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Private Sector Incentives and the Diffusion of Agricultural Technology: Evidence from Developing Countries

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Research Question

- Do intellectual property rights (IPRs) affect the transfer of productivity-enhancing agricultural technologies to developing countries?
- What is the relative influence of biological and legal forms of IPRs on yield gap convergence between developed and developing countries?

Literature Review

- Positive effect: IPRs can potentially encourage private investment in research and development of the adoption of new cultivars, genetically modified crops, crop protection chemicals, and other inputs to developing-country agricultural production (Lesser et al., 2000; Eaton et al., 2006; Pray, 1992).
- Negative effect: IPRs can provide private firms with temporary monopolies of a welfare-reducing nature which, for small-scale, resource-poor farmers in developing countries, might deny them of important technological solutions to reducing poverty and vulnerability (Srinivasan and Thirtle 2000; Goeschl and Swanson 2000).
- Mixed effect or irrelevant: IPRs in agriculture may be irrelevant because firms in developed countries rarely seek IPR protection for their technologies in developing countries thus giving freedom to operate to researchers, firms, and farmers (Binenbaum et al., 2000).

Lead-Follower Model

Our theoretical model is based on the "follow-the-leader" model originally proposed by Barro and Sala-i-Martin (1995) in the new economic growth theory literature. The model posits that the growth rate of a follower country tends to catch up to that of a leader country because followers can imitate innovations produced by leaders at a lower cost. As a result, followers and leaders tend to converge to the same steady state rate of growth in the long term.
One result of the model is that:

$$\gamma_2 = \gamma_1 - \nu log\left(\frac{\frac{y_2}{y_1}}{(\frac{y_2}{y_1})^*}\right),$$

where γ_1 and γ_2 are the output growth rates of leader country 1 and follower country 2, y_1 and y_2 denotes the productivity in each country and $(\frac{y_2}{y_1})^*$ the optimal productivity ratio. The above equation suggests that increased innovation in country 1 leads to an increase in country 2's growth rate, while increased imitation in country 2 leads to decrease in country 2's growth rate, a movement along the convergence path at points closer to convergence.
The lead-follower model can be readily adopted to the context of yield-enhancing technologies that are transfered from developed countries to developing countries through imitation and adaptive research.

Empirical Model

The main specification of our empirical model is

$$\begin{aligned} G_{it} &= c_i + \beta G_{i,t-1} + \gamma \Delta MKT_{i,t} \\ &+ \theta_1 \Delta IPR_{i,t} + \theta_1 \Delta IPR_{i,t-1} + \theta_1 \Delta IPR_{i,t-2} \\ &+ \varepsilon_{i,t} \end{aligned}$$

where

- $G_{i,t}$ denotes the gap in yield growth rates between the lead country and the follower country i at time t for a given crop, $G_{i,t-1}$ is its one time period lagged value. It is further defined as

$$G_{it} = \frac{Y_t^* - Y_{t-1}^*}{Y_{t-1}^*} - \frac{Y_t - Y_{t-1}}{Y_{t-1}} = \frac{Y_t^*}{Y_{t-1}^*} - \frac{Y_t}{Y_{t-1}}$$

  where Y_{it} is the yield of country i in time t and Y_t^* is the yield in the lead country at time t.
- c_i denotes the time-invariant country-specific structural factors for the follower country i,
- $\delta MKT_{i,t}$ is the change of agriculture market size,
- $\Delta IPR_{i,t}$, $\Delta IPR_{i,t-1}$ and $\Delta IPR_{i,t-2}$ are the change of IPR regime strength and its lagged terms.
- $\varepsilon_{i,t}$ is the random shock.

Data and Result

Data and data source:

- Yield of eight crops: barley, cotton, maize, millet, rice, sorghum, soybean and wheat from 1961 to 2010 in majority of developing countries. Data source: Food and Agricultural Organization's online database (FAOSTAT).
- Market size: total population as a proxy. Data source: World Development Indicators, World Bank, 2012.
- IPR regime strength: 1) The Ginarte-Park Index constructed by Ginarge and Park (1997), Park and Wagh (2002), Park (2008). 2) Years of joining the International Union for the Protection of New Varieties of Plants (UPOV).

Result: Arellano-Bond linear dynamic panel-data estimation

		Barley	Cotton	Maize	Millet	Rice	Sorghum	Soybean	Wheat
β	$G_{i,t-1}$	0.096	0.410***	0.244***	0.248***	0.444***	0.231***	0.228***	0.272***
		0.063	0.026	0.049	0.030	0.026	0.063	0.040	0.046
γ	ΔMKT	1.065**	-0.293	1.146***	0.827**	-0.101	0.501*	-0.198	0.433***
		0.386	0.302	0.348	0.356	0.285	0.290	0.296	0.156
θ_1	$\Delta IPR_{i,t}$	0.021**	0.003	0.017	0.000	0.013*	-0.014	0.004	-0.002
		0.010	0.010	0.012	0.008	0.007	0.013	0.009	0.011
θ_2	$\Delta IPR_{i,t-1}$	0.006	0.005	0.024***	0.004	0.003	0.002	-0.013**	-0.021**
		0.013	0.011	0.007	0.007	0.006	0.008	0.007	0.009
θ_2	$\Delta IPR_{i,t-2}$	-0.021	-0.019	-0.013	0.013	0.015**	-0.013	-0.020**	-0.020**
		0.014	0.012	0.009	0.010	0.007	0.014	0.009	0.010

Summary:

- The yield gap between developed country and developing countries is decreasing over our study time period.
- Changes in IPR regime strength have mixed results across crops: positive for soybean and wheat; negative for barley, maize and rice; insignificant for cotton and millet.
- An expanding agriculture market is associated with increases in the yield gap.
- Other estimation results suggest that commercialization and hybridization reduce the yield gap between the lead country and follower countries.

Conclusion

Our results suggest that overall the yield gap is decreasing and the yield growth rate between developed and developing countries are converging, although the convergence rate is different across crops. Our findings suggest that a stronger IPR regime has mixed effect in reducing the yield gap while an expanding agricultural market in the follower country is associated with increases in yield gap between the lead country and the follower country. Our conclusion holds with other IPR measures such as patentability of plant variety and membership status in UPOV.

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