

MANAGEMENT OF CLIMATIC RISKS AND ITS EFFECTS ON AGRICULTURAL PRODUCTIVITY: EVALUATING THE IMPACTS OF GOVERNMENT POLICY

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Abstract

Risk management has virtually become increasingly important in all the aspects of the economy, including agriculture. Every country that considers agriculture a strategically significant economic sector strives for effective public climatic risk management in agriculture.

We distinguish two major types of risk in agriculture. First, business risk includes production, market, institutional and personal risks. Second, financial risks result from different methods of financing the farm business.

The nature of climate risk is supposed increasing uncertainty which impacts agriculture productivity. This has contributed to the development and acceptance of forms of public intervention aiming to reduce income variability. In particular, subsidized crop insurance is a widely used tool.

The significance of this issue has grown in parallel with the growth in the importance of the collective role of agriculture sector that has addressed the recent guidelines in many developed countries. To examine the effects of public risk management programs on agricultural productivity in case of climatic risks, this study carries out an empirical analysis by developing an econometric application in American and European countries over the period 2000-2015.

Key words: *Risk management; crop insurance; agriculture.*

JEL Classifications code: *G32; G22; Q1*

1. Introduction

Risk management in agriculture and the role of insurance have long been the center of attention for researchers and policymakers. A review of the literature on this subject consistently shows the failure of private markets for comprehensive (multiperil) agricultural insurance and their unsustainability in the absence of any public intervention.¹ Even with a strong public support, insurance demand is not often higher than expected. Reasons for such failure are usually found in either supply or demand conditions. On the supply side, the most explored issues are asymmetric and incomplete information (Chambers, 1989; Miranda, 1991; Skees et al., 1997; Just et al., 1999; Mahul, 1999; Bourgeon and Chambers, 2003), with resulting problems of adverse selection, moral hazard and systemic risk, which may pose the most serious obstacle to the emergence of an independent private comprehensive crop insurance industry.

In general, the farmer knows better than any other agents (including insurance companies) the degree of risk exposure associated with his own production decisions (hidden information that may generate adverse selections). Farmers also have less incentive to avoid risk once they are insured (hidden actions that generate moral hazard). Those situations can generate market

failure in the related risk markets. Asymmetries of information affect different types of risk in different ways. For instance price related risk does not usually generate information asymmetries since market prices are known by all agents at the same time. On the contrary yield/production related risk may have associated information asymmetries because the farmer has better knowledge about his own production risks than any other agent. The existence of —cognitive failure can also contribute to generate information asymmetries. In these contexts, there is a potential role for government to help to establish, regulate and supervise risk markets, and to provide risk instruments when markets are constrained or fail. But it is also possible that —asymmetric information applies also to the relation between the citizen and the government leading to government failure and political risk (Holzmand & Jorgensen, 2001).

Especially, due to the systemic character of yield risks, reinsurance becomes very expensive. Without government subsidies or public reinsurance, insurers pass this high cost to the farmers' premiums (Doherty & Dionne, 1993; Miranda & Glauber, 1997; Mahul, 2001).

On the demand side, the inability of farmers to precisely assess the benefits derived from agricultural insurance is often cited as one possible reason for limited demand. Another explanation for the limited interest in Multi-Peril Crop Insurance (MPCI) is simply that the organizational structure of farming is such that farmers can use other private instruments – like product diversification, credit, and financial markets and so on – to manage risk. Therefore, the potential demand for crop insurance is lower than what is commonly believed to be (Wright & Hewitt, 1994).

Every country that considers agriculture a strategically important economic sector strives for effective risk management in agriculture. In our study, we demonstrate that the public risk management may improve the agricultural productivity in the presence of natural disasters.

Our contribution consists in evaluating the consequences of the protective measures of the subsidized agricultural programs of insurance on agricultural productivity. We will find in this study that the agricultural risk management policy by subsidizing the premiums of agricultural insurance or by *expost* compensation to face natural disasters will probably impact agricultural productivity.

After presenting in the first section how agricultural risk management policy is introduced as an institutional factor in the economic literature of the field, we focus in the second section on the theoretical analysis explaining the relation between the agricultural risk management policy and the agricultural productivity. In the third section, we develop an empirical model in which the agricultural risk management policy is a determinant factor of agricultural productivity. Our model is structured to examine the effects of the application of two agricultural insurance programs on agricultural productivity. The policy variables include subsidy rates on the premiums paid directly by farmers and the compensation rates set for insurance agents in the catastrophic risk' case. Finally, in the last section, we conclude the study and advocate some policy recommendations.

