The impact of public research expenditure on agricultural productivity: evidence from developed European countries

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Motivation and objectives

- Productivity growth in agriculture is of core importance to meet food demand of the rapidly increasing world population.
- The potentiality of public investments in agricultural research to stimulate the required productivity progress is widely acknowledged.
- United States of America (USA) and developed European countries have been leaders in science-based agricultural productivity increase since the middle of the 20th century, motivating hundreds of studies about the impact of public research expenditure on agricultural productivity.
- Unfortunately, the almost totality of these studies have been focused on USA, with few scattered contributes on European countries.
- This research has the objective to assess the impact of public research expenditure on agricultural productivity in developed European countries and to make a comparison with existing studies focused on USA.

Data

- EU15 countries plus Iceland, Norway and Switzerland.
- Yearly data in the period 1970–2016:
  - ✓ agricultural Total Factor Productivity (**TFP**) indices computed by the US Department of Agriculture (USDA);
  - ✓ Government Budget Appropriations or Outlays for R&D (**GBAORD**) in agriculture from OECD, as a proxy of public agricultural research expenditure (unavailable for European countries).

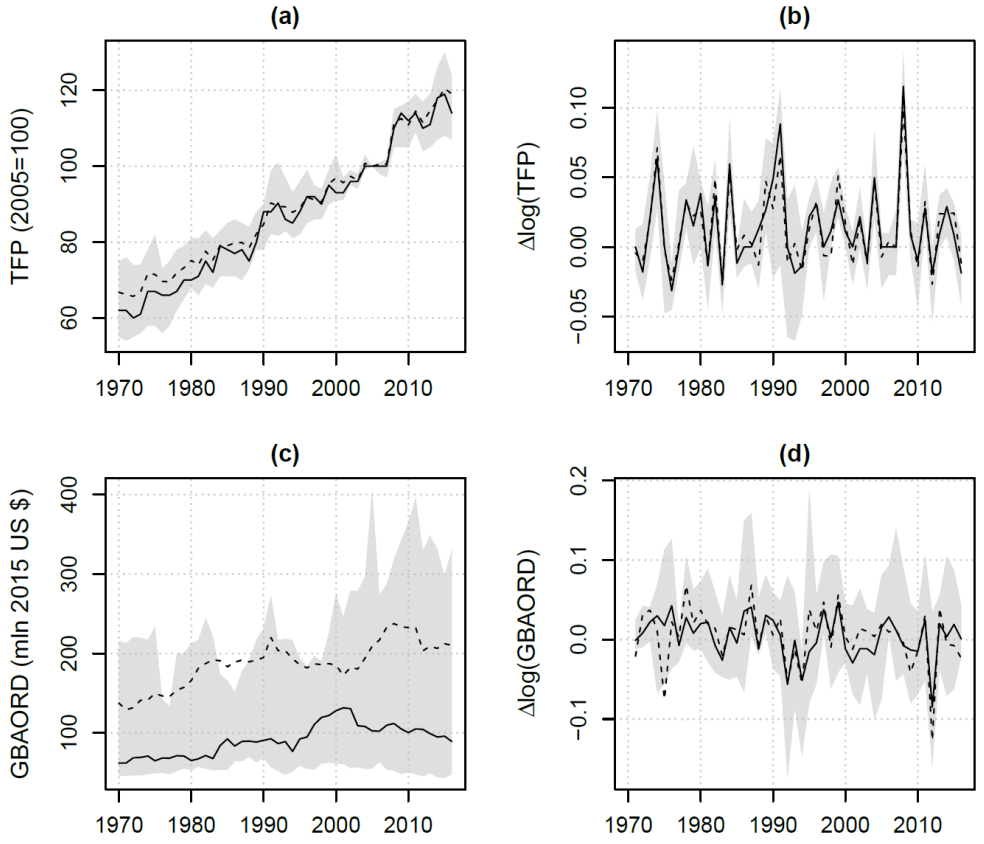


Figure 1: Time series by year. a) TFP, index 2005=100; b) TFP, log return; c) GBAORD, million 2015 US dollars; d) GBAORD, log return. Straight lines, dotted lines and shaded regions indicate, respectively, median, mean and interquartile range across the countries.

Statistical model

- Fixed effects Gamma distributed-lag model (j denote the country and t the year)

$$\Delta \log \mathrm{TFP}_{j,t} = \alpha_j + \theta \, \mathrm{KS}_{j,t} + \varepsilon_{j,t}$$

$$\mathrm{KS}_{jt} = \sum_{k=0}^{\infty} w_k(\delta, \lambda) \cdot \Delta \log \mathrm{GBAORD}_{j,t-k}$$

where $w_k(\delta, \lambda)$ are weights of a Gamma lag distribution:

$$w_k(\delta, \lambda) = \frac{(k+1)^{\frac{\delta}{1-\delta}} \lambda^k}{\sum_{l=0}^{\infty} (l+1)^{\frac{\delta}{1-\delta}} \lambda^l}$$

and $\varepsilon_{j,t}$ is an exogenous random error.

