The impact of risk management practices on wheat productivity in France and Hungary

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Abstract: Wheat is a key staple crop for global food security, but its production is strongly concentrated in a few regions, among which the EU is the first producer. EU farmers are struggling to keep high productivity levels due to global market and climate challenges. Risk management practices (RMP) are often advocated as viable tools to cope against these uncertainties, but their adoption can also subtract resources to the production activity, resulting in a controversial impact on the overall farm productivity. This paper analysis whether and how much four RMP contribute to wheat farming efficiency in France and Hungary using i) a stochastic frontier model to obtain a measure of farms efficiency; ii) an endogenous switching regression model to quantify the RMP impact. Results show that RMP can benefit farm efficiency, but not all the RMP have the same effect. While insurance, diversification and contract farming can positively affect farm efficiency, cultivating different varieties can reduce farm efficiency of about 10% depending on the production conditions.

Keywords: risk management, wheat, productivity, stochastic frontier, endogenous switching regression

JEL codes: J43, G22, G32, Q12, Q18

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1. Introduction

Wheat is one of the most important crops for food security, providing 20% of the food calories to a growing global population. Because of its low adaptability and the need of specific environmental and climatic conditions, wheat production is highly concentrated in a few countries. The EU is the first wheat producer and exporter worldwide, with wheat yields largely above the world average. However, farms in the EU are struggling to keep high productivity levels because of a series of challenges: changes in policies, ban of key pesticides and technologies (e.g. azoles and GMOs), market signals, lack of innovation for sustainable intensification and climate change (Vigani et al., 2013).

The current literature largely studied the effects of price volatility (Rakotoarisoa, 2011), policies (Rizov et al., 2013) and of innovations (Petersen et al., 2010) on the productivity of the EU farms, and a lot of studies on the impact of climate change are going on (Challinor et al., 2014). These studies suggest the adoption of suitable on-farm risk management practices (RMP) to adapt to new environmental and climatic conditions and to cope with unexpected natural catastrophes or market risks. But, RMP can come at a cost. As pointed out by Kim et al. (2012), RMP require financial and organizational resources that can be subtracted to the production activity.

The aim of this paper is to answer the following questions: are RMP inefficient or beneficial to wheat farming productivity? And if they are beneficial (as advocated by many authors), how much they contribute to wheat farming productivity when a natural disaster or a market risk occur? Our strategy to answer these questions consists in (i) obtaining a measure of wheat farming productivity through a stochastic frontier model, (ii) estimate the technical efficiency impact of adopting RMP using an endougenous switching regression model, (iii) quantify the different in efficiency between adopters and non-adopters of RMP, by calculating a treatment effect adjusted for potential selection bias. We use data from a dedicated survey on risks and RMP for wheat in two selected EU producers: France and Hungary.

2. Conceptual Framework

The stochastic frontier is estimated by ML estimation of the following Normal-Truncated Normal SF model (Battese and Coelli, 1995). y represents the output of farm i at year t, x_{it} is a vector of production inputs, β is a vector of parameters to be estimated and ε_{it} is the error term composed by the statistical noise v_{it} and the inefficiency term u_{it}:

$$y_{it} = \alpha + \boldsymbol{x}_{\boldsymbol{it}}^{'}\boldsymbol{\beta} + \varepsilon_{it}, \quad i = 1, \dots, N, \;\; t = 2, \dots, T_i$$
$$\varepsilon_{it} = v_{it} - u_{it}$$
$$v_{it} \sim N(0, \sigma_v^2)$$
$$u_{it} \sim N^{+}(\mu_{it}, \sigma_u^2)$$

To control for exogenous effects, the mean of the pre-truncated inefficiency distribution is parametrized with a vector of exogenous variables z_{it} and the estimated parameters ψ (Huang and Liu, 1994):

$$\mu_{it} = z_{it}^{'}\psi$$

Given

$$\mathbb{E}(u_{it} | z_{it}^{'}\psi) = \widehat{\boldsymbol{u}}$$

estimates of efficiency are obtained by:

$$TE = \exp(-\widehat{\boldsymbol{u}})$$

The estimated technical efficiency can be used as a dependent variable to analyse if the adoption of RMP benefit farm productivity when production and market risks occur. We control for the potential selection biases of RMP adoption decisions by estimating a simultaneous equation model with endogenous switching regression (ESR) by full-information ML (FIML) estimator (Lokshin and Sajaia, 2004). Consider the selection equation A_i*. Farmers face two regimes, adoption (1) and non-adoption (2) of RMP:

$$A_i^* = \boldsymbol{Z_i}\boldsymbol{\alpha} + \eta_i \;\text{ with } A_i = \begin{cases} 1 & if A_i^* > 0 \\ 0 & \text{otherwise} \end{cases}$$
$$\text{Regime 1: } y_{1i} = \boldsymbol{X_{1i}}\boldsymbol{\beta_1} + \varepsilon_{1i} \quad if\ A_i = 1$$
$$\text{Regime 2: } y_{2i} = \boldsymbol{X_{2i}}\boldsymbol{\beta_2} + \varepsilon_{2i} \quad if\ A_i = 0$$