2. Literature Review

Agricultural production is a risky activity Factors beyond the manager's control most often affect final outcomes. In particular, agriculture is largely affected by weather fluctuations and climate change (Knox & Wade, 2012). As a result, there has been increasing attention in planning public interventions aimed for reducing income variability.

Climate change ²affects the mean and variability of weather conditions and the frequency of extreme events, which, to a great extent, determines the variability of production and yields. The risk management response to these changes is part of farmers' adaptation strategies. Climate change affects the distribution of yields under a given set of management practices, which in turn affects the probability distribution for farmers' expected income. Farmers can adopt several adaptation strategies in response to these changes. Adaptation through cropping

pattern change can in some cases ease the exposure of plants to critical higher temperatures (Peltonen-Sainio et al., 2011).

Risk management instruments, such as crop insurance and disaster assistance programs, and especially how they are designed, will affect the incentives to adapt (Collier et al., 2009). For example, traditional agricultural insurance (which makes an indemnity payment when the farm incurs a verifiable production loss) can help to manage production risk, but it is known to be expensive. When a loss caused by a natural disaster is large, governments will try to limit further losses and help compensate farmers. One area where such an intervention is important is in providing assistance to prepare for and recover from natural disasters.

There are many reasons why governments and donors subsidize agricultural insurance. Some are based on narrow economic arguments like market failure, externalities and establishment problems which constrain the development of private sector insurance and insurance markets, or which systematically exclude certain segments of farmers from insurance, such as poor or women farmers, or farmers in high risk regions. Many governments also subsidize agricultural insurance as a way of achieving other social and political goals in addition to risk management, where insurance subsidies are seen as a more politically acceptable or cost-efficient way of achieving those goals than other available policies. Despite their varying purposes, insurance subsidies all seek to reduce the risk exposure for farmers, whether against catastrophic natural disasters or more normal agricultural production risks. Most often, subsidies also help scale up the demand for agricultural insurance.

Historically, there have been many arguments put forward in the literature that have supported the government's involvement in agricultural insurance markets. These can be separated into two categories: those dealing with market failure (e.g. moral hazards, adverse selection, and spatially correlated risks), and those dealing with political economy (e.g., subsidization and ad-hoc disaster assistance) (Barnett, 2014).

Moral hazards occur when the insured engages in actions, after the purchase of an insurance contract, which increases the probability or severity of a loss. With multiple-peril crop insurance producers can engage in moral hazardous activities such as reducing costly inputs (see for example Quiggin, Karagiannis, & Stanton (1993); Smith & Goodwin (1996); Babcock & Hennessy (1996); Goodwin (2001); Goodwin & Smith (2003); Goodwin, Vandever, & Deal (2004)).

Adverse selection occurs when the insured know more about their expected losses than the insurers. As a result, there is a greater participation from producers facing underpriced contracts where indemnities exceed premiums compared with overpriced contracts. Many researchers have considered the problem of adverse selection in American multi-peril crop insurance (see for example Goodwin (2001); Knight & Coble (1999); Babcock, Hart, & Hayes (2004)). As with moral hazards, insurers can protect against adverse selection by using more disaggregated risk measures. Nevertheless, obtaining insurance contracts can be quite costly. It is worth noting that with recent improvements in precision agriculture and data collection, these costs are decreasing and may not be a significant barrier for private firms.

We now turn to the political economy reasons for the lack of private insurance involvement, specifically crowding out. Assuming there is no publicly subsidized crop insurance, thus little producer participation, the argument is as follows: A sufficient number of uninsured producers suffer a loss (to say a drought), political pressure is brought to bear by the agricultural constituency, and *ad-hoc* disaster aid is given out by government (Coble & Barnett, 2013; Barnett, 2014).

Several economic arguments have been made in the literature in favor of subsidizing agricultural insurance programs to correct market failures and externalities (Hill et al., 2014; Clarke, 2011). Siamwalla and Valdes (1986) argued that a subsidy might be warranted in some

circumstances when region-wide agricultural losses had an impact on the nonfarm population by reducing farmers' demand for the services and outputs of small businesses in the rural nonfarm economy. In this case, the insurance subsidy might help by buffering reductions in farmers' spending, though it ought first to be established that insuring farmers was more effective than offering insurance products to the community at large.

