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Intellectual Property Rights and Agricultural Development: Evidence from a Worldwide Index of IPRs in Agriculture (1961-2018)

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ABSTRACT *This paper revises and updates the Campi-Nuvolari index of intellectual property protection for plant varieties. The new index provides yearly scores for the period 1961–2018 for 104 countries, which have legislation on plant variety protection in force. The new evidence highlights the ongoing shift towards more similar and stronger systems of intellectual property rights (IPRs) worldwide, regardless of individual characteristics of countries. The signing of the TRIPS and trade agreements with TRIPS-Plus provisions are major drivers of this process. In addition, certain characteristics of countries such as the regulatory environment, the level of human capital, the importance of agricultural production, and openness to trade, are also significant determinants of the evolution of IPRs systems. We conclude by discussing other possible applications of the data.*

1. Introduction

Recent decades have witnessed a global process of strengthening and harmonisation of intellectual property rights (IPRs). While this was a gradual process during most of the twentieth century, it was strongly accelerated by the signing of the agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) in 1994, which has had significant effects on the design of the main IPRs regimes worldwide.

In the case of agriculture this is particularly significant because, before the signing of the TRIPS, several countries were characterised by lax IPRs regimes and many other countries did not provide any type of formal intellectual property (IP) protection for plant varieties at all. The TRIPS agreement made it compulsory to provide IP protection for plant varieties – either by patents or by a *sui generis* system– and to allow patentability of microorganisms, non-biological and microbiological processes for the production of plant varieties, as well as for pharmaceutical products. As a result, a significant number of countries had to implement dramatic changes in their IP protection systems, in particular developing countries, which were mainly those with weaker IPRs systems in agricultural and biological domains.

Simultaneously, another driver of IP reforms has been the signing of an increasing number of trade and investment agreements that include legally enforceable provisions related to IPRs (Biadgleng & Maur, 2011; Campi & Dueñas, 2019; Morin & Surbeck, 2020). The signing of these types of agreements imply clearly defined obligations that effectively bind the parties to implement measures

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that strengthen their IPRs systems (Horn, Mavroidis, & Sapir, 2010). They include legally enforceable provisions that go beyond the minimum requirements of the TRIPS and, for this reason, they are known as TRIPS-Plus or TRIPS+ (Mercurio, 2006).

Both the signing of the TRIPS and of trade and investment agreements with IP provisions have generated changes in IPRs systems, with possibly far-reaching effects on research and development (R&D) activities in agriculture and, more generally, on agricultural practices and performance. Accordingly, the implementation of these agreements implies a real and complex challenge, mainly for developing countries. Unsurprisingly, this process has been surrounded by lively controversies on its impact on economic performance and on its broader effects on social welfare (Campi, 2018).

Quantitative indicators measuring these jurisdictional and regulatory shifts are important tools to empirically assess the effects of different configurations of IPRs systems and for policy design. Some scholars have constructed indexes that provide measures of the strength of patent protection (Ginarte & Park, 1997; Morin & Gold, 2014; Papageorgiadis & McDonald, 2019; Park, 2008), while Liu and La Croix (2015) have developed a sector-specific index of intellectual property protection for pharmaceutical inventions. Using these indicators, several empirical works have analysed the implications of shifts in IPRs systems on a wide variety of dimensions such as innovation, productivity, economic growth, and development, using indicators of patent protection for the manufacturing sector or for the whole economy (for example, Chen & Puttitanun, 2005; Falvey, Foster, & Greenaway, 2006; Gold, Morin, & Shadeed, 2019; Kanwar & Evenson, 2003; Sweet & Maggio, 2015). Instead, in the agricultural sector, where the emergence and consolidation of formal IP protection is more recent, the empirical literature is significantly more limited even if it is increasing. In this context, the construction of a comprehensive indicator – one that is capable of capturing the variation of IPRs regimes on a comparative basis – would represent an important research tool for tackling a number of important research questions.

In Campi and Nuvolari (2015), we constructed the index of IP protection for plant varieties by means of a detailed study of the historical evolution of the legislation in each country, identifying the key features characterising the differences of IPRs systems for plant varieties. Next, we developed a simple approach for transforming these legislative provisions into quantitative indicators. We selected countries that are characterised by a rather similar basic legal framework regulating plant variety protection (PVP), which follows the general guidelines established by the UPOV and seeks to comply with the TRIPS agreements.

The index has been used to investigate the impact of IPRs systems on agricultural productivity (Campi, 2017), international trade of agricultural products (Campi & Dueñas, 2016), and mergers and acquisitions in the agri-food sector (Campi, Dueñas, Barigozzi, & Fagiolo, 2019). In addition, other scholars have resorted to the index to illustrate the strengthening and harmonisation of IPRs systems in agriculture to analyse their impact on agricultural productivity, or they have cited the index as a reliable synthetic indicator of the evolution of agricultural IP protection (see, for example Adebola, 2019; Baker, Jayadev, & Stiglitz, 2017; Clancy & Moschini, 2017; Gold et al., 2019; Nhemachena, Kirsten, & Muchara, 2019; Papageorgiadis & McDonald, 2019; Spielman & Ma, 2016; Zhou, Sheldon, & Eum, 2018).

Although there is evidence of an ongoing process of strengthening and harmonisation of IPRs regimes in agriculture, there is still an open debate in the literature on the welfare effect of IP protection and on the role of IPRs in encouraging innovation and agricultural development (for a useful comprehensive survey of the evolution of IPRs systems in plant breeding and agriculture, see Smith (2019)). IPRs can foster investment in R&D, and innovation, which, in turn, might augment agricultural production – for example, by allowing production in areas previously not suitable for agricultural production–, the value of agricultural production – by allowing the production of new products of higher value–, and agricultural productivity – by allowing increases in yields or the production of higher-yields products (see, for example Kolady & Lesser, 2009; Lipton, 2007; Naseem, Oehmke, & Schimmelpfennig, 2005).

However, IPRs also restrict access to knowledge, which might hinder future innovation, production, and productivity, in particular in poor countries. Indeed, there is actually limited evidence on the

impact of agricultural IPRs systems on innovation, agricultural production, and productivity. For different countries and regions, the evidence is mixed and it mainly depends on specific features of countries, such as their development level and characteristics of their agricultural systems (see, for example: Campi, 2017; Louwaars et al., 2005; Moser, Ohmstedt, & Rhode, 2017). In addition, plant breeding has recently been transformed by important technological changes, which resulted in a process of industrial concentration that affect differently developed and developing countries (Deconinck, 2019, 2020; Pray & Naseem, 2007; Zilberman, Ameden, & Qaim, 2007). Thus, empirical analysis addressing the effect of changes in IPRs systems in different contexts are critically important to understand the net effect of formal IP protection on agricultural development.

Using the approach adopted in Campi and Nuvolari (2015), in this paper we present a substantially revised and updated index that covers 104 countries and the period 1961–2018. We document trends and patterns in the evolution of the index and we observe that all countries have been significantly increasing their levels of IP protection for plant varieties, particularly after TRIPS, while there seems to be no relationship between the level of IPRs and the level of GDP per capita of countries. We conclude that the recent strengthening and harmonisation of IPRs systems was not the outcome of an endogenous process but instead it was, by and large, driven by exogenous policies pushed from the obligations of the TRIPS and the adoption of TRIPS-Plus provisions.

