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Assessing the effects of premium subsidies on crop insurance demand: An analysis for grain production in Southern Brazil

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Abstract:

Following the well-succeed experience of developed countries such as Canada and the United States, Brazil implemented the Crop Insurance Program (PSR) in 2005 seeking to provide subsidies for the purchase of crop insurance policies by Brazilian farmers. Despite the importance of this public policy, there is no empirical investigation about the effects of premium subsidies on the quantity demanded for crop insurance in Brazil. This paper aimed to fill this gap through the investigation of the three grains – corn, soybeans and wheat – that are most cultivated in southern Brazil, the region where PSR is most developed. A fixed effects model was applied to an unbalanced panel data of municipalities of southern Brazil considering the years between 2006 and 2015. Three measures of crop insurance demand were considered: level of total premiums, level of total premiums per hectare and level of total liability per hectare. Results was in line with previous literature, suggesting the existence of a positive, although inelastic, effect of the subsidy level on the demand for crop insurance.

Acknowledegment:

JEL Codes: Q18, Q14

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Abstract

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Keywords: crop insurance; demand; premium subsidies; grains; Brazil
JEL codes: C23, Q18

1. Introduction

The agricultural activity directly depends on nature and its resources. Considering crop failures caused by unpredictable natural events and the negative impacts in the economy, governments worldwide have long implemented agricultural risk management policies. Among these initiatives, one can highlight the governmental participation in the crop insurance market. Well-succeed cases are the crop insurance schemes of Canada and the United States. Indeed, these two countries accounted for approximately 55% of global crop insurance premium written in 2011 (Swiss Re, 2013).

Following the successful initiatives of developed nations, some developing countries have been implementing similar crop insurance schemes for the last decades. The Crop Insurance Program (PSR), established in 2005 in Brazil, is such an example. Through the PSR, the Brazilian government subsidies part of the crop insurance premium charged by the insurers, helping the farmers to protect their production against adverse events. PSR is considered as one of the pillars of the agricultural risk management policy conducted by the Ministry of Agriculture, Livestock and Supply (MAPA), and have a complementary role to credit and commercialization policies (Brasil, 2016).

From a theoretical point of view, all governments expect the subsidies they provide to raise the demand for crop insurance. In other words, it is expected that the payment of a portion of the price charged by insurers will make crop insurance more accessible to a large number of farmers. Despite the fact that the bulk of eligible crops in PSR have a subsidy of almost 50% of the premium, the demand for crop insurance in Brazil is not as high as expected. Only approximately 14% of the Brazilian planted area are insured (Buainain et al., 2014). For comparison, 84% of US cropland was insured in 2012 (O'Donoghue, 2014). Given the lack of demand for crop insurance in Brazil, one can question if the subsidies are that important for the development of this market in the country.

For the last decades, several studies examined the nature of crop insurance demand and, more specifically, the effects of premium subsidies on this demand. In general, evidences point to an inelastic nature of the crop insurance demand. Nevertheless, the bulk of researches focus solely the US crop insurance program. To what is known, there is no empirical investigation of this type for Brazil's PSR or any other developing country at all. PSR is a relatively recent program and, because of this, knowing the demand's responsiveness to governmental subsidies can have important

policy implications to Brazilian crop insurance scheme. In this sense, the present study aims to provide evidences about the behavior of the crop insurance demand in response to variations in governmental subsidies. Initially, it is believed that Brazilian farmers respond to government incentives similar to US farmers, i.e., inelastically.

The focus of this empirical research is on the three most cultivated grains in southern Brazil: corn, soybeans, and wheat. Considering the period between 2006 and 2015, these grains were responsible for approximately 90% of the area insured through the PSR. In addition, these crops also accounted for 75% of the subsidies distributed by the Brazilian government during the first decade of PSR operation. The south region of Brazil was choose because its states – Paraná, Rio Grande do Sul, and Santa Catarina – concentrate a large part of the program's resources. For instance, farmers in those states contracted more than two-thirds of PSR-subsidized policies.

The results showed that the grain farmers of southern Brazil present positive responses to variations in subsidy, increasing the quantity demanded as government aid also rises. Although the estimates' magnitude varied according to the demand variable considered, the responses were, in most cases, inelastic. Therefore, there is a consistency with the results previously presented in the literature.

