The Effect of Intellectual Property Rights on Agricultural Productivity

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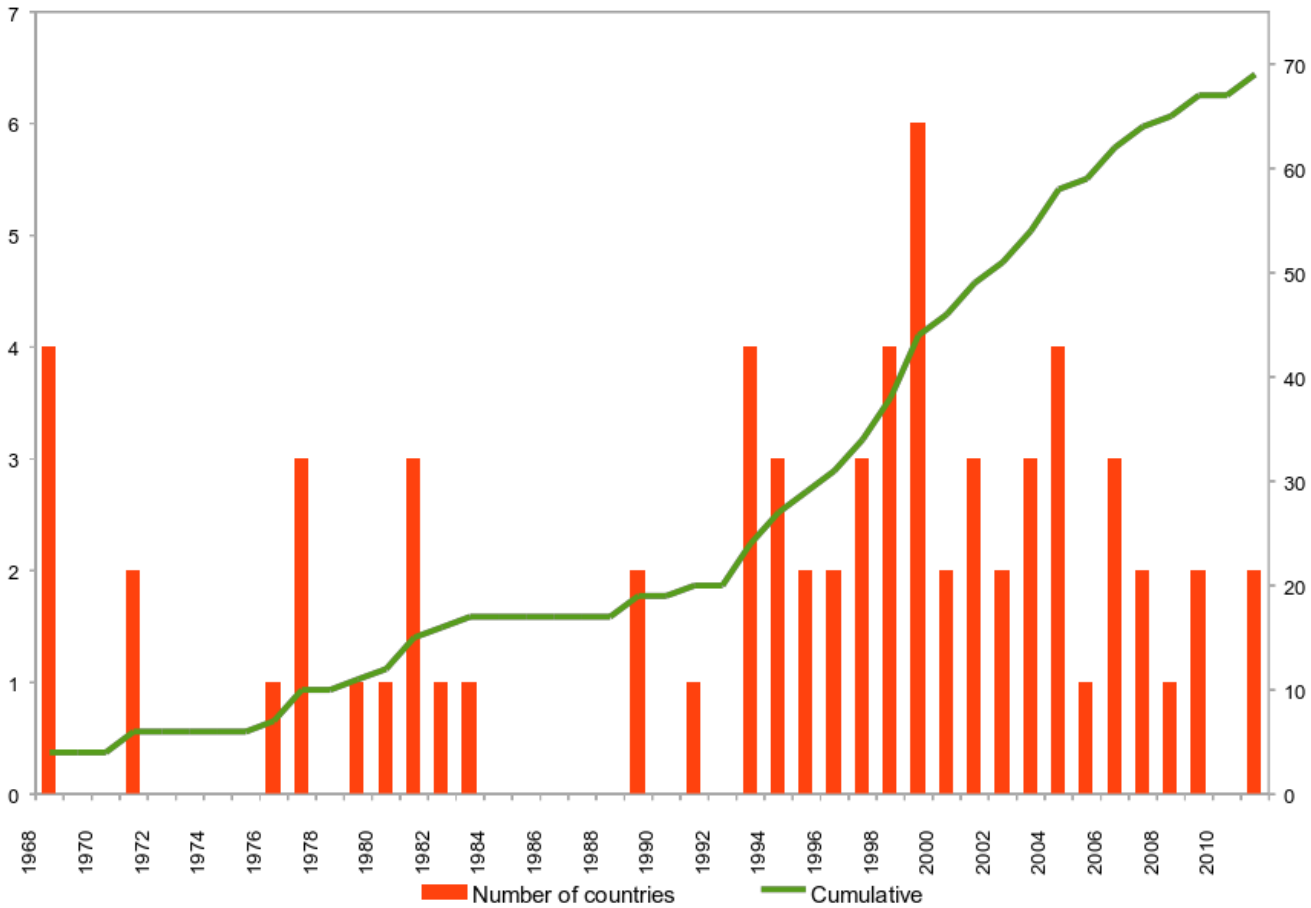
Motivation

- Effect of IPRs on R&D, innovation and productivity is still a matter of a contentious debate
- Necessary incentive to innovate vs.
  - Technology and sector specific
  - Social inefficiencies
- Effect on developing countries
- In spite of that, there is a global progressive tightening and harmonization of IP protection systems, especially since the signing of the Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement in 1995

