Product diversification, technical efficiency and education of maize farmers in Italy

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Farms generate a variety of outputs

- agricultural products (crops and animal product),
- non agricultural products (touristic/recreational services, wind energy, etc.), and
- (earn off-farm income).

These production processes rely on a wide variety of inputs including labor, land, machinery,as well as livestock and crop-specific materials (e.g. fuel, fertilizer, seed and feed, and other general expenses.

Efficiency and diversification

While there are many studies about the factors that support the uptake of both on- and off-farm diversification strategies, on the contrary it is not yet clear whether on- and off-farm diversification can improve the efficiency of farm. A few recent studies have started to tackle this issue (Paul and Nehring 2005; Nehring, et al. 2005; Chavas, et al. 2005; Gonzalez and Lopez, 2007).

First objective

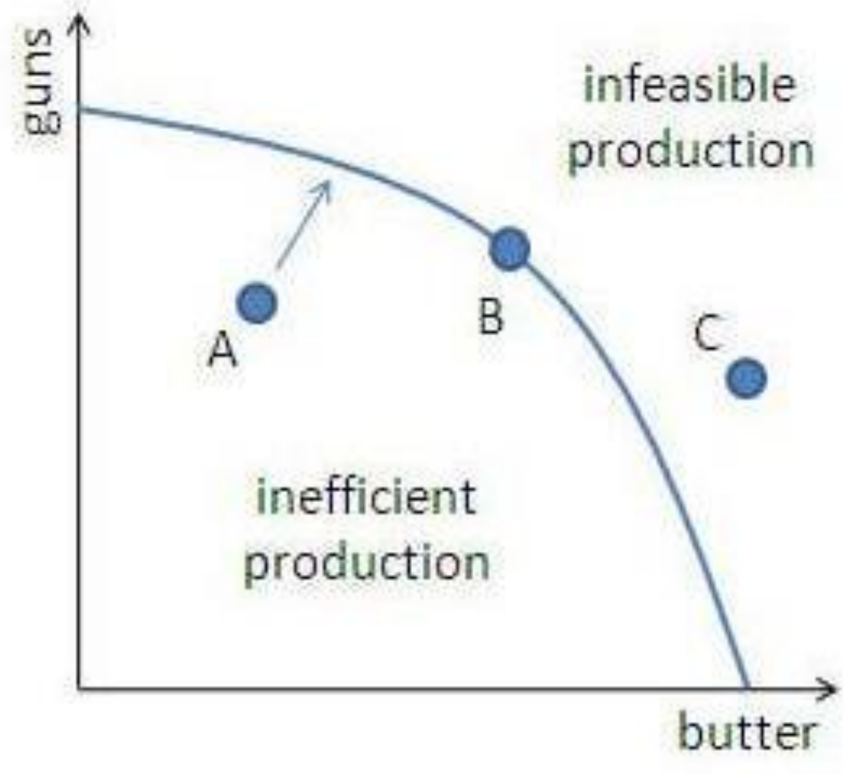
- to **measure technical efficiency**: we account explicitly for **the returns from the commitment of some farm resources within the context of the broader farm household production activities.**

- We distinguish between the following outputs:
  - agricultural output and
  - non-agricultural outputs produced on farm (agri-tourism, energy, educational services, green care etc.).

TE: multi output – multi input

Production frontier

Our measure of efficiency is derived from estimated **stochastic multiproduct, output-oriented distance function** for farm households.



Second objective

to test whether the **efficiency differential between diversified and non-diversified farms is affected from the education level of the farmer**.

In other words we question if education creates separation, in efficiency terms, between diversified and non-diversified farms.

Methodology

1.1. Characterization of the structure of production technology in the multi-output case.

1.2. Selection of the functional form

1.3 Estimation of a Stochastic Distance Function

2.1 Capturing the heterogeneity in Technical Efficiency: the Machada-Mata approach

Characterization of the structure of production technology in the multi-output case.