We study which factors determine the adoption of IPRs systems. We conclude that certain features of countries such as the regulatory environment, the level of human capital, the importance of agricultural production, and openness to trade, are significant determinants of IPRs systems. Finally, the signing of the TRIPS and of trade agreements with TRIPS-Plus provisions are significant drivers of this process, especially for developing countries.

The rest of the paper is organised as follows: In Section 2, we first explain in detail the index and the main changes and updates. In Section 3, we analyse the evidence of this new version of the index, which highlights the tendency towards more similar and stronger systems of IPRs worldwide, regardless of individual characteristics of countries. In Section 4, we present the econometric estimations. Finally, in Section 5, we conclude discussing the findings of the empirical analysis and other possible applications of the data.

2. The construction of the index

In this section, we describe the index and the main revisions and updates that we included in this new version. The index considers the elements that, within the common framework provided by the UPOV and by TRIPS, tend to vary more from country to country and over time. The index has five components:

(1) *Ratification of UPOV conventions*: this component considers whether a country has adhered to the subsequent revisions of the UPOV Convention (1961, 1978 and 1991).

(2) *Farmers' exception*: this component considers the so-called farmers' right to save seeds, which entitles farmers to use the product of their harvests obtained from a protected plant variety for the purpose of reproduction in their farms. The scope of this right varies largely and the component considers whether it is permitted, limited, or forbidden in the PVP legislation.

(3) *Breeders' exception*: this component considers the so-called breeders' exception – which states that the exclusion right does not extend to the use of a plant variety for experimental or research purposes by other breeders. Although the breeders' exception is compulsory in all UPOV conventions, the version of 1991 introduced the concept of 'essentially derived variety' – one that is clearly distinguishable from the initial one but retains its essential characteristics–, which are excluded from the breeders' exception, resulting in a limitation of its scope because a breeder working on the development of a variety considered 'essentially derived' needs the authorisation of the owner of the initial variety even for its experimental use.

(4) *Protection length*: this component considers the duration of the right.

(5) *Patent scope*: this component considers whether patents are allowed in five domains which are related to plant breeding and agriculture: (i) food, which processes products from agriculture; (ii) microorganisms, which are closely related to the development of biotechnology and its application to plant breeding; (iii) pharmaceutical products because this industry also relies on biodiversity and genetic resources; (iv) plant and animals – when the invention is not limited to a specific variety; and (v) plant varieties (either sexually or asexually reproduced specific plant varieties).

We develop a simple approach for transforming these features into quantitative indicators and, subsequently, we aggregate these indicators in a composite index. We normalise the values of each component so that, for any country in a given year, the index can take a score from 0 to 5, with higher scores indicating a stronger intensity of IP protection.[1] Table A1 presents the index components and the scores of the updated version of the index.

The new features of the revised version of the index are the following:

Time update: We present a yearly index for the period 1961–2018 (58 years).

Country coverage: In the previous version of the index, we considered 69 countries, which were members of the UPOV in 2011. In this updated version, we have included 73 countries that are members of the UPOV convention in 2018 and 31 additional countries whose PVP systems are broadly similar to those of the UPOV members. Some of these countries have initiated the procedure for acceding to the UPOV convention, and some others have been in contact with the UPOV office for assistance in the development of laws based on the UPOV convention (see: UPOV, 2019). In particular, among the countries that could become members of UPOV, we have included the ones that have already implemented some kind of IP protection for agriculture. Finally, we have included countries that have PVP legislation in force although they are not members of the UPOV convention nor have they contacted the UPOV, but still have comparable systems. Table 2 presents the list of countries for which we have annual data on our index.

Revision and sources: The index is constructed by a detailed study of the IP-related legislation at the country level using several sources. Newly available sources have helped us to revise and update the index. Several documents of IP-related legislation, amendments, regulations, and patent guidelines are currently available online in different repositories (see Appendix). We have also consulted several secondary sources such as Baxter, Sinnott, and Cotreau (2018); Bent, Schwaab, Conlin, and Jeffery (1987); Park (2008); Siebeck, Evenson, Lesser, and Braga (1990); Thorpe (2002); Westlaw

Table 1. Index components and scores

	Component	Score Range	Normalised Score
1	*Ratification of UPOV conventions*	*0–3*	[0,1]
	1961	0–1	
	1978	0–1	
	1991	0–1	
2	*Farmers' Exception*	*0–2*	[0,1]
	Limited	0–1	
	Not considered	0–1	
3	*Breeders' Exception*	*0–1*	[0,1]
	Essentially derived variety	0–1	
4	*Duration*	*0–35*	[0,1]
	At most 35 years	0–35	
5	*Patent Scope*	*0–5*	[0,1]
	Pharmaceuticals	0–1	
	Microorganisms	0–1	
	Food	0–1	
	Plants and Animals	0–1	
	Plant Varieties	0–1	
	Index	*0–46*	[0,5]

Table 2. List of countries

Developing countries
Albania; *Algeria*; Argentina; *Armenia*; Azerbaijan; Belarus; *Belize*; Bolivia (Plurinational State of); *Bosnia and Herzegovina; Botswana*; Brazil; Bulgaria; *Cambodia*; Chile; China; Colombia; Costa Rica; *Dominica*; Dominican Republic; Ecuador; *Egypt; Ethiopia*; Georgia; *India; Indonesia; Iran; Iraq*; Jordan; *Kazakhstan*; Kenya; Kyrgyzstan; *Lao People's Democratic Republic*; Lithuania; *Malaysia*; Mexico; *Montenegro*; Morocco; *Mozambique; Myanmar*; Nicaragua; North Macedonia; *Pakistan*; Panama; Paraguay; Peru; *Philippines*; Republic of Moldova; Russian Federation; *Rwanda; Serbia*; South Africa; *Tajikistan; Thailand*; Tunisia; Turkey; *Turkmenistan; Ukraine; United Republic of Tanzania*; Uruguay; Uzbekistan; Viet Nam; *Zambia; Zimbabwe*
Developed countries
Australia; Austria; *Barbados*; Belgium; *Brunei Darussalam*; Canada; Croatia; *Cyprus*; Czech Republic; Denmark; Estonia; Finland; France; Germany; Hungary; Iceland; Ireland; Israel; Italy; Japan; Latvia; *Malta*; Netherlands; New Zealand; Norway; Oman; Poland; Portugal; Republic of Korea; Romania; *Saudi Arabia*; Singapore; Slovakia; Slovenia; Spain; Sweden; Switzerland; Trinidad and Tobago; *United Arab Emirates*; United Kingdom; United States of America

Note: countries in italics were not considered in the previous version of the index.