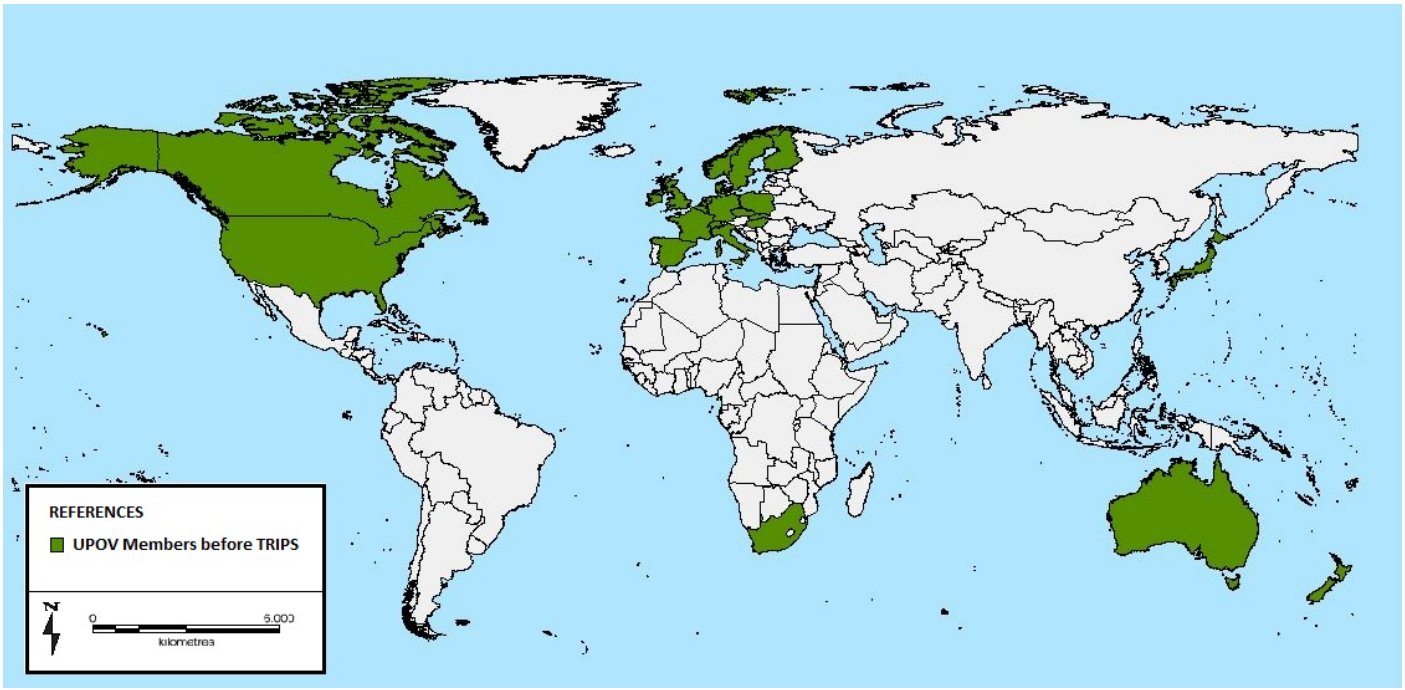
Number of Countries Becoming Members of UPOV by Year