This paper is organized as follows. Section 2 presents a brief literature review about the effects of premium subsidies on crop insurance demand. Section 3 describes the PSR. Section 4 describes the empirical strategy applied and the data used. Section 5 discusses the results and section 6 presents the paper's conclusions.

2. Brief literature review

Given that the bulk of crop insurance schemes existing all around the world heavily relies on governmental subsidies, some empirical research conducted through the last three decades focused on the investigation of the effects of government participation in the crop insurance market. Recognizing (or not) the need for government action in the market, a large number of papers sought to estimate the effects of subsidies on crop insurance demand.

Goodwin (1993), Coble et al. (1996), and Serra, Goodwin and Featherstone (2003) modeled the demand for crop insurance in US using farm-level data. The first evaluated the demand for crop insurance by a panel of Iowa corn producers. The second applied random-effects, binomial probit model to a panel data of Kansas wheat farms. The third

analyzed the crop insurance purchase decision for a group of Kansas farmers using a standard probit specification.

Differently, some papers used county-level data for modeling crop insurance demand. O'Donoghue (2014) examined the effects of premium subsidies on the demand for crop insurance across major crops and production regions of the US, considering various measures of crop insurance participation. O'Donoghue and Tulman (2016) added yield shocks to the estimation of the degree to which crop insurance demand varies in relation to changes in the price of crop insurance. Going further, Yi, Richardson and Bryant (2016) explored the impacts of crop insurance premium subsidies on the demand for corn crop insurance at different coverage levels.

In general, all these papers found that, although farmers tend to respond positively to declines in premium value, demand for crop insurance is inelastic relative to government subsidies. However, some recent results go in an opposite way. Given that subsidy rates varies with coverage level, Woodard (2016) considered the presence of endogeneity in the estimation of crop insurance demand, giving evidences of elastic responses from US farmers.

3. Policy context – PSR

The involvement of the Brazilian government in the agricultural insurance market dates back to the mid-1950s, when the National Agricultural Insurance Company (CNSA) was created. Just over a decade later the CNSA was dissolved, been replaced by the National Private Insurance System (SNSP). During this same period, the mid-1960s, the Rural Insurance Stability Fund (FESR) was established. These measures, and some smaller ones, proved to be inefficient in terms of their main objective: the promotion and consolidation of agricultural insurance in Brazil (Almeida, 2007).

In the early 2000s, the Brazilian government substantially changed its modus operandi in the agricultural insurance market. Law No. 10,823/2003 authorized the executive branch to grant economic subsidy to agricultural insurance premium. Subsequently, Decree No. 5,121/2004 regulated this law, establishing the PSR. Implementation and maintenance of the PSR is responsibility of the Ministry of Agriculture, Livestock and Food Supply (MAPA), that operates through the Risk Management Department (DEGER) of the Agricultural Policy Secretariat (SPA).

The Agricultural Insurance Inter-Ministerial Committee (CGSR) approves decisions about the rules governing PSR through resolutions published on the Official Gazette of the Federal Government (DOU). Specifically, the CGSR is responsible for approving and releasing information on the percentage of subsidy on the rural insurance premium and the maximum amounts of subsidy per beneficiary, the operational conditions of the program, the technical conditions to be met by the beneficiaries and the budget for each year (Schwantes, 2017). CGSR is composed of representatives of MAPA (the chairman of the committee), Ministry of Finance (MF), Ministry of Planning, Budget, and Management (MPOG), Special Secretariat for Family Farming and Agrarian Development (SEAD, former Ministry of Agrarian Development), and Superintendence of Private Insurance (SUSEP).

Among the objectives of the PSR, the main ones are related to the reduction of the cost of insurance acquisition (premium), the diffusion of the use of rural insurance in Brazil, and the stabilization of farmers' income. In order to contract rural insurance with governmental subsidy, farmers must negotiate with insurers qualified to operate in the PSR. Currently, ten insurers are accredited in the Program, offering policies on agricultural, livestock, aquaculture and forest modalities (MAPA, 2017).

PSR started operations at the end of 2005. Considering the years between 2006 and 2016, Table 1 shows some performance indicators of the PSR.

[Table 1]

In its first decade of operation, all indicators evolved in a similar way. PSR evolved significantly until 2014. There was, however, a sharp fall in the indicators between 2014 and 2015. This situation, according to Loyola and Moreira (2015), is explained by delays in payments and the contingency of program resources. Even so, the indicators resumed the growth trajectory in 2016.