Agricultural insurance faces challenges of its own when it comes to the design, delivery and administration of insurance contracts that farmers are willing to buy, and as reviewed elsewhere, important problems remain despite the considerable progress over recent decades (Hess and Kuhn, 2016).

In reviewing the available literature and evidence on insurance subsidies, we are struck by how little is really known about the effectiveness of insurance subsidies in achieving their intended purposes, or whether the impacts they generate justify their costs. In many cases, it is hard to obtain even basic performance data about subsidized insurance programs and pilot projects, let alone evidence about how they affect the behavior of financial institutions and private insurers, or how they have an impact on the farmers themselves. This leads us to one general recommendation: There is a fundamental need for more evaluations and impact assessments of subsidized agricultural insurance programs. This should involve: a) a more widespread use of *ex ante* impact assessments at the design stage of subsidized insurance programs, b) the collection, release and analysis of basic data about the operations and performance of subsidized insurance programs, and c) the implementation of more formal monitoring and evaluation (M&E) system that can provide credible data for assessing the impacts of insurance subsidies.

3. Theoretical Analysis

Public intervention in agricultural insurance markets is not different from intervention in other markets. Such intervention may be intended to address the real or perceived failure of the market. In such cases, the general economic welfare may be improved as a result of the intervention. Therefore, a certain degree of protection and special treatment of agriculture is common in both developed and developing countries.

However, regarding politics of agricultural regulation, it seems very hard to define one market model through which insurance in agriculture can be accomplished. Hence, we can define three basic market models which are:

1. Systems fully controlled by the government: They are characterized by a very intensive government support with the existence of one unified monopolistic insurance product usually commercialized through a state-owned insurance company. Those systems are characterized, expectedly, with a large market penetration due to the obligation and good portfolio diversification, but they mean high fiscal expenses because such systems do not charge the esperance of loss, and are thus chronically in deficit and frequent give bad services caused by monopolistic positions. In this model, the role of the state is the key, i.e. that of the insured where the state has full control.
2. Public – private partnerships: They have a high penetration and good diversified portfolio. Technical criteria dominate over commercial ones. There is competition in the provision of services, and the state reinforces system stability. Also, the private sector provides the knowledge and technology, all with reasonable fiscal benefits.
3. Complete market systems: They have low to moderate penetration and a low level of risk diversification. Commercial criteria dominate over technical ones, with the realization of competitive prices and without fiscal expenses. Practically, this model depends on the interests by insurers for dealing with this kind of insurance. This interest also depends on the definition of the agricultural policy in one country.

Since many governments throughout the world have paid or are still paying high subsidies to sustain agricultural insurance, it is therefore legitimate to study the effects of a hypothetical policy intended to sustain agricultural insurances through a subsidy on premiums or *expost* compensation on agricultural productivity.

We present a simple model of full risk yield insurance to know the effects of subsidies in agricultural premiums paid by the government on agricultural production.

3.1 Simple Model of full Risk Yield Insurance³

We assume a set of N farms specialized in the production of one product and we indicate with $y_{i,t}$ the unit (per hectare) detrended actual crop yield of the i^{th} farm in period t .

We assume that the farmer has the option of buying financial insurance under the following contracts: (i) The farmer chooses the fraction of insurance coverage (a); $a \in [0, 1]$. (ii) They will receive (pay) (a) which is multiplied by $(\epsilon s - s)$ from (to) the insurance company as an actuarially fair indemnification benefit (insurance premium) if their realized income is below (above) the mean income. In order to abstract from any problems related to informational asymmetry, we assume that the statistical distributions are observable to both the insured and the insurance company. (iii) In addition to (a), the farmer pays the transaction costs of insurance.

The costs of insurance over and above the actuarially fair insurance premium, which are a measure of the real costs of insurance to the farmer, are assumed to follow the cost function $\Delta a \geq 0$ describes how actuarially unfair is the insurance contract.

The total costs increase linearly with the insured part of the income variance. This simply shows that the costs per unit of insurance rise with the extent of insurance. The farm yield varies for reasons beyond the farmer's control, so that there may exist a potential demand for insurance.