(2018); WIPO (1988); WIPO (2004). We have also revised the component of patent scope with the information contained in Park (2008) and ongoing updates of this work.[2] Additionally, we have consulted with a number of experts from different countries in the cases of missing data or to confirm information. In particular, we had several exchanges with Walter Park looking for consistency on the patent scope component with the index of patent protection of Park (2008). Given that we found new online sources available for the years already covered by the previous version of the index, we have revised all the information from 1961 to 2018 introducing corrections or emendations when necessary.[3]

Extended information on farmers' exception component: While the first conventions of the UPOV considered the farmers' exception, the 1991 convention made it optional for their members. Unlike the 1978 Act, the 1991 version does not allow farmers to sell or exchange seeds with other farmers for propagating purposes. This limitation has been criticised for being inconsistent with the practices of farmers in several developing countries (Leskien & Flitner, 1997). Regarding the right to save seeds for their own use, rather than forbidding it, many countries have been limiting it for some crops, or for farmers of up to a certain size, or by demanding a lower price for the use of saved seeds. Therefore, in order to enrich the information of this component, we now evaluate whether the farmers' exception is considered, limited, or not considered in the related legislation.

3. Agricultural IPRs: trends and patterns

In this section, we discuss the evidence provided by the revised and updated index of IP protection. In Table A1 of the Appendix, we present the updated index scores for 104 countries and selected years. The data for all years and components are available at the Supplementary Material file. Updates and possible revisions canbe downloaded from: https://www.openicpsr.org/openicpsr/project/121001/version/V1/view (Campi and Nuvolari, 2020).

Figure 1 shows the evolution of IP protection for plant varieties for 41 developed countries (DCs) and 63 developing or least developed countries (LDCs) in selected years between 1965 and 2015.[4]

We observe that DCs have been increasing their levels of IP protection since 1975, while for LDCs the main increase in the index scores is observed after 1995, possibly driven by the signing of the TRIPS agreement. Although countries classified as less developed were granted transition periods to implement the demands of the TRIPS, several of them swiftly adopted these reforms well before the expiration of the transition periods granted to them.[5] Therefore, we observe that in the group of LDCs there are several outliers in 1995 and that the average level of IP protection significantly increased in

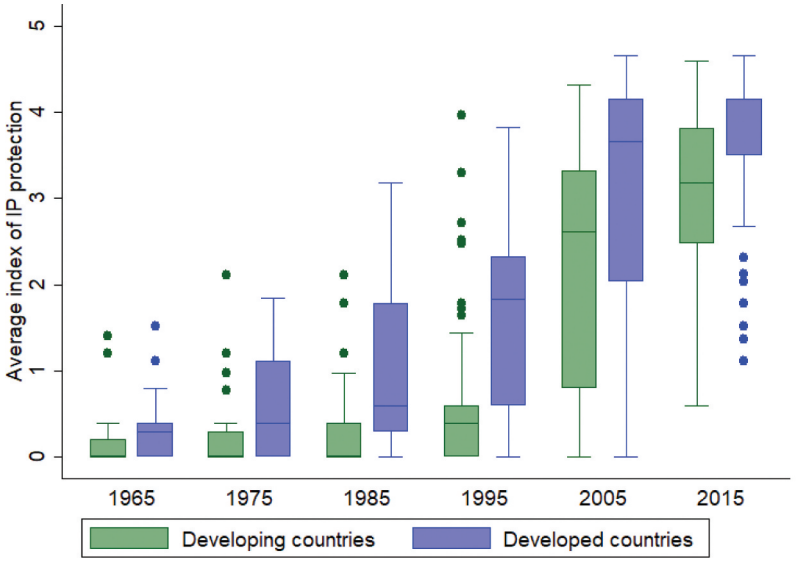

Figure 1. Evolution of the index of IP protection according to development level. 1965–2015.

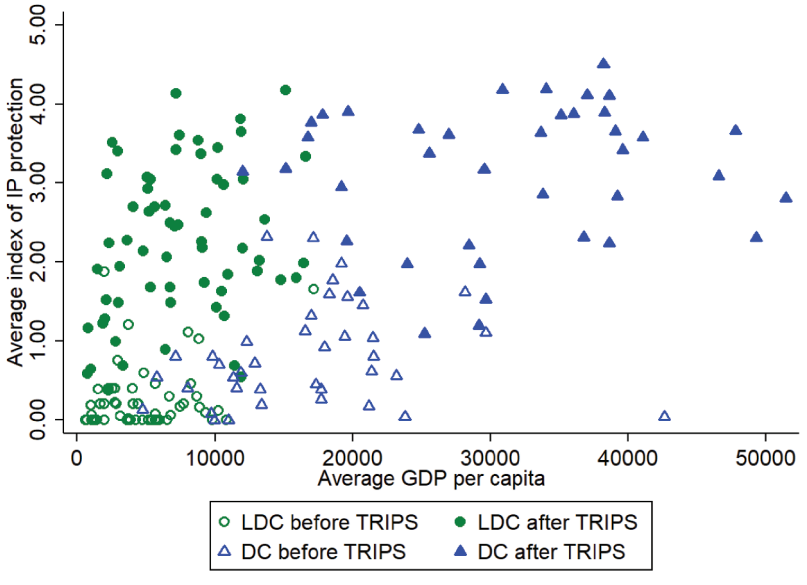

Figure 2. Average index of IP protection and average level of GDP per capita before and after TRIPS by development level of countries. Brunei Darussalam and the United Arab Emirates are excluded to allow a better visualisation given that they have outlier values for their income levels.

2005. In 2015, both developed and developing countries are characterised by strong levels of IP protection and the dispersion between and within groups has decreased.

Notably, the increase in IP protection at the country level is not related to their development levels, rather it seems to be driven by an exogenous process. This point emerges vividly from Figure 2 that shows a scatter plot of the averages of the GDP per capita and of the index of IP protection for the

years before (1961–1994) and after TRIPS (1995–2018) for all the countries in our sample classified according to their development level.

We observe that all countries have significantly increased their levels of IP protection for plant varieties. But, while most DCs have also increased their levels of GDP per capita between these two periods, most LDCs maintain relatively low levels of GDP per capita but with high levels of IP protection. While the shift of the hollow markers is consistent with a process in which countries becoming richer increase IP protection, the filled markers show an increase in the level of their index regardless of the development level of countries. In other words, after TRIPS, there seems to be no relationship between the level of IPRs and the level of GDP per capita.

It is worth noting that the level of economic development of countries does not necessarily reflect the level of development of their agricultural systems, which might be expected to be better linked to the evolution of their IPRs systems. Although there is no direct indicator of agricultural development, we consider that countries that can have a sufficient food supply for their population and an extra production that can be exported, also have more developed agricultural systems. Instead, countries that depend on external sources to achieve a sufficient food supply for their populations are usually countries with less developed agricultural production systems. Using this approach, we also divide countries into two groups. The first one includes countries that are net exporters of food products, while the second one includes those countries that are net importers of food products.

Figure 3 presents the evolution of the average index of IP protection for plant varieties for net food-exporters (NFE) and net food-importers (NFI) in selected years between 1965 and 2015.[6] We observe that IPRs systems were weak in both types of countries, although on average slightly tighter for NFI, until the signing of the TRIPS, where all groups started increasing their levels of IPRs ending up with very similar levels of IP protection. Therefore, it seems that the recent increase in IP protection is not necessarily related to specific characteristics of countries or agricultural systems, but with an external process that is driving the strengthening of IPRs systems.