Despite the importance of crop insurance for the Brazilian agriculture, there is a lack of empirical/econometric analysis for the PSR. This study intends to fill this gap. The bulk of papers related to the PSR lies on qualitative approaches, going from historical to comparative studies (e.g. Almeida, 2007; Ozaki, 2008; 2010; Ramos, 2009; Santos; Souza; Alvarenga, 2013). Knowing the nature of the demand for crop insurance in Brazil is important to justify the governmental intervention in the market in the form of premium subsidies.

4. Methodology

4.1. Empirical strategy

To achieve the objectives of this research, a panel data model is used. Among the advantages related to this form of data structure, it is worth highlighting the possible increase in the estimation accuracy and the possibility of a more effective analysis of the individual behavior dynamics (Hsiao, 1986). These advantages are even more pronounced in the present research, since it is aimed to investigate farmers' response to variations in governmental subsidies.

In addition to these benefits, panel data allow a consistent estimation of models that consider the presence of time-fixed unobserved heterogeneity. Under the hypothesis of fixed effects, the unobserved heterogeneity is allowed to correlate with the observable explanatory variables. On the other hand, if one assumes no correlation, the random effects model allows the consistent estimation of the parameters.

For the present study, time-fixed unobserved heterogeneity is possibly important in determining the relation of interest. It is believed that some unobserved factors may influence the relationship between the subsidy value and the quantity demanded for crop insurance. In particular, it is assumed that soil quality did not vary substantially on the analyzed years, although it may have varied from one municipality to another. Given that soils with worse attributes may lead to a greater probability of crop losses and to a consequent rise in the demand for crop insurance, it is important to control for this unobserved component.

In order to consider the effects that climatic conditions may have on agricultural production and, consequently, on the quantity demanded for crop insurance, it is also assumed fixed effects for the periods analyzed. Farmers in the southern region are expected to be affected in a relatively similar way to adverse weather events that may ultimately influence their insurance decisions.

Given these considerations, the following basic model was estimated:

$$\ln y_{it} = \alpha_i + \gamma_t + \delta \ln sub_{it} + \mathbf{x}'_{it}\beta + u_{it}, \quad (1)$$

in which y_{it} is the measure for crop insurance demand; α_i is the municipality unobserved effect; γ_t is the time-fixed effect; sub_{it} is the total subsidy by insured hectare for municipality *i* in the period *t*; $\mathbf{x}_{it}$ is a set of controls; and u_{it} is the idiosyncratic error. The variables for crop insurance demand and subsidies are expressed in logarithmic terms, in order to enable the direct interpretation of δ as the elasticity of the demand for crop insurance in relation to the total value of subsidies.

In the context of the US subsidy program, there is an evident endogeneity of the subsidy value in terms of the quantity demanded for crop insurance given that the premium percentage subsidized is influenced by the coverage level specified in the insurance policy. For the Brazilian case, however, one can consider the subsidy value as an exogenous variable. This is true because, although the subsidy percentage has varied over the period under analysis, it has always been the same for any coverage level contracted by the farmer.

4.2. Data

In this paper, the demand for crop insurance is modeled at the municipality level. Following Gardner and Kramer (1986), Goodwin (1993), and Yi, Richardson and Bryant (2016), each municipality is treated as a representative farmer. The use of data at aggregate levels may reduce sample variability compared to the use of data at the individual level, however, given the constraint of the used dataset, the analysis at the municipality level is the best alternative for estimating the demand for crop insurance (Yi; Richardson; Bryant, 2016).

The data used are presented in longitudinal terms, comprising several municipalities for the period between 2006 and 2015. However, because it is a relatively recent policy, the PSR has not yet evenly spread on the studied region. Given this, the database used is an unbalanced panel, since certain municipalities do not present purchases of crop insurance policies for one or more years. The attrition problem here is of the opposite nature to what is usually stressed in the literature, because instead of municipalities getting out of the sample over the years, it is observed, in fact, some entry delay of certain municipalities in the sample.

