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Intellectual Property Rights and International Trade of Agricultural Products

MERCEDES CAMPI [a,b] and MARCO DUEÑAS [c,*]

[a] *LEM & Institute of Economics—Scuola Superiore Sant'Anna, Pisa, Italy*
[b] *IIEP-Baires, UBA-CONICET, Buenos Aires, Argentina*
[c] *Department of Economics and Trade—Universidad de Bogotá Jorge Tadeo Lozano, Colombia*

Summary. — The signing of the agreement on Trade-Related Aspects on Intellectual Property Rights (TRIPS) had led to a process of global harmonization and tightening of intellectual property rights (IPRs) systems. As part of this process, the use of IPRs in agriculture has been increasing in the last decades. This paper studies the effect of intellectual property rights on agricultural trade, for the post-TRIPS period (1995–2011), using a new yearly index of IPRs, for 60 developed and developing countries. We study the effect of stronger IPRs on total trade, bilateral trade, and trade margins using different econometric techniques. We found that the strengthening of IPRs has been having a negative and uneven effect on agricultural trade at different levels of disaggregation. The gravity estimation showed that both the IPRs of the importer and the exporter have negative effects on total bilateral trade and that the probability of creating new bilateral trade links increases with the importer's IPRs. Finally, we found that stronger IPRs have a negative effect on the intensive margin of trade and a positive impact on the extensive margin. Overall, the evidence shows that agricultural trade related to the developing world has been more negatively affected, which calls the attention to the idea that a common system can equally work for all countries.

Key words — intellectual property rights, international trade, agriculture, gravity model, intensive margin, extensive margin

1. INTRODUCTION

The signing of the agreement on Trade-Related Aspects on Intellectual Property Rights (TRIPS) in 1994 had led to a process of global diffusion and tightening of intellectual property rights (IPRs) systems. While developed countries (DC) have increased the level of existing intellectual property (IP) protection, developing countries (LDC) have adopted new IPRs systems with strong levels of protection or have adapted their existing systems to the "minimum standards" demanded by the TRIPS.

This process has implications for innovation, productivity, trade, and economic development. IPRs are theoretically considered as incentives to innovate and, thus, are expected to have a positive effect on economic growth (Gould & Gruben, 1996). However, the role of IPRs as incentives to innovate has been both theoretically and empirically criticized. Moreover, the evidence suggests that the impact of strengthening IPRs is sector and technology specific (Dosi, Marengo, & Pasquali, 2006).

Regarding international trade, changes in IPRs may influence returns to innovation, affecting decisions of firms to trade in different markets. From a theoretical point of view, the net effect of increasing IP protection is unclear. Maskus and Penubarti (1995) argued that stronger IPRs systems are expected to have contrary effects on trade. On the one side, firms should be encouraged to export patentable goods to countries with stronger IP protection because the risk of imitation is lower. Simultaneously, stronger IPRs increase the market power of firms, which may encourage them to behave in a monopolistic way, increasing prices and reducing sales. The net result will depend on the sectors and the level of development of trading partner countries. Therefore, empirical analysis are needed to disentangle the effect of stronger IPRs on trade volumes and bilateral trade flows of different sectors and countries.

The contradictory effects are mostly theorized for manufacturing products. In the agricultural sector, the analysis must also consider some distinct features. Also, most of the empirical literature concentrates on trade flows of manufacturing products and a few empirical studies on the agricultural sector analyze the effect of IPRs on specific products, such as seeds, see for example: Yang and Woo (2006), Galushko (2012), and Eaton (2013). Considering the relevance of both trade and IPRs on the agricultural sector, our study contributes to the empirical analysis of the relation between IPRs and agricultural trade.

The use of IPRs in agriculture (plant breeders' rights, plant patents and utility patents) has been increasing in the last decades for several reasons: (i) the TRIPS agreement, which demanded IP protection for plant varieties either by patents or a *sui generis* system and patent protection for other related products such as micro-organisms, (ii) changes in the quantity and quality of the demand for agricultural products that resulted in changes in their production, and (iii) technological changes, such as the development of biotechnology applied to agriculture, which have caused an increase in private investments and adjustments in innovation activities.

Therefore, using an IP protection index for the agricultural sector recently created by Campi and Nuvolari (2015), this paper explores the effect of strengthening IPRs systems in the agricultural sector for the post-TRIPS period (1995–2011) on traded volumes, bilateral trade flows and the margins of trade,

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for a set of 60 countries, which includes 28 developed and 32 developing countries.

To do this, we carry out several econometric exercises. First, we study whether the recent tightening of IPRs has had an effect on total trade of agricultural products, at different levels of disaggregation, considering separately imports and exports. Secondly, we use a gravity model to investigate the effect of IPRs on bilateral trade and on the probability for a country to increase the number of trading partners. Additionally, we check the robustness of the estimation results adopting the recent specification of the gravity model suggested by Anderson and van Wincoop (2003) that includes multilateral resistance in the regression. Thirdly, we explore the effect of IPRs on the total number of agricultural sub-sectors with positive trade, which we define as the industry extensive margin, and on the average value of exports by sub-sector, defined as the industry intensive margin.

Overall, our results show that the strengthening of IPRs has been having a negative and uneven effect on agricultural trade. Our main findings are the following: (i) the recent strengthening of IPRs systems has been negatively affecting total agricultural trade; (ii) at a more disaggregated level, the effect is also negative for total trade in most sub-sectors; (iii) the gravity model showed that both the IPRs of the importer and the exporter have negative effects on total bilateral trade, except for developed countries; (iv) the probability of creating new bilateral trade links increases with the importer's IPRs; and (v) stronger IPRs have a negative effect on the average value of exports by sub-sectors (intensive margin), except for developed countries, and a positive impact on the total number of agricultural sub-sectors with positive trade (extensive margin). The evidence shows that agricultural trade related to the developing world has been more negatively affected, which calls the attention to the idea that a common system can equally work for all countries.

The remaining of the paper is organized as follows. The next section briefly discusses the relation between IPRs and international trade, reviewing both theoretical and empirical approaches. Section 3 addresses the issue for the agricultural sector. The forth section presents the data used for the empirical analysis. The fifth section presents the econometric estimations for the effect of IPRs on trade volumes. Section 6 explores the effect of IPRs on bilateral trade volumes and links, and the intensive and extensive margins of trade. Finally, Section 7 presents the main conclusions.

2. HOW ARE IPRS AND TRADE RELATED?

The effect of stronger IPRs on international trade has recently spurred a great interest among economists. Economic theory and empirical studies have identified contradictory effects and determining the net result seems to be an empirical question.

Different models have concluded that the effect of IPRs on trade is ambiguous (Grossman & Helpman, 1990; Grossman & Lai, 2004). In models of dynamic general equilibrium of two regions, North and South, where innovation takes place in the North while the South imitates technologies invented in the North, Helpman (1993) identified four channels through which IPRs are likely to affect trade between countries: (i) terms of trade; (ii) inter-regional allocation of manufacturing; (iii) product availability; and (iv) R&D investment patterns. He concluded that the question of whether the strengthening of IPRs is desirable cannot be answered theoretically. However, his model predicts that "if anyone benefits, it is not the South" (Helpman, 1993, p. 1274).

Also, Maskus and Penubarti (1995) have shown that we can expect contradictory effects of stronger IPRs on trade. Considering a price-discriminating firm deciding on the distribution of exports to different countries, the authors argue that there is a trade-off between the enhanced market power for the firm created by stronger IPRs systems and the larger effective market size generated by reduced abilities of local firms to imitate the patentable product. The "market-power effect" would reduce the elasticity of demand faced by the foreign firm, inducing it to export less of its patentable product to the market with stronger IPRs. Conversely, the "market-expansion effect" would increase the demand curve faced by the firm and attract larger sales. In addition, in larger markets, we might find a "cost-reduction effect" that would raise exports if stronger IPRs reduce the need of the foreign firm to undertake private expenditures to deter local imitation.

In turn, other factors may also affect market power and market size effects. Decisions of firms to export new patentable products to a particular market will depend not only on IPRs systems, but also on decisions of licensing and foreign direct investment (FDI). In other words, strong IP protection in a market could enhance licensing agreements or FDI instead of trade (Maskus, 2000). Moreover, imitating is costly, time-consuming and depends on capabilities that vary across countries. Thus, a weak IP protection system in a country with low imitation abilities will not necessarily discourage an innovative firm to enter that market. Finally, changes in IPRs would also interact with and be affected by local market parameters, such as demand and trade barriers.

Several empirical studies have found evidence supporting the hypothesis that the effect of IPRs on trade flows varies according to product sectors. Maskus and Penubarti (1995) investigated whether the distribution of bilateral trade across nations depends on the importing country's patent regime. They found that exporting firms discriminate in their sales decisions across export markets, considering local patent laws, but they concluded that the influence of changes in IPRs on international trade depends on the sector and development level.

Fink and Primo Braga (2005) found that stronger IPRs increase bilateral trade flows of manufactured non-fuel imports but they do not affect trade flows of high technology products. Delgado, Kyle, and McGahan (2013) investigated how implementing IPRs in developing countries under the TRIPS agreement has affected trade in knowledge-intensive goods. They found an increase in developing countries' imports driven by the exchange with high-income countries. They also found that the effect on knowledge diffusion from high-income to developing countries varies across sectors.

Several authors have studied the effect on trade of the interaction of imitation abilities and IPRs. Smith (1999) found for the United States (US) that the link between IPRs and trade depends on the ability of the importer to imitate the exporter's technologies. She found evidence of both a market expansion and a market power effect for the US manufacturing exports, but the latter is more relevant for exports to countries with weak capacity of imitation. Co (2004) studied how sensitive are US exports to importing countries' IPRs regimes. She found that IPRs regimes matter when they are considered together with imitative abilities of importing countries. Also, for a panel of countries, Falvey, Foster, and Greenaway (2009) found that imitative abilities influence the effect of IPRs on trade.

Other authors have investigated the issue for developing countries. For example, Ivus (2010) studied how stronger patent rights in developing countries have affected exports from the innovating developed world. She found that the strengthening of IPRs in developing countries has raised the value of developed countries' exports in patent-sensitive industries. The results are consistent before and after the signing of the TRIPS. In a similar direction, Shin, Lee, and Park (2012) studied the role of IPRs in global trade considering the level of technology of the exporting countries. They found that IPRs may act as an export barrier to lower-income countries. They argue that while recent IPRs reforms have facilitated global trade, they have not helped promoting exports of developing countries.