UPOV: International Union for the Protection of New Varieties of Plants



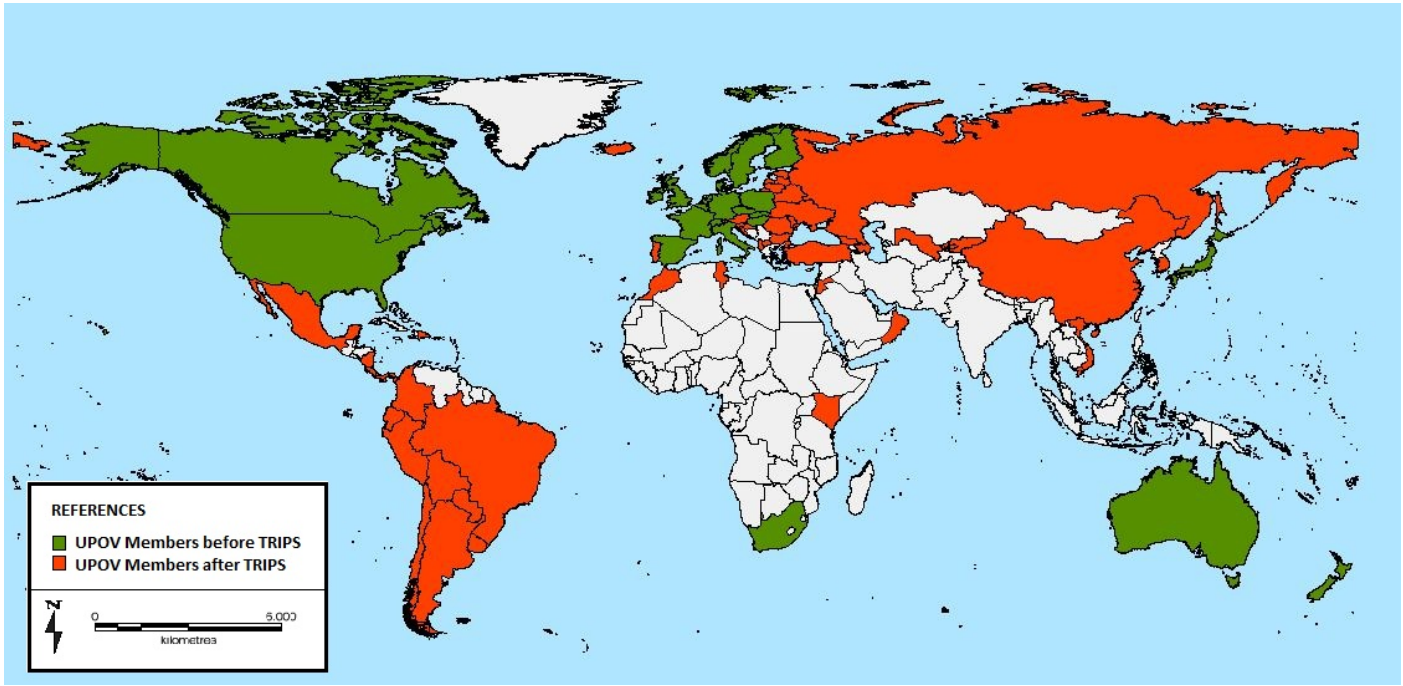
Members of UPOV Convention

Before TRIPS Agreement



Members of UPOV Convention

Before & After TRIPS Agreement



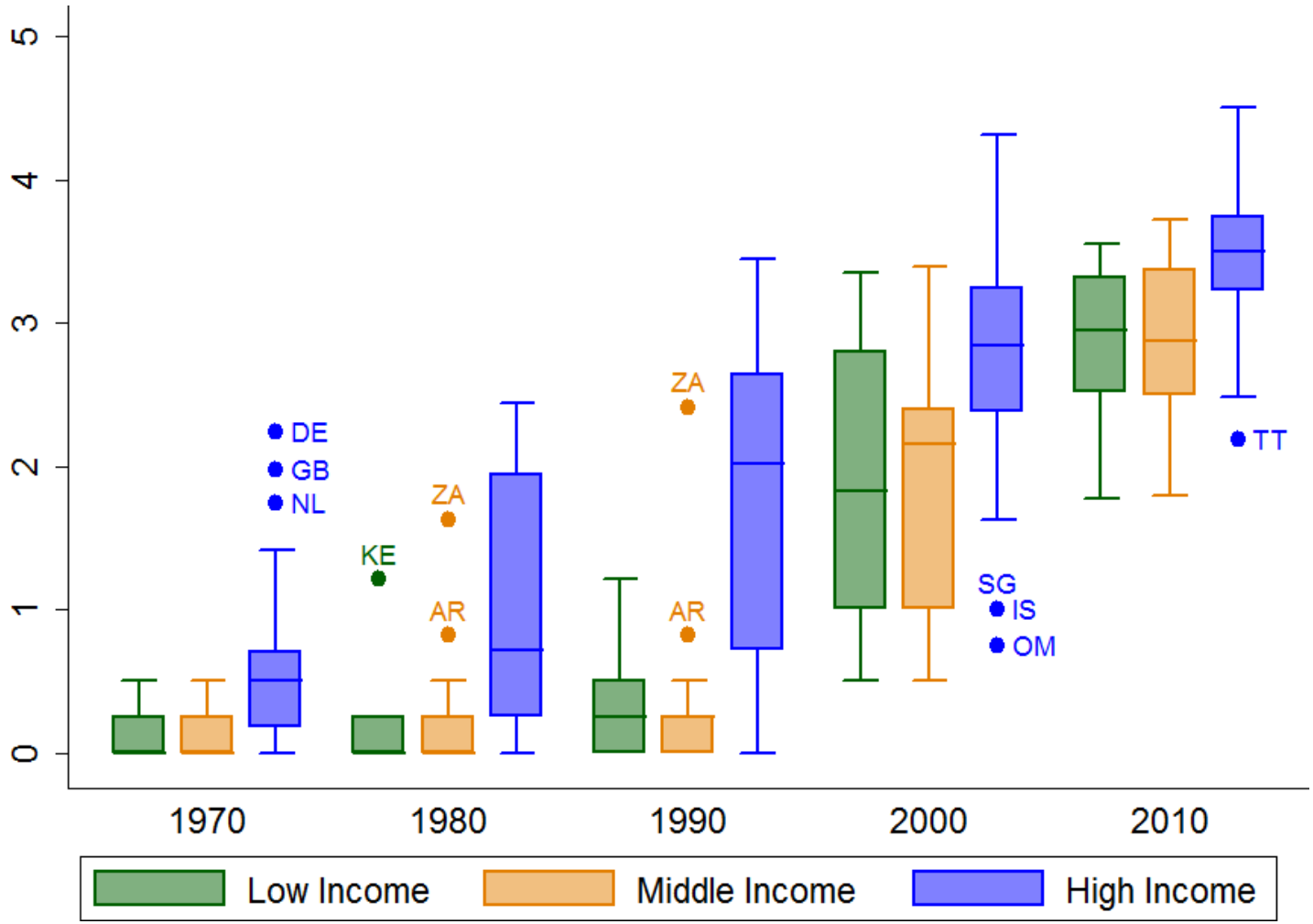
Objectives and Contribution

- Develop an index that measures the strength of IP protection for plant varieties that provides a comparable general measure
- Perform an empirical and econometric analysis to study the effect of IPRs on productivity and productivity growth in agriculture, considering its specificities and the possible divergent results for DCs, LDCs, Latin American countries and different income levels
- Provide broader sectoral evidence to the ongoing debate
- In agriculture and other sectors: mixed evidence
  - Imperfect data
  - Sectoral, technological and development specificities
  - Causality is not uniquely determined
- Panel Data: 1961-2011 (51 years) and 69 countries (members of the UPOV Convention, International Union for the Protection of New Varieties of Plants)

Data. Index of IP Protection for Plant Varieties

	Component	Score Range	Normalized Score
1	Ratification of UPOV Conventions	0-3	[0,1]
	1961	0-1	
	1978	0-1	
	1991	0-1	
2	Length of Membership	0-51	[0,1]
	At most 51 years	0-51	
3	Exceptions	0-3	[0,1]
	No compulsory license	0-1	
	No farmer's exception	0-1	
	Essentially derived variety	0-1	
4	Duration	0-35	[0,1]
	At most 35 years	0-35	
5	Patentability	0-4	[0,1]
	Pharmaceuticals	0-1	
	Microorganisms	0-1	
	Food	0-1	
	Plants and animals	0-1	
	Index	0-96	[0,5]

