Genetically Modified Organisms and Agricultural Labor Productivity

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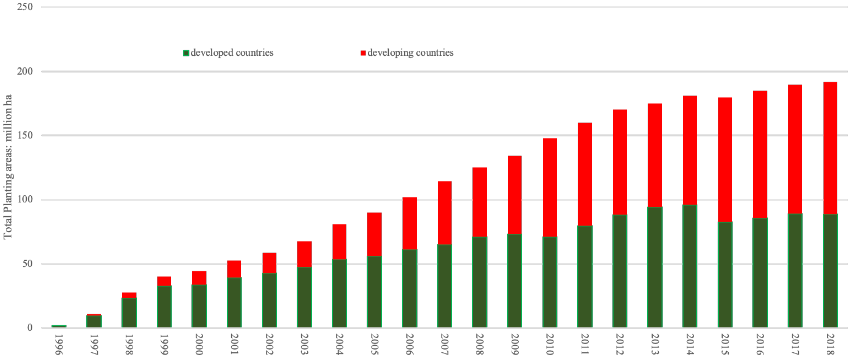
Introduction

- Biotechnological innovations in the form of genetically modified organisms (GMOs) and gene-edited crops are believed to have revolutionized agricultural production.
  - Wheeler ad von Braun 2013; Bailey-Serres et al. 2019; Eshed and Lippman 2019; Zaidi et al. 2019 etc.
- Little is known about their aggregate impact.

Introduction

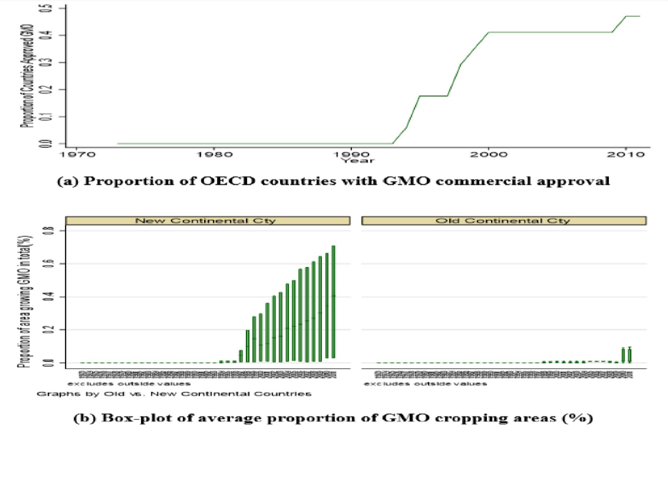
- Using a cross-country panel for 15 OECD countries, we investigate the impact of GMO introduction on aggregate agricultural labor productivity
  - United States, Canada, Australia, and 12 European Union countries
  - Labor productivity = aggregate agricultural value added per unit of labor.

Figure 1. Area planted to GMO crops: developed vs. developing countries: 1996-2018



Source: ISAAA (2020)

Figure 2. GMO adoption in 15 OECD countries



Source: ISAAA (2020)

Figure 3. Box plot of agricultural labor productivity for the 15 OECD countries

Source: Authors' own estimation.

Model and method

Following the macroeconomic tradition, aggregate value added in agriculture, Y, is a constant returns Cobb-Douglas function of capital, K, and labor, L:

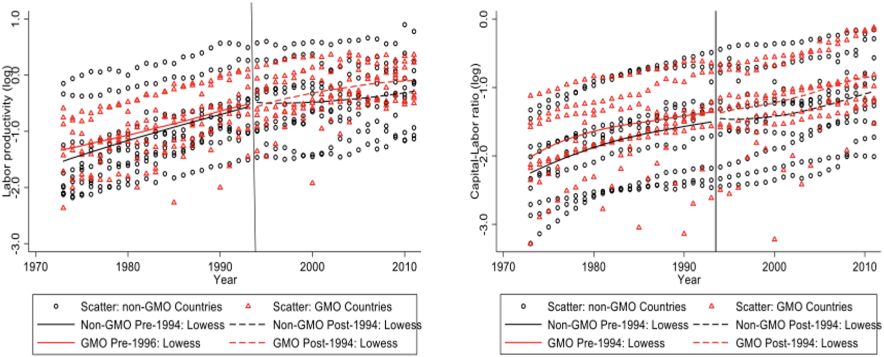
$$Y = AK^b L^{1-b},$$

where A represents *total factor productivity*. Dividing both sides of this expression by L and taking natural logarithms:

$$\ln y = a + b * \ln k,$$

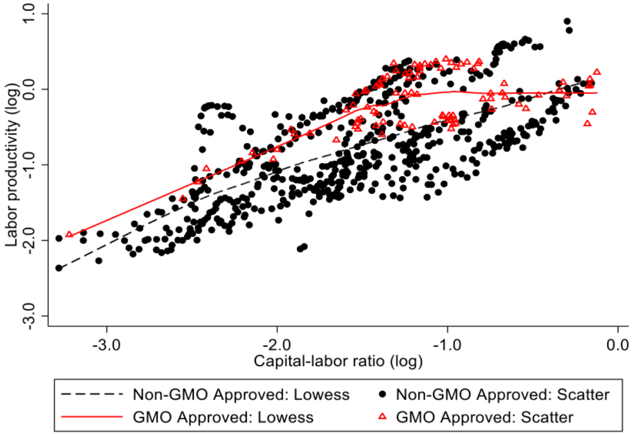
where $a = \ln A$ and lower case letters represent variates represented in per unit of labor terms, $y = \frac{Y}{L}$, labor productivity and $k = \frac{K}{L}$, capital-labor ratio

Figure 4. Change in labor productivity and capital-labor ratio for 15 OECD countries



Source: Authors' own estimation.

Figure 5. the y-k relationship between the GMO approved and non-approved countries: 1973-2011



Source: Authors' own estimation.

Model and method

Our specification is:

$$\ln y\left(0\right)_{it} = a\left(0\right)_{it} + b\left(0\right)_{it} * \ln k_{it}$$

for a non-GMO technology and

$$\ln y\left(1\right)_{it} = a\left(1\right)_{it} + b\left(1\right)_{it} * \ln k_{it}$$

for a GMO technology.
Let G_{it} denote a GMO indicator variable and y_{it} observed value of labor productivity.

$$\ln y_{it} = G_{it} \ln y\left(1\right)_{it} + \left(1 - G_{it}\right) \ln y\left(0\right)_{it},$$

whence

$$\ln y_{it} = a\left(0\right)_{it} + b\left(0\right)_{it} * \ln k_{it} + \alpha_{it} G_{it} + \beta_{it} G_{it} \ln k_{it},$$

where $\alpha_{it} = a\left(1\right)_{it} - a\left(0\right)_{it}$ and $\beta_{it} = b\left(1\right)_{it} - b\left(0\right)_{it}$.

Empirical specification

- Baseline empirical model specification is written as:

  $$lny_{it} = c_0 + c_1 T_t + g_0 lnk_{it} + g_1 T_t lnk_{it} + \overline{\alpha_{it}} G_{it} + \overline{\beta_{it}} G_{it} \ln k_{it} + u_i + v_t + \epsilon_{it},$$

  where ϵ_{it} is a white noise.
- Three econometric issues to be resolved
  - GMO adoption is not randomly assigned:
    Neighborhood matching
  - Endogeneity:
    Fixed-effect (FE) model and FE-IV model
  - Disparity in GMO adoption intensity across countries:
    GMO adoption intensity used to reweight observations.

Table 1. Regression results for the FE-IV models

	Base Model (Full Sample)		P-score Match 2-v (Sub Sample)	
	No lnkl	With lnkl	No lnkl	With lnkl
	(1)	(2)	(3)	(4)
Dependent variable: agricultural output per capita (log): ln_yl				
c_1	1.096***	0.588**	0.985***	0.370**
	(0.095)	(0.248)	(0.116)	(0.182)
g_0	-	0.623***	-	0.794***
	-	(0.218)	-	(0.207)
g_1	-	0.232***	-	0.314**
	-	(0.0733)	-	(0.124)
$\overline{\alpha_{it}}$	0.184***	-0.861***	0.234***	-0.577**
	(0.059)	(0.303)	(0.068)	(0.277)
$\overline{\beta_{it}}$	-	-0.850***	-	-0.704***
	-	(0.236)	-	(0.229)
Control GMO Adoption cty. group				
β_{GA}	-	0.244	-	0.080
	-	(0.174)	-	(0.170)
u_i	Yes	Yes	Yes	Yes
v_t	Yes	Yes	Yes	Yes
Heteroskedasticity	Yes	Yes	Yes	Yes
Number of Observations	585	585	453	453
R-squared	0.783	0.840	0.763	0.853
Number of countries	15	15	15	15

Note:The first-stage regression results are available upon request. The F-statistics for the over-identification test have all been passed. Robust standard errors in parentheses, and *** p¡0.01, ** p¡0.05, * p¡0.1.

Concluding Remarks

- Biotechnology and GMOs promise to revolutionize agricultural production
- Widespread evidence exists from micro-oriented studies
- Aggregate labor productivity and TFP appear to have been negatively affected
- If accurate, why? Value added?

Choice of instrumental variables

- For propensity score based neighbor matching:
  - GDP per capita (from the Penn World Table 10.0);
  - The relative price of intermediate inputs.
- The instrument used for dealing with the endogeneity problem:
  - "the relative price of capital to labor in agriculture" (for capital-labor ratio);
  - "the total number of GMO events in the past 10 years" and "the number of patents related to GMOs" (for GMO adoption).