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## Estimating the technical efficiency of damage abatement inputs: an application to pesticides in France

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## BACKGROUND

- Technical inefficiency in pesticide use: potential reduction of pesticide applications
- **Econometric estimation** of technical efficiency: mainly output – not input – efficiency considered in stochastic frontier analysis
- **Specification** of crop production technology: productive inputs (e.g. fertilizers, seeds) and **damage control inputs** (e.g. pesticides) (Lichtenberg and Zilberman, 1986)
- Primal representation of production technology: potential issues related to **endogeneity** of inputs may lead to biased results (Frisvold, 2018)

## OBJECTIVES

- Estimate an **input-specific** measure of the **technical efficiency of damage abatement inputs**, namely pesticides, using a stochastic frontier approach.
- Rely on a dual approach to overcome endogeneity issues
- Assess the role of crop diversification on pesticides efficiency.

## THEORETICAL MODEL

- **Production technology** (Lichtenberg and Zilberman, 1986)

$$y = G(z)f(x)$$

$y$ : Production,  $x$ : Productive input,  $z$ : Damage control input

$G(z) \in (0,1)$ : damage abatement

- In the presence of **inefficiency** in the damage control input:

$$y = G(\exp(-u)z)f(x)$$

$u$ : inefficiency, captures excess use of damage control input

- Farmer's **profit maximization** objective:

$$\pi(p, w, v) = \max_{y, x, z} \{py - w'x - vz\}$$

$$s. t. \quad y \leq G(z)f(x)$$

- Following Chambers and Lichtenberg (1994):

$$\pi(p, w, v) = \max_g \{R(p, w, g) - c(v, g)\}$$

$R(p, w, g)$ : restricted profit function defined for a given abatement level  $g$

**Optimal abatement** satisfies first order condition:

$$R_g(p, w, g) = c_g(v, g)$$

## ECONOMETRIC MODEL

- **Exponential specification** of the damage abatement function  $G(\cdot)$ :

$$G(\exp(-u)z) = 1 - \exp(\alpha - \lambda \exp(-u)z)$$

- Derived pesticide use level:

$$z = \lambda^{-1}[\alpha + \ln(\lambda p y(p, w, v) + v) - \ln v] \exp(u)$$

- $p y(p, w, v)$ : approximated considering a Translog restricted profit function (land is fixed input)

- Estimated econometric model:

$$z = \lambda^{-1}[\alpha + \ln(\lambda \widehat{p y} + v) - \ln v] \exp(u + \omega)$$

$w$ : stochastic noise,  $\sigma_v^2 = \exp(a + \eta E)$  and  $\sigma_u^2 = \exp(c + \beta E)$  with  $E$  an index of **crop diversification** (Shannon index of acreages)

## DATA

- Farm accountancy **panel** data
- **1,662 farms** located in the North of France
- Acreages, yields and input uses per crop for each farm between **1998 and 2014**
- Focus on **wheat** production

## MAIN RESULTS

- Maximum likelihood estimation results

	Parameters	Estimates	Std. Error
Damage control function	$\alpha$	0.034***	0.002
	$\lambda$	0.383***	0.018
Technical inefficiency	$c$	-1.729***	0.045
	$\beta$	-0.803***	0.094
Variance of error terms (log)	$a$	-7.468***	0.867
	$\eta$	5.338***	1.192

- Crop diversification: Positive effect on pesticides efficiency ( $\beta$ )
- Pesticide inefficiency for each farm of the sample estimated following Jondrow et al. (1982):
  - Pesticide use could be reduced by 7.07% on average
  - Low average abatement level 30.2%

## CONCLUSION

- The estimated potential reduction in pesticides use is very low compared to the figures found in a recent French agronomic study (Lechenet et al., 2017)
- Future work: Extension to multiple damage inputs.