A simple insurance contract can be defined by the pair (π, Φ) where π is the premium and Φ is the guaranteed yield. Each farmer has a Willingness To Pay (WTP) for insurance, denoted by $WTP_i(\Phi)$, which depends on their risk preferences, on the distribution of his income and on the insurance characteristics (guaranteed yield)⁴.

The total demand for this type of insurance will be equal to the sum of the individual demands by farmers whose WTP is equal to or exceeds π . Given the distribution of farms in terms of individual yield productivity and the level of guaranteed yield, we can derive the market demand function by summing up, for each premium value the total area of farms whose WTP is higher or equal to the required premium as follows:

$$D_i(\pi, \Phi) = \sum_{i=1}^N \gamma_i h_i \tag{1}$$

Where

$$\left. \begin{aligned} & h_i \text{ is the area of the } i^{th} \text{ farm and } \gamma_i \text{ is an index:} \\ & \gamma_i = 1 \text{ if } WTP_i(\Phi) \geq \pi \\ & \quad 0 \text{ otherwise} \end{aligned} \right\}$$

For any conceivable yield distribution, the demand will be such that $\partial D(\pi, \Phi) / \partial \pi < 0$ and $\partial D(\pi, \Phi) / \partial \Phi > 0$

for a given sample of firms, an insurance contract will determine revenues (given by the premiums paid by farmers) and costs (indemnity payments) for the insurance industry. The expected net profits of the insurance industry will be:

$$P(\pi, \Phi) = \sum_{i=1}^N \{ \gamma_i E(h_{it} [\pi - \max\{\Phi - y_{it}, 0\}]) - \gamma_i h_i C \} \quad (2)$$

We call C the total (fixed and unitary) administrative costs of the insurance company, expressed as unitary costs per insured hectare. We will consider C a fixed amount for practical reasons. We predict that, the profit function when plotted against π will assume an inverted U-shape. Initial values of profits are certainly negative, corresponding to zero values for the revenues. For $\pi = 0$, all farmers will sign the contract, with no revenues for the insurance company and the highest possible amount of indemnities to be paid. As the value of the premium increases, some farms will refrain from signing the contract. As a consequence, the value of indemnities to be paid will fall. Whereas, the value of revenues for the insurance industry will grow because of the payments by those remain in the contract. At higher premium levels, the firms that remain in the market will be those with higher risk. Hence, the total amount of indemnities to pay will decrease more slowly than the amount of collected premiums.

3.2 Subsidy Introduction

The above-mentioned simple model can be used to simulate the effects of the introduction of a subsidy paid by the government, so that the effective premium paid by farmers will be $\bar{\pi} = (1 - s)\pi$.

Where s is the subsidy level expressed as a percentage of the market premium. Accordingly, the demand from Equation 1 is modified so that the index γ_i becomes:

$$\begin{cases} \gamma_i = 1 & \text{if } WTP_i(\Phi) \geq \pi = (1 - s)\pi \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

How this will change the profit function for the insurance industry is not clear: Higher participation will raise both revenues and costs; the premiums received by the insurer are the revenues, while costs are identified with the amount of paid indemnities and the administrative cost. The ultimate change in the profit function of insurance industry will depend on the distribution of yields across farms and on the utility distribution function.

4. Econometric Issues

Throughout the paper, we consider two different types of government policies: the premium subsidy rate (*saa*) and the *expost* compensation rate (*ico*). In general, the government chooses these policy parameters to balance two varied policy objectives: The adequate participation in the crop insurance program and the minimization of the taxpayer/net social costs of the program (Goodwin and Smith, 1995; Gardner and Kramer, 1986).

The following hypotheses consider marginal changes in *saa*, and *ico* on the premium rate farmers pay for insurance (p).

Hypothesis 1: A growth of the subsidy rate *saa*, decreases the premium rate that farmers pay for insurance ($\frac{dp}{dsaa} < 0$).

Hypothesis 2: A rise in the compensation *expost* rate (an increase in *ico*) reduces also the premium rate that farmers pay for insurance ($\frac{dp}{dico} < 0$).

Note that those hypotheses just consider changes in the premium rate paid by farmers. Any changes in *saa* or *ico* have other effects on the equilibrium of the model.