The multi-output/multi-input technology can be modelled either by

aggregating the multiple outputs into a single index of outputs (Caves, et al., 1982)	**It needs output prices be observable, and reflects revenue maximizing behaviour**
making use of a **dual cost function** (e.g., Schmidt and Lovell, 1979, Ferrier and Lovell, 1990) Alternatively a dual profit or revenue function could be considered.	requires that output and input prices be observable and requires the assumption of cost-minimizing behavior
estimating **an output- or input-orientated distance function** (Lovell et al, 1994, Grosskopf et al., 1996)] which can accommodate both multiple inputs and multiple outputs	observations on output and input prices **are not needed** (Coelli and Perelman,1996, 2000).

Selection of the functional form: translog distance function

$$\frac{\ln D_{o,i}}{y_{1,i}} = \alpha_0 + \sum_m \alpha_m \ln y_{m,i} + 0.5 \sum_m \sum_n \beta_{m,n} \ln y_{m,i} \ln y_{n,i} + \sum_k \alpha_k \ln x_{k,i}$$
$$+ 0.5 \sum_k \sum_l \beta_{k,l} \ln x_{k,i} \ln x_{l,i} + \sum_k \sum_m \ln y_{m,i} \ln x_{k,i} = TL_O(x, y)$$

This specification fulfils a set of desirable characteristics (Coelli and Perelman,1999): a) flexible, b) easy to derive and allowing the imposition of homogeneity.

Furthermore, the Cobb-Douglas transformation function is …is not concave in the output dimensions (Klein,1953).

In order to empirically implement the distance function we need to normalize the output distance function by one of the outputs (Lovell et al., 1994)…imposing homogeneity of degree +1.

Estimation of a Stochastic Distance Function

- **stochastic frontier model** introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977).

$$\ln q_i = \beta_0 + \beta_1 \ln x_i + v_i - u_i$$

inefficiency

deterministic component

noise

- The assumption about the **distribution of the inefficiency term** is needed to make the model estimable. Aigner et al. (1977) assumed a half-normal distribution, i.e. , while Meeusen and van den Broeck (1977) opted for an exponential one. Other commonly adopted distributions are the truncated normal (Stevenson, 1980) and the gamma distributions (Green 1980a, b; 2003).

Capturing the heterogeneity in Technical Efficiency: the Machada-Mata approach

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method to decompose the changes in the distribution a variable, efficiency score in our case, **in several factors contributing to those changes.**

Based on the estimation of marginal efficiency score distributions consistent with a conditional distribution estimated by quantile regression as well as with any hypothesized distribution for the covariates. The comparison of the marginal distributions implied by different distributions for the covariates enables to perform **counterfactual** exercises.

The changes are decomposed into

- a **characteristics (endowment) effect** which measures the impact of the difference in the average characteristics of two groups of farms on the differences in their efficiency
- a **coefficients effect** that measures the impact of the differences in the returns on these characteristics on the same.

DATA

We focus on farms producing **maize** on the basis of two major reasons:

1) **technology differs across crops**, as a consequence crop specific efficiency frontiers need to be estimated; and
2) **CAP provisions**, in particular types and amount of subsidies are different depending on the production specialization.

2011 Farm Accountancy Data Network (FADN): 1892 farms, 255 out of which are diversified.

Outputs and inputs

- The 3 **outputs** are:
  - y1, maize gross output (in Euros);
  - y2, gross output from all other agricultural products (in Euros).
  - y3, the revenues from non- agricultural farm products (in Euros).

- The 4 **inputs** included are:
  - x1 is Total Farm Area in hectares;
  - x2 is the depreciation of assets (Capital) i.e. buildings and machinery devoted to farm production;
  - x3 is total labor used in annual working units;
  - x4 is all other expenses (in Euros).

Results: Technical Efficiency

We estimated **eight alternative models**, two for each of the four distributions of inefficiency term.

- half-normal,
- exponential,
- truncated normal
- gamma distribution.