The data used in this research come from three different sources. The variables for the subsidy value and the quantity demanded for crop insurance were collected from the Crop Insurance Atlas, a website maintained by the MAPA to present the main data

related to the PSR. Control variables were extracted from two different annual surveys conducted by the Brazilian Institute of Geography and Statistics (IBGE): the Municipal Agricultural Production (PAM) and the Municipal Livestock Production (PPM). As data from the IBGE show the results for the maize production in general, without discrimination between the two existing harvests, the MAPA data were compatibilized, considering the two maize harvests together.

Literature presents several measures for the demand for crop insurance. Following O'Donoghue (2004) and adjusting to data availability, this paper represents the demand in three different ways: level of total premiums, level of total premiums per hectare and level of total liability per hectare. Assuming that premiums are actuarially fair, the price paid by farmers can express the risk level covered by the insurer. Total premiums per hectare insured adjusts total premiums to the volume of agricultural area insured, providing an average of the intensity of insurance use per unit area. Liability per hectare provides a measure of the value of the grains that are insured. Given that the subsidy directly affects the price paid by the farmer to the insurer, decreasing it, the law of demand indicates that the level of subsidies and the quantity demanded for crop insurance should present a positive relationship.

Based on previous literature (e.g. O'Donoghue and Tulman, 2016; O'Donoghue, 2014; Coble et al., 1996; Goodwin, 1993), the controls used covered the potential demand for crop insurance, an alternative to crop insurance, and the expected values and the variations of the average yield of the analyzed crops. The average yield of municipal production was used as the expected value of municipal yield for each analyzed year. The expected yield was built as the average of yields for the previous three years.

In order to control for the variation of yields over time, the standard deviation of yields was constructed for each year, based on the previous 10 years. That is, the standard deviation of yields of municipality *i* at time *t* takes into account the yields observed for this same municipality in the years from *t-1* to *t-10*.

The cultivated area for each crop in each municipality was used as a measure of the potential demand for crop insurance. It is believed that any area produced with a certain culture has the possibility of being insured, acting as a shifter of the demand for crop insurance. A variable of indication of the diversification of agricultural production was also used, since a diversified farm is theoretically less exposed to risk. Following Featherstone and Goodwin (1993), this variable is represented by the participation of livestock in the value of municipal agricultural production.

5. Results and discussion

5.1. Descriptive statistics

Table 2 presents descriptive statistics for the variables used to estimate the effect of premium subsidies on the demand for crop insurance. These statistics are separated for the three grains, with the exception of the diversification indicator, which does not vary among the analyzed crops. The statistics related to this variable point to a great variability regarding the diversification of the municipal agricultural production in southern Brazil, considering that its average and its standard deviation presented similar values.

[Table 2]

The three first variables presented for each grain are those used as measures of the demand for crop insurance. Comparatively, soybeans concentrate, on average, the highest volume of premiums paid by producers to insurers, while corn presents the greatest variability in this value. Adjusting premiums for insured area, the highest average is observed for wheat and the lowest for soybeans, while corn is the crop whose values most vary. This is an evidence that, on average, premiums paid for soybeans insurance in the South region are spread over a comparatively larger area than for the other two grains. As for liability per hectare, the highest average is obtained for the corn, while soybeans and wheat present average values and variability very close to each other.

On average, subsidy per hectare – the main explanatory variable considered in this study – is comparatively higher for wheat than for corn and soybeans. Although there is a direct effect of the total area insured for each crop, there is also a direct relationship with the subsidy percentage. This occurs because, historically, wheat has the highest subsidy percentage among grains, while the lowest rates are applied to soybeans. The evolution of PSR subsidy percentage is presented in Table 3.

[Table 3]

The other explanatory variables, used as controls to estimate the elasticity of the demand for crop insurance in relation to premium subsidy, refer to planted area, expected

yield and yield variation of each grain in the municipalities of southern Brazil. On average, soybeans presented the large planted are, followed by corn and then wheat. On the other hand, corn is the grain with the highest variation in yield, providing indications that among these crops, corn is the one with the highest production risk.

5.2. Empirical results

Estimates of crop insurance demand function for grain production in southern Brazil are presented in Table 4. Municipalities of the three southern states are considered together. Because three different measures of demand and three grain types were considered, results are presented for nine different models. Seeking en empirical validation of the choice for the fixed effects model, Chow and Hausman tests were applied. The first compares the fixed effects model with the pooled model, testing for the null hypothesis that coefficients for the fixed effects are equal to zero, while the second compares fixed and random effects models, testing for the null hypothesis that the unobserved heterogeneity is uncorrelated with the regressors. The statistics presented by both tests allowed the rejection of null hypotheses, showing that the fixed effects model is the ideal for the empirical application proposed in the present research.