For the case of China, Awokuse and Yin (2010) found that the strengthening of Chinese patent laws has a strong market expansion effect for trade from both developed and developing countries, which lead to an increase in China's import flows, particularly in knowledge-intensive goods. In turn, for the post-TRIPS period, Lesser (2001) found that the effect of stronger IPRs on both FDI and imports was positive and significant for developing countries.

3. IPRS AND AGRICULTURAL TRADE: A FRAMEWORK

In this section, we discuss the main expected effects of IPRs on agricultural trade and we highlight some features of the sector and countries of different development level that may derive in different effects of IPRs.

It is worth noticing that there is less evidence available for the agricultural sector. Some empirical studies concentrate on seeds trade. Yang and Woo (2006) studied how national differences in IPRs affect the flow of planting seed imports from the US. They found that whether or not a country adheres to IPRs agreements has no impact on planting seeds imports. In line with these results, Eaton (2013) found no evidence that adopting plant breeders' rights benefits seed imports. Galushko (2012) has challenged this evidence concluding that stronger IPRs can foster international seed exchange.

Agricultural trade is a relevant global issue since there are countries in the world with surpluses of agricultural production and others with shortages. How to increase production and provide food to countries that need it are global challenges. In this sense, the analysis of the effect of IPRs on agricultural trade is an important matter because IPRs may have an effect on both agricultural production and trade.

In general, supporters of IPRs systems argue that developing countries will benefit from strong and harmonized IPRs systems because they have positive effects on innovation, technology transfer and trade.

The International Union for the Protection of New Varieties of Plants (UPOV), that advocates for harmonized and strong IPRs systems in the agricultural sector, argues that an effective IP protection system will provide an incentive to stimulate new and more effective breeding work at the domestic level (UPOV, 2005). It also argues that, in an international context, IPRs systems can provide important benefits by removing barriers to trade, thereby increasing domestic and international market scope. It holds that access to foreign-bred varieties enabled by IPRs would improve production as well as exports. Thus, it considers that IPRs are an important means of technology transfer and effective utilization of genetic resources. Similar arguments are used to advocate for strong IP protection for other products of the agricultural and manufacturing sectors.

Conversely, several authors have raised concerns regarding potential negative effects on domestic industries of developing countries derived from the monopoly power of IPRs, which may deter innovation, technology transfer and trade (Boldrin & Levine, 2010).

Our case of study has some relevant specificities that we have tried to consider in our analysis. Many agricultural products are final goods, whose production may be more related with natural endowments of the producing country and, therefore, imitation abilities may not matter as much as in other types of products. Moreover, innovation in this sector depends on local needs related with agro-ecological conditions, which often imply the need of interaction with domestic firms that own local knowledge. To take into consideration the differences in natural endowments, we consider a set of control variables related with comparative advantages for the agricultural production.

For other agricultural products imitation abilities do matter but in a distinct way. Despite several types of seeds can be easily imitated, other seeds and products require specific knowledge and imitation abilities. For example, genetically modified products demand management of complex knowledge and high investment capacity, which surely not all firms possess.

Besides, as in any other product, imitation depends on capabilities of the country receiving the inflow of technology, which is codified in products. Thus, we expect the development level of the country, associated with different imitation abilities, to influence the effect of IPRs on trade.

The market power effect derived from IPRs that would induce firms to increase prices and reduce sales may not be applied to commodities whose prices are globally determined but it is more likely to exist for other products of the agricultural sector, such as quality-differentiated products. Moreover, the concentration observed in the agri-food production and the presence of a few multinational firms in the global markets might be an indicator of the existence of the market power effect.

Thus, as in other sectors, the expected effects of IPRs systems on trade cannot be determined a priori because of the aggregation of products with different expected reactions to IPRs and because of the interaction of theoretical contradictory effects.

Considering the mixed evidence and the lack of studies for agricultural trade, our study contributes with empirical evidence to the current debate investigating for the post-TRIPS period the effect of stronger IPRs on trade of agricultural products, including raw material and manufactured products that use agricultural inputs. We use a broad concept of agriculture in order to address the average expected effect of IPRs on total agricultural trade but we also check for possible different effects at a more disaggregated level.

In addition, we are interested in determining if the effect is different for developed and developing countries considering that, particularly in the developing world, the effect of IPRs is still a matter of a contentious and open debate. Also, several factors lead to expect differential effects. In the first place, for developing countries, agricultural exports have a higher share in their total exports and a greater economic relevance, compared with developed countries (Figure 1).

Secondly, as part of a global process, IP protection has been increasing worldwide. But, while several developed countries

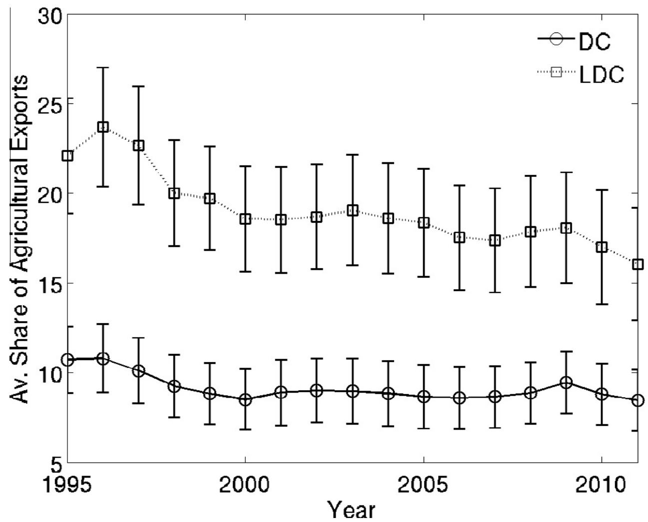

Figure 1. *Share of agricultural exports on total exports. Developed Countries (DC) and Developing Countries (LDC).*

used to have in place a system of IP protection before the signing of the TRIPS, most developing countries have been adopting these systems after 1995 (see Figure 2). Thus, we check if the different timing in the signing of the TRIPS influences trade.

As a final remark, most authors addressing the effect of IPRs on trade, focus on the level of IP protection of the importing country. In contrast, we consider separately the effect of increasing IPRs in the importing and the exporting country of agricultural products, as we may expect two different effects. An increase in the IPRs of the importing country may have an effect on agricultural trade due to the market power and market size effects already discussed. But also, an increase of the IPRs of the exporting country might affect productivity, innovation, access to foreign technologies and competitiveness, which may be reflected in agricultural exports. Accordingly, we consider IPRs systems of both the importers and the exporters.

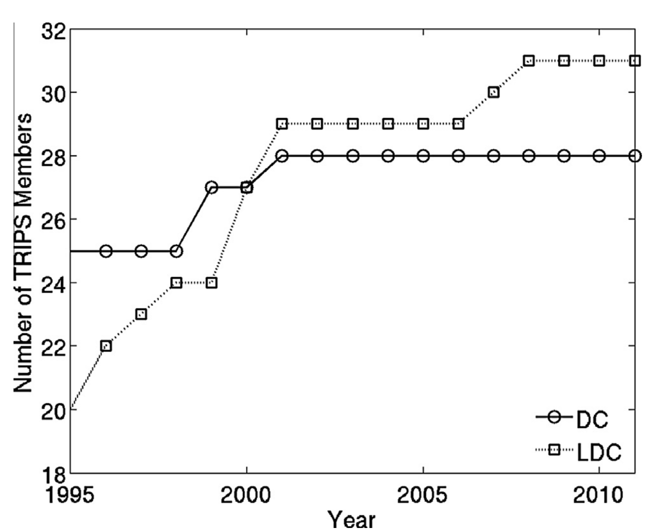

Figure 2. *Number of members of the TRIPS by year and development level. Developed Countries (DC) and Developing Countries (LDC).*

4. DATA

Our panel data consist of 60 countries, including 28 developed and 32 developing economies (see Appendix, for the list of countries), for the post-TRIPS period (1995–2011). [1]

The data for trade are from Gaulier and Zignago (2010) (BACI-CEPII). We have computed total trade of agricultural products by adding trade of chapters 1–24 of the Harmonized System Codes (HS Code) Commodity Classification, excluding chapters 3 and 16, which are related with fishery, and other categories in chapters 29–53, as defined by the World Trade Organization (WTO) (see Table 11 in Appendix). [2] We present the categories of chapters 29–53 aggregated in their three corresponding sections: 6, 8, and 11. Agricultural data aggregate products of several chapters and sections that we call sub-sectors. Thereby, this broad consideration of the agricultural sector includes grains and vegetables, but also animal products and products that have vegetable or animal origin.

We have transformed the original data from current US dollars into constant dollars (base 2000). As a proxy of changes in global prices, we used the US imports price index provided by the US Bureau of Labor Statistics. [3] To consider heterogeneity among price variations for different sub-sectors, we applied the index of each corresponding chapter to the data.

As a measure of IPRs, we used a yearly index developed by Campi and Nuvolari (2015) for the agricultural sector, which aggregates five components that indicate the strength of each country's IP protection system (*IP Index*). The index is based on a comparative historical perspective and it covers a set of countries that by 2011 had signed the UPOV convention and are characterized by a rather similar basic legal framework regulating plant variety protection and other agricultural products, which follows the general guidelines established by the UPOV and the TRIPS. Within this common framework, the index considers the elements that tend to vary more from country to country and over time.

The index consists of five components that together determine the overall strength of IP protection for the agricultural sector prevailing in each country. The five components of the index are: (i) ratification of UPOV conventions; (ii) farmers' exception; (iii) breeders' exception; (iv) protection length; and (v) patent scope (Campi & Nuvolari, 2015). The component patent scope indicates whether patents are allowed in five specific domains related to plant breeding and agriculture. More specifically, the fields are: (i) food, which processes products from agriculture; (ii) plants and animals (when the invention is not limited to a specific variety); (iii) microorganisms, which are closely related to the application of genetic engineering to plant breeding; (iv) pharmaceutical products because their production may also rely on biodiversity and genetic resources; and (v) plant varieties (either sexually or asexually reproduced). While many countries regarded some or all of these domains as not patentable subject matter, after the TRIPS agreement most countries have been including them in their patent systems.

Thus, the index measures the strength of IP protection for plant varieties provided by specific rights, i.e., plant breeders' rights and plant patents, but also IP protection for other agricultural products, in the broader definition of the WTO, such as animals and food, as well as by-products of vegetable and animal production.

The index shows that the mean of protection has been steadily increasing over time, especially after the signing of the TRIPS agreement, and dispersion has fallen as developing countries have been adopting stronger IPRs systems during the last two decades (Campi & Nuvolari, 2015). This reflects the process of strengthening and harmonization of IPRs systems.

