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Measuring the Strength of Intellectual Property Protection. A New Index for Plant Varieties (1961-2011)

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Abstract

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State of the Art and Research Gap
The progressive adoption of tighter intellectual property rights (IPRs) regimes by developing countries after the ratification of the Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement has spurred the interest of economists on the possible effects of this policy shift on innovation and economic development. In particular, the TRIPS Agreement demands higher protection in domains which were not subject of IP protection in the past. This is the case of genetic resources including plant varieties. Despite the interest in IPRs has been increasing, most research works are focused on patents, leaving aside other types of protection. This research project addresses the study of plant breeders' rights (PBRs), a particular type of IPRs used to protect plant varieties, and intends to measure the strength of IP systems for plant varieties as other authors have done for patent systems (Ginarte and Park, 1997; Lerner, 2002).

Theoretical Arguments
In this paper, we construct a new index of the strength of IPR protection for plant varieties at the country level.

Having a measurement for a cross section of countries may contribute to the economic analysis of IPR in two main ways. First of all, it may allow to study the determinants of different IPRs systems. In the second place, it allows making international comparisons and using the index as an indicator to study other issues in the field of innovation policies. Therefore, measuring the strength of IPRs systems may enable a better policy design by giving information about the determinants of IP protection, as well as their economic and social effect, both in a historical and global perspective.

Method and Data

This paper examines the strength of IP protection available for plant varieties during 50 years (1961-2011) in 69 countries which are members of the International Convention for the Protection of New Varieties of Plants (UPOV) Convention in 2011. The consists of the following five components: 1) ratification of UPOV Conventions, which considers whether the country had adhered to the subsequent revisions of the Convention in 1961, 1978 and 1991; 2) length of membership, which considers for how long the country has been a member of the UPOV; 3) exceptions, which takes into account whether the country?s legislation includes three possible exceptions to the right, which are compulsory licenses, farmers? exception and breeders? exception; 4) protection length, considering for how long the protection is granted, and finally, 5) coverage of patentability, which reflects if a country allows patentability in five sectors related with the breeding industry: food, microorganisms, plant and animals, and pharmaceutical products. The information is gathered by examining national legislative texts. The value of each component is transformed into a unit-free value that ranges between 0 and 1, allowing to add together the different components. Thus, the value of the index for a given country and a given year ranges between 0 and 5 and indicates the strength of each country?s IP system for plant varieties.

Results

The robustness of the indicator was checked through different methods including cluster analysis and factor analysis. As well, its analytical validity was checked by analyzing and comparing in detail the results for a sample of countries. In addition, an econometric analysis was developed in order to find which variables can be considered statistically significant determinants of the IP index.

The paper finds that the mean of protection has been increasing continuously, reflecting the increase in the strength of protection. More developed countries have been offering IP protection for plant varieties for many years while less developed countries have adopted PBRs mainly after the signing of the TRIPS. Moreover, countries recently adopting IP systems are entering with an already high level of protection.

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Measuring the Strength of Intellectual Property Protection. A New Index for Plant Varieties (1961-2011)

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Abstract

This paper constructs an index that measures the strength of intellectual property protection for plant varieties during 51 years (1961-2011) in 69 countries. The robustness of the indicator was checked through factor analysis and by the comparison with other measures of IP protection. In addition, an econometric analysis was developed in order to find which variables can be considered statistically significant determinants of the IP index. The paper finds that the mean of protection has been increasing continuously and the distribution of the index score over the decades has shifted from a positively skewed towards a negatively skewed, which implies that most countries have an index score that is above the mean. More developed countries have been offering IP protection for plant varieties for many years while less developed countries have adopted plant breeders' rights mainly after the signing of the Trade Related Aspects of Intellectual Property Rights (TRIPS). Moreover, countries recently adopting IP systems are entering with an already high level of protection. The econometric analysis shows that the GDP per capita, the political system, the institutional environment and the importance of agriculture for the economy are the main determinants of the level of IP protection for plant varieties.

Keywords: Intellectual Property Rights; Plant Breeders' Rights; UPOV Convention; International Comparison

JEL Codes: O10, O34, 050, Q19

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1. Introduction

The progressive adoption of tighter intellectual property rights (IPRs) regimes by developing countries after the ratification of the Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement has spurred the interest of economists on the possible effects of this policy shift on innovation and economic development. In particular, the TRIPS Agreement demands higher protection in domains which were not subject of IP protection in the past. This is the case of genetic resources including plant varieties. Despite the interest in IPRs has been increasing, most research works are focused on patents, leaving aside other types of protection. This paper addresses the study of plant breeders' rights (PBRs), a particular type of IPRs used to protect plant varieties, and intends to measure the strength of IP systems for plant varieties as other authors have done for patent systems (Ginarte and Park, 1997; Lerner, 2002).

In this paper, we construct a new index of the strength of IPR protection for plant varieties at country level. Having a measurement for a cross section of countries may contribute to the economic analysis of IPRs in two main ways. First of all, it may allow studying the determinants of different IPRs systems. In the second place, it allows making international comparisons and using the index as an indicator to study other issues in the field of innovation policies both in developed and developing countries. Therefore, measuring the strength of IPRs systems may enable a better policy design by giving information about the determinants of IP protection, as well as their economic and social effect, both in a historical and global perspective.

The robustness of the indicator was checked through different methods including factor analysis and its correlation with other measures of IP protection. As well, its analytical validity was checked by analyzing and comparing in detail the results for groups of countries according to the income level and geographical location. In addition, an econometric analysis was developed in order to find which variables can be considered statistically significant determinants of the IP index.

The paper finds that the mean of protection has been increasing continuously, reflecting the increase in the strength of protection worldwide. More developed countries have been offering IP protection for plant varieties for many years while less developed countries have adopted PBRs mainly after the signing of the TRIPS. Moreover, countries recently adopting IP systems are entering with an already high level of protection.

The results of the different models show that the level of IP protection for plant varieties is determined by the level of the GDP per capita, the political system and institutional factors. In countries where agriculture is relevant for the economy the index tends to be higher. Moreover, the proportion of urban population over rural population also has a positive effect in the strength of the IP index. Finally, the latitude, which represents the geographical location, also seems to play a role in determining the index, but not much more can be said about its influence.

