.001**	–0.003**	–0.003***	–0.003*	–0.005***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
IF	0.003	0.004**	0.004**	0.005***	–0.001
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
RE	–0.018***	–0.018***	–0.021***	–0.016***	–0.024***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
LF	–0.013***	–0.014***	–0.014***	–0.015***	–0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HE	–0.004*	–0.005	0.001	0.011	0.014***
	(0.002)	(0.003)	(0.003)	(0.008)	(0.004)
CF	–0.003	0.001	0.001	0.005	0.003
	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)
GDP	0.013***	0.015***	0.013***	0.015***	0.010***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)
URB	0.002**	0.001	0.001	0.000	–0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
TRIPS	0.050*	0.061*	0.043	0.052*	0.080**
	(0.029)	(0.030)	(0.031)	(0.026)	(0.031)
USTR	–0.053	–0.050	–0.050	–0.035	–0.087**
	(0.031)	(0.034)	(0.033)	(0.036)	(0.041)
IC	0.101***	0.051	0.092***	0.037	0.076**
	(0.026)	(0.030)	(0.031)	(0.037)	(0.029)
_const	1.334***	1.447***	1.451***	1.429***	1.732***
	(0.070)	(0.069)	(0.068)	(0.117)	(0.088)
Time-year dummy	Included	Included	Included	Included	Included
Observations/countries	205/18	205/18	205/18	168/18	177/18
Prob > F	2293.79***	9274.43***	5327.15***	5914.99***	8485.67***
R-squared	0.5940	0.6130	0.6494	0.7388	0.7135

Notes: Driscoll and Kraay robust standard errors are provided in parentheses. ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$.

Table 5
Test monotonic curve – Utest specification.

Dependent variable (TFP)	Model 3
Slope of IPR (lower bound)	–5.788
Slope of IPR (upper bound)	8.547
$P>\|t\|$ (lower bound)	0.01
$P>\|t\|$ (Upper bound)	0.01
Extreme point	2.548
95% Fieller Confidence Interval	[1.922; 4.463]
99% Fieller Confidence Interval	[1.746; 8.364]
Overall test of presence of an inverse U-shape:	
Presence of U shape	H1: Inverse U-shape vs. H0: Monotone or U-shape
t-value	3.12
$P>\|t\|$	0.01

Notes: Overall test of presence of inverse-U shape is based on Model 3 using the Driscoll-Kraay robust standard errors.

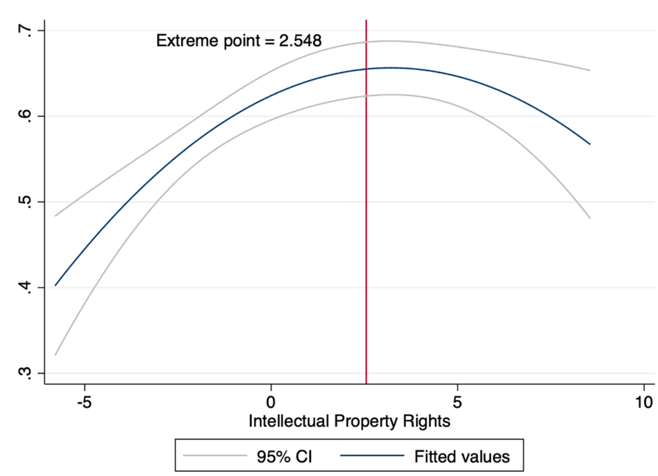

Fig. 1. The Inverse U-shaped relationship between IPRs and the economic activity.

alternative approach. We utilized the 2SLS/IV estimator with the “ivreg2” package in STATA 15, employing the robust option to account for heteroscedasticity (Baum et al., 2007). While finding valid external

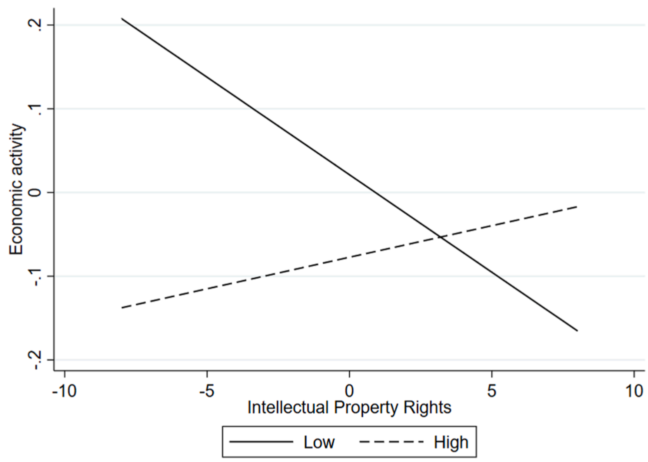

Fig. 2. Marginal effects of domestic innovation on economic activity at lower and higher IPRs.