Evolution of Index over Decades by Income Level



Data. Productivity

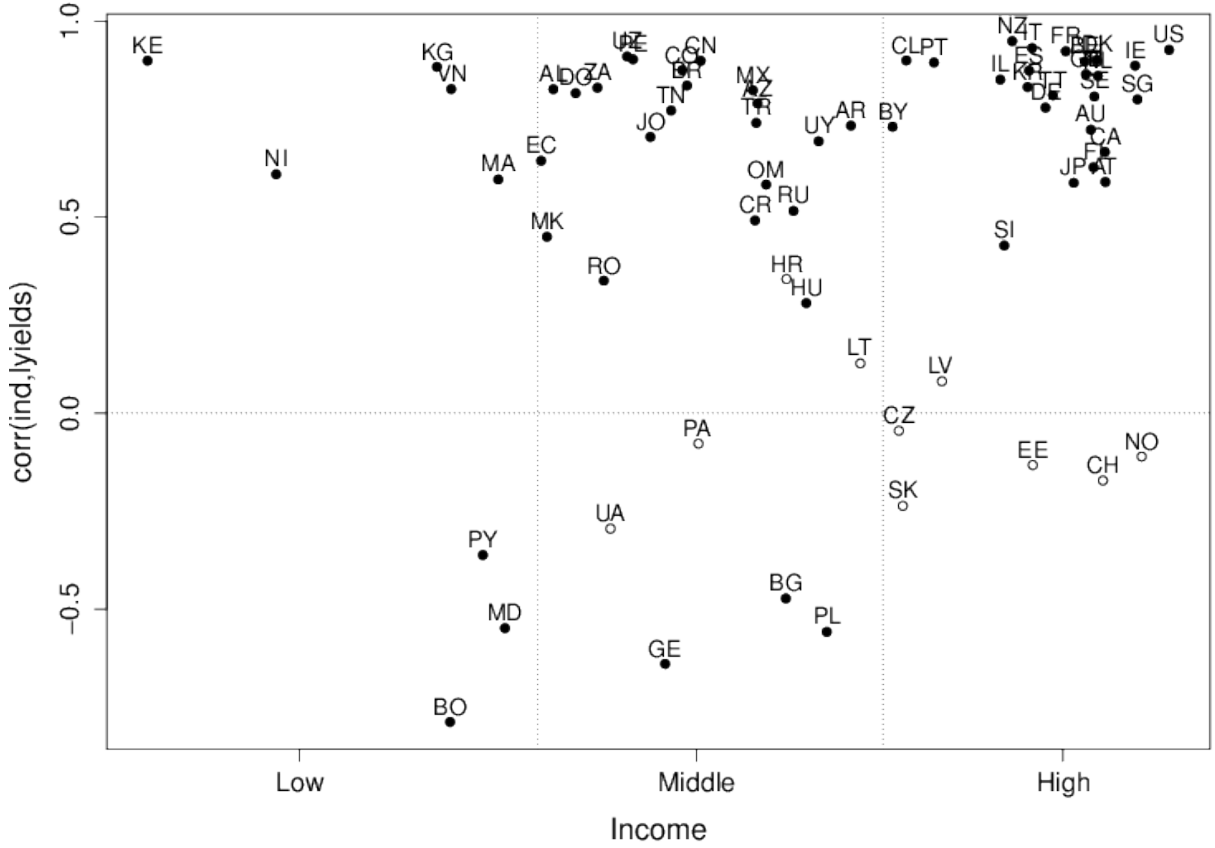
- Yields = Output / Cultivated Land
- Other types of indicators of productivity are: TFP or output/labor
- Drawbacks:
  - Single-dimensional measure
  - Adds quantities of non homogeneous products
  - May be biased by capital and labor intensities
- Advantages:
  - Data more reliable
  - Avoids the problem of price input measures for determining how much prices vary per constant-quality unit
  - Does not assume that technology is common
  - It is not represented by a well-defined production function
  - It reflects better the technological change of the second half of the XXth century: biological innovations and fertilization

Yields and Lagged IP Protection Index

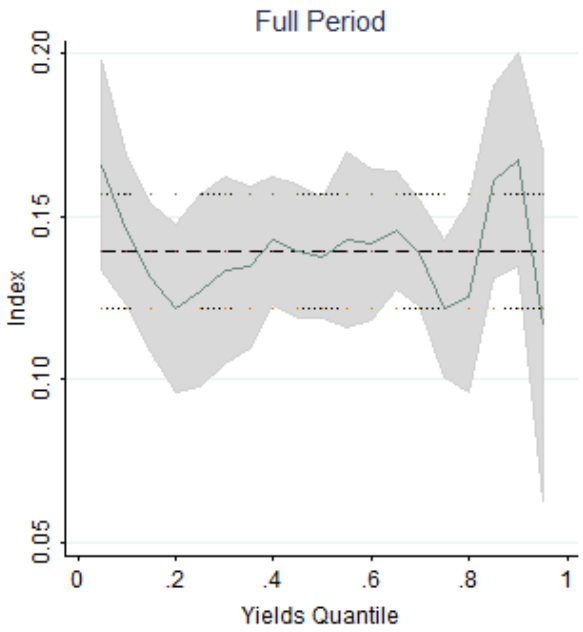
Year	$Index_{t-5}$		Constant		Observations	R-squared
1975	0.477**	(0.156)	7.933***	(0.099)	51	0.161
1980	0.382**	(0.130)	8.024***	(0.107)	51	0.150
1985	0.335**	(0.105)	8.078***	(0.105)	51	0.172
1990	0.270**	(0.078)	8.127***	(0.103)	52	0.192
1995	0.218***	(0.076)	8.177***	(0.112)	55	0.136
2000	0.150**	(0.073)	8.174***	(0.128)	69	0.060
2005	0.056	(0.077)	8.334***	(0.192)	69	0.008
2010	0.003	(0.097)	8.488***	(0.285)	69	0.000