The paper is organized as follows. The following section discusses in detail how the measurement of IP protection for plant varieties was constructed, as well as the data used and the sources. Section 3 analyses the evidences arising from the index. In section 4, an econometric analysis is developed in order to study the possible determinants of the index strength. Finally, in the last section, the main conclusions are presented.

2. Measuring IP Protection for Plants

Economic theory postulates that IPRs enhance research and development (R&D) leading to innovation by giving a temporary exclusive right on inventions and creating the right incentives to

allocate resources in R&D. Thus, according to this view there is a positive relationship between IPRs and innovation. However, empirical studies have shown that the effect of IPRs over innovation is technology and sector specific (Dosi, Marengo and Pasquali, 2006; Boldrin and Levine, 2010) and that IPRs may not have a positive and significant impact on R&D in developing countries (Léger, 2007).

In the particular case of plant varieties and genetic resources, the relation between IPRs and innovation still remains a matter of debate that demands further analysis. In addition, the problem has other edges that add complexity to the issue like the moral aspects related with the property protection of life or the fact that a major part of the biodiversity from which genetic resources used in economic production was originated in what are nowadays developing countries (Kloppenburg, 2004). Besides, even when the economic and social consequences of granting IPRs for plant varieties has not been studied enough, there is a pressure towards stronger IP protection systems that derives from trade agreements (Jaffe and van Wijk, 1995).

Thus, in this context and considering that so far there is a considerable group of countries that have been offering different degrees of IP protection for plant varieties, it is possible to create a measure to capture this strength and its evolution. Why should we measure the strength of IP protection? Having a measurement for all countries allows making international comparisons that may shed some light on the determinants of IP protection as well on the effects of the systems in different variables. Other measures for IP protection, but specifically for patent protection, were already done by Ginarte and Park (1997) and Lerner (2002).[1] A cross-national measure of IP protection, in our case for plant varieties, may lead to loosing some specificity but can undercover the tendencies of IP protection and their determinants. Bellow, we explain in detail how the index was constructed.

2.1 Index Components

The index takes a cross-country and historical perspective as it measures how strong IP protection available for plants is in a group of countries and shows how this has been changing over a period of 51 years (1961-2011). It was constructed for 69 countries, which are members of the International Convention for the Protection of New Varieties of Plants (UPOV) Convention in 2011.[2] It consists of five components that, as a whole, indicate the strength of each country's IP system for plant varieties. The index has the following five components: 1) ratification of UPOV Conventions; 2) length of membership; 3) exceptions; 4) protection length; and finally 5) coverage of patentability.

1 Different revisions and updates of Ginarte and Park (1997) can be found in Park (2001); Park and Wagh (2002); and Park (2008).

2 It is worth noting that there is a set of countries which offer protection for plants but are not UPOV member (for instance, India), which were not included in our database. Also, some of the countries considered used to offer some kind of IP protection before becoming members of UPOV (as Argentina or Australia).

Table 1. Index Components

	Component	Maximum Value	Normalized Value
1	**Ratification of UPOV Conventions**	**3**	
	1961	1	**Between 0 & 1**
	1978	1	
	1991	1	
2	**Length of Membership**	**44**	**Between 0 & 1**
	At most 44 years	44	
3	**Exceptions**	**3**	
	No compulsory license	1	**Between 0 & 1**
	No farmer's exception	1	
	Essentially derived variety	1	
4	**Duration**	**35**	**Between 0 & 1**
	At most 35 years	35	
5	**Patentability**	**5**	
	Pharmaceuticals	1	
	Microorganisms	1	**Between 0 & 1**
	Food	1	
	Plants and animals	1	
	Index		**Between 0 & 5**

While laws regarding plant variety protection tend to be similar in the different countries, as they are based on the guidelines provided by the UPOV, the index was constructed considering the elements that tend to vary more from country to country and over time, and that are indicators of stronger protection. This may lead to loose specificities but it has the advantage of generating a comparable general measure of IP protection. The index components are explained bellow.

Ratification of UPOV Conventions

This component considers whether a country had adhered to the subsequent revisions of the UPOV Convention: the "1961/1972 Act" which is the International Convention for the Protection of New Varieties of Plants of December 2, 1961, as amended by the Additional Act of November 10, 1972; the "1978 Act", which refers to the Act of October 23, 1978, of the Convention; and the "1991 Act", which is the Act of March 19, 1991, of the Convention.[3] A country adhering to the three Conventions or Acts receive a total value of 3; 1 for each one. The first countries entering the UPOV signed the 1961/1972 Convention and later, most of them, ratified the following revisions. However, if a country enters the UPOV Convention when already two or three revisions have taken place, it can decide which revision to sign. As instance, Argentina became member of the UPOV in 1995 when the 1991 Act was already available, but adhered to the 1978 Convention. However, since 1998 new members are not allowed to enter the UPOV 1978 and they may only join the 1991 Act. For the purpose of constructing the index, it was considered that a country signing the 1991 Convention adheres also to the previous ones. For example, when Bulgaria in 1998 became a member of UPOV and adhered to the 1991 Act, it receives a value of 1 for each revision.

Length of Membership

Length of membership measures, for every given year, the time a country has been a member

3 The first UPOV Convention was adopted by the Diplomatic Conference on 1961 and it was amended on 1972. The amendments modified, among other issues, the majorities required for decisions of the Council; the Convention finances; the contribution classes of member States; the signature, the ratification and accession; the entry into force; and reservations. Thus, unlike the following revisions (1978 and 1991) the 1972 amendment did not modify the type of IP rights proposed by the 1961 Convention.

of the UPOV. Considering this component, assumes that countries with a longer length were early willing to protect plant varieties through plant breeders' rights (PBRs). The first UPOV Convention was signed by a group of European countries, which wanted to protect plant varieties but found that patent systems were not appropriate mainly because of the self-reproduction characteristic of plants. Thus, the Convention had the objective of creating a *sui generis* system which reflects their willingness to provide plant variety protection. Only five European countries became members of UPOV in 1961 and three more did it the following year. However, the Convention of 1961 did not entered into force until 1968, as it established that at least three countries ratifications were needed and it took seven years for the countries to adequate or create their plant variety protection systems, which was required for the ratification of the Act (Heitz, 1987; Dutfield, 2009). Afterwards, countries becoming members adopted the revised Act of 1961/1972. More recently, the UPOV Convention was signed mainly by non developed countries that seek to implement the provisions of the TRIPS Agreement, which made compulsory to provide protection of IPRs for plant varieties, either through patents or an effective *sui generis* system.