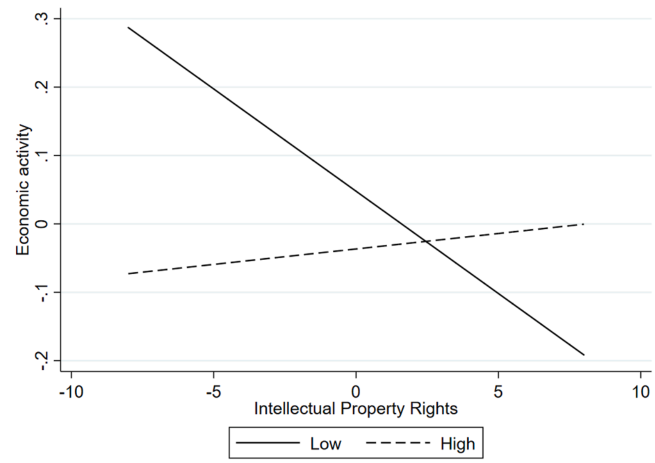

Fig. 3. Marginal effects of foreign innovation on economic activity at lower and higher IPRs.

Table 6
Marginal effects of IPRs and IPRs squared.

Percentile values	Domestic innovation and IPRs Coefficients	Percentile values	Domestic innovation and IPRs squared Coefficients
10th percentile	0.093**(0.041)	10th percentile	–0.077***(0.016)
25th percentile	0.052*(0.033)	25th percentile	–0.075***(0.016)
50th percentile	0.017(0.030)	50th percentile	–0.053***(0.018)
75th percentile	–0.055*(0.032)	75th percentile	0.066(0.048)
90th percentile	–0.107***(0.040)	90th percentile	0.156**(0.075)
Percentile values	Foreign innovation and IPRs Coefficients	Percentile values	Foreign innovation and IPRs squared Coefficients
10th percentile	0.137***(0.026)	10th percentile	–0.036**(0.018)
25th percentile	0.085***(0.023)	25th percentile	–0.034*(0.018)
50th percentile	0.041**(0.020)	50th percentile	–0.022(0.017)
75th percentile	–0.076***(0.019)	75th percentile	0.055**(0.024)
90th percentile	–0.125***(0.022)	90th percentile	0.115***(0.036)

Notes: Marginal effects based on Table 4 (Model 4 and 5); Robust standard errors are provided in parentheses. $^{***}p \leq 0.01$, $^{**}p \leq 0.05$, $^{*}p \leq 0.10$.

instruments for the model is challenging (Gonçalves et al., 2021), we meticulously selected appropriate matrices of instrumental variables (Piteli et al., 2021) to address endogeneity, omitted-variable bias, and potential generalizations, considering not only the lag of endogenous variables but also the total population (Papageorgiadis and Sharma, 2016) and the human capital index from the PWT (Gonçalves et al., 2021) as instruments for domestic innovation infrastructure. Following the recommendations of prior studies, we employed the lagged values of FDI inflows (in current US dollars) and GDP (in current PPPs, USA = 1) as instruments for foreign innovation (Piteli et al., 2021). Additionally, we included "Protection of Property Rights" from the Fraser Institute and political stability from the Worldwide Governance Indicators (Khoury et al., 2014) as suitable instruments for IPRs. Following Bogliacino and Pianta (2013) and to maintain robustness, we included the same matrices of instruments from the 2SLS/IV approach into the two-step GMM equations, controlling for the size of the adopted instruments. The key results of the 2SLS/IV and two-step GMM regressions are displayed in Table 7.

The 2SLS/IV method aligns with the Driscoll-Kraay regression. The Cragg-Donald Wald F-statistic significantly exceeds the 10% tolerance threshold of critical values from Stock–Yogo (2015), suggesting the validity of the instruments. The Sargan and Hansen J-statistics confirm the validity of the selected instruments. The presence of an inverted U-shaped curve remains robust in the 2SLS/IV estimates, indicating that the curvilinear relationship shifts when IPRs reach the extreme point of 3.365, with a 95 percent confidence interval of CI =[2.319, 4.969], and an overall "utest" (t-value = 3.71; $p \leq 0.01$). In terms of the moderating effects of IPRs, the robustness of the non-linear interactions significantly impacts both domestic and foreign innovation.