After the validation of the estimation via the fixed effects model, the existence of serial autocorrelation in the idiosyncratic errors was tested by the Wooldridge test and the existence of heteroscedasticity was tested through the modified Wald test. It was observed that the variance of the errors is not constant and that the errors are correlated. In order to correct these conditions, the model was estimated with robust clustered standard errors. A final test was performed prior to the estimation of the empirical model. In order to analyze whether, in addition to the fixed-effect of the individual, the existence of fixed effects of time is also present, the condition that the set of dummies for the analyzed years was equal to zero was jointly tested. Rejecting this hypothesis, the unobserved heterogeneity was controlled for municipalities (cross-section unit) and years (time series unit).

Controls presented different magnitudes and significances between the models. Nevertheless, the models were, in general, robust to the exclusion of variables with no statistical significance, maintaining the magnitude and significance of the effect of interest. Planted area was only significant for corn, positively affecting total premiums and negatively influencing liability per hectare. Expected yield, by contrast, presented

positive relation with total premiums for corn and negative relation with soybeans liability. On the other hand, yield variation showed statistical significance only for corn, indicating that higher production risks would be associated to increases in total premiums per hectare and liability per hectare. Finally, it is noted that the measure of diversification is not statistically different from zero in any of the models.

[Table 4]

Consistent with the theoretically expected, the demand for crop insurance has a positive relationship with subsidy values, given that subsidy acts by reducing the prices paid by the farmers to the insurers. Overall, however, it was observed an inelastic response to the demand for crop insurance in relation to the level of subsidies. That is, for most of the cases analyzed, a 1% increase in subsidy per hectare would be related to an increase of less than 1% in the quantity demanded for crop insurance. O'Donoghue (2014), analyzing the US case, also noted positive and inelastic responses from farmers to changes in subsidy values.

It is also evidenced that farmers of different grains respond differently to variations in subsidy values. This is a relatively predictable result given that the crops under consideration have different subsidy percentages during the analyzed period. Considering an actuarially fair premium, crops with yields more susceptible to variations due to climatic factors would be related to higher premiums, which would therefore decrease the incentive to contract the policy. In this sense, higher subsidy percentages would tend to demonstrate the level of risk involved in each crop.

It should be noted that, for the same crop, the elasticity is significantly sensitive to the crop insurance demand indicator used. For the three grains, lowest responses are presented for liability per hectare, while the highest ones are obtained for total premiums per hectare. It must be observed that this last measure of demand showed unit elasticity for the case of wheat.

Total premiums presented the highest responses for corn, where a 10% increase in subsidy is related to a 7.74% increase in total premiums paid by corn producers. On the other hand, the lowest responses were obtained for soybeans, since at each increase of 10% in liability, total premiums paid by soybeans producers increased by just over 5%. Wheat presented intermediate values, having a responsiveness closer to that presented by corn.

In the case of total premiums per hectare, it should be noted that wheat presented unit elasticity, so that an increase in subsidies leads to an exactly proportional increase in total premiums per hectare. Although they did not present unit elasticities, corn and soybeans yielded elasticity slightly higher than 0.90. The relevance of subsidies for each hectare insured by southern grains producers are evident and the estimated values were higher than those presented by O'Donoghue (2014) for the same crops in the US.

Total liability per hectare presented a relatively low elasticity for all grains. In this case, soybeans presented the greater responsiveness, since a 10% increase in subsidies would lead to a 3.7% increase in total liability per hectare. For corn and wheat, there is a positive variation of approximately 2.9 and 2.3 per cent, respectively, in response to a 10% growth in subsidy value.

These results show that, in fact, an increase in subsidies is associated with an increase in the level of participation of grain producers in the crop insurance program. In particular, farmers in the southern Brazil appear to respond to subsidies, especially by raising the coverage level. This is indicated by the results related to total premiums per hectare, given that, for an actuarially fair premium, coverage level expansion leads to an increase in farmer's risk exposure and, consequently, to an increase in the premium paid by the farmer. The elasticity of the demand for crop insurance with respect to subsidy values are presented in Table 5. Although the results indicate that increases in subsidies are related to an expansion of the quantity demanded for crop insurance, variation level is different between crops and states.