5. IPRS AND TOTAL TRADE: ECONOMETRIC ESTIMATIONS

In this section, we study the correlation between the index of IP protection and both total imports ($timpa_t$) and total exports of agricultural products ($texpa_t$). We expect that the increase in the levels of IPRs might affect imports mainly through the interaction of the market expansion effect (lower risk of imitation) and the market power effect (monopolistic behavior). But also, stronger IPRs might influence innovation and productivity and, thus, competitiveness and exports of the exporting country.

Because the simple correlation between IPRs and total trade may mask more complex relations, we considered a set of control variables and carried out a multivariate regression (see Table 12 in Appendix). The first variable is GDP per capita at constant 2005 national prices (in millions of 2005 US dollars) (*GDPpc*). We included an indicator of human capital per person, which is based on years of schooling from Barro and Lee (2013) and returns to education from Psacharopoulos (1994) (*hc*). We expect human capital to have a positive effect on productivity and, therefore, also a positive impact on trade. In addition, human capital might capture heterogeneity in countries' capabilities and it might also be a proxy of imitation abilities. Finally, we considered openness to trade, computed as the sum of total exports and total imports, divided by the total GDP, all in constant prices (*open*) (Feenstra & Timmer, 2013). This variable is also regarded as the interaction across country borders and it is expected to ease and spur technology transfer and innovation. With this set of variables we carry out a first estimation.

In addition, we run a second specification of the model in which we included other control variables most of them related to the agricultural sector. We included the agricultural area in 1,000 hectares (*agri_area*) as an indicator of the natural endowment of each country. We considered tractors per arable land (*tract*) as an indicator of the stock of capital and the number of economically active adults in agriculture (*labor*) as a proxy of the labor factor. We also included the total consumption of fertilizers (*fertil*) divided by the number of agricultural land in the country, which is likely to improve agricultural yields. All the variables related to the agricultural sector were constructed using data of FAO (faostat.fao.org).

Moreover, we included a country-specific variable that indicates in which year each country has signed the TRIPS agreement (*TRIPS*), using data of WIPO (www.wipo.int). All signatory countries of the WTO were given different time periods to apply the provisions of the TRIPS. Developed countries were granted a transition period of one year after the entry into force of the WTO Agreement, i.e., until January 1, 1996. Developing countries and transition economies were allowed a further period of four years (to January 1, 2000). Least-developed countries were granted a longer transition period of eleven years (until January 1, 2006), with the possibility of an extension. For pharmaceutical patents, the transition period has been extended to January 1, 2016. Thus, we expect that this difference in the time of compliance of the provisions of the TRIPS may have different impacts on trade.[4]

Finally, we also considered two additional variables: the one-year lag of total agricultural exports (texpa_{t-1}) and the one-year lag of total agricultural imports ($timpa_{t-1}$). We have included these variables to avoid an autoregressive effect and to rule out a simultaneity issue because imports of $t-1$ are likely to influence exports of t, and vice versa.

In both specifications, we considered the full sample, a sample of developed countries and a sample of developing countries. Table 1 displays the correlation matrix of the independent variables.

Taking advantage of the panel structure of the data, we applied a fixed effects estimation method[5] using the following log-linearized models:

$$\log(texpa_{i,t}) = x_{i,t} \cdot \beta_x + \mu_{xi,t}; \tag{1}$$

$$\log(timpa_{i,t}) = x_{i,t} \cdot \beta_m + \mu_{mi,t}; \tag{2}$$

where,

$$\begin{aligned} x_{i,t} = \{&1, \text{IP index}_{i,t}, \log(\text{GDPpc}_{i,t}), \text{hc}_{i,t}, \log(\text{open}_{i,t}), \\ &\log(\text{agri\_area}_{i,t}), \log(\text{tract}_{i,t}), \log(\text{labor}_{i,t}), \\ &\log(\text{fertil}_{i,t}), \text{TRIPS}_{i,t}, \log(\text{timpa}_{i,t-1}), \log(\text{texpa}_{i,t-1})\}. \end{aligned} \tag{3}$$

Table 2 displays the results of the fixed effects estimations using the panel data for the model with total exports of agricultural products as the dependent variable. Models 1–3 present the estimations of the simple specification to keep the greatest number of observations. Models 4–6 present the estimations of the specification that includes all the control variables.

In models 1–3, the control variables present the expected signs when they are significant: GDP per capita, human capital and openness to trade are positive. The index of IP protection is negative and significant for the full sample and the sample of developing countries, but not significant for the sample of developed countries.

In the second specification of the model (4–6), the control variables also present the expected signs when they are significant. GDP per capita, human capital and openness to trade have positive coefficients when they are significant. Considering agricultural specific variables improves the performance of the model, despite the lower number of observations. Agricultural area and fertilization have positive effects on the total quantity of agricultural exports. Agricultural labor and tractors turn out to be not significant. The variable that indicates the year of the signing of the TRIPS agreement turns out to be negative and significant for the three samples, meaning that signing the TRIPS agreement has a negative impact on agricultural exports. Finally, the significance and sign of the coefficients of the index remain the same as estimated in the previous model (negative and significant for the full sample and developing countries).

Table 3 displays the results for the estimations using total imports of agricultural products as the dependent variable. Also in these estimations (models 1–6), the control variables have the expected signs when they are significant. The GDP per capita and openness to trade are positive, while human capital is negatively correlated with total imports, except for developed countries. This may be explained by different imitation abilities of countries and by the fact that an increase in human capital may imply an increase in imitation abilities. The index of IP protection results negative and statistically significant for all the samples in both specifications, except for developed countries in the extended specification (model 5).

Regarding the control variables related to agriculture used in the extended specification (models 4–6), only agricultural area turns out to be significant for the full sample and the sample of developed countries (models 4 and 5). The signing of the

Table 1. *Correlation matrix of independent variables*

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	inda	1									
(2)	log(GDPpc)	0.311	1								
(3)	hc	0.461	0.640	1							
(4)	log(open)	0.152	0.638	0.418	1						
(5)	log(agri_area)	0.041	−0.227	−0.256	−0.589	1					
(6)	log(tract)	0.132	0.747	0.442	0.621	−0.520	1				
(7)	log(labor)	−0.117	0.062	0.087	0.271	−0.292	0.013	1			
(8)	log(fertil)	0.210	0.602	0.357	0.365	−0.325	0.548	0.107	1		
(9)	log($texpa_{t-1}$)	0.284	0.421	0.105	−0.006	0.609	0.048	−0.260	0.306	1	
(10)	log($timpa_{t-1}$)	0.307	0.625	0.273	0.076	0.387	0.274	−0.182	0.513	0.798	1

Table 2. *Total exports of agricultural products. Fixed effects estimations*

Model	(1)	(2)	(3)	(4)	(5)	(6)
Sample	FS	DC	LDC	FS	DC	LDC
IP Index	−0.032***	−0.024	−0.056***	−0.035**	−0.020	−0.061**
	(0.011)	(0.017)	(0.013)	(0.018)	(0.022)	(0.025)
log GDP per capita	0.374***	1.018***	0.112	0.392***	0.607***	0.263
	(0.066)	(0.109)	(0.078)	(0.127)	(0.167)	(0.205)
human capital	0.632***	0.060	1.150***	0.416**	−0.173	0.844***
	(0.106)	(0.133)	(0.145)	(0.186)	(0.274)	(0.272)
log openness to trade	0.750***	0.812***	0.618***	0.468***	0.436***	0.501***
	(0.040)	(0.055)	(0.052)	(0.084)	(0.117)	(0.118)
log agricultural area				0.538**	0.182	1.300***
				(0.257)	(0.269)	(0.493)
log tractors per arable land				0.010	0.068	0.020
				(0.087)	(0.127)	(0.120)
log labor				−0.027	−0.014	−0.080
				(0.024)	(0.018)	(0.247)
log fertilization				0.056***	0.045**	0.058**
				(0.018)	(0.022)	(0.027)
TRIPS				−0.185***	−0.162**	−0.250***
				(0.056)	(0.077)	(0.083)
log $exports_{(t-1)}$				0.420***	0.694***	0.201***
				(0.048)	(0.071)	(0.069)
log $imports_{(t-1)}$				−0.029	−0.135	0.027
				(0.047)	(0.096)	(0.058)
Constant	4.977***	−0.252	6.761***	−3.476	−3.620	−8.345
	(0.455)	(0.857)	(0.487)	(2.730)	(2.943)	(5.239)
Observations	1,020	476	544	392	182	210
R-Squared	0.647	0.779	0.596	0.656	0.803	0.618
Number of countries	60	28	32	48	21	27

Note: The dependent variable is total exports of agricultural products. Standard errors are in parenthesis. Significance level: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$. FS: Full Sample; DC: Developed Countries; LDC: Developing Countries.

TRIPS agreement plays a negative role for imports of agricultural products of developed countries (model 5).

The effect of IPRs may be different when considering exports or imports at a more disaggregated level (see Awokuse and Yin (2010) for the case of industrial products), especially considering that agricultural products aggregate a wide variety of products. Therefore, we perform fixed effects estimations on the panel data where the dependent variables are the quantity of exports or imports of each of the 25 sub-sectors (2-digits level); and the independent variables are those specified in Eqn. (3).[6]

By carrying out a sub-sectoral analysis we want to study which sectors are sensitive to changes in IPRs because, like in other industries, there are specificities of the sub-sectors that could lead to different reactions.

We have classified the sub-sectors in three main categories: (i) vegetable-products that include chapters and sectors in which all the products are vegetables or derived from vegetables; (ii) animal-products that include chapters and sections in which products have an animal origin; and (iii) chapters and sectors containing products from both animal and vegetable origin.