Exceptions

This part of the index takes into account whether the countries consider in their legislations three exceptions or limitations to the PBR: compulsory licenses, farmers' exception and breeders' exception.

The first exception, which most of the countries consider, is compulsory licenses. This exception implies that an individual or the government may ask for a compulsory license in different situations, which mainly arise when the variety has not been used for a given period since the date of filling or grant of the right; the variety has not been used to a degree sufficient to satisfy the national needs; and when it is declared a national emergency.

The second exception regards the so-called farmers' privilege or farmers' exception, which states that farmers have the right to use the product of harvests they have obtained through planting in their own farm, for the purpose of reproduction in their own farms, without paying royalties again to the breeder. In some cases, this exception also considers that farmers have the right to sell the product of their harvest to be sown in other lands. This exception was compulsory in the first two Acts of the UPOV and it is optional in the 1991 Act. Countries have been limiting this exception and many others forbid the reproduction of harvested genetically modified seeds. This practice has been decreasing in some countries, reaching almost zero, like in the United Sates, and in others it is still a widespread practice. For the construction of the component, the value is taken from the legal documents and not from the practice, implying that even when countries imposed restrictions to the exception, it was considered as available. When it was explicitly written not to be considered in the country or when it was accepted only if paying, then it was considered as not being in force. These two first exceptions have a negative impact on the strength of the index as, when a country considers them, the protection of the granted right is lower. Thus, in the construction of the component each of these two exceptions add 1 when they are not considered, increasing the final value of the index.

Finally, the third exception is the so-called breeders' exception, which states that the right does not extend to acts done for experimental purposes by other breeders. It implies that a breeder can use any protected plant variety, without authorization of its owner, to conduct research that may lead to the creation of a new plant variety, as long as the initial variety is not used repeatedly. This exemption seeks to protect innovations without preventing improvements and obtaining of new creations. The breeders' exception is compulsory in all the conventions. However, the 1991 Act introduced the concept of essentially derived variety, which limits the breeders' exception. According to the Act, an essentially derived variety is one that is clearly distinguishable from the initial one but retains the essential

characteristics. When this limit is introduced, a breeder willing to obtain a variety considered essentially derived needs to get the authorization of the owner of the initial variety via a contract or license, paying a right for its use. Thus, as all countries must include the breeders' exception, but not all of them consider the essentially derived concept, this final part of the component adds 1 whenever a country's legislation has included this limitation.

Protection Length

This component considers the duration of the right. The legislation regarding plant varieties protection, in general, discriminates between plant varieties and trees and vines, receiving the former a shorter term of protection. For the construction of this index it was decided to use the longer protection, that is, the one given to trees and vine, when a country does the discrimination between them and varieties. The 1961/1972 and 1978 Convention suggested a minimum protection period of 15 years for plant varieties and 18 years for vines and trees. Any country may adopt, however, a longer period of protection (UPOV 1961/1972, 1978). Meanwhile, the last UPOV Convention states that duration of the breeders' right should be for a fixed period no shorter than 20 years for plant varieties and 25 years for vines and trees (UPOV, 1991).

Coverage of Patentability

In this component, the strength of protection is measured by the patentability allowance in four sectors which are related with plant breeding. The sectors are: 1) food, which uses as inputs products from agriculture; 2) plant and animals, which countries may exclude or include when they can be used to make more than a specific variety or when the technical feasibility of the invention is not confined to a particular plant variety; 3) micro-organisms, which are closely related with the development of biotechnology and its application to plant breeding; and 4) pharmaceutical products, as the industry relies to such an extent on biodiversity. While many countries used to exclude some or all of these products from their patent laws, considering them contrary to public order, morality, health or national interest or security, the TRIPS Agreement made compulsory to declare patentable micro-organisms, non-biological and microbiological processes for the production of plant varieties, and to provide some kind of IP protection for plant varieties. As it was done in the patent index of Ginarte and Park (1997), each of these sectors adds 1 to this component when they were declared as patentable or not specifically unpatentable in their patent laws.

2.2 Sources and Construction of the Index

The information used in the index construction was gathered by examining legislative texts of each country which are mostly available on-line. All websites were accessed between July and November 2012. In addition, personal communications with experts of different countries were held in order to check or find missing information.

For the data regarding the ratification of the UPOV Conventions as well as the length of membership, the source of information are the convention notifications documents which contain the ratification of each convention by each country. These documents are available at UPOV website: upov.int/upovlex/en/notifications.jsp. Information regarding early signatory countries can be found in Heitz (1987).

The information concerning the duration of protection and exceptions was taken from national legislative texts that are available on: WIPO Intellectual Property Laws and Treaties Database: www.wipo.int/wipolex/en/; UPOV Lex: www.upov.int/upovlex/en/; Farmers' Rights Database: www.farmersrights.org/database; and The World Law Guide: www.lexadin.nl/wlg/. For some

countries, data regarding exceptions was extracted from the "Questionnaire on Exceptions and Limitations to Patents Rights", conducted by WIPO and available at: www.wipo.int/scp/en/exceptions/.

Finally, for patentability on the sectors considered in the last component of the index, the main information comes from data provided by a personal communication with Walter Park, who made available the data used in the construction of his patent index. As well, the following secondary sources were employed: Ginarte and Park (1997), Lerner (2002), Park (2008) and WIPO (2009). For the countries that were not included in those sources, we used national documents from the WIPO Intellectual Property Laws and Treaties Database: www.wipo.int/wipolex/en/; and The World Law Guide: www.lexadin.nl/wlg/.

The value of each component was transformed into a unit-free value that ranges between 0 and 1, allowing the addition of the different components.[4] The values for each variable are standardized according to: Xit = (xit value − minimum Xi value) / (maximum Xi value − minimum Xi value), where X is the value of each component i = 1, … , 5 of the index for each year t = 1969, … , 2011. Afterwards, the transformed values of the components were added and, as a consequence, the value of the index for a given country and a given year ranges between 0 and 5 and indicates the strength of each country's IP system for plant varieties.