The model with **exponential distribution of inefficiency term minimizes the AIC, BIC criteria and maximizes the Log-likelihood criteria.** For this reason we will focus our comments on this latter model

	exponential distribution					
	base			*diversification*		
variables	*value*	*z -value*	*sign*		*z -value*	*sign*
ξyx	1,013	0,000	***	0,980	0,000	***
TE	**0,824**			**0,858**		
ξyx1	0,550	0,000	***	0,481	0,000	***
ξyx2	0,003	0,621		0,003	0,586	
ξyx3	0,168	0,001	***	0,169	0,001	***
ξyx4	0,292	0,001	***	0,327	0,000	***
ξyy2	-0,534	0,000	***	-0,496	0,000	***
ξyy3				-0,036	0,000	***

Results: Technical Efficiency

scale economy measure: close to 1, implying inputs increases generate proportional changes in all outputs.

individual input contributions underlying the scale economies: **land** (x1) and **other expenses** (x4) are the main drivers of farm output.
Labour: Very small elasticities
Capital: no significant effect

Substitution relationship between outputs. +1 % of non ag. products decreases total farm output by -0,036

	exponential distribution					
	base			*diversification*		
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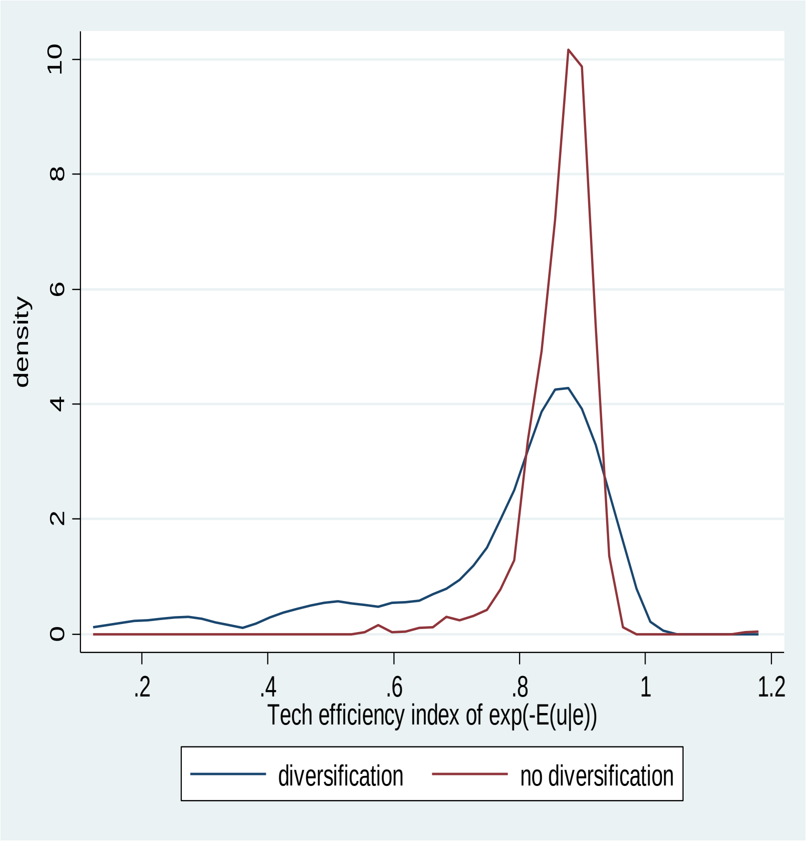
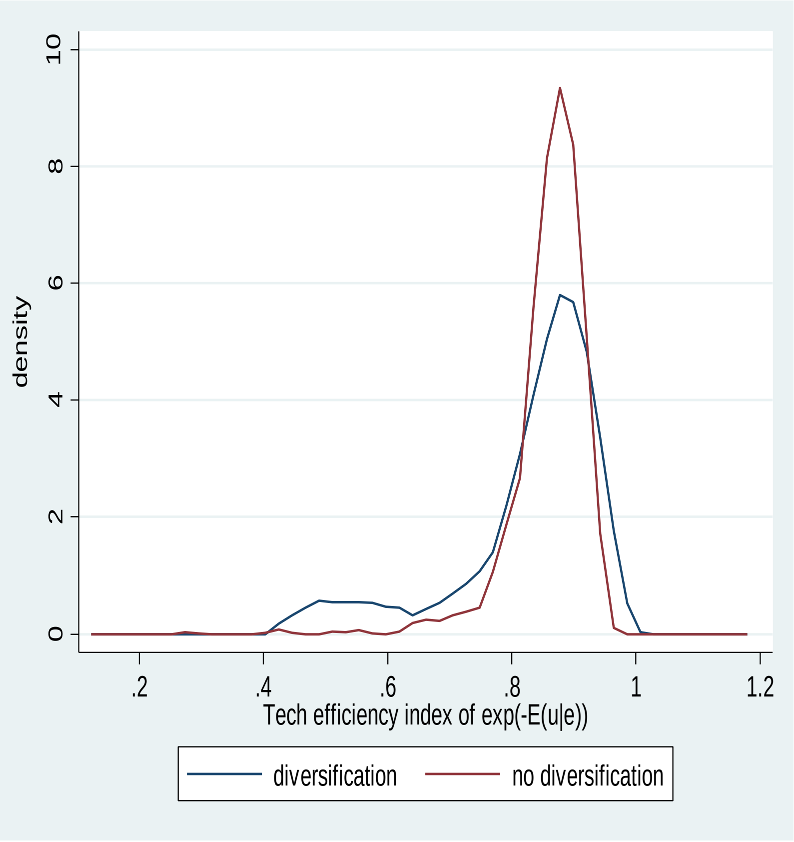
Efficiency scores distributions in diversified and non-diversified farms by level of education