5. Discussion

5.1. *Findings*

In recent decades, the institutional theory framework has become pivotal in explaining a country's economic growth and development (North, 1990). In this context, IPR protection aids in mitigating the vulnerabilities of the legal environment in many developing countries (Peng et al., 2017). Nonetheless, the prior literature on IPRs has yielded mixed conclusions over years of uncertainty about the advantages of strengthening IPRs in developing countries (Cho et al., 2015; Lee et al., 2018; Cui et al., 2022; Su et al., 2022). In an endeavor to provide clarity on this matter, our findings offer new and valuable insights into the relationship between IPR protection and economic activity within the Latin American context. Specifically, our research paints a picture of how IPR protection moderates the interplay between two knowledge sources: domestic and foreign innovation activities.

Although the business and economics literature views IPR as an effective tool for fostering innovation and economic growth (Kafouros et al., 2015; Wu et al., 2017), our study reveals that IPR exerts a negative influence on the economic activity of Latin America and the Caribbean countries (inverted U-shape). Contrary to our expectations, this finding is intriguing as many developing countries exhibit positive productivity in the presence of strong IPRs (Su et al., 2022) or even negligible effects (Sweet and Eterovic, 2019). The productivity outcome aligns with the findings of Furukawa (2007; 2010), suggesting that robust IPRs do not invariably guarantee higher economic growth in developing countries. This negative effect is concerning, particularly since it is more likely to manifest in low-income countries (Su et al., 2022). Consequently, after more than a decade of international pressure to safeguard and promote knowledge-related activities, the economies of Latin America have demonstrated insufficient productivity gains from robust IPRs.

Table 7
Results of 2SLS/IV and Two-Step GMM regressions.

Dependent variable TFP	2SLS/IV regression				Two-Step GMM regression		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
L1.TFP (lagged)					0.912***	0.859***	0.904***
					(0.016)	(0.028)	(0.015)
DI			–0.122***			–0.016**	
			(0.021)			(0.007)	
FI				–0.053***			–0.009**
				(0.017)			(0.004)
IPR	0.017***	0.027***	0.019***	0.003	0.003**	0.005***	0.002
	(0.004)	(0.005)	(0.005)	(0.006)	(0.001)	(0.002)	(0.001)
IPR squared		–0.004***	–0.003***	–0.002	–0.001**	0.000	0.000
		(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
DI*IPR			–0.034***			–0.006***	
			(0.007)			(0.002)	
DI*IPR squared			0.008***			0.001**	
			(0.001)			(0.000)	
FI*IPR				–0.028***			–0.002*
				(0.006)			(0.001)
FI*IPR squared				0.004***			0.000***
				(0.001)			(0.000)
TR	0.001*	0.001***	0.001	0.001	0.000	–0.000	–0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ICT	–0.004**	–0.005***	–0.003**	–0.005***	–0.000	–0.001	–0.000
	(0.002)	(0.002)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)
IF	0.005***	0.005***	0.005***	–0.000	0.001***	0.002***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
RE	–0.019***	–0.021***	–0.019***	–0.026***	–0.001**	–0.002***	–0.002***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.000)	(0.001)	(0.001)
LF	–0.015***	–0.015***	–0.015***	–0.017***	–0.001***	–0.002***	–0.001**
	(0.002)	(0.001)	(0.002)	(0.001)	(0.000)	(0.001)	(0.001)
HE	–0.006	0.002	0.022**	0.018***	0.002	0.003	0.003*
	(0.005)	(0.006)	(0.010)	(0.006)	(0.001)	(0.002)	(0.002)
CF	0.002	0.004	0.006***	0.004*	–0.001	0.001	0.000
	(0.003)	(0.003)	(0.002)	(0.002)	(0.000)	(0.001)	(0.000)
GDP	0.016***	0.014***	0.009***	0.008**	0.006***	0.007***	0.005***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.001)	(0.001)	(0.001)
URB	0.000	–0.000	0.001	0.001	–0.000	0.000	–0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
TRIPS	0.066**	0.046	0.043	0.075**	0.005	0.011	0.002
	(0.029)	(0.030)	(0.030)	(0.034)	(0.007)	(0.008)	(0.006)
USTR	–0.048*	–0.048	–0.022	–0.072**	–0.012*	–0.009	–0.000
	(0.031)	(0.031)	(0.028)	(0.033)	(0.007)	(0.008)	(0.006)
IC	0.013	0.055**	0.050	0.073***	–0.006	0.004	–0.009
	(0.029)	(0.027)	(0.040)	(0.023)	(0.007)	(0.013)	(0.008)
_const	1.532***	1.562***	1.257***	1.664***	0.133***	0.202***	0.116***
	(0.175)	(0.161)	(0.185)	(0.151)	(0.046)	(0.048)	(0.040)
Time-year dummy	Included	Included	Included	Included	Included	Included	Included
Observations/countries	205/18	205/18	168/18	163/18	188/18	154/18	163/18
Prob > F	28.83***	25.70***	29.58***	22.63***	667.95***	526.99***	564.40***
Centered R-squared	0.6023	0.6283	0.7093	0.7118			
Cragg-Donald Wald F	136.672	105.471	61.965	54.517	82.333	39.870	56.341
Stock-Yogo weak ID test (10%)	19.93	19.93	19.93	19.93	19.93	19.93	19.93
Sargan statistic (p-value)	0.1670	0.3641	0.1787	0.4451			
Arellano-Bond test for AR(1)					0.6397	0.9626	0.4330
Arellano-Bond test for AR(2)					0.9275	0.5700	0.3708
Hansen J statistic (p-value)					0.1613	0.6921	0.1873