The validity of the index constructed by the simple addition of the normalized components was checked by carrying out a factor analysis on the five components. We used the principal component factor estimation as this extraction method allows combining the different components, which are expected to be highly correlated, into a single factor. Principal components method assumes that all the variability in a component should be used in the analysis which is useful for our case. The results are shown in Table 2. The Kaiser criterion suggested that only one factor, with eigenvalue greater than 1, should be retained and this factor explains 68.10% of the total variance.[5]

Table 2. Factor Analysis of the Index Components (Factor Loadings and Unique Variances)

Variable	Factor Loading	Uniqueness
Ratification of UPOV Conventions	0.91084	0.17037
Length of Membership	0.7782	0.39441
Exceptions	0.73302	0.46268
Duration of right	0.89411	0.20057
Patentability	0.79571	0.36684

Note: Number of observations: 2993; LR test (independent vs. saturated) chi2(10) = 8570.14 Prob>chi2 = 0.000.

As expected, all the loadings on the factor are high, meaning that they are all relevant in defining the factor's dimensionality. Except for the variable duration, in relative terms, the degree of uniqueness is low for all the factor loadings, which implies that they are all relevant in the factor model and that there are not many unexplained factors affecting the relationships among them. In fact, as shown in Table 3, all the index components are highly correlated and they are all significant.

4 This methodology was used until 2011 by the United Nations Development Programme (UNDP) to construct the Human Development Index. See: Anand and Sen (1994).

5 As well, other estimation methods, as principal factor and iterated principal factors, retained factors with very similar loadings and explained even higher total variance.

Table 3. Spearman's Rank Correlation Matrix of Index Components

Indicator	1	2	3	4	5
1. Ratification of UPOV Conventions	1				
2. Length of Membership	0.9097***	1			
3. Exceptions	0.6160***	0.4712***	1		
4. Duration of right	0.7794***	0.7558***	0.6829***	1	
5. Patentability	0.6539***	0.6619***	0.4498***	0.6486***	1

Note: All coefficients are significant at the 1% probability level (***).

The factor obtained is a linear combination of the five components. Then, in order to achieve a weighted index, we used the loadings assigned to each of the five components and compute a new index. We applied each factor loading to each value of the different variables, and added them obtaining a new index with the new weights. The old unweighted index and the new weighted index have a Spearman's rank correlation coefficient of 0.9986. This high correlation implies that the absolute values of the index slightly change but the ranking remains unchanged when using the weighted index. Therefore, for the sake of simplicity, we choose the unweighted index.

Another interesting exercise that may help testing the empirical validity of the index is to compare it with other measures of IP protection. The following table summarizes the Spearman's rank correlation coefficients of our plant variety protection index and other indicators with which we would expect a positive correlation: 1) patent protection index of Ginarte and Park (1997) and Park (2008); 2) an Intellectual Property Rights Index[6], which is part of the Global Competitiveness Index[7] developed by the World Economic Forum (www.weforum.org); 3) an indicator of Intellectual Property Rights[8] protection which is part of the International Property Right Index[9] developed by Property Rights Alliance (www.propertyrightsalliance.org/).

Table 4. Spearman Correlation between IP Plant Varieties Index and other IPRs Measures

Indicator and Source	Correlation with Plant Variety Protection Index
Patent Index (Park and Ginarte, 1997; Park; 2008)	0.8516***
Intellectual Property Protection (The World Economic Forum)	0.4121***
Global Competitiveness Index (The World Economic Forum)	0.4659***
Intellectual Property Rights (Property Rights Alliance)	0.5181***
International Property Right Index (Property Rights Alliance)	0.4495***

Note: All coefficients are significant at the 1% probability level (***).

As shown in table 4, the plant variety index is positively and highly correlated with the patent protection index of Ginarte and Park (1997) and Park (2008) which covers almost the same time period as our index. This is not surprising as the processes towards tighter IP regimes are verified in patents as well. The correlation is also positive and significant with other indicators that are wider that Ginarte

[6] This component derives from surveys asking how would the interviewed rate intellectual property protection, including anti-counterfeiting measures, in her country [1 = very weak; 7 = very strong].

[7] In the index, competitiveness is defined as the set of institutions, policies, and factors that determine the level of productivity of a country and its' growth potential (Sala-I-Martin et al., 2012).

[8] It considers: Protection of Intellectual Property Rights; Patent Protection; and Copyright Piracy; and Trademark Protection.

[9] This index has the following dimensions: Legal and Political Environment; Physical Property Rights; Intellectual Property Rights.

and Park (1997) index as they also consider other types of IPRs and other dimensions as physical property rights as instance.

3. Evidences from the Plant Varieties Index

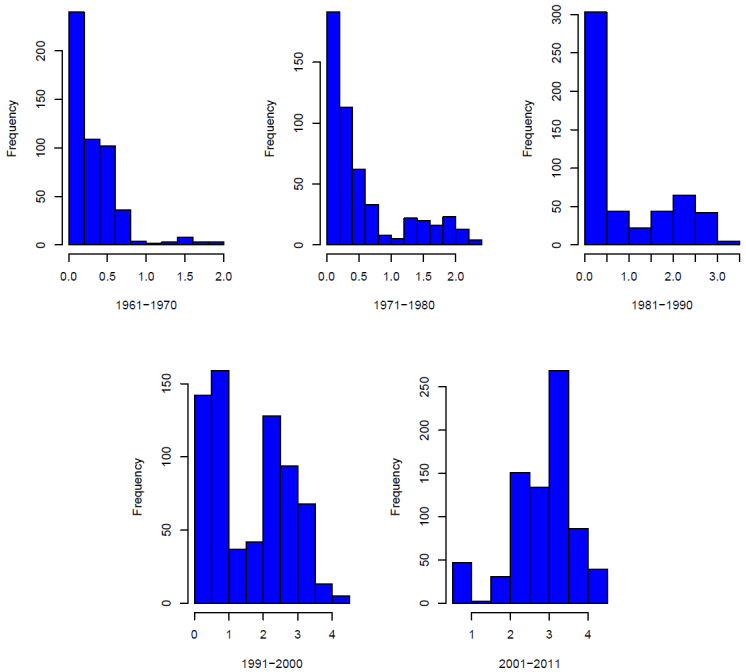
The summary ratings by decade of the plant varieties IP protection index for every country are presented in the appendix. In this section we perform and analysis of the evolution of the index revealing some interesting facts.