(a) higher education



(b) compulsory education

- For both levels of education, the distribution of efficiency scores of **non-diversified** farms is characterized by a **higher density function around the mode and a lower dispersion**.

The Machada and Mata decomposition divides the efficiency scores differential between diversified and non-diversified farms at each percentile into **coefficient** and **covariate effects**

Control variables : age, size, location in the plains, land, squared land, owned to land ratio, hired to total labour ratio, legal status, altimetry, mechanical horsepower, contract work

NO **statistically significant characteristics effect** at both the education levels, i.e. farm and farmer specific characteristics have no impact on the performance gap.

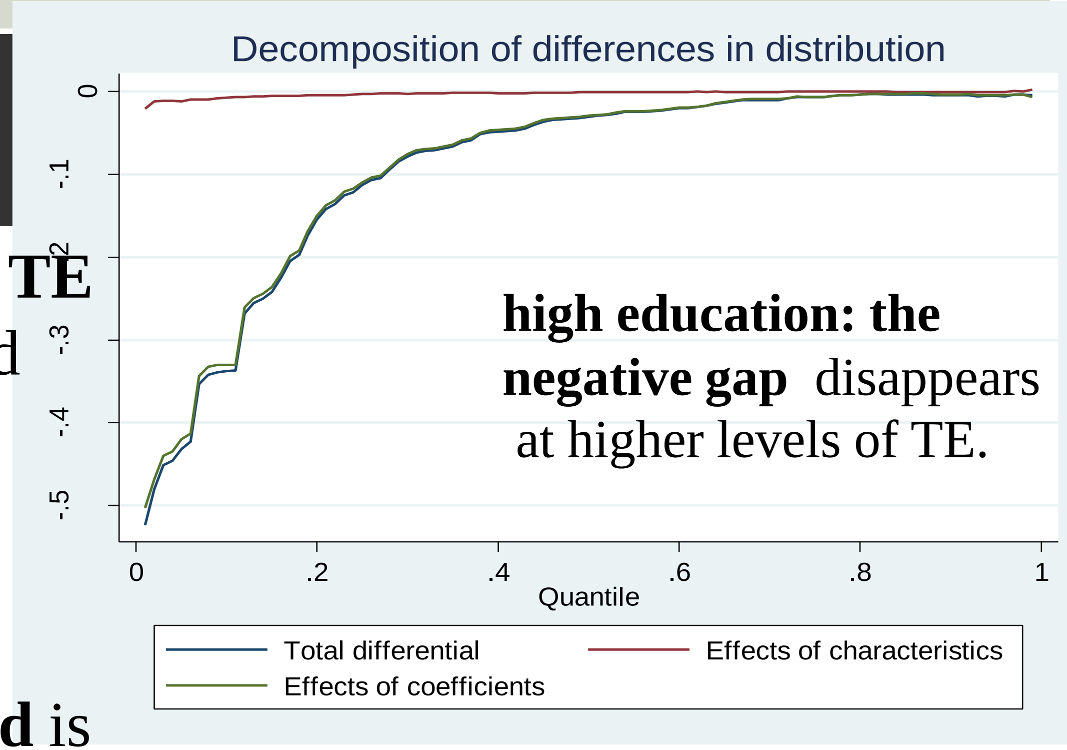
The **effects of coefficients** are **significant in both levels of eduction at all deciles**. They decrease moving toward the upper tail of the distribution.