Notes: Robust standard errors are in parentheses. ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$. GMM estimated by "ivreg2, gmm2s endog (), robust".

A pivotal implication is that not all Latin countries are receptive to IPR-friendly policies. Thus, there are limitations to intensifying IPRs, potentially due to divergences in productive factors. For instance, in low-income countries, patents or licensing elevate business costs, thereby increasing overall production expenses (Kim et al., 2012). This is why imitation through reverse engineering, copying, and emulating may be preferable in less developed countries with weak IP protection (Lorenczik and Newiak, 2012; Steel et al., 2019). Notably, early-stage local industries, as observed in China and other East Asian economies, extensively leveraged foreign knowledge before embracing a pro-IPR stance (Branstetter and Saggi, 2011; Peng et al., 2017). This underscores the notion that the impact of strong IPRs could differ across developing countries (Arza et al., 2023). Therefore, strong IPR policies may not hold the same value as they do in more advanced countries (Chang, 2002), and a "one-size-fits-all" approach is suboptimal (Hall, 2007), further underscoring the paradox of fostering innovation (Brüggemann et al., 2016). Consequently, strong IPR regimes might backfire due to substantial structural differences in technological and productive endowments among low- and middle-income countries (Crespi et al., 2014), while only a handful of Latin countries are technologically oriented toward innovation (Viglioni et al., 2020). Hence, companies with a limited technological orientation may have a less significant role in enhancing economic activity under high IPR protection.

Specifically, our focus was on the impact of IPRs on two simultaneous sources of innovation, namely domestic and foreign innovation activities (Khoury and Peng, 2011; Wu et al., 2017). Concerning the moderating role of IPR protection, heightened IPRs exert a meaningful and positive influence on the connection between domestic innovation and economic activity, serving as a favorable incentive for native industries investing in knowledge-related endeavors. This outcome contradicts prevailing literature that suggests developing countries generally lack the necessary knowledge base to support strong IPR protection (Stel et al., 2019). Importantly, this aligns with the idea that Latin American countries are advancing their domestic innovation efforts (Crespi et al., 2014; Viglioni et al., 2020). This underscores the significance of increasing the number of high-quality scientific publications (Khoury and Peng, 2011; Kafouros et al., 2015) and quality education structure in developing countries (Coe et al., 2009; Varsakelis, 2006; Wu et al., 2017). Overall, the marginal effects indicate that domestic innovation plays a positive role in enhancing a country's economic activity, particularly at higher percentile values of IPR protection. Nevertheless, it appears that not all domestic firms benefit equally from strong IPRs. This result suggests that the composition effect of strong IPRs causes a structural change. Therefore, companies with limited investment in innovation experience compromised productivity, while those with high levels of innovative effort gain from stricter IPR regulations.

Ultimately, we also observe that IPRs play a significant role in the relationship between foreign innovation and the economic activity of countries. It is undeniable that foreign capital relies on robust IPR enforcement to safeguard innovations from appropriation (Smarzynska-Javorcik, 2004; Maskus et al., 2019; Belderbos et al., 2021). While not entirely unexpected, this finding remains relevant for developing countries that are proactively enhancing their IPR systems to attract more FDI inflows (Khoury et al., 2014). This becomes particularly crucial as it fosters domestic innovation, enabling local industries to learn from and collaborate with foreign counterparts (Rossetto et al., 2018), potentially leading to greater technological spillovers under strong IPR regulations (Krammer, 2015). Our findings are in line with previous research, asserting that robust IPR institutions are essential for developing countries to attract foreign investments (Khoury and Peng, 2011; Alexiou et al., 2016; Klein, 2018). Thus, robust IPR protection reduces the risks of knowledge expropriation (Tebaldi and Elmslie, 2013; Lee et al., 2018) and, when combined with FDI inflows, stimulates the economic activity of developing countries.