Table 5. Summary Statistics of the Index by Decades

Period	% Obs = 0	% Obs > 0	Mean without zeros	Mean	Sd	Min	Max	Skew
1961-1970	44.5	55.5	0.49	0.27	0.35	0	1.97	1.97
1971-1980	37.3	62.7	0.82	0.51	0.64	0	2.33	1.26
1981-1990	32.4	67.6	1.3	0.88	0.98	0	3.09	0.77
1991-2000	8.6	91.4	1.8	1.65	1.09	0	4.29	0.15
2001-2011	0.0	100.0	2.86	2.86	0.81	0.5	4.5	-0.91
1961-2011	21.6	78.4	1.78	1.38	1.29	0	4.5	0.46

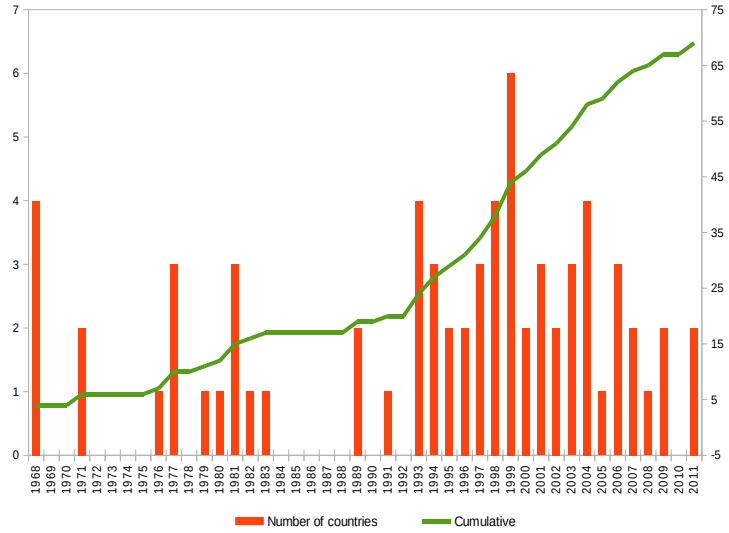
The summary statistics show that the mean of the index has been increasing over time, even when not considering the years in which countries have a value of zero, which means that there is no IP protection available at that time. Meanwhile, the distribution has shifted from a positively skewed towards a negatively skewed one in the last decade considered, meaning that most countries have an index score that is above the mean. These two tendencies reflect the fact that countries, already providing protection in the past, have been tightening their systems, while countries entering UPOV and adopting IP protection systems in recent years are undertaking already stronger levels of protection. The change from a positively skewed distribution of the index values towards a negatively skewed distribution can be graphically observed in the index histograms by decade where the frequency is given by the observations for all countries in each decade.

Figure 1. Index Histograms by Decades



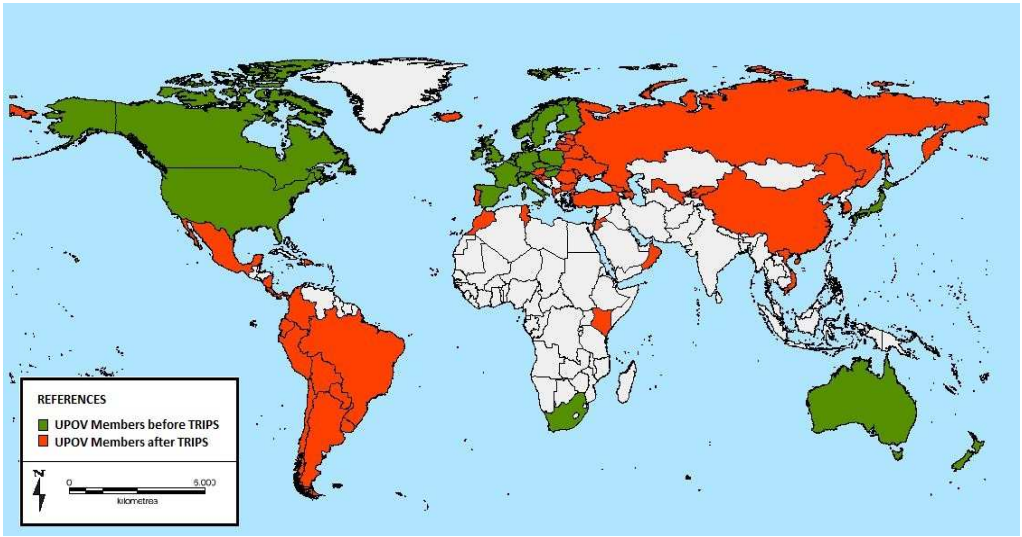
This evidence is related with the ratification of the TRIPS Agreement, whose article 27.3(b) establishes that members of the World Trade Organization (WTO) may exclude from patentability plants and animals other than micro-organisms; however, they must provide protection for plant varieties, either by patents or by an effective *sui generis* system or by any combination thereof. As shown in the following figure, the UPOV consisted of a relatively small group of countries for many decades. It was around the mid 1990s when many more countries became members. This is coincident with the signing of the TRIPS Agreement and the progressive adoption of tighter IPRs regimes.

Figure 2. Number of Countries adopting UPOV Conventions by Year



From a geographical point of view, we observe that before the ratification of the TRIPS Agreement, UPOV members were Western European countries and other developed economies as the United States, Australia, Canada and South Africa. More recent members entering the Convention after the ratification of TRIPS Agreement in 1994 are mostly developing countries in Latin America, Africa, Asia as well as former socialist economies of Eastern Europe, as can be observed in figure 3.

Figure 3. Members of UPOV Convention before and after TRIPS Agreement



The analysis of the index evolution by income groups confirms that they all have been increasing the strength of IP protection offered for plant varieties.[10] As well, high income countries have started offering a stronger protection and continue to do so but the gap between them and the lower income groups has been narrowing as long as middle and low income countries have been tightening their IP protection systems.

Table 6. Evolution of the IPR Index for Plant Varieties by Income Groups

Country	1961-1970	1971-1980	1981-1990	1991-2000	2001-2011
High Income (32)	0.43	0.80	1.39	2.24	3.18
Middle Income (24)	0.12	0.20	0.28	1.13	2.57
Low Income (12)	0.13	0.18	0.25	1.08	2.57

Note: See the Appendix for the classification of countries according to their income.

Another interesting exercise can derive from the geographical analysis of the index evolution by decades. As can be observed in the following table, the evidence is not as clear as in the case of income groups. However, at the end of the period, we observe that, in line with the evidence found before, Western Europe, East and Central Europe, Oceania and North America are the regions with higher income levels and stronger IP systems. As to the remaining regions, the evidence is mixed, with some of them starting with relatively high protection levels and other with lower ones but all of them increasing the mean of the index score over the decades.