Almost all estimates were statistically significant by at least 10% of significance. Exceptions are the estimates for total liability per hectare of corn producers of Paraná and Santa Catarina. It is observed that total premiums per hectare was the measure of the demand for crop insurance that presented the highest elasticity in relation to subsidies. It should be noted that estimates of the effect of the subsidies on total premiums per hectare for wheat were statistically equal to one for all states, providing a unit elasticity. On the other hand, the lowest responses were obtained when considering total liability per hectare, while intermediate responses were observed when considering total premiums.

[Table 5]

Considering the case of corn, for two of the three measures of demand considered, the farmers of Rio Grande do Sul presented the highest levels of response to subsidies.

However, despite a relatively high elasticity, total premiums per hectare in this state respond less expressively than those of the other southern states.

In the case of soybeans, it is noteworthy that producers in Paraná and Rio Grande do Sul presented similar elasticity for total premiums and total premiums per hectare. The state of Santa Catarina, in turn, presented the highest elasticity when considering total premiums per hectare and total liability per hectare, besides presenting less responsiveness of total premiums to subsidy values in comparison to the other states. It should be noted that the farmers in Santa Catarina increase total premiums per hectare by almost 1% in response to a 1% increase in subsidies, indicating an almost unitary elasticity.

Excluding the case of total premiums per hectare, the results presented for wheat were especially heterogeneous. For this measure of demand, the three states presented unit elasticity. In the case of total premiums, the farmers of Paraná presented an elastic demand, considering that the expansion of subsidies leads to a more than proportional increase in the quantity demanded for crop insurance. On the other hand, producers in Rio Grande do Sul raised the total premium in a much smaller proportion, of only 4.4% to every 10% increase in subsidies. Also relevant is the fact that in the states of Paraná and Santa Catarina, the variation of the subsidy does not present impacts on the variation of the total value insured per hectare.

6. Final remarks and policy implications

The present study sought to analyze the effect of premium subsidies on the demand for crop insurance, considering the scope of the Crop Insurance Program (PSR). Specifically, it was analyzed the responses of corn, soybeans and wheat producers located in southern Brazil, given the significant participation of these crops and of this region in the PSR.

Results showed that, in general, grain producers in the South region of Brazil appear to respond positively to changes in subsidy values, increasing the quantity demanded for crop insurance. However, it must be emphasized that this response, measured in terms of elasticity, was, in most cases, inelastic. Estimates of the elasticity were higher when considering total premiums per hectare as a measure of the demand for crop insurance. In this case, even the coefficients estimated for wheat were statistically equal to one for all states, giving a unitary elasticity, where the increase in the volume of

government subsidies would be accompanied by an exactly proportional expansion in the quantity demanded for crop insurance.

It was concluded that the hypothesis initially raised, that the responses to the subsidy would be inelastic, was not rejected. Indeed, this result is in line with what was previously presented in the literature, which mostly analyzed the case of US crop insurance. Therefore, there is no reason to condemn the PSR simply because farmers do not respond in a more than proportional way to government incentives, since this seems to be the rule and not the exception within the scope of governmental crop insurance programs worldwide.

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Tables

Table 1. PSR performance indicators, 2006-2016

Years	Performance indicators			
	Insured area[1]	Total liability[2]	Total premium[2]	Total subsidy[2]
2006	1,761,653	2,870,174,189	38,797,657	31,161,633
2007	2,271,536	2,715,475,197	65,012,845	60,946,215
2008	4,697,796	7,117,398,081	162,097,311	156,272,540
2009	6,583,345	9,528,240,687	213,465,151	258,880,017
2010	4,760,528	6,526,976,056	166,017,669	197,170,559
2011	4,469,851	7,220,707,440	205,810,922	249,195,322
2012	5,195,160	8,724,747,252	246,494,914	317,952,271
2013	9,824,811	16,810,119,612	442,089,999	556,457,170
2014	9,883,546	18,502,497,431	539,815,730	689,113,412
2015	2,646,521	5,424,627,724	185,566,432	276,932,173
2016	5,470,608	12,893,013,061	523,422,784	388,003,306

Notes: [1] Values in hectares; [2] Values in US dolars. Source: Rural Insurance Atlas (2017).