Finally, Figure 4 illustrates the evolution of the index disaggregated by each of the five components for the 104 countries, for 1994 (before the signing of the TRIPS) and 2018. Comparing both years, we clearly observe the general increase in the total scores of the index for all countries. In fact,

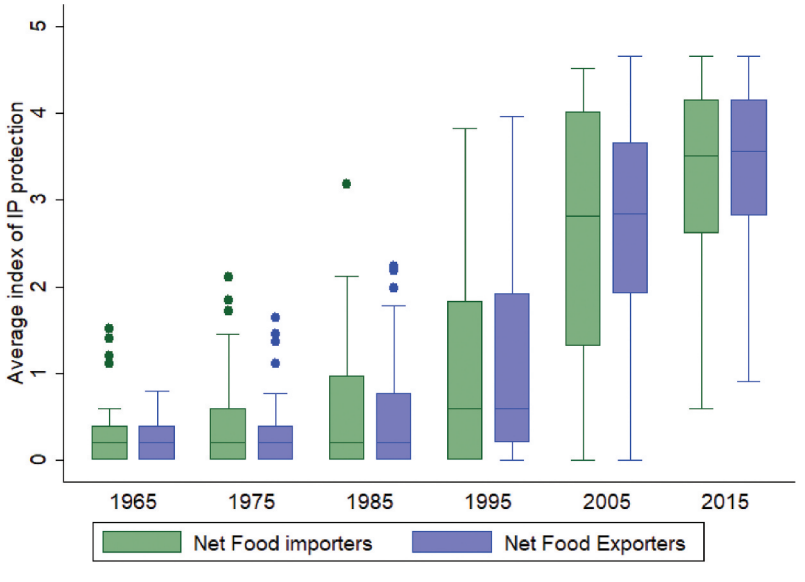

Figure 3. Evolution of the index of IP protection for net food-exporters and net food-importers. 1965–2015.

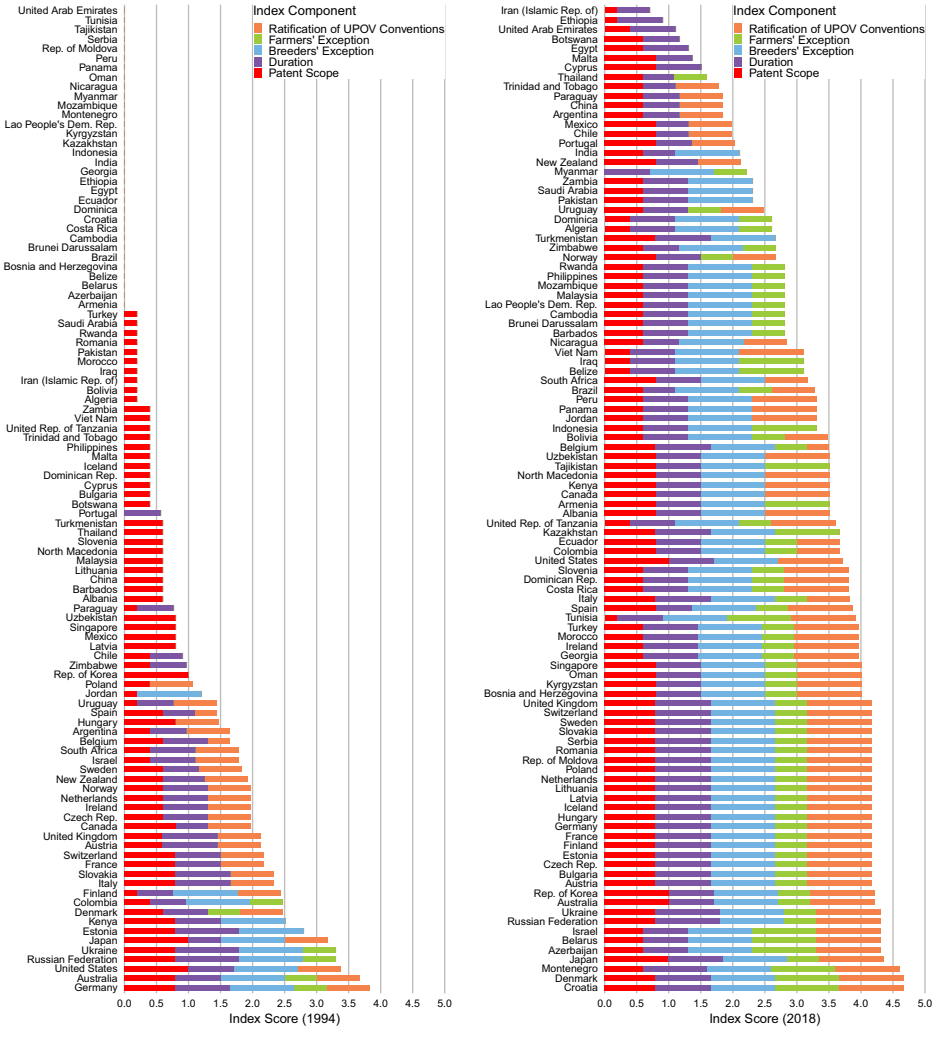

Figure 4. Evolution of the index scores by components. 1994 (left) and 2018 (right).

many countries in our sample did not have IPRs systems in place before the signing of the TRIPS, particularly developing countries.

The general increase of the index is driven by a heterogeneous evolution of the components, although all of them contributed to the increase of the aggregated index. The component that indicates adherence to different versions of the UPOV convention has increased in several countries, reflecting the higher number of members. Another possible reason is that since 1998, new members of the UPOV are only allowed to adhere to the latest revision of the convention (1991). Therefore, countries that were not members of the UPOV before 1998 and adopted a *sui generis* system of IP protection based on the UPOV had to adhere to the latest version, which creates the highest possible score for this component. Comparing both years, we observe that the limitation of the breeders' exception with the introduction of the concept of essentially derived variety is a recent phenomenon since only a few countries considered it in 1994. Likewise, the farmers' exception has been limited or it is not considered in 2018 in many countries, while it was accepted in almost all countries in 1994. Also, we observe an increase in the length of protection for several countries. Finally, the component

indicating patentability in agricultural-related domains has also increased in most cases, reflecting the necessity to adapt patent systems to the demands of the TRIPS agreement.

Overall, the evidence presented in this section illustrates the process that followed the signing of the TRIPS, which had different implications for DCs and LDCs. While DCs used to have in place relatively strong IPRs systems well before the TRIPS agreement, LDCs started adopting strong IP protection systems only more recently, guided by the demands of the TRIPS. Most LDCs were reluctant to tighten their IPRs systems and, therefore, the actual strengthening was not an endogenous response to domestic innovation. In contrast, several DCs were the ones pushing for uniform reforms across countries (Delgado, Kyle, & McGahan, 2013; Dutfield, 2019; Ivus, 2010; Morin & Gold, 2014). Similar conclusions can be drawn if we classify countries by their agricultural development level.