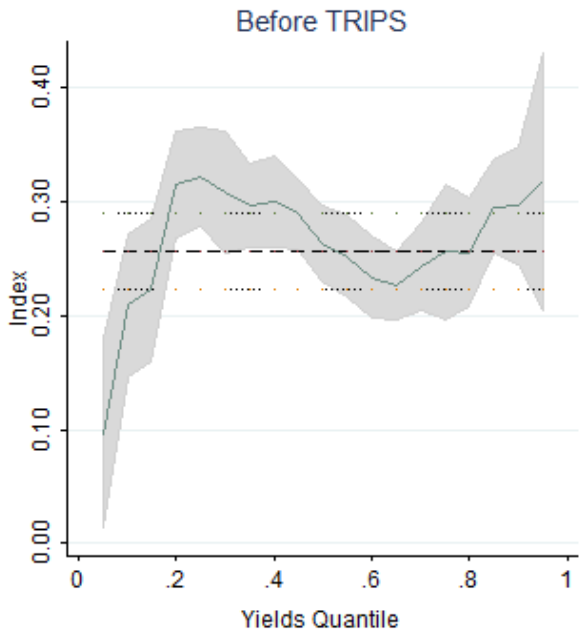
Note: The dependent variable is the log of yields. Standard errors are in parenthesis. Significance level: *** p<0.01, ** p<0.05, * p<0.10.

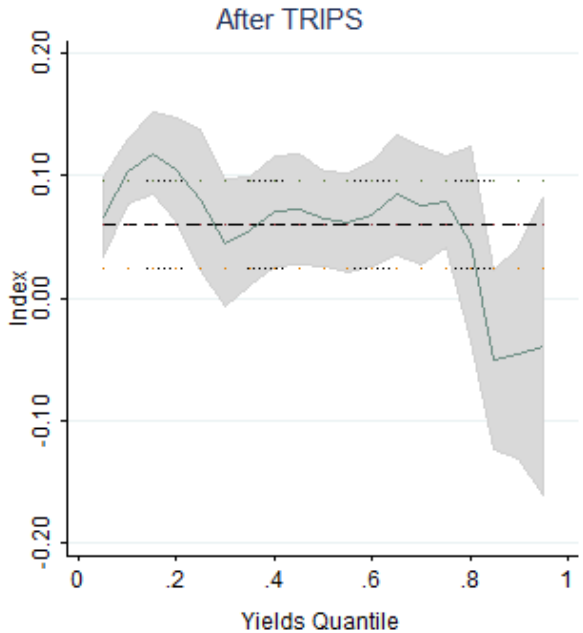
Correlation between Yields and IP Protection for Plant Varieties. 1961-2011



Quantile Regression Estimates. Full Period (1961-2011) Before TRIPS (1961-1994) and After TRIPS (1995-2011)







Econometric Analysis. IPRs and Yields

Table: Variables Descriptions and Sources

Variable	Name	Source
Yields (in log)	*lyield*	FAOSTAT
Index of IP protection for plant varieties	*ind*	Campi and Nuvolari (2013)
Educational Attainment Total Population	*schoo*	Barro and Lee (2010)
Tractors per 100 km^2 of arable land (in log)	*ltract*	FAOSTAT
Total area equipped for irrigation (1000 hectares)	*irrig*	FAOSTAT
Fertilizers consumption over agricultural land (in log)	*lfertil*	FAOSTAT
International land quality index for crop land	*qual*	Peterson (1987)
Average precipitation in depth (m per year)	*prec*	WDI

$$\begin{aligned} lyield_{i,t} = &\beta_1 + \beta_2 ind_{i,t} + \beta_3 schoo_{i,t} + \beta_4 ltract_{i,t} + \beta_5 irrig_{i,t} \\ &+ \beta_6 lfertil_{i,t} + \beta_7 qual_{i,t} + \beta_8 prec_{i,t} + \mu_{i,t} \ ; \end{aligned} \tag{1}$$