Where y_i is the technical efficiency. After the parameters are estimated, the conditional expectations can be calculated as follows:

$$E(y_{1i}|A_1 = 1) = \boldsymbol{X_{1i}\beta_1} + \sigma_{1\eta}\frac{\phi(\boldsymbol{Z_i\alpha})}{\Phi(\boldsymbol{Z_i\alpha})} = \sigma_{1\eta}\lambda_{1i}$$

$$E(y_{2i}|A_1 = 0) = \boldsymbol{X_{2i}\beta_2} + \sigma_{2\eta}\frac{\phi(\boldsymbol{Z_i\alpha})}{1-\Phi(\boldsymbol{Z_i\alpha})} = \sigma_{2\eta}\lambda_{2i}$$

$$E(y_{2i}|A_1 = 1) = \boldsymbol{X_{1i}\beta_2} + \sigma_{2\eta}\lambda_{1i}$$

$$E(y_{1i}|A_1 = 0) = \boldsymbol{X_{2i}\beta_1} + \sigma_{1\eta}\lambda_{2i}$$

Where $\sigma_{1\eta}$ and $\sigma_{2\eta}$ represent the covariance of η_i and ε_{1i} and ε_{2i}; $\phi(.)$ is the standard normal probability density function; $\Phi(.)$ is the standard normal cumulative density function. Finally, following Heckman et al. (2001), we calculate the effect on productivity of adopting RMP on adopters (TT) and on the non-adopters (TU):

$$TT = E(y_{1i}|A_1 = 1) - E(y_{2i}|A_1 = 1)$$

$$TU = E(y_{1i}|A_1 = 0) - E(y_{2i}|A_1 = 0)$$

3. Data and empirical specification

Data come from a dedicated survey of 700 wheat farmers (350 in France and 350 in Hungary) for three wheat seasons: 2010/2011, 2011/2012 and 2012/2013. The technology for wheat production is represented by a Cobb–Douglas stochastic production frontier, estimated through the following ML random-effects time-varying model:

$$ln\bar{y}_{it} = \beta_0 + \beta_1(lnLabour_{it}) + \beta_2(lnLand_{it}) + \beta_3(lnAssets_{it}) + \sum_{n=4}\beta_n(lnIntermediate\ inputs_{it}) + v_{it} - u_{it}$$

Where intermediate inputs are fertilizers, pesticides, gasoline and seeds. The inefficiency model contains exogenous variables potentially affecting the farm efficiency (standard household characteristics such as age, education and experience; a dummy on weather damages; region and year FE) and it is defined by the equation:

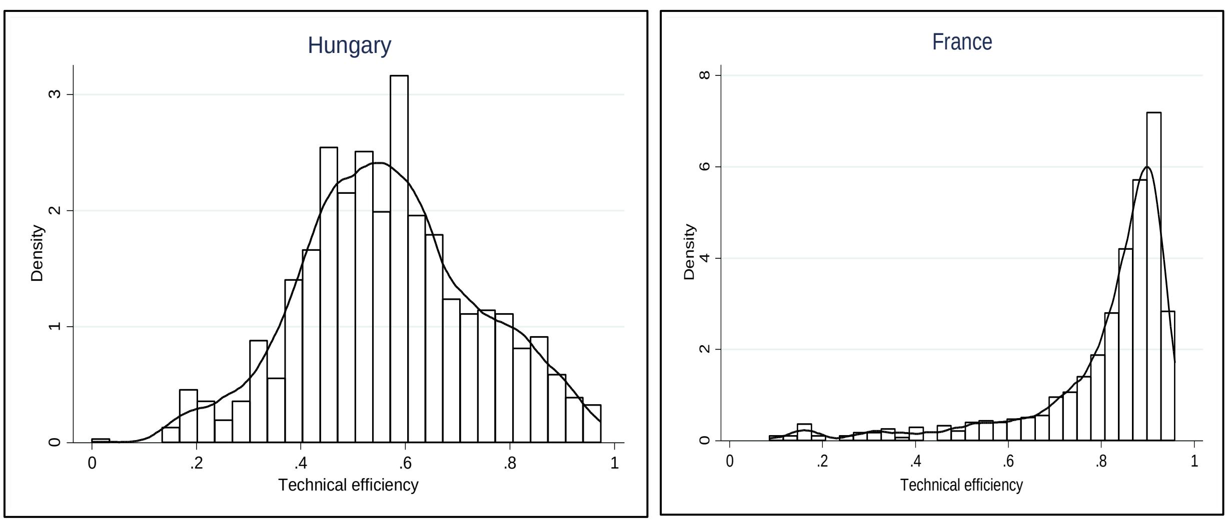
$$TE_{it} = \delta_0 + \sum_{n=4}\delta_n\, HHCaracteristics_{it} + \delta_2(dWheather\ damage_{it}) + \sum_{k=9}\delta_k\, dRegion_{it} + \sum_{l=3}\delta_l\, dYear_{it}$$