Table 7. Evolution of the IPR Index for Plant Varieties by Region

Country	1961-1970	1971-1980	1981-1990	1991-2000	2001-2011
Asia	0.38	0.45	0.72	1.24	2.62
Sub Saharan Africa	0.50	0.97	1.70	2.14	2.80
Latin America and the Carribean	0.13	0.16	0.16	1.07	2.26
North America	0.53	0.79	1.61	2.59	3.03
Oceania	0.38	0.50	1.51	2.70	3.12
Western Europe	0.44	0.94	1.64	2.58	3.36
East and Central Europe	0.08	0.17	0.35	1.37	3.03
Middle East and North Africa	0.15	0.33	0.50	1.06	2.41

Special considerations deserve the countries which belonged to the former Union of Soviet Socialist Republics or were part of Yugoslavia. These countries are considered since the 1990s when they became independent States (starting on different years depending on each case). The reason is that these economies used to have no IP protection laws or, when they did have, they were based on a different and non comparable system. As instance, the Soviet invention system was composed of two main parts: the granting of inventor certificates for domestic inventors, and IP rights similar to the ones provided in Western countries (Blair, 1973).[11] The case of China is similar as since the 1950s there was a dual system that considered the granting of inventor's certificates and exclusive patent rights. However, the importance of the regulations was marginal and it was only at the beginning of the 1980s when an IPR law was enacted after a political, economic and social change that included the consideration of IPRs as promoters of economic development, which turned into one of the main

[10] Classification according to the income level is taken from the World Development Indicators (databank.worldbank.org). High income are both OECD and non-OECD High Income economies; middle income are Upper Middle Income; and low income includes both Lower Middle Income and Low Income.

[11] A major distinction between the inventor's certificate and the patent is that the former was assigned to the State, while the patent was owned by the inventor or the party to whom he assigned it, as in Western countries.

objectives in the political agenda (Ganea et al., 2009).

4. Determinants of IP protection

In this section, we perform and econometric analysis in order to test which countries characteristics may predict the level of plant variety protection. The variables considered aim to capture the following features which may impact on the decision of having a plant variety IPRs system: development level; institutional and political factors; importance of agriculture; and geographical location.

As indicator of economic development we use the log of the GDP per capita, as estimated by the Maddison Project (www.ggdc.net/maddison/maddison-project/index.htm) and the proportion of urban population over rural population, provided by FAOSTAT. More developed countries usually have more urban population and, as a consequence, this proportion is expected to increase with the level of development. In fact, as can be observed in table C of the Appendix, the correlation matrix shoes that this variable is positively and highly correlated with the GDP per capita.[12]

Another relevant aspect which may determine the level of IP protection is the importance that agriculture has for a given economy. The effect of this factor can be in both directions given that agriculture can be relevant for an economy because it is a developed sector but it can also be relevant in relative terms as other sectors are not developed, which in this case indicates a general low level of economic development. Therefore, what needs to be taken into account is that the relevance of agriculture for an economy can be linked with its level of development in different ways. In order to consider this and the possible ambiguity, we include two measures developed by FAOSTAT: the export value index of agricultural products, which represent the change in the current values of Export FOB (free on board) expressed in US dollars; and the net per capita production index of agricultural products, which shows the relative level of the aggregate volume of agricultural production for each year in comparison with the base period 1999-2001, divided by the index of population.[13]

For the institutional and political factors we use two variables: 1) the index of political system developed by Marshall, Jaggers and Gurr (2010) for the Polity IV Project, which provides annual information on regime authority characteristics and level of democracy; and 2) the Index of Economic Freedom (IEF) developed by The Heritage Foundation (www.heritage.org); which measures the following features of the institutional environment: business freedom; trade freedom; fiscal freedom; government spending; monetary freedom; investment freedom, financial freedom; property rights; freedom from corruption; and labor freedom. As can be observed in the correlation matrix of the Appendix (Table C) these two variables are positively correlated with the GDP per capita as they are expected to have a higher score as long as the GDP per capita increases and they are not correlated among them as they capture different dimensions of the political and institutional framework.

Additionally, we use openness to trade at constant prices from the Penn World Table 7.1 (pwt.sas.upenn.edu/) available at Heston, Summers and Aten (2012), as it may be expected that a more open economy would have a stronger IPR index as a way of protecting its innovations. Finally, as a

12 In addition, we initially considered the average years of schooling among the population aged between 15 and 64 years old to capture the level of human capital from Morrison and Murtin (2009). However, this variable was highly correlated with the GDP per capita (0.9124) and was not available for all the countries with a bias towards developed countries. Therefore, we decided not to include it in the regressions.

13 The index is based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of quantities used as seed and feed weighted in a similar manner. The resulting aggregate represents, therefore, disposable production for any use except as seed and feed. For more details on the methodology see: faostat.fao.org/site/362/DesktopDefault.aspx?PageID=362, [accessed on November 2012].

geographical indicator, we consider the latitude taken from the CIA's World Factbook (www.cia.gov/library/publications/the-world-factbook/).

The following table summarizes the sources, the independent variables and their possible effects as determinants of the level of IP protection for plant varieties.

Table 8. List of Variables

Dimension	Variable	Source
Dependent Variable		
Strength of IP Protection for Plant Varieties	Index	
Independent Variables		
Economic Development	GDP per capita (1990 International Geary-Khamis dollars)	Maddison
Economic Development	Urban population (1000) / Rural Population (1000)	FAOSTAT
Political Regime	Polity2	Polity IV Project
Institutional Framework	Economic Freedom	The Heritage Foundation
Importance of Agriculture	Export Value Index (2004-2006 = 100) (%)	FAOSTAT
Importance of Agriculture	Net per capita Production Index Number (2004-2006 = 100)	FAOSTAT
Competition	Openness at 2005 constant prices (%)	PENN World Table 7.0
Geography	Latitude	CIA's World Factbook

For the estimation of the model we considered the period 1961-2009, as data for the other variables was not available for the last two years that were computed for the index (2010 and 2011). We used the complete unbalanced panel data set and started with a pooled OLS regression with robust standard errors. In the first place, we simply do a regression of the index on the GDP per capita (in log) as this variable seemed to be important in determining the IP protection level. As can be observed in the following table, the coefficient of the GDP per capita is positive and significant, meaning that richer economies provide stronger IP protection for plant varieties. In the second model estimated with pooled OLS with robust standard errors, all the estimators included are positively correlated with the index of intellectual property plant variety protection and are significant at the 1% level, except for openness to trade that is significant at the 10% level.