Log return to have weekly stationary time series

Knowledge stock: accumulation of the weighted past research expenditure.

According to the economic theory, the weights must have an inverted-U shape (adoption and disadoption of the technology.

Statistical model (continued)

$$\Delta \log \mathrm{TFP}_{j,t} = \alpha_j + \theta \mathrm{KS}_{j,t} + \varepsilon_{j,t}$$

$$\mathrm{KS}_{jt} = \sum_{k=0}^{\infty} w_k(\delta, \lambda) \cdot \Delta \log \mathrm{GBAORD}_{j,t-k}$$

$$w_k(\delta, \lambda) = \frac{(k+1)^{\frac{\delta}{1-\delta}} \lambda^k}{\sum_{l=0}^{\infty} (l+1)^{\frac{\delta}{1-\delta}} \lambda^l}$$

Weights sum to 1.

- Several dummy variables were added to take into account breaks in the TFP series due to whether disasters (in 2003) and economic recessions (in 1974, 2008, 2012).
- $\beta_k = \theta w_k$ is interpreted as the elasticity of TFP with respect to GBAORD at lag k.
- θ is interpreted as the long-term elasticity of TFP with respect to GBAORD.
- Estimation: minimize residual sum of squares for several different pairs of δ and λ.

Results

$$\hat{\delta} = 0.9,\ \hat{\lambda} = 0.6$$

$$\hat{\theta} = 0.172$$

HAC standard error 0.084
(p-value: 0.040)