Interestingly enough, the pattern of change in our index, showing a marked acceleration after TRIPS, mirrors the dynamics emerging from more comprehensive IPRs indicators such as that of Ginarte and Park (1997); Park (2008); and Morin and Gold (2014). As discussed by Shadlen (2017), these trends suggest that, in the new international environment, the degree of autonomy that countries could enjoy in the configuration of their IPRs regimes is becoming increasingly restricted. Thus, the strengthening of IPRs systems can be regarded as an exogenous policy shift for LDCs because the TRIPS agreement was included in a package of agreements whose acceptance was a compulsory requirement of the World Trade Organisation (WTO) membership. As a consequence, the decision of signing the TRIPS and the implications on IPRs systems might not be interpreted – in most cases – as determined by specific developments at country level, but rather by external factors. In this sense, IPRs systems in the post-TRIPS period might be reasonably regarded as 'exogenous'.

4. The determinants of IPRs in agriculture: a simple econometric model

As we observed above, the process towards stronger and more similar agricultural IPRs systems seems to have been somewhat detached from the development levels of countries. In addition, we have speculated that the main drivers of this process might be the signing of the TRIPS agreements and of trade agreements that include IPRs chapters with TRIPS-Plus provisions. In this section, we provide a further assessment of the role played by TRIPS and TRIPS-plus on the evolution of IPRs systems in agriculture also considering the effect of other factors by means of a simple econometric exercise. Our benchmark model is the following:

$$IPR_{i,t} = \beta_0 + \beta_1 X_{it} + \beta_2 TRIPS_{i,t} + \beta_3 PTA(IP)_{it} + \gamma_i + \gamma_t + \mu_{i,t}\ ; \tag{1}$$

where the dependent variable *IPR* is the index of agricultural IP protection for $t = \{1961, \cdots, 2018\}$ and for country i; β_0 is a constant term; $X_{it} = \{GDPpc_{i,t}, hc_{i,t}, ag\_prod_{i,t}, open_{i,t}, regul_{i,t}\}$ contains a set of institutional and economic variables characterising countries that could be possible determinants of their levels of IPRs: GDP per capita (*GDPpc*), which captures the development level of countries; human capital (*hc*) that is a proxy of the stock of human capital based on average years of schooling and an assumed rate of return to education; the net per capita agricultural production index (*ag_prod*), which aims to capture the economic structure of the country and, in particular, the significance of the agricultural sector[7]; openness to trade (*open*), defined as the sum of total exports and total imports of a country divided by its GDP, which is included because IPRs are increasingly related to international trade; and, regulation (*regul*), which is an index that measures a set of areas regulating business activities.

We include two additional variables related to the timing and implementation of the TRIPS agreement. The first variable is *TRIPS* that aims to capture the effect of the signing of the TRIPS on IPRs systems. Although all the countries in our sample have signed the TRIPS agreement and have become members of the WTO, signatory countries were given different time periods to apply the provisions of the TRIPS.[8] Thus, we expect that this difference

in the time of compliance with the provisions of the TRIPS may have different impacts. We created this variable using data from Delgado et al. (2013), Park (2008), Maskus and Ridley (2016), WIPO, and WTO.[9] Thus, the variable *TRIPS* is a dummy – which is specific for each country – that takes the value of 1 once the country has complied with the demands of the TRIPS and 0 otherwise. The second variable $PTA(IP)$ is the cumulative number of preferential trade agreements (PTAs) with legally enforceable provisions on the protection of IPRs in foreign markets that a country has in force. Undertakings may be in line with, deepen and/or broaden the scope of provisions specified in the TRIPS (Kohl, Brakman, & Garretsen, 2016). We consider PTAs from the year of entry into force. This variable aims to capture the effect of the so-called TRIPS-Plus and, in some specifications, it is lagged by two years.[10] The main reason is that the change in IPRs systems deriving from the entry into force of these PTAs might take a certain time to take place. However, PTAs are negotiated for several years during which countries usually start implementing the related reforms. An additional motivation for the lagged variable is that it could help to address possible endogeneity of PTAs.

Finally, γ_i and γ_t are country and time fixed effects, respectively, and $\mu_{i,t}$ are the residuals. Table A2 in the Appendix describes the variables used in the econometric estimations and their sources.

Because countries of different development levels might have different agricultural systems and also different IPRs systems, we estimate the model for the full sample of countries and for two samples of DCs and LDCs. All the estimations include robust standard errors.[11]

In addition, we include an interaction variable between the level of IPRs and the date in which countries comply with the demands of the TRIPS, in order to better understand possible heterogeneous effects of the TRIPS. Table A3 in the Appendix presents the summary statistics of the explanatory variables for different samples.

Table 3 shows the estimation results. Model (1) is the benchmark model of Equation (1) estimated using the full sample of countries, while models (2) and (3) restrict the sample to DCs and LDCs, respectively. In model (4) we include interaction variables between the signing of the TRIPS and the level of development of countries. Models (5) to (8) are robustness checks including preferential trade agreements with legally enforceable IPRs lagged by two years.

Interestingly, GDP per capita is insignificant in all the specifications. However, this is not surprising, considering the evidence presented in Figure 2, where the development level seems to be uncorrelated with the level of IP protection, particularly for the post-TRIPS period. Human capital is positive and statistically significant for all samples and in all specifications. A relevant share of agriculture and plant breeding has been shifting towards more science–based sectors, thus, countries with higher human capital can also have more technologically advanced agriculture and, therefore, be keener to adopt stronger IPRs systems.

The coefficients of the index of agricultural production are significant and positive for the full sample of countries and for DCs but are intead not statistically significant for LDCs. We estimate positive and significant coefficients for openness to trade for the full sample of countries and for LDCs. Conversely, openness to trade is not significant for DCs. The index of regulation is positive and statistically significant in all the estimated specifications, reflecting that countries with a better regulatory environment for business activities also have stronger IPRs systems.

The variable TRIPS is positive and statistically significant in all the specifications. Interestingly enough, in the models where this variable interacts with the level of development of countries (4 and 8), we observe that the effect of complying with the demands of the TRIPS is higher for LDCs. This reflects the significant impact of TRIPS for LDCs. Although the TRIPS also had an effect on DCs, many of them already had articulated IPRs systems in place before 1994 for which the effect is lower. Finally, the variable that indicates the number of PTAs with legally enforceable IPRs is significant for both DCs and LDCs.

Overall, the TRIPS agreement seems to be a significant driver of stronger IPRs, particularly in LDCs, most of which had no elaborated IP protection systems in place and were reluctant to strengthen their level of protection before TRIPS. The results of Table 3 suggests that this agreement pushed them to implement stronger IP regimes. In this perspective, the adoption of stronger IPRs was, an exogenous process unrelated to the development level of countries. Similarly, LDCs often sign PTAs including