Table 9. Estimation Results. Pooled OLS with Robust Standard Errors

Variables	Pooled OLS. Model 1		Pooled OLS. Model 2	
	b	SE	b	SE
Constant	-5.418	(0.202)	-1.779	(0.325)
GDP per capita	0.762***	(0.0230)	0.128***	(0.0408)
Urban Population / Rural Population			0.116***	(0.0126)
Export Value Index of Agricultural Products			0.0161***	(0.000733)
Index of Political System			0.0400***	(0.00385)
Economic Freedom			0.0844***	(0.0169)
Openness to Trade			0.000706*	(0.000412)
Latitude			0.00515***	-0.000863
Observations	2,736		1,568	
R-squared	0.266		0.547	

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1

Next, we performed further estimations using fixed effects (FE) and random effects (RE) estimation methods. The Hausman test rejected the null hypothesis that individual effects are random. Thus, fixed effects estimation method, where explanatory variables are treated as non-random, is used. In the he following table, the results of the estimated models using FE are shown.

Table 10. Estimation Results. Fixed Effects Models

Variables	Fixed Effects. Model 3		Fixed Effects. Model 4		Fixed Effects. Model 5	
	b	SE	b	SE	b	SE
Constant	-15.81***	(0.385)	-2.158***	(0.600)	-2.403***	(0.611)
GDP per capita	1.948***	(0.0439)	0.160**	(0.0729)	0.183**	(0.0737)
Urban Population / Rural Population			0.294***	(0.0256)	0.285***	(0.0259)
Export Value Index of Agricultural Products			0.0114***	(0.000740)	0.0114***	(0.000739)
Index of Political System			0.0261***	(0.00392)	0.0259***	(0.00392)
Economic Freedom			0.0236*	(0.0139)	0.0257*	(0.0139)
Openness to Trade			0.00904***	(0.000988)	0.00923***	(0.000991)
Net per capita Agricultural Production Index					0.000291**	(0.000141)
Observations	2736		1,568		1,568	
R-squared	0.424		0.627		0.628	

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1

The first specification simply considers the GDP per capita (in log) revealing once again that richer countries provide higher IP protection for plant varieties. However, from the evidence that derives from the second specification of the pooled OLS, it appears that IP protection is determined by other factors other than economic development measured by the level of the GDP per capita, and that it differs across countries driven by other factors. Therefore, in the second specification of the FE estimation (Model 4) we added all the explanatory variables that we used for the pooled OLS estimation, except for latitude, which being time-invariant cannot be considered in FE models. The sign of the estimators remain equal for all the regressors, which are all significant as well. In the last specification (Model 5) we added another variable: per capita production index of agricultural products, which may be an indicator of the importance of agriculture to test the possible ambiguous effect mentioned before. This variable is also significant and positively correlated. Compared with the pooled OLS models, the standard errors are higher as fixed effects models only take into account within variation of the data.

The results of the different models show that the level of IP protection for plant varieties is determined by the level of the GDP per capita, the political system and the institutional factors considered in the index of economic freedom. The proportion of urban population over rural population, which is an indicator of the development level of a country, also has a positive effect in the strength of the IP index. Richer countries with certain political and institutional systems provide stronger IP protection for plant varieties. In countries where agriculture is economically relevant, both in terms of net income per capita and for the export value, the index tends to be higher. Finally, the latitude which represents the geographical location also seems to play a role in determining the index, but not much more can be said about its influence.

5. Conclusions

The main contribution of this paper is the constructing of a new index of intellectual property protection for plant varieties for a set of countries including developed and developing countries. This measure enables international comparisons over the time and discriminating by region, income or development level among others.

This new index revealed some interesting facts, which are in line with evidences found for other kind of IPRs. In our case, the mean of the index score has been increasing all over the period reflecting the tendency towards tighter IP regimes. More developed countries have been offering IP protection for plant varieties for a longer period over which the level of protection has been increasing as well. Meanwhile, most developing countries have started offering IP protection in the last decades, mainly after the signing of the TRIPS Agreements, and they adopted already high levels of protection.

In addition, the index may help studying the determinants of the strength of the IP protection level for plant varieties. The exploratory econometric exercise showed that the level of development, political and institutional factors, as well as the relevance of agriculture act as determinants of the strength of protection. As well, openness to trade and geographical location have also an impact in the level of IP protection.

Finally, the index presented in this paper intends to be a useful tool for studying the effect of IPRs for plant varieties over different variables such as innovation, economic development, productivity and technology transfer, among others. The better understanding of these relations for developed and developing countries will serve the purpose of designing policy.

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Appendix

Table A. Evolution of the Index Intellectual Property Protection of Plant Varieties