Table 2. Descriptive statistics by grain, Southern Brazil

Variables[1]	Mean	Standard deviation	Maximum	Minimum
Diversification	0,21	0,20	1,00	0,00
	Corn			
Total premiums	10,32	1,91	16,43	4,62
Total premiums per hectare	4,61	0,58	8,70	1,07
Liability per hectare	7,16	0,42	10,50	3,82
Subsidy per hectare	4,02	0,63	8,34	0,37
Planted area	7,38	1,57	11,30	0,00
Expected yield	6,79	0,52	7,98	2,87
Yield variation	8,27	0,45	9,28	6,14
	Soybeans			
Total premiums	10,91	1,75	15,63	5,09
Total premiums per hectare	4,17	0,51	8,41	0,98
Liability per hectare	6,95	0,37	10,83	5,12
Subsidy per hectare	3,51	0,54	7,71	0,47
Planted area	8,01	2,02	11,88	0,00
Expected yield	6,18	0,40	7,49	1,80
Yield variation	7,71	0,30	8,34	5,81
	Wheat			
Total premiums	10,60	1,66	15,29	4,61
Total premiums per hectare	4,71	0,41	9,08	2,81

Liability per hectare	6,96	0,37	10,68	5,02
Subsidy per hectare	4,33	0,43	8,72	2,30
Planted area	6,65	1,90	10,71	0,00
Expected yield	6,13	0,48	7,40	1,44
Yield variation	7,63	0,26	8,32	5,99

Note: [1] Diversification is expressed in percentage terms while the other variables are expressed in logarithms.

Table 3. Crop insurance subsidy percentage, selected crops, 2006-2015.

Year	Crop			
	Corn: harvest 1	Corn: harvest 2	Soybeans	Wheat
2006	50%	60%	50%	60%
2007	50%	60%	50%	60%
2008	50%	60%	50%	60%
2009	50%	70%	50%	70%
2010	50%	70%	50%	70%
2011	50%	70%	50%	70%
2012	50%	70%	50%	70%
2013	50%	70%	50%	70%
2014	40%	60%	40%	70%
2015	40%	60%	40%	70%

Source: Several Resolutions of the MAPA.

Table 4. Crop insurance demand estimates for selected grains in Southern Brazil

Variables	Total premiums	Total premiums per hectare	Liability per hectare
		Corn	
Subsidy per hectare	0,7740***	0,9109***	0,2877***
Planted area	0,1824***	-0,0014	-0,0738***
Expected yield	0,3677*	0,0184	0,0430
Yield variation	-0,1500	0,0588**	0,1785***
Diversification	-0,4508	-0,0376	0,0576
Constant	5,7632***	0,4174***	4,7592***
		Soybeans	
Subsidy per hectare	0,5325***	0,9318***	0,3700***
Planted area	0,0104	-0,0001	0,0005
Expected yield	0,0015	0,0000	-0,0205*
Yield variation	-0,0702	-0,0061	0,0036
Diversification	0,0847	0,0100	0,0196
Constant	9,0499***	0,9164***	5,6144***
		Wheat	
Subsidy per hectare	0,6938***	1,0003***	0,2314**
Planted area	0,0168	0,0001	-0,0012
Expected yield	0,0864	-0,0025	-0,0389
Yield variation	-0,0056	0,0004	-0,0058
Diversification	0,1037	-0,0054	-0,0310
Constant	5,7844***	0,5216***	5,8759***

Notes: *** p<0.01; ** p<0.05; * p<0.1.

Table 5. Elasticity of the demand for crop insurance with respect to subsidy per hectare, selected grains, states of the Southern Brazil

State	Total premiums	Total premiums per hectare	Total liability per hectare
		Corn	
Paraná	0.6966***	0.9117***	0.3096***
Rio Grande do Sul	0.7348***	0.8666***	0.3247**
Santa Catarina	0.5971***	0.9168***	0.2374*
		Soybeans	
Paraná	0.6235***	0.9099***	0.3470***
Rio Grande do Sul	0.6052***	0.9032***	0.2467***
Santa Catarina	0.5402***	0.9896***	0.4904***
		Wheat	
Paraná	1.1410***	0.9994***	0.0481
Rio Grande do Sul	0.4401**	1.0000***	0.4000***
Santa Catarina	0.7275*	1.0002***	-0.0042

Notes: *** p<0.01; ** p<0.05; * p<0.1.