In practice, the government subsidizes insurance contracts in two ways: by reducing premiums paid by farmers through a premium subsidy rate, and by paying *expost* compensation besides a direct subsidy to insurant to cover catastrophic risks. The premium rate subsidy is the proportion of the total premium paid by the government, and the *expost* compensation rate is defined as the ratio between the compensation for the agricultural disasters and the value of agricultural production.⁵

We try to evaluate the effect of the application of two types of agricultural programs of risk management in case of natural risks on the agricultural productivity, which is an issue that previous studies in this research area have not empirically treated. To meet such an objective, we use a statistical model of the function of agricultural productivity, which contains information on the relative importance of the climatic variables to answer the effects of the systems of agricultural management further to extreme climate-related events.

Our model is structured to examine the implications of the application of two different instruments of the management of natural risks on agricultural productivity: direct subsidies of agricultural insurance premiums and *expost* compensation in case of catastrophic risks.

The model is used to evaluate the effects of the application of some policy variables and crop prices on agricultural productivity. The policy variables include subsidy rates on the premiums paid directly by farmers as well as *expost* compensation paid by government to farmers in case of natural disasters. We also examine the effects of subsidizing agricultural prices on agricultural productivity.

Our study covers 24 countries selected on the basis of data availability. They include: (a) the European countries, consisting of 7 countries, namely : Austria, Russia, France, Greece, Portugal, Italy and Spain; (b) the American countries, consisting of 15 countries, namely: Brazil, Canada, Mexico, Panama, Chile, Dominique Republic, Argentina, Costa Rica, Paraguay, Australia, the USA, Colombia, Peru, Uruguay and Venezuela; and (c) the Asian countries, consisting of 2 countries, namely: India and China.

4.1 Model Specification

In our model of agricultural productivity, the government provides direct subsidies to insurance companies and may establish the maximum compensation rate that insurance companies can use to pay insured farmers in case of a natural disaster.

Weather conditions are a determining factor affecting the growth of agricultural production. The incentives connected to the prices and the aids per hectare are a key factor of agricultural production. The explanatory variables are climatic variables and variables of management of agricultural risks.

In what follows, we estimate the impacts of the direct subsidies of agricultural premium insurance and the *expost* compensation in case of natural disasters on agricultural productivity.

The specific model of the regression is the following:

$$AGTFP_{it} = a_0 + a_1 \ln vA_{it} + a_2 YiC_{it} + a_3 lClim + a_4 Saa_{it} + a_5 Ico + a_6 Sprice + a_7 death_{it} + u_{it} \quad (4)$$

The total factor agricultural productivity growth⁶ (AGTFP) is the growth of the production which is due to the factor growth, adjusted by the quality of soil, labour, power of machines, capital and synthetic fertilizers, which is determined by using the basic year (1961=100) and the data of the FAO of 1961-2015, completed in some cases of the national statistics. Ico is an indicator of *expost compensation*⁷. Saa is subsidies of agricultural insurance. IClim is an indicator of climatic risks (droughts, floods, extreme temperatures, hails) (in ù of population)⁸. A death is the number of deaths from natural disaster events. Sprice is an indicator of the subsidies of production prices. YiC is an indicator of cereal yields per capita. InvA is an indicator of agricultural investments rate.

The following data are sourced from the databases of the ministries of agriculture of 24 countries and from the International Observatory of the Agricultural Insurance, an indicator of climatic risks. Disasters and climatic indicators are from the World Development Risk Indicators, 2015. The subsidies of agricultural production prices are from agricultural Statistics, OECD.

4.2 Interpretations of Results

The model is globally significant and has a good quality. There is at least a variable in the model which allows explaining the effect of the programs of supports of agricultural insurance in case of natural risks on agricultural productivity for various countries over the period 2000-2015.

The estimated model with corrected random effects is the following: (Results of the estimation 5 are presented in Table 1)

$$R^2 \text{ Between} = 97.36\%$$

$$\text{WaldChi2}(7) = (712.07)^{***}$$

$$\begin{aligned} AGTFP = & 9.25 \quad 0.091Ico + 0.231Saa + 0.583 \text{ death} + 0.509IClim \quad 0.075Sprice \\ & (14.14)^{***} \quad (1.78)^* \quad (5.60)^{***} \quad (7.27)^{***} \quad (10.26)^{***} \quad (1.13) \\ & + 0.162InvA + 0.292YiC. \quad (5) \\ & (3.78)^{***} \quad (3.42)^{***} \end{aligned}$$

As it can be seen from Table 1, a natural disaster is statistically significant and negatively affects agricultural productivity in those countries, which confirms that agriculture is an activity at risk. It is submitted to climatic hazards like drought, floods and extreme temperatures, which affect agricultural production.