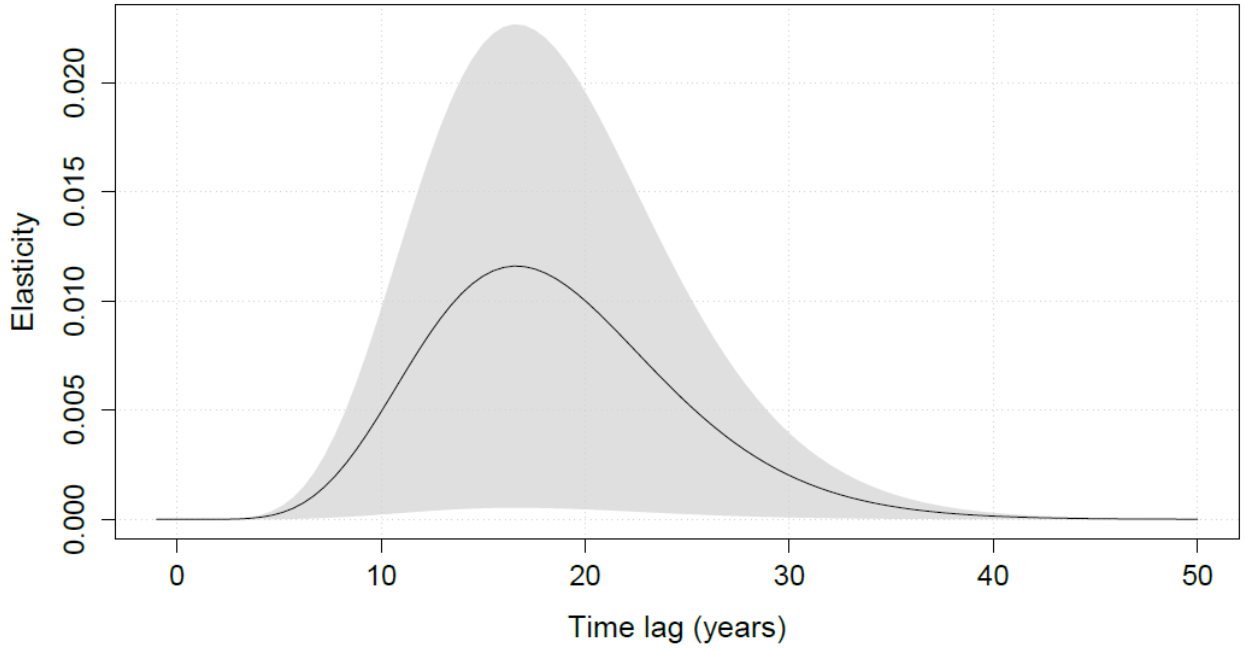


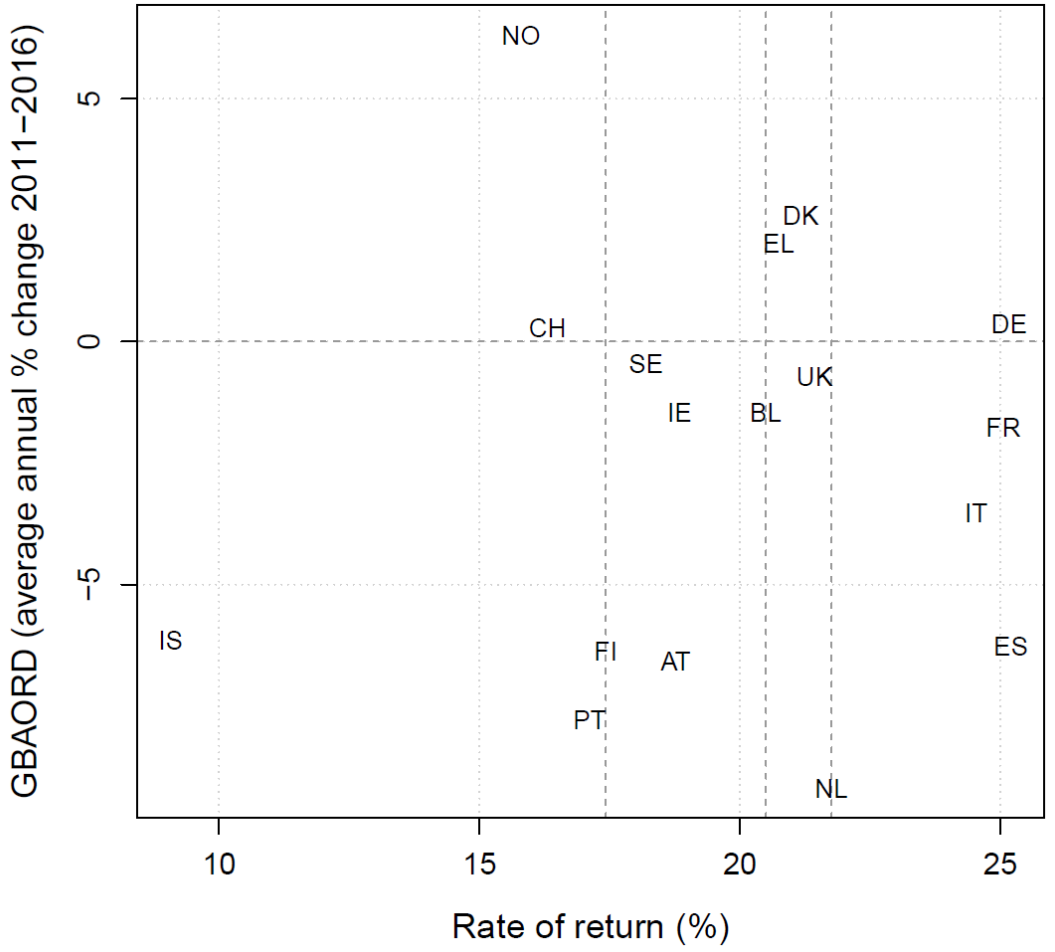
Figure 2: Estimated lag distribution for the impact of GBAORD on TFP. The shaded region represents 95% confidence bands.

Results (continued)

- Our resulting lag distribution for the impact of GBAORD on TFP has 99th percentile at 35 years, peak at 17 years and long-term elasticity equal to 0.172.
- It is a bit shorter than the ones reported by recent studies on USA, i.e., 99th percentile at 51 years, peak at 24 years and long-term elasticity equal to 0.15.
- Since the latest studies on USA consider a period starting from the 1950s and ending no later than 2011, while our period of analysis is from 1970 to 2016, this difference may be explained by a reduction of the lag due to technology adoption in the last one or two decades.
- Based on our model and on the real value of agricultural production (FAO data), we also computed the rates of return by country and compared them with the average annual change of GBAORD.

Results (continued)

- The countries with the highest rate of return resulted Germany, Spain, France and Italy (24.5–25.2%), followed by Netherlands, United Kingdom, Denmark, Greece, Belgium and Luxembourg (20.5–21.8%).
- However, only Germany, Denmark and Greece increased agricultural research expenditure in recent years.
- The estimated rates of return are in line with the ones reported by existing studies on USA ➡ developed European countries, just like USA, could benefit from research investments in agriculture to a much greater extent than they currently do.



Conclusions and future developments

- We have provided original evidence on the return of agricultural research expenditure in developed European countries, and we have made a comparison with existing studies focused on USA.
- The main limitation of our research relies on availability and quality of data:
  - ✓ use of budget allocations as a proxy of expenditure;
  - ✓ lower length of the time series compared to existing studies on USA.
- Research expenditure from other countries (spillovers) and from the private sector are also expected to influence TFP, but data on them are unavailable. In the future, we plan to estimate these missing data indirectly from available statistics.
- Results suggest the existence of unexplained heterogeneity in the relationship between research expenditure and TFP. In the future, we plan to identify groups of countries with homogeneous characteristics and to specify separate models.

Thank you
for your
attention!