Figure 3 shows graphically the estimated coefficients of the IP indexes for each sub-sector and group of countries. Red bars illustrate the significant coefficients of the IP index of the exporter in the regressions with total exports as the dependent variable while blue bars are the significant coefficients for the IP indexes of the importer for the model estimated with total imports as the dependent variable. No color bars indicate no significant estimated coefficients. Vertical lines separate the

Table 3. *Total Imports of Agricultural Products. Fixed Effects Estimations*

Model	(1)	(2)	(3)	(4)	(5)	(6)
Sample	FS	DC	LDC	FS	DC	LDC
IP Index	−0.035***	−0.052***	−0.022*	−0.039**	−0.004	−0.055**
	(0.009)	(0.013)	(0.012)	(0.016)	(0.015)	(0.025)
log GDP per capita	1.188***	1.158***	1.266***	0.770***	0.202*	0.941***
	(0.054)	(0.080)	(0.074)	(0.114)	(0.112)	(0.204)
human capital	−0.396***	0.174*	−0.880***	−0.611***	0.323*	−1.021***
	(0.088)	(0.099)	(0.137)	(0.167)	(0.184)	(0.271)
log openness to trade	0.754***	0.662***	0.809***	0.774***	0.407***	0.944***
	(0.033)	(0.041)	(0.049)	(0.076)	(0.079)	(0.118)
log agricultural area				0.632***	0.301*	0.777
				(0.231)	(0.180)	(0.490)
log tractors per arable land				0.124	0.034	0.152
				(0.078)	(0.085)	(0.119)
log labor				−0.008	−0.014	0.036
				(0.022)	(0.012)	(0.245)
log fertilization				−0.026	0.007	−0.036
				(0.016)	(0.015)	(0.027)
TRIPS				−0.004	−0.111**	0.041
				(0.051)	(0.052)	(0.082)
log exports$_{(t\text{-}1)}$				−0.076*	0.008	−0.077
				(0.043)	(0.047)	(0.068)
log imports$_{(t\text{-}1)}$				0.395***	0.544***	0.315***
				(0.042)	(0.064)	(0.058)
Constant	0.275	−0.802	0.725	−6.290**	−1.307	−8.115
	(0.377)	(0.635)	(0.461)	(2.455)	(1.975)	(5.215)
Observations	1,020	476	544	392	182	210
R-Squared	0.797	0.850	0.778	0.731	0.853	0.724
Number of countries	60	28	32	48	21	27

Note: The dependent variable is total imports of agricultural products. Standard errors are in parenthesis. Significance level: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$. FS: Full Sample; DC: Developed Countries; LDC: Developing Countries.

groups of products: vegetable products (V-P), animal products (A-P), and products of animal and vegetable origins (Both). For most sub-sectors, the regressors are negative when they turn out to be significant regardless the sample and the group of products.

In the estimations for total exports, we observe that most significant coefficients are negative both if we consider vegetables and animal products and for all the samples. This means that the strengthening of IP protection systems will have a negative impact on the exports of most sub-sectors, especially for developing countries.

In the case of imports, the results are mixed. While most significant coefficients are still negative, we observe positive coefficients in several sub-sectors, especially in the sample of developing countries. This implies that developing countries are more likely to import agricultural products of several sub-sectors when they increase their IPRs systems.

Thus far, the evidence points an average negative effect of strengthening of IP protection on total trade of agricultural products, especially for developing countries, both considering imports and exports.

6. DO STRONGER IPRS ENHANCE BILATERAL TRADE?

IPRs might also affect bilateral trade in different ways that will ultimately be determined by sector or countries' specificities. A natural framework to explore the possible implication of IPRs on bilateral trade is the gravity model (GM) of trade, which has a relevant empirical success at explaining an important extent of the observed trade flows. Initially proposed by Tinbergen (1962), the GM has become the baseline empirical model to explain bilateral trade flows among countries, taking as explanatory variables the GDP of both the importer and the exporter, as well as the distance between them. The modern economic interpretation of the gravity expression has generalized the original idea by including proxies of possible trade barrier-aspects related with geography, culture, bilateral trade agreements, among others. The GM considers separately the effect of such variables for importers and exporters, allowing the possibility of asymmetric effects. The GM emerges from a wide set of theoretical models, including monopolistic competition (see: Fratianni (2009), for a comprehensive survey) and Heckscher-Ohlin model with specialization (Anderson, 1979; Bergstrand, 1985).

In this section, we aim to explain bilateral total trade using the GM. We complement our analysis of the effect of IPRs on trade volumes by investigating whether strong IPRs facilitate the creation of bilateral trade relationships and trade flows. In addition, we study the intensive and extensive margins of trade.

As we postulate different effects according to the development level, we split the data into four groups of analysis. In the first group, we consider all trade relationships present in our data base (Full Sample). The second group considers all those trade relationships between developed countries (DC–DC); the third one considers trade relationships between developed and developing countries (DC–LDC); and the last group considers only relationships among developing countries (LDC–LDC).

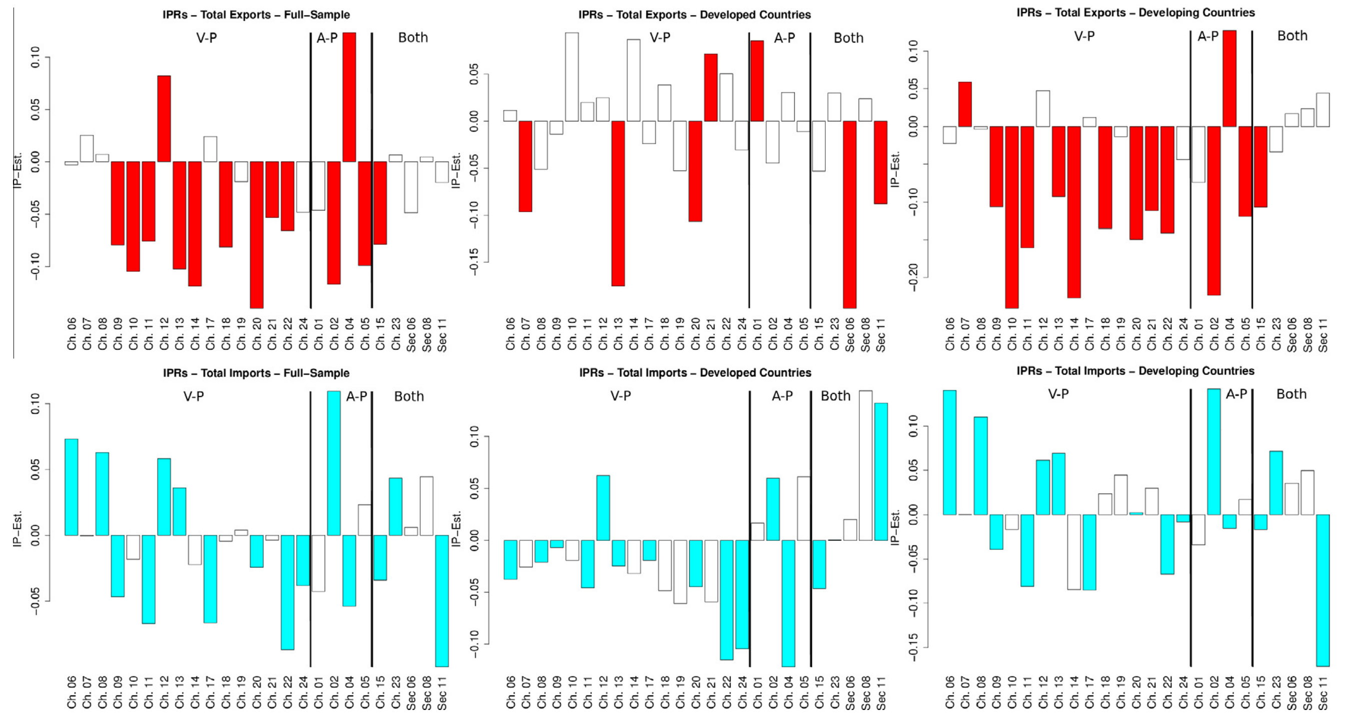

Figure 3. *Impact of IPRs on total exports and imports. Agricultural sub-sectors. Notes: Top: IPRs regressors for the estimations using total exports for the full sample (left), DC (middle) and LDC (right). Bottom: IPRs regressors for the estimations using total imports for the full sample (left), DC (middle) and LDC (right). Vertical lines separate groups of products. V-P: vegetable products; A-P: animal products; Both: sectors with animal and vegetables products. Color bars indicate significant estimated coefficients. No color bars indicate no significant estimated coefficients. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)*

(a) *Total bilateral trade*

For the estimation of the GM, we use the following benchmark specification. Let $W_{ei}(t)$ be the export from country e to country i in the year t. Therefore, the gravity equation is:

$$W_{ei}(t) = \exp\{x_{ei}(t) \cdot \beta\}\eta_{ei}(t), \quad (4)$$

where,

$$x_{ei} = \{\log(Y_e), \log(Y_i), \log(X_e), \log(X_i), Z_e, Z_i, \log(d_{ei}), D_{ei}, \gamma_e, \gamma_i, \tau\}; \quad (5)$$

$e, i = 1, \ldots, N$; $Y_e = \{GDP_e,\ GDPpc_e\}$ is a vector of annual GDP and annual GDP per capita for country e; $X_e = \{\text{area}_e,\ \text{pop}_e, \text{agri\_area}_e,\ \text{tract}_e,\ \text{labor}_e,\ \text{fertil}_e\}$ is a vector of country-specific macro variables, some of them related to the agricultural sector; $Z_e = \{\text{landlocked}_e,\ \text{IP Index}_e,\ \text{TRIPS}_e\}$ includes a country-specific dummy, the IP index and a variable indicating the signing of the TRIPS; d_{ei} is the geographical distance between both countries; $D_{ei} = \{\text{contig}_{ei},\ \text{comlang}_{ei},\ \text{comcol}_{ei},\ \text{colony}_{ei}\}$ is a vector of link-specific variables indicating barriers to trade; γ_e and γ_i are exporter and importer country's dummies; τ is a set of time dummies; and it is assumed that $E[\eta_{ei}|Y_e,\ Y_i,\ d_{ei}, \ldots] = 1$. See Table 12 in Appendix for a complete description of variables and sources.

The estimation of Eqn. (4) is not straightforward. It requires a special treatment of heteroskedasticity (non-linearity), zero-valued flows, endogeneity, and omitted-term biases (Santos Silva & Tenreyro, 2006). The GM can be fitted to data using different econometric techniques, ranging from simple ordinary least squares applied to the log-linearized equation (Glick & Rose, 2002; Subramanian & Wei, 2007), the two-stage Poisson estimations, which considers the probability of having zero trade flows (Burger, Van Oort, & Linders, 2009), and panel data techniques with instrumental variables (Awokuse & Yin, 2010). A common feature of the estimation techniques is that they achieve high R-squared coefficients of determination, i.e., a quite satisfactory goodness of fit, which explains the success of the gravity model.

As notice in Eqn. (4), to study the effect of IPRs on bilateral trade, we expand the standard GM specification by adding IP protection indexes represented in two country-specific variables, related to exporters and importers: IP Index_e and IP Index_i. This enriches our analysis, allowing to explore whether bilateral trade volumes and bilateral trade relations increase when the exporter and/or the importer strengthen their IPRs systems.