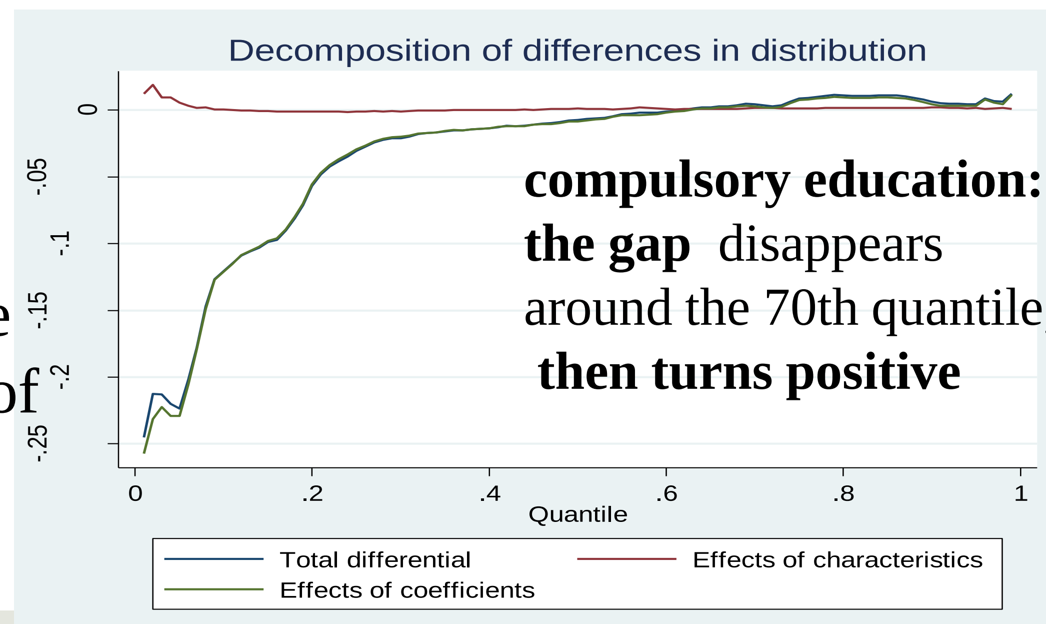
Results

education has **little impact on TE differential** between diversified and not diversified farms.

The **TE differential** between **diversified and non-diversified** is at both levels of education

- **negative** and **large at low levels of efficiency**,
- it tends to **vanish** as we move towards the higher quantiles of the efficiency scores distribution.





Conclusions

- The output distance function specification used for this analysis reveals
  - the existence of almost **constant scale economies** in both farms with and without product diversification;
  - quite **high technical efficiency**.

- **not efficient farms better focussing on farming activity rather than diversifying,** since the broadening of their activities to non-agricultural productions tends to further lowering their TE.
- **the most efficient low-educated farmers can gain a benefit in terms of efficiency by broadening their activities**.

Thank you for your attention