Table 3. Determinants of agricultural IPRs systems

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	FS	DC	LDC	FS	FS	DC	LDC	FS
GDP per capita	−0.042	0.209	−0.141	−0.032	−0.044	0.207	−0.152	−0.038
	(0.153)	(0.247)	(0.182)	(0.153)	(0.152)	(0.248)	(0.181)	(0.153)
Human capital	1.208***	1.478***	0.923*	1.194***	1.223***	1.505***	0.937*	1.216***
	(0.265)	(0.351)	(0.507)	(0.260)	(0.266)	(0.358)	(0.508)	(0.262)
Agricultural production index	0.213**	0.504***	0.336	0.192*	0.200*	0.505***	0.337	0.188*
	(0.104)	(0.152)	(0.351)	(0.112)	(0.105)	(0.150)	(0.353)	(0.113)
Openness to trade	0.301***	0.203	0.252**	0.290***	0.298***	0.199	0.255**	0.293***
	(0.101)	(0.155)	(0.119)	(0.107)	(0.101)	(0.153)	(0.119)	(0.107)
Index of regulation	0.151***	0.214***	0.134**	0.152***	0.152***	0.214***	0.136**	0.152***
	(0.044)	(0.079)	(0.052)	(0.044)	(0.044)	(0.079)	(0.051)	(0.044)
TRIPS	0.775***	0.532**	0.936***		0.799***	0.572***	0.942***	
	(0.134)	(0.198)	(0.182)		(0.132)	(0.189)	(0.180)	
PTAS with IPRs	0.036***	0.028**	0.050***	0.038***				
	(0.010)	(0.014)	(0.015)	(0.011)				
TRIPS * DC				0.718***				0.770***
				(0.196)				(0.187)
TRIPS * LDC				0.818***				0.824***
				(0.160)				(0.161)
PTAS with IPRs (t-2)					0.035***	0.026**	0.049***	0.036***
					(0.009)	(0.013)	(0.014)	(0.010)
Constant	−3.038***	−8.558***	−1.654	−3.021***	−2.992**	−8.600***	−1.593	−2.981**
	(1.136)	(2.372)	(1.129)	(1.143)	(1.140)	(2.336)	(1.130)	(1.143)
Observations	3,054	1,405	1,649	3,054	3,054	1,405	1,649	3,054
R-squared	0.715	0.778	0.660	0.716	0.715	0.777	0.660	0.715
Number of countries	92	39	53	92	92	39	53	92

Notes: The dependent variable is the index of IP protection in agriculture. FS: full sample. DC: developed countries. LDC: least developed or developing countries. Robust standard errors are in parenthesis. Significance level: *** p<0.01, ** p<0.05, * p<0.10.

trade-related provisions, such as those on IPRs, in order to access trade benefits. Thus, the adoption of TRIPS-Plus reforms can also, to a certain degree, be regarded as exogenous and not necessarily related to countries' characteristics and needs in terms of IP protection. Obviously, there are still endogenous reasons guiding the process and this is reflected in significant effects of certain features such as the regulatory environment, the level of human capital, the importance of agricultural production, and openness to trade. Although some DCs set the standards for other countries to follow, developing countries might still have some breathing space to devise their own policy approaches (Dutfield, 2019).

5. Concluding remarks

In this paper, we have introduced a new cross-country index of IPRs in the agricultural sector. The aim of the index is to provide a synthetic and comprehensive characterisation of the evolution of IPRs and to provide a tool that can contribute to assessing its effects.

The evidence provided by the index points to a process of strengthening and harmonisation of IPRs systems in agriculture on a global scale. Furthermore, a simple econometric exercise suggests that the TRIPS and PTAs including legally enforceable IP provisions (TRIPS-Plus) were significant drivers of the process towards stronger and harmonised IPRs systems. Some features of countries, such as the regulatory environment, the level of human capital, the importance of agricultural production, and openness to trade, are significant determinants of agricultural IPRs systems. Interestingly enough, GDP per capita indicating the level of development is instead a non-significant determinant of IPRs systems.

This evidence is in line with that provided by other authors who show that the actual strengthening of IPRs is not a complete endogenous response to domestic needs (Delgado et al., 2013; Ivus, 2010; Morin & Gold, 2014). In this perspective, Dutfield (2019) claims that developing countries are 'policy takers' rather than 'policymakers' in the field of IPRs in agriculture. Accordingly, developing countries are running the risk of adopting IPRs regimes that are not appropriate to contexts in which traditional knowledge and collective invention are important components of farming practices.

Furthermore, we should notice that the effect of IPRs on agricultural performance is notoriously ambiguous. Accordingly, for many countries, a context-specific, tailor-made articulation of IPRs reform may be more useful than a broad-brush approach.

In prospect, our cross-country index of IPRs for agriculture could contribute to study several delicate issues concerning the role of IPRs on agricultural performance and, thereby, providing interesting inputs for policy designs.

For example, in combination with indicators of innovation – such as plant breeders' rights, patents, investment in agricultural R&D at the firm or country level, or the number and quality of new plant varieties – the index could be used to investigate how stronger IPRs are actually affecting inventive activities. Moreover, the index could be used to assess the effect of IPRs on agricultural productivity and value-added, considering also different stages of global value chains.

In addition, although plant breeding is an activity that has been developing during the last century, the application of techniques from molecular biology and modern biotechnology has radically changed it in the last three decades. The development of new plant varieties using techniques derived from modern biotechnology – genetically modified plant varieties and conventional plant varieties that are obtained using different and more precise techniques from modern biotechnology – is closely linked to the availability of stronger IPRs, which are widely used in an increasingly concentrated industry dominated by a few multinational companies. This process has Of course, this process has consequences on access to technology, costs of conducting research, and distribution of economic benefits (Pray & Naseem, 2007). The index could help to understand the effect of IPRs on the development path of this industry, as well as the effect of this development on different types of countries.

Moreover, the recent process of harmonisation and strengthening of IPRs systems is expected to have implications for global relations among countries (Maskus, 2012). However, the effect of IPRs on international trade, foreign direct investment, technology transfer, and mergers and acquisitions is not clear either from a theoretical perspective or from an empirical point of view (Campi & Dueñas,

2016; Foley, Fisman, & Branstetter, 2006; Maskus, 2000; Maskus & Penubarti, 1995). Several authors have studied how IPRs affect the manufacturing sector, but less evidence is available for biotechnology and agri-food sectors. Therefore, the index could be useful for empirical studies seeking to understand the effect of IPRs on foreign direct investment in the agri-food sector and on international trade of seeds and agricultural products.

Last but not least, IPRs can affect food security, biodiversity, and sustainability. By creating incentives to produce certain types of commercial seeds and concentrating the market of seeds, IPRs can reduce agricultural biodiversity, risking food security and sustainability. A balance between providing incentives for investments and for the conservation of biodiversity is needed (Caixia & Yanping, 2012; Kothari & Anuradha, 1999). In the context of climate change, this has an increasing relevance that deserves urgent attention and whose quantitative impact could be assessed by using an indicator of the strength of IPRs in the agricultural sector.