In our analysis, we estimate the traditional GM under a wide set of specifications and we use the following econometric techniques: (i) a panel data estimation that assumes fixed effects (FE), and (ii) a zero inflated Poisson pseudo maximum likelihood (ZIP) estimation with time dummies, pooling all cross-sections. The ZIP model preforms a Poisson pseudo maximum likelihood (PPML),[7] which estimates total trade among positive observed trade volumes; and a logit estimation that considers zero trade flows. In some specifications of the PPML and the logit estimations, we included country dummies.

Notice that in both the FE and the PPML, the dependent variable proxies the observed trade volumes, while in the logit estimation, the dependent variable is a binary variable representing the observed bilateral trade relationships.

The FE estimation could be at disadvantage against the PPML in controlling heteroskedasticity due to the non-linearity of the gravity model. Despite this, we included the FE estimation with panel data because it can control the unobserved heterogeneous components related to trade links.[8]

Table 4 displays the estimation results of the aggregate bilateral trade in agricultural products using the full sample of

Table 4. *Total bilateral exports of agricultural products. Gravity model estimations. Full sample*

Model	Simple Model					Extended Model				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Method	FE	PPML		Logit		FE	PPML		Logit	
IP Index$_e$	−0.025***	0.047**	−0.012	0.037	0.009	0.030**	0.038	0.017	−0.046	0.159***
	(0.007)	(0.021)	(0.013)	(0.024)	(0.015)	(0.015)	(0.045)	(0.021)	(0.068)	(0.033)
IP Index$_i$	−0.046***	−0.072***	−0.006	0.088***	0.284***	−0.016	−0.114**	−0.015	−0.062	0.224***
	(0.007)	(0.020)	(0.013)	(0.024)	(0.014)	(0.015)	(0.045)	(0.025)	(0.067)	(0.033)
log GDP$_e$	−0.293***	−1.376***	0.540***	−1.001***	0.891***	−0.877**	−1.184	0.383***	−4.062**	0.578***
	(0.091)	(0.310)	(0.011)	(0.372)	(0.015)	(0.359)	(1.319)	(0.041)	(1.764)	(0.060)
log GDP$_i$	0.965***	1.239***	0.853***	−0.931**	0.519***	−0.118	2.901**	1.220***	−4.757***	0.552***
	(0.091)	(0.333)	(0.014)	(0.398)	(0.014)	(0.359)	(1.235)	(0.045)	(1.750)	(0.053)
log GDPpc$_e$	0.790***	1.746***	0.304***	0.471	0.324***	1.090***	1.525	0.472***	2.933*	0.358***
	(0.094)	(0.308)	(0.020)	(0.333)	(0.020)	(0.364)	(1.310)	(0.056)	(1.576)	(0.066)
log GDPpc$_i$	0.506***	0.123	0.131***	1.983***	0.519***	1.285***	−1.974*	−0.205***	4.825***	0.456***
	(0.093)	(0.315)	(0.022)	(0.359)	(0.019)	(0.362)	(1.082)	(0.067)	(1.627)	(0.065)
log dist		−0.819***	−0.550***	−1.575***	−0.807***		−0.815***	−0.734***	−1.617***	−1.062***
		(0.011)	(0.016)	(0.041)	(0.018)		(0.025)	(0.026)	(0.078)	(0.046)
contig		0.667***	0.923***	0.037	1.011***		0.652***	0.612***	0.032	0.005
		(0.033)	(0.044)	(0.245)	(0.228)		(0.062)	(0.067)	(0.342)	(0.290)
comlang		0.088**	0.171***	1.116***	1.652***		−0.065	−0.097*	1.243***	1.718***
		(0.036)	(0.038)	(0.138)	(0.092)		(0.061)	(0.057)	(0.245)	(0.190)
comcol		0.889***	0.351***	3.221***	2.056***		0.756***	0.902***	2.325***	1.906***
		(0.077)	(0.078)	(0.141)	(0.123)		(0.170)	(0.163)	(0.251)	(0.238)
colony		0.304***	−0.022	−0.001	0.352		0.094	−0.125*	−0.964***	−0.537*
		(0.039)	(0.036)	(0.292)	(0.272)		(0.074)	(0.066)	(0.338)	(0.275)
log area$_e$			0.070***		0.093***			−0.471***		−0.222***
			(0.011)		(0.011)			(0.029)		(0.049)
log area$_i$			−0.165***		−0.077***			−0.093***		−0.093*
			(0.009)		(0.012)			(0.034)		(0.050)
landlocked$_e$			−0.785***		−0.367***			−0.869***		0.141
			(0.034)		(0.032)			(0.066)		(0.086)
landlocked$_i$			−0.510***		−0.050			−0.625***		0.161*
			(0.031)		(0.035)			(0.069)		(0.089)
log agri_area$_e$						0.854***	0.623	0.741***	1.637*	0.598***
						(0.277)	(1.001)	(0.035)	(0.940)	(0.051)
log agri_area$_i$						−0.339	−0.434	−0.301***	0.350	0.191***
						(0.264)	(0.978)	(0.047)	(1.142)	(0.051)
log tract$_e$						0.306***	0.105	−0.150***	−0.284	0.201***
						(0.075)	(0.175)	(0.027)	(0.334)	(0.036)
log tract$_i$						0.137*	0.032	0.095**	−1.157***	0.292***
						(0.075)	(0.209)	(0.047)	(0.331)	(0.034)
log labor$_e$						−0.013	−0.002	0.047***	0.880*	−0.096***
						(0.015)	(0.014)	(0.011)	(0.463)	(0.014)
log labor$_i$						−0.018	−0.019	0.025**	2.081***	0.016
						(0.015)	(0.019)	(0.011)	(0.516)	(0.014)
log fertil$_e$						0.129***	0.007	0.050	−0.018	0.244***
						(0.021)	(0.064)	(0.038)	(0.081)	(0.042)
log fertil$_i$						0.021	−0.107**	−0.333***	0.018	−0.010
						(0.020)	(0.051)	(0.034)	(0.082)	(0.041)
TRIPS$_e$						−0.139***	−0.043	1.157***	−0.025	1.203***
						(0.050)	(0.134)	(0.091)	(0.175)	(0.080)
TRIPS$_i$						0.055	0.240**	0.291***	0.039	0.161**
						(0.047)	(0.113)	(0.089)	(0.182)	(0.081)
Constant	Yes					Yes				
Country Dummies		Yes		Yes			Yes		Yes	
Time Dummies		Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
Observations	62,900	62,900	62,900	61,132	72,930	16,436	16,436	16,436	15,365	19,328

Note: Standard errors are in parenthesis. Significance level: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

countries. We estimated models 1 to 5 with the simple specification of the gravity equation and models 6 to 10 with an extended specification that includes agricultural-related variables and a variable that indicates the year of accession to the TRIPS.

The differences in the country-specific estimates related to the importer and the exporter suggest asymmetries between their profiles. Actually, the null hypothesis that importer and exporter variables affect proportionally trade flows is rejected for both FE and PPML estimations.

Models 1–3 show the estimations of trade volumes with the simpler specification of the model. In model 3, the gravity structure of trade is mirrored by the signs of the countries' size variables (GDP, GDPpc and area), which are positive, and distance regressors that are negative.

For the IPRs indexes, in the FE estimation, we observe significance in the indexes associated both with the exporter and the importer. In the PPML estimation with country dummies (model 2), the coefficient of the IP index of the importer remains negative and significant while the coefficient of the IP index of the exporter turns out to be positive. In the PPML estimation without country dummies, the coefficients are no significant.

In the logit estimation (model 5), we also found the expected structure of the gravity model: for a couple of countries the probability of creating a bilateral relationship increases with the countries' sizes and decreases with the distance between them. All the other regressors have the expected signs. In both logit estimations (with and without country dummies), the country-specific IP Index_i is positive and significant for the creation of trading channels. This suggests that the creation of new markets, i.e., new links in the trade network, is expected to grow with the tightening of IPRs in the importing countries.

As a robustness check, in models 6–10, we consider further control variables that indicate comparative advantages for agricultural production and a variable indicating the signing of the TRIPS. Although these estimations reduce the sample around 75%, we found no significant differences in the estimated coefficients. The IP indexes lose significance in some of the estimations, but also other variables, and when they turn out to be significant their signs remain equal except for the case of the IP index of the exporter in the FE estimation.

Table 5 shows that some differences arise on the coefficients of the IP indexes if we sample on the restricted groups of countries.[9] In the estimations for bilateral trade volumes (FE, PPML and PPML with country dummies), for the case of trade between developed countries (models 1–3), we found that the effect of the IP index of the importer is negative in all the estimations and the effect of the index of IPRs of the exporter is positive in the estimation of PPML with country dummies. For the case of trade between developed and developing countries (models 5–7), the expected effect of stronger IPRs is negative, for the IP Index_e in the FE and PPML models, and for the IP Index_i in the FE and PPML with country dummies. Finally, for the case of trade between developing countries (models 9–11), the estimated effect is negative for the index of IPRs of the exporter in the FE and PPML estimations. The index of IPRs of the importer is negative in the FE and the PPML with country dummies while positive in the estimation with PPML. Notice that, in the PPML estimation (model 11), the estimated IP indexes for the exporter and importer have opposite signs. However, in absolute values, the negative estimate of the IP index of the importer is higher than the positive estimate of the IP index of the exporter, suggesting a negative net effect for trade between countries with similar IPRs systems.

To estimate the bilateral trade relations we used a logit estimation method.[10] For the case of developed countries, we found no significant effect of IPRs (model 4). It is worth noticing that, at the aggregated level, most developed countries are completely integrated so the probability of creating new bilateral trade links might be difficult to capture in the sample restricted to developed countries. For the sample including trade between developed and developing countries (model 8) the strengthening of IPRs systems leads to an expected extension of bilateral trade relationships when the importer's IPRs increase. For the case of trade between developing countries (model 12) the effect might be ambiguous because the IP indexes estimated for the exporter and importer have opposite signs. However, they are quite asymmetric suggesting that the global effect for the extension of trade markets between developing countries with similar IPRs systems might be positive.

These findings suggest that it may be beneficial for a given country that other countries increase their IP protection because this increases the probability of selling to those countries, but that there might be no incentives for a country to increase its own IP protection because this does not increase the probability of trading with more countries.