5.2. Implications for public policymakers

Our analysis offers important policy recommendations. A crucial consideration for policymakers is the careful assessment of IPR enforcement, as it could potentially have a negative impact on economic activity. This is especially important for countries in early stages of development. Government policies often lack alignment due to the varying optimal levels of IPR protection based on country-specific strategic development perspectives (Cui et al., 2022). Policymakers should aim for balanced IPR policies to encourage domestic innovation. This can be achieved by gradually adjusting IPR systems, implementing supportive policies for specific industry sectors (Bogliacino and Ramos, 2008; Maskus et al., 2019). Additionally, governments should enhance local knowledge activities such as R&D, quality education, patent applications, and scientific citations (Kafouros et al., 2015; Wu et al., 2017) to promote innovation and propel latecomer economies of third-world countries into progress (Viglioni et al., 2020). Policymakers face challenges in strengthening domestic innovation and attracting FDI (Lee et al., 2018). Thus, they should explore innovative IPR policies beyond traditional methods and international agreements to foster higher economic development (Arza et al., 2023). Policymakers should evaluate and implement optimal IPR policies that increase FDI inflows to developing countries (Khoury and Peng, 2011) while aligning with their economic rationale.

5.3. Limitations and future research

While this study contributes significantly, it is not without limitations. We focused on the moderating role of IPRs in the context of Latin American countries to capture region-specific characteristics (Khoury and Peng, 2011; Khoury et al., 2014). Consequently, while the results are comparable, they may not be directly applicable to other economies, given variations in institutional and economic factors. Future research could expand this analysis to other regions like Africa, Asia, Western and Eastern Europe to uncover how IPRs influence innovation activities there (Lee et al., 2018). Moreover, further investigation is needed to explore how country income groups and human development differences relate to internal technological factors and IPRs (Arshed et al., 2022; Su et al., 2022). To advance the innovation literature, researchers are encouraged to consider other contemporary IPR protection indices (e.g., Papageorgiadis and Sofka, 2020; Papageorgiadis et al., 2013). As our analysis is not firm-level, scholars should explore IPR effects using micro-level data (Bogliciano and Pianta, 2013) and regional analyses to capture knowledge disparities across industries in developing countries (Cui et al., 2022; Maskus et al., 2019). Additionally, a comprehensive analysis should encompass the bilateral knowledge spillover between domestic and foreign activities under varying IPR settings in developing countries (Maskus, 2015; Christopoulou et al., 2021).

6. Conclusion

Rooted in the legal context of institutional economics, this study aimed to comprehend the role of IPRs in influencing economic activity within Latin American and Caribbean countries. By contributing to the ongoing debate on IP protection in developing countries, this study illuminates the impact of stronger IPRs. Specifically, we examined how enhanced IPRs influence economic activity and moderate the crucial knowledge channels of domestic and foreign innovation activities. Importantly, our research underlines the necessity of considering these relationships collectively in the unique context of Latin America, where both knowledge sources are pivotal for economic growth and technological advancement.

Our analysis confirms a significant inverted U-shaped relationship between IPRs and economic activity. Under robust IPR regulations, results show positive moderating effects of strong patent protection on both knowledge sources and a country's economic activity. However, it is crucial to note that increasing strong IPRs does not guarantee across-the-board economic improvements. Policymakers must tailor IPR policies to fit their country's specific development and industry needs, considering the particular productive factors tied to each country's technological progress. This contribution enhances our understanding of IPR protection in developing countries, even as challenges persist.

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CRediT authorship contribution statement

Marco Túlio Dinali Viglioni: Writing – original draft, Conceptualization, Methodology, Software, Investigation, Data curation, Writing – review & editing, Funding acquisition. **Cristina Lelis Leal Calegario:** Formal analysis, Methodology, Supervision, Funding acquisition, Writing – review & editing. **Carlos Eduardo Stefaniak Aveline:** Visualization, Validation, Supervision. **Manuel Portugal Ferreira:** Visualization, Validation. **Felipe Mendes Borini:** Visualization, Software, Validation. **Nádia Campos Pereira Bruhn:** Visualization, Validation.

Data availability

The data is publicly available data and has all sources mentioned.

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