Notes

1. For further details on the methodology and robustness checks, see: Campi and Nuvolari (2015).
2. The updates are available at: http://fs2.american.edu/wgp/www/.
3. Despite our best efforts, the data may still be affected by mistakes in the source data, errors induced by the conversion of images to readable documents, or translations.
4. The classification of countries by development level is based on the World Bank classification in 2012 (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups). High-income countries are considered as developed countries, while middle- and low-income countries (i.e., those with GNI per capita less than 12,175 dollars in 2012) are considered as less developed or developing countries. Our results are not affected if, instead of using the 2012 distinction between developed and developing countries, one adopts that of 1995.
5. In a study for the Commission on Intellectual Property Rights developed in 2002, Thorpe (2002) argued that very few developing countries were still denying patent protection for pharmaceutical products. All but three of the 30 least developed countries in Africa were already providing patents for such products despite not having to comply so until 2016, a period that was later extended until 2033. See: https://www.wto.org/english/news_e/news15_e/trip_06nov15_e.htm
6. The classification of countries in net food-exporters and net food-importers is based on United Nations: http://unctadstat.unctad.org/EN/Classifications.html
7. In constant 2004-2006 1,000 international dollars. The value of net production is computed by multiplying net production in physical terms by output prices at the farm gate. The value of production measures production in monetary terms at the farm gate level. See: FAO http://fenixservices.fao.org/faostat/static/documents/QV/QV_e.pdf.
8. Developed countries were granted a transition period of one year after the entry into force of the WTO Agreement, this is until 1 January 1996. Developing countries and transition economies were allowed a further period of four years (until 1 January 2000). Least-developed countries were granted a longer transition period of eleven years (until 1 January 2006), which was extended to 1 July 2021, and more recently until at least 2033. See detailed information on transition periods at: www.wto.org/english/theWTO_e/whatis_e/tif_e/agrm7_e.htm, accessed on August 2020.
9. See: www.wipo.int and www.wto.org.
10. We also estimated the model with different numbers of lags and the results hold. Results are available upon request.
11. We also estimated the models for the full sample of countries using robust standard errors clustered by development levels of countries. Although some coefficients become statistically non-significant, the main results of the exercise still hold.

Disclosure statement

The authors declare no conflict of interest.

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Appendix

Online databases of legislation on patent and plant variety protection

EBA Seed: https://eba.worldbank.org/en/data/exploretopics/seed
ECOLEX: www.ecolex.org
FAOLEX: www.fao.org/faolex/country-profiles/en/
Farmers' rights, legislation database: www.farmersrights.org/database/index.html
GRAIN: www.grain.org/en
InforMea: www.informea.org
PAHO: www.paho.org
Thomson Reuters Practical Law: https://uk.practicallaw.thomsonreuters.com
WHO: www.who.int/en
WIPO LEX: www.wipo.int/wipolex/en/
The World Law Guide: www.lexadin.nl/wlg/legis/nofr/legis.php

Index of intellectual property protection for plant varieties

Table A1. Evolution of the index of IP protection for plant varieties. Selected years

Country	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
Albania	0	0	0	0	0	0	0	0.6	0.6	3.31	3.51	3.51
Algeria	0	0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.61	2.61	2.61
Argentina	0.2	0.2	0.2	0.77	0.77	0.77	0.77	1.64	1.84	1.84	1.84	1.84
Armenia								0	3.51	3.51	3.51	3.51
Australia	0.2	0.2	0.2	0.2	0.2	0.4	1.98	3.68	4.21	4.21	4.21	4.21
Austria	0.2	0.2	0.2	0.2	0.2	0.4	0.6	2.32	2.32	4.16	4.16	4.16
Azerbaijan								0	3.31	4.31	4.31	4.31
Barbados	0	0	0	0	0	0.6	0.6	0.6	0.6	2.81	2.81	2.81
Belarus								2.71	2.71	4.31	4.31	4.31
Belgium	0.4	0.4	0.4	1.11	1.45	1.45	1.65	1.65	1.65	1.85	1.85	3.49
Belize	0	0	0	0	0	0	0	0	3.11	3.11	3.11	3.11
Bolivia	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.07	3.28	3.48	3.48
Bosnia and Herzegovina								0	0	0.8	3.01	3.01
Botswana	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.17	1.17
Brazil	0	0	0	0	0	0	0	0	3.28	3.28	3.28	3.28
Brunei Darussalam	0	0	0	0	0	0	0	0	0	0	0	2.81
Bulgaria							0	0.4	3.76	3.76	4.16	4.16
Cambodia	0	0	0	0	0	0	0	0	0	0.4	2.61	2.81
Canada	0.2	0.2	0.2	0.2	0.2	0.6	1.31	1.98	1.98	1.98	1.98	3.51
Chile	0	0	0	0	0	0	0	0.91	1.58	1.78	1.98	1.98
China						0.2	0.2	0.6	1.84	1.84	1.84	1.84
Colombia	0	0	0	0	0	0	0	2.47	3.54	3.68	3.68	3.68
Costa Rica	0	0	0	0	0	0	0	0	0.4	0.4	3.81	3.81
Croatia								0	2.81	4.51	4.66	4.66
Cyprus	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.8	1.51	1.51	1.51
Czech Rep.								1.98	3.82	4.16	4.16	4.16
Denmark	0	0	0.33	0.33	0.33	1.07	2.48	2.48	4.66	4.66	4.66	4.66
Dominica	0	0	0	0	0	0	0	0	2.61	2.61	2.61	2.61
Dominican Rep.	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	3.81	3.81
Ecuador	0	0	0	0	0	0	0	0	3.68	3.68	3.68	3.68

(*continued*)

Table A1. (*Continued*)

Country	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
Egypt	0	0	0	0	0	0	0	0	0	1.31	1.31	1.31
Estonia								2.8	4.16	4.16	4.16	4.16
Ethiopia	0	0	0	0	0	0	0	0.2	0.2	0.2	0.91	0.91
Finland	0	0	0	0	0	0.2	0.2	2.84	3.62	4.16	4.16	4.16
France	0.4	0.6	1.31	1.65	1.65	2.18	2.18	2.18	2.18	2.18	2.32	4.16
Georgia								0	2.6	2.6	3.96	3.96
Germany	0.4	0.4	1.65	1.85	1.85	1.99	2.32	3.82	4.16	4.16	4.16	4.16
Hungary							0.67	1.47	1.98	2.31	4.16	4.16
Iceland	0	0	0	0	0	0	0	0.4	0.6	3.16	4.16	4.16
India	0	0	0	0	0	0	0	0	0	2.11	2.11	2.11
Indonesia	0	0	0	0	0	0	0	0	3.31	3.31	3.31	3.31
Iran	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.71	0.71	0.71
Iraq	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	3.11	3.11	3.11
Ireland	0	0.4	0.4	0.4	0.4	1.98	1.98	1.98	3.62	3.62	3.62	3.96
Israel	0.4	0.4	0.4	1.11	1.45	1.78	1.78	1.78	4.31	4.31	4.31	4.31
Italy	0.4	0.4	0.4	1.26	1.79	1.79	2.32	2.32	3.82	3.82	3.82	3.82
Japan	1.51	1.51	1.51	1.71	2.51	3.18	3.18	3.18	4.21	4.36	4.36	4.36
Jordan	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.31	3.31	3.31	3.31
Kazakhstan								0	3.66	3.66	3.66	3.66
Kenya	1.4	1.4	1.4	2.11	2.11	2.11	2.51	2.51	3.18	3.18	3.18	3.18
Kyrgyzstan								0	4.3	4.01	4.01	4.01
Lao People's Dem. Rep.	0	0	0	0	0	0	0	0	0	0	0.91	2.81
Latvia								0.8	0.8	4.16	4.16	4.16
Lithuania							0	0.6	1.66	4.16	4.16	4.16
Malaysia	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.6	2.81	2.81	2.81
Malta	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.37	1.37	1.37
Mexico	0	0	0	0	0	0	0	0.8	1.98	1.98	1.98	1.98
Montenegro											3.6	4.6
Morocco	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.61	2.61	3.76	3.96
Mozambique	0	0	0	0	0	0	0	0	0.2	0.2	1.81	2.81
Myanmar	0	0	0	0	0	0	0	0	0	0	0	2.21
Netherlands	0.71	0.71	1.45	1.45	1.45	1.78	1.98	2.18	3.51	3.66	4.16	4.16
New Zealand	0.4	0.4	0.4	0.4	0.4	1.72	1.72	1.92	1.92	1.92	1.92	2.12
Nicaragua	0	0	0	0	0	0	0	0	1.97	2.84	2.84	2.84
North Macedonia								0.6	0.6	0.6	2.51	3.51
Norway	0	0	0	0	0	0.2	0.2	1.98	1.98	1.98	2.68	2.68
Oman	0	0	0	0	0	0	0	0	1.31	1.31	4.01	4.01
Pakistan	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.6	0.6	0.6
Panama	0	0	0	0	0	0	0	0	1.98	1.98	1.98	3.31
Paraguay	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.77	1.44	1.84	1.84	1.84
Peru	0	0	0	0	0	0	0	0	2.11	2.11	2.31	3.31
Philippines	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	2.81	2.81	2.81
Poland							0.67	1.07	2.92	4.16	4.16	4.16
Portugal	0	0	0	0	0	0	0.57	1.84	1.84	2.04	2.04	2.04