This result is crucial because it identifies that agricultural productivity depends on climate changes, which legitimizes the search for a suitable natural management policy. The second important fact, presented in Table 1 concerns the impacts of the subsidies of agricultural insurance premiums on agricultural productivity. It means that the state improves agricultural productivity when it supports farmers by exante aids in case of natural risks by securing financial resources for those affected - farmers and governments alike - before a natural disaster happens. This allows governments to avoid inefficient ad-hoc financing measures after disasters to support affected farmers. The estimation results demonstrate that these impacts are significant and go up with subsidies of agricultural insurance premiums in the sample. The third result is about the impact of *expost compensation* in case of natural disasters on agricultural productivity. The management of such a risk by compensating farmers in an *expost*

way comes out negative, but statistically significant in the sample. This result can be explained by the cost supported by states as far as farmers are certain to have the compensation further to natural disasters, which will clear their responsibility.

Table 1. Agricultural Productivity Growth Regressions: Impacts of Programs of Insurance in Case of Natural Risks.

Dependent variable: Total factor agricultural productivity growth is determined by using the basic year (1961=100)			
Variables	MEF	MEA	MEA Corrected
Ico	-0.052 (-1.07)	-0.256 (-3.1)***	-0.091 (-1.78)*
Saa	0.478 (5.81)***	0.348 (6.28)***	0.231 (5.6)***
Sprice	-1.128 (-1.19)	0.095 (0.84)	-0.075 (-1.13)
death	-0.091 (-1.06)	-0.453 (-4.72)***	-0.583 (-7.27)***
IClim	0.109 (1.45)	0.409 (5.9)***	0.509 (10.26)***
InvA	0.196 (2.5)*	0.204 (2.41)*	0.162 (3.78)***
YiC	0.129 (0.86)	0.196 (1.2)	0.292 (3.42)***
Constant	8.32 (5.93)***	7.33 (8.42)***	9.25 (14.14)***
R ²	60.84%	97.36%	97.36%
N. obsX T	360	360	360
Test of Hausman		(88.99)***	
B-Pagan $\chi^2(\cdot)$		2.67	
Pr > χ^2		0.102	
Test of Breush-Godf		8.832	
Pr > F		0.0208	

Notes: t-statistics are in brackets and estimations in this case are run using 2SLS technique. MEF: Fixed Effects Model; MEA: Random Effects Model; MEFC: Corrected Fixed Effects Model. *, **, *** indicate the level of significance at 10 %, 5 % and 1 % respectively.

These results are novel as they blatantly identify which type of programs of insurance could improve agricultural productivity in American, European and Asian countries. It follows that the higher the agricultural subsidies of insurance rates, the higher is the agricultural productivity rate. The policy implication of such a result is obvious. Countries chosen should develop the direct policy of supporting agricultural insurance premiums in case of natural risks.

The results in Table 1 provide support that the *expost* compensation negatively affects the growth of the agricultural production because it is considered as an enormous cost supported by states. Also, the estimation results show an increasing impact of agricultural investments on agricultural productivity. This suggests that improving agricultural productivity in these countries supposes promoting agricultural investments.

One should notice that agricultural productivity requires increased cereal yields. The higher the coverage of this level, the more rapid the agricultural productivity. However, this productivity goes with the subsidies of agricultural production prices. This suggests that the

agricultural development policy, especially agricultural management risk policies combined with agricultural investments policies contributes to the improvement of agricultural productivity

5. Conclusion and Policy Implications

The agricultural sector is highly exposed to climate risks. The majority of risks associated with production are caused by adverse climatic conditions and inherent climate variability.

Extreme natural disasters have effects that extend beyond agriculture (e.g., catastrophic flooding), further weakening the financial sector and increasing poverty trap vulnerability for millions of smallholders.

In the absence of well-functioning risk management markets, governments must assume a large part of costs, adding another element of instability that stifles private investment and growth.