In a second moment, we run the ESR for each of the RMP analysed. Two RMP are used for coping against production risks: production insurance and variety diversification; two against market risks: contract farming and production diversification. These are also the dependent binary variables for the selection equations. The explanatory variables of the efficiency model are common for each RMP as they explain the farm productivity level. Four groups of explanatory variables: farm characteristics, other RMP adopted and risks occurred. The explanatory variables of the selection model include the previous variables plus the selection instruments that specifically explains the adoption of a given RMP.

4. Results

Figure 1 shows the distributions of the TE calculated through SF. Wheat productivity in France (mean=0.8) is on average more efficient than in Hungary (mean=0.57).

Fig.1 – Distribution of technical efficiency from the SF estimation.



Tab. 1 shows the result of the ESR. For each RMP, columns show the results on TE for non-adopters (A=0), adopters (A=1) and of the selection equation. Notably, in all the selequion equations the occurrence of natural or market risks explain the adoption of RMP. Moreover, all the instruments for the selection equations are significant, with the only exception of insurance.

Tab.1 – Result of the endogenous switching regression model

	Insurance			Activities diversification			Contract farming			Variety diversification		
	A=0	A=1	Sel. eq.	A=0	A=1	Sel. eq.	A=0	A=1	Sel. eq.	A=0	A=1	Sel. eq.
Dependent Variable	TE	TE	Adoption 1/0	TE	TE	Adoption 1/0	TE	TE	Adoption 1/0	TE	TE	Adoption 1/0
Farm characteristics:												
CAP	0.002	0.0330***	-0.131***	0.0214*	-0.0155*	0.136***	0.012	0.0672***	0.022	0.001	0.009	-0.144**
TUA	0.004	-0.0777***	0.322***	-0.006	-0.0672***	0.100**	-0.005	-0.001	-0.0850*	0.0374***	-0.0450***	0.531***
Property	0.019	-0.029	-0.137	-0.013	-0.012	-0.081	0.030	0.028	-0.309**	-0.022	0.010	-0.555***
Reinvestements	-0.114***	-0.045	0.034	-0.028	0.0927***	-0.435**	-0.0561**	0.130***	-0.492***	0.033	-0.0601**	-1.137***
Liquidity	-0.0363**	0.023	0.075	0.009	-0.008	0.176**	0.011	0.016	-0.096	0.0318*	-0.0352***	0.124
Prive volatility	-0.043	-0.098	0.006	0.135	0.088	-1.108***	0.015	0.128	-1.481***	-0.173	0.035	0.843*
Arable farm	-0.021	-0.0682***	0.245***	0.214***	0.133***	-1.515***	-0.007	0.011	-0.033	-0.0926***	0.0415**	0.160
Family farm	-0.0526*	0.0411*	-0.227***	0.023	-0.011	-0.322***	0.019	0.0445*	-0.301***	0.032	-0.023	-0.309**
Compensations	-0.016	-0.0832**	0.409***	-0.036	-0.008	-0.074	-0.012	-0.028	-0.038	-0.020	0.016	0.384
Off-farm labor	-0.0823***	-0.0527*	0.105	-0.036	0.0475*	-0.363***	-0.0846***	-0.153***	0.572***	-0.0853***	0.0951***	-0.621***
RMP:												
Insurance				0.0461**	0.016	-0.028	0.019	-0.008	0.177**	0.020	0.0267**	-0.327***
Production diversification	0.009	-0.010	-0.045				-0.006	0.001	-0.196**	-0.0598***	-0.011	-0.312***
Production contracts	0.001	-0.023	0.055	0.0386*	0.0383**	-0.308***				0.020	0.009	0.009
Variety diversification	0.034	0.0865***	-0.271***	0.020	0.127***	-0.372***	0.0358**	0.000	0.066			
Risks:												
Natural risks	-0.004	-0.023	0.066	-0.027	-0.0310**	0.259***	0.013	0.002	-0.111	0.0567***	-0.0559***	0.600***
Market risks	-0.006	-0.025	0.193**	0.0356*	-0.0310*	-0.151	-0.0296**	-0.0659***	0.265***	-0.035	-0.017	-0.291**
Selection variables:												
Cooperative			0.031			0.232***			0.263***			0.273**
Union			0.049			0.309***			0.169***			0.320**
IPM						0.164**						
Conservation tillage						0.142*						
% wheat sold									1.073***			
Sold in different moments									0.227***			
Certified seeds												-0.520***
Hired labour												-0.00856***
Nitrogen												0.966**
Manure												0.253**
*Dummy Country*Year*		YES			YES			YES			YES	
Constant	0.738***	1.062***	-0.487	0.101	0.986***	0.839**	0.552***	0.522***	-0.989**	0.588***	0.961***	-0.855
lns	-1.735***	-1.363***		-1.528***	-1.551***		-1.692***	-1.354***		-1.723***	-1.714***	
r	0.004	-2.892***		-1.417***	-1.767***		-0.490***	-2.421***		0.741***	-0.943***	
N. obs.		1369			1208			1334			1190	