(*continued*)

Table A1. (*Continued*)

Country	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
Rep. of Korea	0.4	0.4	0.4	0.4	0.4	0.4	1	2.71	2.71	3.71	4.21	4.21
Rep. of Moldova								0.6	3.46	3.46	3.66	4.16
Romania							0	0.2	2.26	3.26	4.16	4.16
Russian Federation								3.3	4.3	4.3	4.3	4.3
Rwanda	0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.6
Saudi Arabia	0	0	0	0	0	0	0.2	0.2	0.2	2.31	2.31	2.31
Serbia											0.6	4.16
Singapore	0	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.8	4.01	4.01	4.01
Slovakia								2.32	3.82	3.82	4.16	4.16
Slovenia								0.6	3.81	3.81	3.81	3.81
South Africa	0.4	0.4	0.4	0.4	1.45	1.78	1.78	1.78	2.98	3.18	3.18	3.18
Spain	0.2	0.2	0.2	0.71	1.05	1.05	1.25	1.45	3.2	3.2	3.87	3.87
Sweden	0	0	0	0.9	1.3	1.84	1.84	1.84	3.96	4.16	4.16	4.16
Switzerland	0.2	0.2	0.2	0.2	1.45	1.78	2.18	2.18	2.18	2.18	4.16	4.16
Tajikistan								0	0	0.8	3.51	3.51
Thailand	0	0	0	0	0	0	0	0.6	1.59	1.59	1.59	1.59
Trinidad and Tobago	0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.78	1.78	1.78	1.78
Tunisia	0	0	0	0	0	0	0	1.71	2.91	3.91	3.91	3.91
Turkey	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.6	2.96	3.96	3.96
Turkmenistan								0.6	0.6	0.6	0.8	2.66
Ukraine								3.97	3.97	3.97	4.3	4.3
United Arab Emirates	0	0	0	0	0	0	0	0	0	0.4	1.11	1.11
United Kingdom	0.4	1.11	1.45	1.45	1.65	2.12	2.12	2.12	4.16	4.16	4.16	4.16
United Rep. of Tanzania	0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	2.11	2.11	3.61
United States of America	0.8	0.8	1.37	1.37	1.57	2.24	2.24	3.38	3.71	3.71	3.71	3.71
Uruguay	0.2	0.2	0.2	0.2	0.2	0.77	0.77	1.44	1.64	1.84	2.48	2.48
Uzbekistan								0.8	0.8	3.51	3.51	3.51
Viet Nam	0	0	0	0	0	0	0.4	0.4	0.4	2.11	3.11	3.11
Zambia	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	2.11	2.11
Zimbabwe	0.4	0.4	0.4	0.97	0.97	0.97	0.97	0.97	0.97	2.67	2.67	2.67

Notes: Missing scores are attached to countries that did not exist in those periods. A score of 0, instead, indicates that no IP protection was available at the time. The data for all years and components, as well as updates and possible revisions, can be downloaded from: https://www.openicpsr.org/openicpsr/project/121001/version/V1/view (Campi and Nuvolari, 2020)

Definition of variables, sources, and summary statistics

Table A2. Variables used in the econometric estimations and sources

Name (Label)	Description	Source
TRIPS compliance (*TRIPS*)	Dummy variable that indicates for each country the year in which they comply with the demands of the TRIPs agreement	Delgado et al. (2013), Park (2008), Maskus and Ridley (2016)
PTAs with IP chapters (*PTA*(*IP*))	Cumulative number of PTAs with legally enforceable IP chapters	Kohl et al. (2016)
GDP per capita (*GDPpc*)	GDP per capita	Feenstra, Inklaar, and Timmer (2015)
Human capital (*hc*)	Index of human capital that considers the average years of schooling and the returns to education	Penn World Tables Version 9.0: Feenstra et al. (2015)
Net agricultural production index per capita (*lnpcpi*)	Net per capita agricultural production index in ln	FAOSTAT*
Openness to trade (*opne*)	Total exports plus total imports divided by GDP	Penn World Tables Version 9.0: Feenstra et al. (2015)
Index of regulation (*regul*)	Index that measures a set of areas that regulate business activities	Fraser Institute**

Notes: *www.fao.org/faostat/en, **https://www.fraserinstitute.org/

Table A3. Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
			Full sample		
GDP per capita	4,822	8.968	1.146	5.506	12.409
Human capital	4,532	2.312	0.703	1.016	3.734
Agricultural production index	5,010	4.296	0.547	1.401	7.000
Openness to trade	4,822	−1.113	1.032	−11.164	2.736
Index of regulation	3,443	6.239	1.449	1.000	9.320
TRIPS	5,175	0.329	0.470	0.000	1.000
Number of PTAs with legally enforceable IPRs	6,032	3.455	7.545	0.000	32.000
			Developing countries		
GDP per capita	2,836	8.291	0.878	5.506	10.247
Human capital	2,591	1.949	0.593	1.016	3.411
Agricultural production index	2,941	4.202	0.533	2.485	5.391
Openness to trade	2,836	−1.507	1.018	−11.164	1.200
Index of regulation	1,853	5.853	1.382	1.000	9.270
TRIPS	3,065	0.262	0.440	0.000	1.000
Number of PTAs with legally enforceable IPRs	3,654	1.125	3.566	0.000	31.000
			Developed countries		
GDP per capita	1,986	9.935	0.708	7.067	12.409
Human capital	1,941	2.797	0.521	1.308	3.734
Agricultural production index	2,069	4.430	0.539	1.401	7.000
Openness to trade	1,986	−0.550	0.753	−4.435	2.736
Index of regulation	1,590	6.688	1.397	2.030	9.320
TRIPS	2,110	0.425	0.494	0.000	1.000
Number of PTAs with legally enforceable IPRs	2,378	7.037	10.185	0.000	32.000