Finally, as a further robustness check, we estimated total bilateral trade of agricultural products adopting the recent specification of the gravity model suggested by Anderson and van Wincoop (2003) that also includes country fixed effects in the regression. Strictly, the theoretical model yields the prediction of unit-income-elasticities. This imposes a restriction on the econometric estimation that can be easily incorporated by estimating the ratio between the bilateral trade flows and the product of the importers' and exporters' GDPs. More precisely, our specification takes the following form:

$$Z_{ei}(t) = \frac{W_{ei}(t)}{\text{GDP}_e(t) \times \text{GDP}_i(t)} = \exp\{x_{ei}(t) \cdot \beta\}\eta_{ei}(t), \tag{6}$$

where,

$$x_{ei} = \{\text{IP Index}_e,\ \text{IP Index}_i,\ \log(d_{ei}),\ D_{ei},\ \gamma_e,\ \gamma_i\}. \tag{7}$$

The parameters γ_{et} are time-varying exporter dummies and γ_{it} are time-varying importer dummies, which serve to proxy for "multilateral resistance" in the framework of Anderson and van Wincoop (2003). As in the classic formulations of the GM, d_{ei} is the geographical distance between both countries; $D_{ei} = \{\text{contig}_{ei}, \text{comlang}_{ei}, \text{comcol}_{ei}, \text{colony}_{ei}\}$ is a vector of link-specific variables indicating barriers to trade; and it is assumed that $E[\eta_{ei}|\cdot] = 1$.

We estimated Eqn. (6) using the PPML estimation method. Table 6 shows the results. In line with previous estimations, we found that strong IPRs systems have a significantly negative effect on bilateral trade. More precisely, the prediction of the Anderson and van Wincoop's specification tells us that this reduction is due to the IP index of the exporter. In model 2, we included two interaction parameters, $\text{LDC}_e * \text{IP Index}_e$ and $\text{LDC}_i * \text{IP Index}_i$, which are dummies

Table 5. *Total bilateral exports of agricultural products. Gravity model estimations. Samples of developed and developing countries*

Model	DC–DC				DC–LDC				LDC–LDC			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation Method	FE	PPML		Logit	FE	PPML		Logit	FE	PPML		Logit
IP Index$_e$	-0.006	0.086^{**}	0.022	-0.171	-0.029^{***}	0.002	-0.112^{***}	-0.007	-0.059^{***}	-0.030	-0.339^{***}	-0.052^{***}
	(0.012)	(0.037)	(0.020)	(0.128)	(0.009)	(0.019)	(0.016)	(0.024)	(0.014)	(0.025)	(0.030)	(0.018)
IP Index$_i$	-0.050^{***}	-0.067^{**}	-0.035^{*}	0.023	-0.034^{***}	-0.093^{***}	-0.002	0.204^{***}	-0.035^{***}	-0.050^{**}	0.115^{***}	0.272^{***}
	(0.012)	(0.029)	(0.018)	(0.141)	(0.009)	(0.021)	(0.018)	(0.023)	(0.013)	(0.025)	(0.027)	(0.018)
log GDP$_e$	-3.302^{***}	-3.399^{***}	0.597^{***}	0.538^{**}	-0.135	0.166	0.460^{***}	1.029^{***}	0.378^{**}	0.772	0.100^{***}	1.025^{***}
	(0.195)	(0.496)	(0.016)	(0.230)	(0.121)	(0.300)	(0.015)	(0.025)	(0.193)	(0.553)	(0.033)	(0.026)
log GDP$_i$	2.821^{***}	1.738^{***}	0.896^{***}	0.752^{***}	0.759^{***}	1.281^{***}	0.922^{***}	0.666^{***}	0.736^{***}	0.260	0.670^{***}	0.540^{***}
	(0.195)	(0.629)	(0.024)	(0.101)	(0.122)	(0.304)	(0.017)	(0.021)	(0.191)	(0.402)	(0.044)	(0.022)
log GDPpc$_e$	4.703^{***}	4.569^{***}	0.438^{***}	2.115^{***}	0.398^{***}	0.135	0.353^{***}	-0.103^{***}	0.035	-0.820^{*}	0.398^{***}	-0.219^{***}
	(0.193)	(0.536)	(0.046)	(0.402)	(0.129)	(0.280)	(0.027)	(0.038)	(0.191)	(0.498)	(0.049)	(0.037)
log GDPpc$_i$	-1.383^{***}	0.283	-0.066^{*}	0.843^{***}	0.458^{***}	-0.197	0.029	0.131^{***}	1.128^{***}	1.247^{***}	0.139^{**}	0.086^{**}
	(0.192)	(0.542)	(0.037)	(0.308)	(0.128)	(0.295)	(0.032)	(0.036)	(0.186)	(0.335)	(0.066)	(0.034)
log dist		-0.857^{***}	-0.578^{***}	-1.502^{***}		-1.151^{***}	-0.238^{***}	-0.529^{***}		-0.926^{***}	-0.585^{***}	-0.752^{***}
		(0.017)	(0.021)	(0.114)		(0.021)	(0.024)	(0.028)		(0.023)	(0.030)	(0.027)
contig		0.399^{***}	0.664^{***}	-		1.254^{***}	1.614^{***}	-		-0.143^{***}	0.247^{***}	1.376^{***}
		(0.037)	(0.044)			(0.053)	(0.070)			(0.051)	(0.091)	(0.227)
comlang		0.549^{***}	0.492^{***}	-		0.032	0.478^{***}	-		0.980^{***}	0.579^{***}	1.996^{***}
		(0.047)	(0.048)			(0.048)	(0.051)			(0.071)	(0.065)	(0.101)
comcol		2.804^{***}	1.747^{***}	-		1.508^{***}	0.752^{***}	3.499^{***}		0.727^{***}	0.745^{***}	1.390^{***}
		(0.071)	(0.124)			(0.103)	(0.100)	(0.329)		(0.092)	(0.129)	(0.145)
colony		0.152^{***}	-0.193^{***}	-		0.784^{***}	0.260^{***}	-		1.083^{***}	0.695^{***}	0.038
		(0.043)	(0.047)			(0.044)	(0.058)			(0.081)	(0.107)	(0.306)
log area$_e$			-0.067^{***}	0.966^{***}			0.224^{***}	0.098^{***}			0.514^{***}	-0.082^{***}
			(0.018)	(0.178)			(0.012)	(0.019)			(0.039)	(0.016)
log area$_i$			-0.219^{***}	0.024			-0.189^{***}	-0.152^{***}			0.112^{***}	-0.147^{***}
			(0.018)	(0.128)			(0.012)	(0.019)			(0.029)	(0.017)
landlocked$_e$			-1.164^{***}	0.974^{**}			-0.603^{***}	-0.475^{***}			-0.083	-0.576^{***}
			(0.051)	(0.426)			(0.049)	(0.048)			(0.083)	(0.052)
landlocked$_i$			-0.629^{***}	-0.035			-0.662^{***}	0.014			-0.061	-0.391^{***}
			(0.039)	(0.417)			(0.042)	(0.054)			(0.074)	(0.056)
Constant	Yes				Yes				Yes			
Country Dummies		Yes				Yes				Yes		
Time Dummies		Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Observations	12,746	12,746	12,746	10,432	32,901	32,901	32,901	33,796	17,253	17,253	17,253	23,902

Note: Standard errors are in parenthesis. Significance level: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 6. *Total bilateral trade of agricultural products. Gravity model. Anderson and van Wincoop specification. Full sample*

Model	(1)	(2)
IP Index$_e$	-0.540^{***}	-0.493^{**}
	(0.165)	(0.202)
IP Index$_i$	-0.100	0.126
	(0.182)	(0.194)
LDC$_e$ $*$ IP Index$_e$		-0.047
		(0.140)
LDC$_i$ $*$ IP Index$_i$		-0.226^{**}
		(0.089)
log dist	-1.027^{***}	-1.027^{***}
	(0.015)	(0.015)
contig	0.333^{***}	0.333^{***}
	(0.040)	(0.040)
comlang	0.667^{***}	0.667^{***}
	(0.038)	(0.038)
comcol	1.573^{***}	1.573^{***}
	(0.048)	(0.048)
colony	0.691^{***}	0.691^{***}
	(0.056)	(0.056)
Time-Varying Country Dummies	Yes	Yes
Time Dummies	Yes	Yes
Observations	62,900	62,900

Note: Standard errors are in parenthesis. Significance level: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 7. *Summary of total bilateral trade estimations*

Sample	IP Exporter	IP Importer
Total Trade		
Full-Sample	Mixed	(−)
DC–DC	(+)	(−)
DC–LDC	(−)	(−)
LDC–LDC	(−)	Mixed
Bilateral Trade Relations		
Full-Sample	n.s.	(+)
DC–DC	n.s.	n.s.
DC–LDC	n.s.	(+)
LDC–LDC	(−)	(+)

Note: Estimation results for total trade are concluded from both FE and PPML estimations (with and without country dummies). n.s.: no significant; (+): positive coefficient; (−): negative coefficient; mixed: opposite significant coefficients from FE and PPML estimations.

associated to developing countries, as exporters or importers, times their corresponding IP indexes.[11] The interaction parameters show an additional reduction of bilateral trade when the importer is a developing country proportional to its IP protection level.

Table 7 summarizes the main results of the GM estimations (Tables 4–6). The evidence suggests that the strengthening of IPRs in the importer and the exporter has a negative effect on total trade of agricultural products, except for the case of trade among DC, where the estimated IP protection index of the exporter resulted positive. These results agree with our findings of Section 5 and suggest that IPRs systems have a negative effect on trade volumes of agricultural products, especially for developing countries.

The logit estimations concluded that the probability of creating new bilateral trade links increases with the strengthening of IPRs in the importing country. This may be related with the effect of a lower threat of imitation but also with the reduction of trade barriers, considering that all the countries in our sample are also members of the WTO, which aims to supervise and liberalize international trade.[12]

(b) *Industry intensive and extensive margins*

In this subsection, we analyze the effects of IPRs on the intensive and extensive margins of trade in agricultural products.[13]

We use the industries defined by the Harmonized Commodity Description and Coding System at 6-digits level of aggregation as reported in Gaulier and Zignago (2010). For the period under study there was trade in 622 categories of agricultural sub-sectors (6-digits). The largest number of bilateral traded agricultural products at 6-digits of disaggregation in our full sample and the sample of DC–DC was 622; in the DC–LDC sample it was 613; and in the LDC–LDC sample it was 498.

We decompose total bilateral trade in the agricultural sector as follows

$$W_{ei} = N_{ei} \times w_{ei}; \tag{8}$$

where N_{ei} is the total number of sub-sectors (6-digits) with positive trade exported by country e to country i, which we define as the industry extensive margin, and w_{ei} the average value of exports by sub-sector (6-digits) from country e to country i, which we define as the industry intensive margin.