Yields Estimation Results. Pooled OLS Estimates

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	FS	HI	MI	LI	DC	LDC	LA
ind	0.107***	0.120***	-0.075	0.193*	0.111***	-0.037	-0.024
	(0.034)	(0.032)	(0.050)	(0.093)	(0.028)	(0.047)	(0.041)
schoo	0.032	0.020	0.135***	0.013	0.004	0.165***	0.102**
	(0.021)	(0.018)	(0.034)	(0.040)	(0.015)	(0.035)	(0.038)
ltract	0.139**	0.157**	-0.108	0.198**	0.178**	-0.019	0.022
	(0.056)	(0.060)	(0.065)	(0.062)	(0.078)	(0.092)	(0.124)
irrig	0.011	0.041	-0.732	2.134	-0.236	-0.184	1.638
	(0.459)	(0.397)	(1.086)	(1.074)	(0.356)	(0.888)	(1.745)
lfertil	0.064	0.187***	0.173***	-0.157***	0.165***	0.091	0.013
	(0.039)	(0.048)	(0.048)	(0.031)	(0.043)	(0.056)	(0.057)
qual	0.003	0.005**	-0.000	-0.001	0.004	-0.001	0.001
	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.005)
prec	0.142	-0.154	0.255***	0.233	0.075	0.114	0.209
	(0.101)	(0.159)	(0.081)	(0.119)	(0.294)	(0.099)	(0.120)
Constant	6.384***	5.862***	7.065***	6.440***	5.864***	6.873***	6.731***
	(0.245)	(0.336)	(0.435)	(0.175)	(0.457)	(0.394)	(0.634)
Observations	1,664	834	600	230	803	861	543
R-squared	0.629	0.722	0.643	0.742	0.759	0.553	0.351

Note: The dependent variable is the log of yields. The models are estimated with cluster-robust standard errors (in parenthesis). Significance level: *** p<0.01, ** p<0.05, * p<0.10. FS: Full Sample; HI: High-Income; MI: Middle-Income; LI: Low-Income; DC: Developed Country; LDC: Developing Country; LA: Latin American Country.

Yields and Index of IPRs. Fixed Effects Estimates

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	FS	HI	MI	LI	DC	LDC	LA
ind	0.022***	0.051***	-0.003	0.097***	0.033***	0.053***	0.114***
	(0.008)	(0.007)	(0.014)	(0.031)	(0.008)	(0.015)	(0.017)
schoo	0.088***	0.050***	0.116***	0.001	0.049***	0.115***	0.039***
	(0.007)	(0.007)	(0.011)	(0.021)	(0.007)	(0.010)	(0.012)
ltract	0.085***	0.077***	0.065**	0.130***	0.088***	0.086***	0.207***
	(0.010)	(0.009)	(0.029)	(0.045)	(0.011)	(0.017)	(0.024)
irrig	0.094	-0.054	-0.025	2.528***	0.086	-0.043	-0.101
	(0.081)	(0.062)	(0.300)	(0.431)	(0.069)	(0.194)	(0.504)
lfertil	0.032***	0.076***	0.108***	-0.078***	0.108***	-0.018	-0.055***
	(0.008)	(0.013)	(0.018)	(0.016)	(0.013)	(0.012)	(0.014)
Constant	6.926***	7.108***	6.729***	6.872***	6.878***	6.880***	6.895***
	(0.047)	(0.066)	(0.104)	(0.138)	(0.072)	(0.062)	(0.079)
Observations	1,729	874	600	255	843	886	543
R-squared	0.445	0.578	0.569	0.319	0.482	0.473	0.413
No. of countries	54	28	18	8	27	27	15

Note: The dependent variable is the log of yields. Standard errors are in parenthesis. Significance level: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. FS: Full Sample; HI: High-Income; MI: Middle-Income; LI: Low-Income; DC: Developed Country; LDC: Developing Country; LA: Latin American Country.

Yields and Lagged Index of IPRs. Fixed Effects Estimates

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	FS	HI	MI	LI	DC	LDC	LA
ind_{t-5}	0.007	0.043***	-0.030*	0.245***	0.034***	0.050***	0.109***
	(0.009)	(0.008)	(0.017)	(0.040)	(0.008)	(0.019)	(0.023)
schoo	0.096***	0.060***	0.119***	0.013	0.047***	0.120***	0.030**
	(0.006)	(0.007)	(0.011)	(0.016)	(0.008)	(0.010)	(0.012)
ltract	0.089***	0.055***	0.084**	0.138**	0.087***	0.141***	0.257***
	(0.017)	(0.015)	(0.037)	(0.054)	(0.017)	(0.029)	(0.032)
irrig	0.087	-0.034	-0.069	2.071***	0.142**	-0.394*	0.911*
	(0.084)	(0.062)	(0.308)	(0.456)	(0.071)	(0.210)	(0.541)
lfertil	0.025***	0.026*	0.133***	-0.123***	0.081***	-0.033**	-0.042***
	(0.009)	(0.014)	(0.020)	(0.017)	(0.014)	(0.014)	(0.015)
Constant	6.904***	7.438***	6.563***	6.838***	7.037***	6.681***	6.666***
	(0.075)	(0.096)	(0.137)	(0.167)	(0.100)	(0.103)	(0.105)
Observations	1,495	753	525	217	729	766	473
R-squared	0.372	0.448	0.539	0.391	0.362	0.431	0.383
No. of countries	54	28	18	8	27	27	15

Note: The dependent variable is the log of yields. Standard errors are in parenthesis. Significance level: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. FS: Full Sample; HI: High-Income; MI: Middle-Income; LI: Low-Income; DC: Developed Country; LDC: Developing Country; LA: Latin American Country.