Country	1961-1970	1971-1980	1981-1990	1991-2000	2001-2011
Albania	0.00	0.00	0.00	1.00	2.64
Argentina	0.25	0.71	0.82	1.97	2.49
Australia	0.25	0.50	1.22	2.77	3.40
Austria	0.25	0.25	0.63	2.08	3.26
Azerbaijan				0.50	2.80
Belarus				0.57	3.16
Belgium	0.61	1.40	2.42	2.74	2.99
Bolivia (Plurinational State of)	0.00	0.00	0.00	0.85	2.62
Brazil	0.00	0.00	0.00	0.85	2.42
Bulgaria	0.13	0.25	0.25	1.54	3.37
Canada	0.25	0.25	0.88	2.29	2.49
Chile			0.13	1.47	2.40
China			0.25	0.75	2.39
Colombia	0.00	0.00	0.00	1.50	2.79
Costa Rica	0.00	0.00	0.00	0.25	1.16
Croatia				0.63	3.52
Czech Republic			0.07	2.12	3.18
Denmark	0.09	0.52	2.06	3.50	4.41
Dominican Republic	0.50	0.50	0.50	0.50	1.80
Ecuador	0.00	0.00	0.00	1.10	2.66
Estonia				1.46	3.33
Finland	0.00	0.00	0.25	2.55	3.56
France	0.68	1.85	2.60	2.95	3.28
Georgia				1.32	2.39
Germany	1.08	1.64	2.00	3.37	4.09
Hungary	0.13	0.25	0.85	2.24	3.11
Iceland	0.00	0.00	0.00	0.63	2.56
Ireland	0.28	0.50	2.11	2.61	3.37
Israel	0.50	1.41	2.26	3.02	3.68
Italy	0.61	1.58	2.69	2.99	3.43
Japan	1.01	1.04	1.95	2.52	3.34
Jordan	0.00	0.00	0.00	0.48	2.83
Kenya	0.50	0.93	1.21	1.48	2.29
Kyrgyzstan				1.00	3.47
Latvia				1.00	3.09
Lithuania			0.50	0.75	3.09
Mexico	0.00	0.00	0.00	1.49	2.38
Morocco	0.25	0.25	0.25	0.79	2.38
Netherlands	1.17	1.85	2.31	3.19	4.04
New Zealand	0.50	0.50	1.80	2.63	2.83
Nicaragua	0.00	0.00	0.00	0.18	1.69
Norway	0.00	0.00	0.00	1.68	2.29
Oman	0.00	0.00	0.00	0.38	1.22
Panama	0.00	0.00	0.00	0.92	2.54
Paraguay	0.25	0.25	0.25	0.94	2.18
Peru	0.00	0.00	0.00	1.59	2.14
Poland			0.14	2.03	3.48
Portugal	0.00	0.00	0.06	1.64	2.47
Republic of Korea	0.00	0.25	0.63	1.42	3.05
Republic of Moldova				1.84	3.28
Romania	0.13	0.25	0.25	1.05	3.64
Russian Federation				2.38	3.51
Singapore	0.50	0.50	0.50	1.00	2.55
Slovakia			0.25	2.21	3.06
Slovenia				1.52	3.20
South Africa	0.50	1.01	2.19	2.80	3.30
Spain	0.25	0.59	1.38	2.14	3.07
Sweden	0.25	1.45	2.10	2.75	3.39
Switzerland	0.34	1.33	2.74	3.06	3.51
The former Yugoslav Republic of Macedonia				1.00	1.24
Trinidad and Tobago	0.50	0.50	0.50	1.04	2.11
Tunisia	0.00	0.00	0.00	0.63	1.95
Turkey	0.13	0.25	0.25	0.63	2.10
Ukraine				2.51	3.35
United Kingdom	1.44	2.08	2.91	3.43	4.07
United States of America	0.81	1.32	2.35	2.90	3.56
Uruguay	0.25	0.25	0.25	1.38	2.53
Uzbekistan	0.00	0.00	0.00	0.50	2.74
Viet Nam	0.00	0.00	0.25	0.50	1.75

Table B. Classification of Countries according to their Income Level and Geographical Region

Country	Income Level	Geographic Region
Albania	LI	East and Central Europe
Argentina	MI	Latin America and the Caribbean
Australia	HI	Oceania
Austria	HI	Western Europe
Azerbaijan	MI	East and Central Europe
Belarus	MI	East and Central Europe
Belgium	HI	Western Europe
Bolivia (Plurinational State of)	LI	Latin America and the Caribbean
Brazil	MI	Latin America and the Caribbean
Bulgaria	MI	East and Central Europe
Canada	HI	North America
Chile	MI	Latin America and the Caribbean
China	MI	Asia
Colombia	MI	Latin America and the Caribbean
Costa Rica	MI	Latin America and the Caribbean
Croatia	HI	East and Central Europe
Czech Republic	HI	East and Central Europe
Denmark	HI	Western Europe
Dominican Republic	MI	Latin America and the Caribbean
Ecuador	MI	Latin America and the Caribbean
Estonia	HI	East and Central Europe
Finland	HI	Western Europe
France	HI	Western Europe
Georgia	LI	East and Central Europe
Germany	HI	Western Europe
Hungary	HI	East and Central Europe
Iceland	HI	Western Europe
Ireland	HI	Western Europe
Israel	HI	Middle East and North Africa
Italy	HI	Western Europe
Japan	HI	Asia
Jordan	MI	Middle East and North Africa
Kenya	LI	Sub Saharan Africa
Kyrgyzstan	LI	East and Central Europe
Latvia	MI	East and Central Europe
Lithuania	MI	East and Central Europe
Mexico	MI	Latin America and the Caribbean
Morocco	LI	Middle East and North Africa
Netherlands	HI	Western Europe
New Zealand	HI	Oceania
Nicaragua	LI	Latin America and the Caribbean
Norway	HI	Western Europe
Oman	HI	Middle East and North Africa
Panama	MI	Latin America and the Caribbean
Paraguay	LI	Latin America and the Caribbean
Peru	MI	Latin America and the Caribbean
Poland	HI	East and Central Europe
Portugal	HI	Western Europe
Republic of Korea	HI	Asia
Republic of Moldova	LI	East and Central Europe
Romania	MI	East and Central Europe
Russian Federation	MI	East and Central Europe
Singapore	HI	Asia
Slovakia	HI	East and Central Europe
Slovenia	HI	East and Central Europe
South Africa	MI	Sub Saharan Africa
Spain	HI	Western Europe
Sweden	HI	Western Europe
Switzerland	HI	Western Europe
The former Yugoslav Republic of Macedonia	MI	East and Central Europe
Trinidad and Tobago	HI	Latin America and the Caribbean
Tunisia	MI	Middle East and North Africa
Turkey	MI	East and Central Europe
Ukraine	LI	East and Central Europe
United Kingdom	HI	Western Europe
United States of America	HI	North America
Uruguay	MI	Latin America and the Caribbean
Uzbekistan	LI	East and Central Europe
Viet Nam	LI	Asia

Note: HI (High Income); MI (Middle Income); LI (Low Income).

TABLE C. Correlation Matrix of Independent Variables

Independent Variable	1	2	3	4	5	6	7	8
1. GDP per capita	1							
2. Urban Population / Rural Population	0.4817	1						
3. Export Value Index of Agricultural Products	-0.0108	0.0817	1					
4. Index of Political System	0.6124	0.3947	0.0389	1				
5. Economic Freedom	0.0202	-0.062	-0.0084	-0.0346	1			
6. Openness to Trade	0.0853	-0.1952	0.0521	-0.0947	0.0268	1		
7. Latitude	0.3829	-0.0229	-0.0674	0.2015	0.0012	-0.0897	1	
8. Net per capita Agricultural Production Index	0.0428	-0.1534	-0.1273	-0.0819	-0.0233	0.5653	-0.0844	1