In order to estimate Eqn. (8) we carry out two independent estimations: a Poisson pseudo maximum likelihood (PPML) on the intensive margin (w_{ei}) and a Bernoulli pseudo maximum likelihood (FLEX) on the extensive margin (N_{ei}), i.e., we assume that both margins are independent.[14] We estimate both N_{ei} and w_{ei} by using the same variables of Eqn. (5) in exponential form. Note that the estimation of Eqn. (8) is different but complementary to the estimation of Eqn. (4) with respect to the effect of IPRs on market expansion. In other words, with the logit estimation we capture the effect of IPRs on the probability of finding new trading partners, while with the FLEX estimation we capture the effect on the quantity of sub-sectors on which a country has trade with the same partner due to the strengthening of IPRs. Table 8 presents the estimation results of the intensive margins of trade for our set of samples.

For the full sample, we observe that the average value of exports by sub-sector diminishes with the IPRs level of both the exporter and the importer. In the case of the DC–DC sample, this average is expected to increase with the exporter's level of IPRs and decrease with the importer's IPRs, according to the estimation with country dummies. For the DC–LDC sample, the average value of exports by sub-sector is expected to decrease with the IPRs

Table 8. *Estimations of the intensive margin of products (PPML)*

Sample	Full-Sample		DC–DC		DC–LDC		LDC–LDC	
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IP Index$_e$	−0.131***	−0.090***	−0.009	0.057***	−0.147***	−0.159***	−0.107**	−0.122***
	(0.021)	(0.011)	(0.025)	(0.014)	(0.021)	(0.013)	(0.042)	(0.024)
IP Index$_i$	−0.133***	−0.004	−0.072***	−0.004	−0.077***	−0.029*	−0.161***	−0.018
	(0.025)	(0.013)	(0.021)	(0.013)	(0.028)	(0.016)	(0.040)	(0.028)
log GDP$_e$	−2.327***	0.086***	−1.671***	0.239***	−1.785***	0.037***	−2.845***	−0.108***
	(0.266)	(0.007)	(0.335)	(0.010)	(0.342)	(0.011)	(0.556)	(0.039)
log GDP$_i$	0.958***	0.523***	1.611***	0.653***	0.883**	0.480***	0.513	0.390***
	(0.330)	(0.012)	(0.439)	(0.014)	(0.423)	(0.013)	(0.588)	(0.038)
log GDPpc$_e$	1.851***	−0.023*	1.727***	0.339***	1.069***	−0.047***	2.141***	0.294***
	(0.250)	(0.013)	(0.361)	(0.031)	(0.312)	(0.018)	(0.450)	(0.040)
log GDPpc$_i$	−0.034	−0.156***	−0.713**	0.009	−0.366	−0.115***	0.583	−0.286***
	(0.342)	(0.020)	(0.351)	(0.028)	(0.374)	(0.027)	(0.536)	(0.060)
log dist	−0.316***	−0.151***	−0.484***	−0.256***	−0.375***	0.066***	−0.261***	−0.194***
	(0.017)	(0.012)	(0.012)	(0.016)	(0.039)	(0.016)	(0.069)	(0.042)
contig	0.469***	0.556***	0.463***	0.635***	0.655***	1.050***	−0.543***	−0.541***
	(0.038)	(0.040)	(0.027)	(0.033)	(0.085)	(0.099)	(0.080)	(0.080)
comlang	0.194***	0.235***	0.128***	0.496***	0.105**	0.041	0.664***	−0.061
	(0.033)	(0.024)	(0.035)	(0.039)	(0.052)	(0.038)	(0.120)	(0.050)
comcol	−0.087	−0.046	0.486***	0.547***	0.072	0.269***	−0.308***	−0.046
	(0.067)	(0.048)	(0.083)	(0.071)	(0.112)	(0.091)	(0.108)	(0.091)
colony	−0.131***	−0.117***	0.005	−0.272***	−0.082	−0.078*	−0.460***	−0.008
	(0.033)	(0.027)	(0.033)	(0.040)	(0.066)	(0.047)	(0.137)	(0.084)
log area$_e$		0.214***		0.014		0.212***		0.461***
		(0.006)		(0.012)		(0.007)		(0.029)
log area$_i$		−0.088***		−0.151***		−0.135***		0.074**
		(0.008)		(0.011)		(0.010)		(0.029)
landlocked$_e$		0.203***		−0.855***		0.093		0.944***
		(0.060)		(0.033)		(0.084)		(0.155)
landlocked$_i$		−0.338***		−0.583***		−0.257***		−0.546***
		(0.028)		(0.026)		(0.041)		(0.099)
Country Dummies	Yes		Yes		Yes		Yes	
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	62,900	62,900	12,746	12,746	32,901	32,901	17,253	17,253

Note: Standard errors are in parenthesis. Significance level: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

of both the exporter and the importer. Finally, for LDC–LDC, both estimation methods reveal that the average value of exports is negatively affected by an increase of the exporter's IPRs. The PPML with country dummies estimates a negative coefficient for the IP index of the importer.

Table 9 presents the estimation of the extensive margins of products using a FLEX estimation method.[15] For the full sample, the total number of sub-sectors with positive bilateral trade is positively affected by an increase on the level of IPRs of the importer while the FLEX estimations with and without country dummies predict opposite effects for the level of IPRs of the exporter. If we restrict our sample to only developed countries (DC–DC), the expected effect of stronger IPRs of both the exporter and the importer is positive. Conversely, in the sample restricted to developing countries (LDC–LDC), we observe that an increase in the level of IPRs of the exporters negatively affects the number of sub-sectors with positive bilateral trade. For trade between developed and developing countries (DC–LDC), the two specifications predict opposite effects for the index of IP protection of the exporter, thus, the net expected effect cannot be determined. The estimated effect of the IP index of the importer in the samples DC–LDC and LDC–LDC is positive.

Table 10 summarizes the main findings of the analysis of the margins of agricultural trade. The strengthening of IPRs systems negatively affect the intensive margin of trade, that is, the average value of exports by sub-sector, except for the case of developed countries, in which an increase of the IP index of the exporters has a positive impact on the intensive margin. Conversely, stronger IPRs systems in the importing country are expected to increase the total number of agricultural sub-sectors with positive trade, that is, the extensive margin of trade.

The results complement what we have observed in Tables 4 and 5. If bilateral volumes in all traded sub-sectors were affected in the same way, we would observe the same effect on the average value and on total trade. However, the estimated effects of IPRs on the total and on the average are different, suggesting that at more disaggregated levels the effect of IPRs can be heterogeneous, supporting the hypothesis that the effect of IPRs depends on the specificities of products and industries.

Table 9. *Estimations of the extensive margin of products (FLEX)*

Sample	Full-Sample		DC–DC		DC–LDC		LDC–LDC	
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IP Index$_e$	0.027***	−0.009*	0.032**	0.088***	0.014*	−0.028***	−0.038**	−0.142***
	(0.007)	(0.005)	(0.014)	(0.009)	(0.007)	(0.006)	(0.016)	(0.012)
IP Index$_i$	0.026***	0.025***	−0.021	0.033***	0.025***	0.026***	0.036**	0.112***
	(0.007)	(0.005)	(0.014)	(0.008)	(0.007)	(0.007)	(0.014)	(0.011)
log GDP$_e$	−0.353***	0.699***	−2.796***	0.672***	0.357***	0.745***	1.021***	0.903***
	(0.100)	(0.005)	(0.199)	(0.009)	(0.107)	(0.010)	(0.271)	(0.018)
log GDP$_i$	0.131	0.323***	0.454**	0.253***	0.076	0.445***	0.735***	0.469***
	(0.096)	(0.005)	(0.229)	(0.007)	(0.109)	(0.008)	(0.225)	(0.016)
log GDPpc$_e$	0.924***	0.195***	3.987***	0.128***	0.106	0.098***	−0.139	−0.013
	(0.100)	(0.007)	(0.204)	(0.020)	(0.102)	(0.012)	(0.237)	(0.023)
log GDPpc$_i$	0.290***	0.330***	0.480**	0.187***	0.299***	0.159***	−0.008	0.106***
	(0.091)	(0.008)	(0.211)	(0.018)	(0.102)	(0.012)	(0.192)	(0.029)
log dist	−0.980***	−0.709***	−1.054***	−0.744***	−1.021***	−0.574***	−1.198***	−0.962***
	(0.008)	(0.005)	(0.016)	(0.013)	(0.012)	(0.010)	(0.024)	(0.022)
contig	0.714***	0.604***	0.790***	0.486***	1.047***	0.655***	0.692***	1.277***
	(0.023)	(0.025)	(0.036)	(0.030)	(0.033)	(0.063)	(0.046)	(0.069)
comlang	0.362***	0.800***	0.297***	0.575***	0.507***	0.971***	0.928***	1.202***
	(0.016)	(0.017)	(0.026)	(0.044)	(0.021)	(0.031)	(0.041)	(0.039)
comcol	1.025***	0.626***	2.003***	1.699***	1.497***	0.795***	0.435***	0.310***
	(0.047)	(0.049)	(0.055)	(0.045)	(0.048)	(0.050)	(0.070)	(0.065)
colony	0.632***	0.269***	0.243***	0.145***	0.481***	0.343***	1.346***	1.025***
	(0.024)	(0.025)	(0.035)	(0.035)	(0.025)	(0.046)	(0.084)	(0.105)
log area$_e$		−0.095***		−0.116***		−0.094***		−0.107***
		(0.004)		(0.008)		(0.006)		(0.011)
log area$_i$		0.004		0.048***		−0.048***		−0.057***
		(0.004)		(0.007)		(0.006)		(0.011)
landlocked$_e$		−0.283***		−0.426***		−0.206***		−0.413***
		(0.013)		(0.018)		(0.020)		(0.045)
landlocked$_i$		−0.216***		−0.302***		−0.299***		−0.082*
		(0.013)		(0.019)		(0.019)		(0.043)
ω	1.966***	1.113***	1.466***	0.681***	1.670***	2.201***	5.743***	6.750***
	(0.047)	(0.049)	(0.052)	(0.045)	(0.088)	(0.192)	(0.324)	(0.520)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes		Yes		Yes		Yes	
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	72,930	72,930	12,852	12,852	36,176	36,176	23,902	23,902

Note: Standard errors are in parenthesis. Significance level: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$. ω is a distributional parameter of the FLEX estimation.

Table 10. *Summary of intensive and extensive margins of trade estimations*

Sample	IP Exporter	IP Importer
	Intensive Margin	
Full-Sample	(−)	(−)
DC-DC	(+)	(−)
DC-LDC	(−)	(−)
LDC-LDC	(−)	(−)
	Extensive Margin	
Full-Sample	Mixed	(+)
DC-DC	(+)	(+)
DC-LDC	Mixed	(+)
LDC-LDC	(−)	(+)

Note: n.s.: no significant; (+): positive coefficient; (−): negative coefficient; mixed: opposite significant coefficients from estimations with or without country dummies.