No-Linearities in the Relation Between Yields and IP Protection

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	HI	MI	LI	LA	HI	MI	LI	LA
ind	-0.005	0.079*	0.365***	0.236***				
	(0.018)	(0.041)	(0.083)	-0.068				
ind^2	0.015***	-0.027**	-0.086***	-0.049*				
	(0.004)	(0.013)	(0.025)	-0.027				
ind2					-0.019	0.017	0.200***	0.195**
					(0.018)	(0.029)	(0.059)	(0.031)
ind3					0.049**	-0.035	0.253**	0.324**
					(0.024)	(0.061)	(0.103)	(0.141)
schoo	0.051***	0.115***	-0.030	0.031**	0.074***	0.117***	-0.006	0.043**
	(0.007)	(0.011)	(0.022)	-0.013	(0.006)	(0.012)	(0.021)	(0.012)
ltract	0.085***	0.054*	0.143***	0.208***	0.076***	0.058*	0.127***	0.209**
	(0.009)	(0.029)	(0.044)	-0.024	(0.009)	(0.030)	(0.044)	(0.025)
irrig	-0.027	-0.071	2.794***	0.025	-0.083	-0.042	2.543***	-0.014
	(0.062)	(0.300)	(0.428)	-0.507	(0.063)	(0.310)	(0.431)	(0.512)
lfertil	0.081***	0.102***	-0.083***	-0.052***	0.074***	0.104***	-0.078***	-0.055**
	(0.013)	(0.018)	(0.016)	-0.014	(0.014)	(0.018)	(0.017)	(0.014)
Constant	7.052***	6.783***	6.900***	6.900***	7.002***	6.761***	6.907***	6.841**
	(0.068)	(0.107)	(0.136)	-0.079	(0.065)	(0.108)	(0.138)	(0.079)
Observations	874	600	255	543	874	600	255	543
R-squared	0.584	0.572	0.351	0.417	0.568	0.570	0.324	0.408

Econometric Analysis. IPRs and Growth of Yields

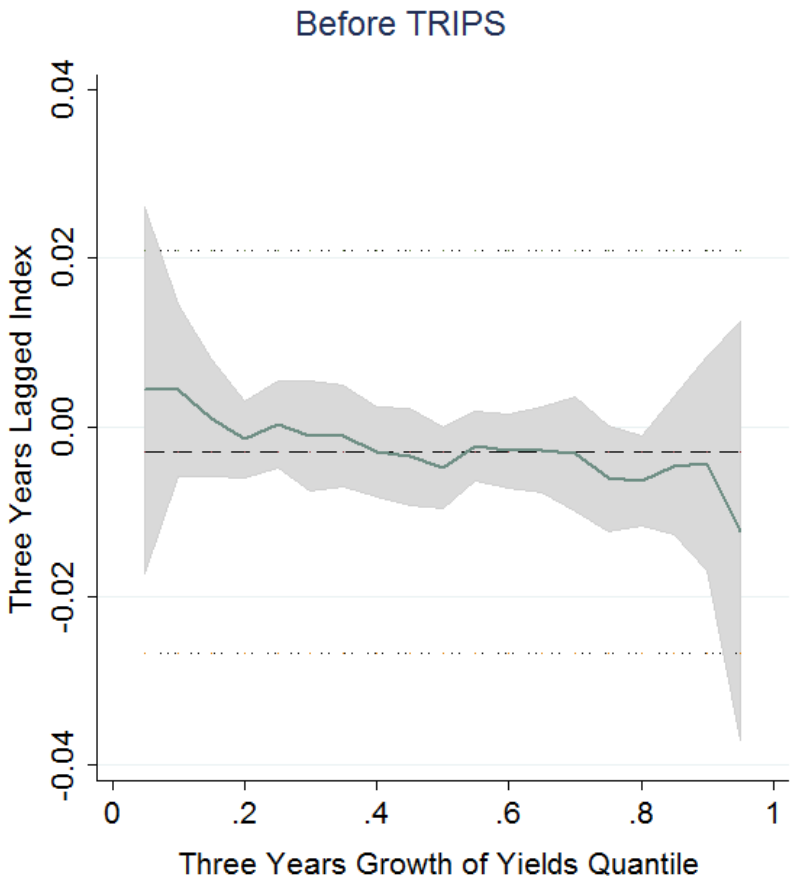
- Growth rate of yields the difference of the log of yields for the three-years mean at the final and the initial time
- $gryields = lyield_{t_2} - lyield_{t_1}$
  where: t_1 mean for the years 1992, 1993 and 1994; and t_2 is the mean for the years 2008, 2009 and 2010
- Control variables are three-years means
- Also included initial value of log of yields, which represents the catching-up potential