Many governments use subsidized agricultural insurance as an instrument of choice for helping farmers and rural communities cope with risks. There are many reasons behind these subsidies, some having to do with market failures and externalities that constrain the development of privately provided and unsubsidized insurance, and some having more overt political and social objectives such as helping specific segments of poorer farmers to access insurance. This encourages increased production of important food or export crops, protects agricultural lending institutions and reduces the need for disaster assistance payments. It can be simply a politically acceptable means of supporting farm incomes. Through the analysis of the relation, which highlights the modalities of action of the state on the market of insurance, we try to find which modality the state could opt for to improve agricultural productivity.

We find that the management of natural risks by subsidizing premiums of agricultural insurance has significant positive effects on agricultural productivity in American, European and Asian countries. This result is associated with the agricultural development policy. On the other hand, the management of natural risks by *expost* compensation negatively affects productivity. The obtained conclusions especially indicate that agricultural productivity: i) improves with subsidizing agricultural premiums of insurance, ii) deteriorates with *expost* payments in case of natural disasters, iii) positively reacts to the subsidies of agricultural production, and iv) rises with the development of agricultural investments.

As a matter of fact, the existence of a natural risk management policy is therefore essential to strengthen agricultural productivity.

Besides, the agricultural development is a determinant factor of the agricultural productivity by developing agricultural investment policies or by promoting agricultural spending intended to help farmers rather than subsidizing prices. Thus, the development of agricultural strategies has to hold in account the development of the strategies to face the climate change and the development of natural risk management policies at the national, regional and local levels.

The main policy implication of this research is that the management of natural risks will have a positive impact on agricultural productivity by the subsidies of the premiums of agricultural insurance and not by *expost* compensation given to farmers. For subsidized insurance intended to compliment or replace disaster assistance payments, it is important to identify which catastrophe risks the insurance will be able to cover, and which will still need to be covered by a disaster assistance program. Without an adequate management policy of disaster risks, agricultural development policies could not reach the goal of improvement of agricultural productivity.

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¹ Capitanio, F., et al (2011), Does market competitiveness significantly affect public intervention in agricultural insurance: the case in Italy. *Applied Economics* 43(27):4149-4159.

² Climate change is inevitably resulting in changes in climate variability and in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events (IPCC, 2012).

³ Capitanio, F., et al (2011),. Does market competitiveness significantly affect public intervention in agricultural insurance: the case in Italy. *Applied Economics* 43 (27) :4149-4159.

⁴ Capitanio, F., et al (2011),. Does market competitiveness significantly affect public intervention in agricultural insurance: the case in Italy? *Applied Economics* 43 (27):4149-4159.

⁵ $I_{expost} = \frac{\sum(expost\ compensation + Ad\ hoc\ Payments)}{Agri\ Production\ Value}$

⁶The total factor agricultural productivity growth is the increase in the production which is due to the growth of factor, adjusted by the quality of soil, the labor, the power of machines, the capital and the synthetic fertilizers. Data are extracted from the Fuglie, Keith O. (2012) "Productivity Growth and Technology Capital in the Global Agricultural Economy." In: Fuglie K., Wang, S.L. and Ball, V.E. (eds.) *Productivity Growth in Method for estimating average annual growth rates*.

$${}^7 I_{\text{exp ost}} = \frac{\sum(\text{expost compensation} + \text{Ad hoc Payments})}{\text{Agri Production Value}}$$

⁸ Droughts, floods and extreme temperatures is the annual average percentage of the population that is affected by natural disasters classified as either droughts, floods, or extreme temperature events. A drought is an extended period of time characterized by a deficiency in a region's water supply that is the result of constantly below average precipitation. A drought can lead to losses to agriculture, affect inland navigation and hydropower plants, and cause a lack of drinking water and famine. A flood is a significant rise of water level in a stream, lake, reservoir or coastal region. Extreme temperature events are either cold waves or heat waves. A cold wave can be both a prolonged period of excessively cold weather and the sudden invasion of very cold air over a large area. Along with frost it can cause damage to agriculture, infrastructure, and property. A heat wave is a prolonged period of excessively hot and sometimes also humid weather relative to normal climate patterns of a certain region. Population affected is the number of people injured, left homeless or requiring immediate assistance during a period of emergency resulting from a natural disaster; it can also include displaced or evacuated people. Average percentage of population affected is calculated by dividing the sum of total affected for the period stated by the sum of the annual population figures for the period stated.

Source: EM-DAT: The OFDA/CRED International Disaster Database: emdat.be, Université Catholique de Louvain, Brussels (Belgium), World Bank.