7. CONCLUDING REMARKS

How the strengthening of IPRs affects trade volumes and bilateral trade links does not have a straightforward answer. As contradictory effects may be expected, the final result turns out to be an empirical question. Empirically, the issue has been investigated mostly for developed countries and the manufacturing sector. This paper has investigated the effect of tightening IPRs systems since the signing of the TRIPS agreement on agricultural total trade and bilateral trade links of 60 developed and developing countries.

We found that stronger IPRs have a negative effect on traded volumes—both considering imports and exports—of agricultural products. At a more disaggregated level of products, we also found that the effect of strengthening IPRs is negative for most sub-sectors. In addition, the estimations of the gravity model also predicted a negative effect on total bilateral trade of stronger IP protection of both the importer and the exporter, except for developed countries.

The gravity model provided additional evidence on how IP protection affects the probability of finding new trading partners. An increase in the IPRs of the exporter, has a negative effect on the probability of creating trade among developing countries. Conversely, the effect of increasing the importer's IPRs has a positive effect on the probability of finding new trading partners for the full sample and the two samples that include developing countries. This may imply that for exporting countries it may be beneficial that other countries increase their level of IPRs but negative or no significant to increase their own level of IPRs. This effect may be due to a reduced threat of imitation for the exporter, but also it can be consequence of a decrease in trade barriers.

Finally, for the intensive margin of trade, we found that the effect of stronger IPRs of both the importer and the exporter is negative, except in the case of developed countries in which the IPRs of the exporter has a positive effect. Conversely, for the extensive margin, we found that strengthening IPRs has a positive effect, except in the case of developing countries in which the IPRs of the exporter has a negative effect.

The robustness of the results was checked using different specifications, estimation methods and samples of countries. The different specifications and estimation methods produced consistent estimates and we confirmed that the level of development of the trading country is often related with different effects of IPRs on trade. This supports previous findings on the effect of IPRs as being sector and country specific.

In brief, our results show that the strengthening of IPRs that is taking place since the signing of the TRIPS agreement had a negative and uneven effect on agricultural trade, affecting more developing countries. Our findings challenge the idea that IPRs promote trade in the agricultural sector and that there is a unique system, such as the one advocated by the TRIPS supporters, suitable for all countries and sectors.

NOTES

1. The classification of countries according to development level is based on the World Bank and United Nations. See: http://data.worldbank.org/about/country-and-lending-groups and http://www.un.org/en/development/desa/policy/wesp/wesp_current/2012country_class.pdf (accessed on February 2014).

2. http://www.wto.org/english/docs_e/legal_e/14-ag_02_e.htm, accessed on February 2014.

3. http://www.bls.gov/web/ximpim/beaexp.htm, accessed on February 2014.

4. See detailed information on transition periods at: http://www.wto.org/english/theWTO_e/whatis_e/tif_e/agrm7_e.htm, accessed on June 2015.

5. The Hausmann test rejected the hypothesis that individual effects are random.

6. We present the estimations of the first specification to keep the largest number of observations in the regressions. The results are similar for the second specification and are available upon request.

7. The GM is usually estimated with a dependent variable in log form, not allowing to include data on zero trade flows. Santos Silva and Tenreyro (2006) suggested this estimation method that avoids possible biased coefficients by dealing with the problem of heteroskedasticity.

8. For this purpose, we could also use country pair dummies in the PPML estimation. However, we could not achieve convergence, possibly because of the high number of zeros. See Santos Silva and Tenreyro (2011) on convergence issues with the PPML estimation.

9. We only present the results of the estimations of the simple model given that the results were not significantly different and that the size of the samples with the extended models were significantly reduced (around 75% for all the groups). The results for the extended models are available upon request.

10. Because most developed countries trade a lot between them, the set of country dummies might predict perfectly trade relationships in the DC–DC sample, making useless the estimation of the logit model with country dummies. Therefore, in order to have similar specifications between sub-samples and to provide an appropriate number of models, in Table 5 we report only logit estimations without country dummies. In the other samples, DC–LDC and LDC–LDC, the logit estimation with country dummies provided consistent results and conveyed the same conclusions. The results are available upon request.

11. It is worth noticing that we could also report results for different sub-samples, however for the DC–DC sample we found convergence problems in the estimation. For the other samples the results were robust and consistent and are available upon request.

12. No consensus exists on the effect of WTO on trade. While Rose (2004) found little evidence that countries becoming members or belonging to the General Agreement on Tariffs and Trade (GATT) or the WTO changed their trade patterns compared with those who are not members; Subramanian and Wei (2007) found that the WTO has had a positive but uneven impact on trade. We have not included a variable indicating the WTO membership because we consider the after-WTO period (1995–2011).

13. The concepts of intensive and extensive margins of trade have been studied in different ways. For example, Dutt, Mihov, and Van Zandt (2011), Santos Silva, Tenreyro, and Wei (2014), and Klenow and Hummels (2005) define and estimate them differently. Foster (2014) has also studied the effect of IPRs on the margins of trade and found a positive impact on imports driven by a positive effect on the extensive margin and a negative effect on the intensive margin.

14. The FLEX estimation was recently introduced by Santos Silva *et al.* (2014) showing a remarkable performance in estimating double bounded data.

15. In the FLEX estimation, ω is a shape parameter that allows the distribution to be symmetric, left skewed or right skewed (Santos Silva *et al.*, 2014). As the estimated ω parameters are different from 1 for all models and samples, the FLEX estimation provides better estimates of the extensive margins of trade in comparison with other econometric models restricted to the logit distribution.

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APPENDIX A

List of Countries

Developed Countries

Australia; Austria; Bulgaria; Canada; Czech Republic; Denmark; Estonia; Finland; France; Germany; Hungary; Iceland; Ireland; Italy; Japan; Latvia; Lithuania; Netherlands; New Zealand; Norway; Poland; Portugal; Slovakia (Slovak Republic); Spain; Sweden; Switzerland Liechtenstein; United Kingdom; United States of America.

Developing Countries

Albania; Argentina; Bolivia; Brazil; Chile; China; Colombia; Costa Rica; Croatia; Dominican Republic; Ecuador; Israel; Jordan; Kenya; Republic of Korea; Kyrgyzstan; Mexico; Republic of Moldova; Morocco; Panama; Paraguay; Peru; Russian Federation; Singapore; Slovenia; South Africa; Trinidad and Tobago; Tunisia; Turkey; Ukraine; Uruguay; Vietnam.

Table 11. *Agricultural exports. Product coverage*

HS classification	Number	Product
Chapter	1	Live animals
Chapter	2	Meat and edible meat offal
Chapter	4	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included
Chapter	5	Products of animal origin, not elsewhere specified or included
Chapter	6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
Chapter	7	Edible vegetables and certain roots and tubers
Chapter	8	Edible fruit and nuts; peel of citrus fruit or melons
Chapter	9	Coffee, tea, mate and spices
Chapter	10	Cereals
Chapter	11	Products of the milling industry; malt; starches; inulin; wheat gluten
Chapter	12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder
Chapter	13	Lac; gums, resins and other vegetable saps and extracts
Chapter	14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
Chapter	15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes
Chapter	17	Sugars and sugar confectionery
Chapter	18	Cocoa and cocoa preparations
Chapter	19	Preparations of cereals, flour, starch or milk; pastrycooks' products
Chapter	20	Preparations of vegetables, fruit, nuts or other parts of plants
Chapter	21	Miscellaneous edible preparations
Chapter	22	Beverages, spirits and vinegar
Chapter	23	Residues and waste from the food industries; prepared animal fodder
Chapter	24	Tobacco and manufactured tobacco substitutes
Section 6		
Code	2905.43	Mannitol
Code	2905.44	Sorbitol
Heading	33.01	Essential oils
Headings	35.01–35.05	Albuminoidal substances, modified starches, glues
Code	3809.1	Finishing agents
Code	3823.6	Sorbitol n.e.p.
Section 8		
Headings	41.01–41.03	Hides and skins
Heading	43.01	Raw furskins
Section 11		
Headings	50.01–50.03	Raw silk and silk waste
Headings	51.01–51.03	Wool and animal hair
Headings	52.01–52.03	Raw cotton, waste and cotton carded or combed
Heading	53.01	Raw flax
Heading	53.02	Raw hemp

Table 12. *Variables employed in the estimation exercises*

Label	Related to	Description	Source
W	Link	Imports in constant (2000) US dollars by sub-sectors	BACI-CEPII Gaulier and Zignago (2010)
texpa	Country	Total exports of agricultural products in constant (2000) US dollars	BACI-CEPII Gaulier and Zignago (2010)
timpa	Country	Total imports of agricultural products in constant (2000) US dollars	BACI-CEPII Gaulier and Zignago (2010)
IP Index	Country	Index of IP protection for plant varieties	Campi and Nuvolari (2015) (mercedescampi.wordpress.com/data/)
GDP	Country	Gross domestic product	Penn World Table Feenstra and Timmer (2013)
hc	Country	Index of human capital	Penn World Table Feenstra and Timmer (2013)
open	Country	Openness to trade	Penn World Table Feenstra and Timmer (2013)
agri_area	Country	Agricultural area	FAO (faostat.fao.org/)
tract	Country	Tractors per arable land	FAO (faostat.fao.org/)
labor	Country	Economically active adults in agriculture	FAO (faostat.fao.org/)
fertil	Country	Consumption of fertilizers per agricultural land	FAO (faostat.fao.org/)
TRIPS	Country	TRIPS membership	WIPO (www.wipo.int)
area	Country	Country area in Km^2	CEPII (http://www.cepii.fr/)
pop	Country	Country population	Penn World Table Feenstra and Timmer (2013)
d	Link	Distance between two countries, based on bilateral distances between the largest cities of those two countries, weighted by the share of the city in the overall country's population	CEPII (http://www.cepii.fr/)
landlocked	Country	Dummy variable equal to 1 for landlocked Countries	CEPII (http://www.cepii.fr/)
contig	Link	Contiguity dummy equal to 1 if two countries share a common border	CEPII (http://www.cepii.fr/)
comlang	Link	Dummy equal to 1 if both countries share a common official language	CEPII (http://www.cepii.fr/)
comcol	Link	Dummy equal to 1 if both countries have had a common colonizer	CEPII (http://www.cepii.fr/)
colony	Link	Dummy equal to 1 if both countries have ever had a colonial link	CEPII (http://www.cepii.fr/)