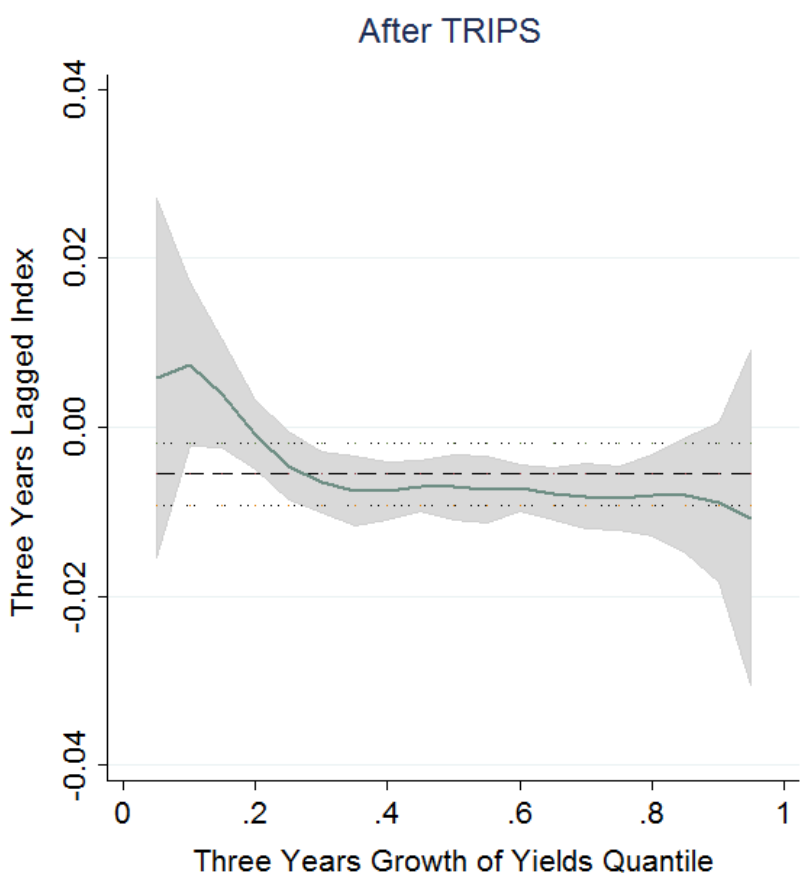
$$\begin{aligned} gryield_{i,t_2} =& \beta_1 + \beta_2 ind_{i,t_1} + \beta_3 lyield_{i,t_1} + \beta_4 schoo_{i,t_1} + \beta_5 irrig_{i,t_1} \\ &+ \beta_6 lfert_{i,t_1} + \beta_7 qual_{i,t_1} + \beta_8 prec_{i,t_1} + \mu_{i,t_2} \ . \end{aligned} \tag{2}$$

Growth Rates of Yields. Control Variables in Initial Levels. Estimation Results

Model	(1)	(2)	(3)	(4)	(5)	(6)
ind_{t_1}	0.0327	0.013	0.316	0.023	0.018	0.042
	(0.0357)	(0.066)	(0.036)	(0.052)	(0.035)	(0.039)
$lyields_{t_1}$	-0.268***	-0.269***	-0.269***	-0.384***	-0.127*	-0.151**
	(0.0590)	(0.059)	(0.060)	(0.080)	(0.065)	(0.066)
$ind_{t_1} * dev$		0.020				
		(0.059)				
$ind_{t_1} * la$			-0.032			
			(0.122)			
$schoo_{t_1}$				-0.013	-0.018	-0.011
				(0.024)	(0.016)	(0.016)
$lfert_{t_1}$				0.107***	0.060*	0.068**
				(0.037)	(0.031)	(0.030)
$irrig_{t_1}$				-0.196	-0.153	0.150
				(0.389)	(0.262)	(0.378)
$ltrac_{t_1}$					-0.055*	-0.080**
					(0.031)	(0.030)
precip						0.047
						(0.053)
qual						-0.001
						(0.001)
Constant	2.275***	2.292***	2.288***	2.972***	1.334***	1.620***
	(0.479)	(0.484)	(0.485)	(0.599)	(0.468)	(0.459)
Observations	69	69	69	57	52	45
R-squared	0.239	0.240	0.240	0.358	0.268	0.413

Quantile Regression Estimates.
Before TRIPS (1961-1994) and After TRIPS (1995-2011)





Concluding Remarks

- The new index of IP protection for plant varieties showed an increase in the mean of protection and dispersion has fallen (strengthening and harmonization of IPRs systems)
- Stronger IPRs were found to be positively correlated with yields for high-, low-income and developed countries but not for middle-income countries. For the lagged index, the correlation was found to be negative for the case of middle-income countries
- For Latin American countries, the index was found to be positively correlated with yields. The increase in the level of protection since the TRIPS did not have an effect on productivity growth
- The estimations provided evidence of the existence of non-linearities in the relation between IPRs and productivity
- Growth regressions showed no significant effect of IPRs
- In terms of policy implications, the analysis provide strong evidence against the idea that there is a unique model that fits all
- On the contrary, the findings support the hypothesis that country specificities are important determinants of the effects of IPRs

Thank you!

Growth Rates of Yields. Control Variables in Changes. Estimation Results

Model	(1)	(2)	(3)	(4)
$\triangle ind$	-0.036	-0.035	-0.033	0.008
	(0.393)	(0.043)	(0.451)	(0.046)
$lyields_{t_1}$	-0.260***	-0.257***	-0.262***	-0.021
	-0.057	(0.058)	(0.058)	(0.089)
$\triangle ind * dev$		-0.016		
		(0.039)		
$\triangle ind * la$			-0.025	
			(0.042)	
$\triangle lfert$				0.053**
				(0.020)
$ltrac_{t_1}$				-0.059*
				(0.030)
$irrig_{t_1}$				1.164**
				(0.560)
$schoo_{t_1}$				-0.013
				(0.020)
$qual$				-0.004**
				(0.002)
$precip$				0.068
				(0.064)
Constant	2.318***	2.298***	2.336***	0.621
	(0.491)	(0.496)	(0.494)	(0.618)
Observations	69	69	69	31
R-squared	0.215	0.240	0.242	0.440