Note: *, ** and *** represents significant *p*-values at 10%, 5% and 1% respectively.

The probability of adopting insurance is higher in large arable farms. TE increases for insurance adopters with higher CAP subsidies per ha. Diversification of activities is more likely to be adopted by larger farms with higher availability of liquidity, and adopters' productivity increase with higher share of income reinvested in the agricultural activity. On the contrary, the probability of adopting contract farming is lower for family farms with low percentage of owned land and reinvestments. About adopting different wheat varieties, the probability increase with high price volatility (calculated as the coefficient of variance of the 3 years wheat prices).

In Tab.2 we calculate the productivity effects of adopters in the case they did not adopt (TT) and of non-adopters if they had adopted (TU). For insurance, activity diversification and contract farming, if non-adopters would have adopted these RMP against natural and market risks, their level of TE would have been much higher. This effect is particularly strong in the case of activity diversification that could have increased the TE of non-adopter of 175%.

It is important to note that if adopters of these three RMP would not have adopt the lost in TE would have been rather small. This suggests that, controlling for selection biases, the adopters would still have higher TE also in the case they would not adopt.

Tab. 2 – Calculation of the treatment effect through conditional expectations

Sub-samples of farmers	**Decision stage**		**Tretament**	**Increase in TE**
	To adopt	Not to adopt		
INSURANCE				
Insured	0.680	0.662	TT = 0.018***	2.7%
Not insured	1.119	0.666	TU = 0.451***	68.2%
ACTIVITIES DIVERSIFICATION				
Diversifying	0.670	0.641	TT = 0.029***	4.5%
Not diversifying	0.986	0.358	TU = 0.627***	175.0%
CONTRACT FARMING				
With contracts	0.732	0.651	TT = 0.081***	12.4%
Without contracts	1.104	0.574	TU = 0.530***	92.3%
VARIETY DIVERSIFICATION				
Diversifying	0.722	0.597	TT = 0.124***	20.8%
Not diversifying	0.823	0.903	TU = -0.079***	-8.8%

The effect of varieties diversification is different. With natural and market risks, adopters gain 20% of TE, but if non-adopters would have cultivated more than one wheat variety they could have lost 8.8% of efficiency. This suggests that both adopters and non-adopters are better off with their current behaviour, and further adaptation would result in TE loss.

5. Conclusions

The productivity of the wheat sector in the EU is facing several global challenges and risks and many authors advocate RMP as suitable strategies to cope against risks. The adoption of RMP can have uncertain effects on farm productivity due to the subtraction of resources to the farming activity. In order to verify if RMP can help increasing the wheat farming productivity when natural and market risks occur, we estimated the RMP impact on TE using original data from a dedicated survey on RMP and wheat risks in France and Hungary. Our results show that RMP can largely benefit farm efficiency, but not all the RMP have the same effect. While insurance, activity diversification and contract farming can double farm TE, cultivating different wheat varieties to cope against production risks can reduce farm efficiency of about 10% depending on the production conditions.

Further analyses are still in progress, more specifically the authors are estimating the impact of RMP not only on the TE of wheat farms, but also on their total factor productivity (TFP) estimated through the Levinson and Petrin (2003) estimator. These updated results will be presented.

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