Available online at www.centmapress.org

INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Int. J. Food System Dynamics 13 (3), 2022, 425-439

DOI: https://dx.doi.org/10.18461/ijfsd.v13i4.D4

Surviving as an Argentine Farmer: Factors that Influence Risk Management Strategies

Pablo Mac Clay[a,b], Federico M. Accursi[a,c], and Pedro Harmath[a]

[a]*Center for Food and Agribusiness (CEAg), Universidad Austral.*
[b]*Center for Development Research (ZEF), University of Bonn.*
[c]*Department of Economics, Universidad de Navarra.*
pmacclay@austral.edu.ar; faccursi@austral.edu.ar; pharmath@austral.edu.ar

Received July 2021, accepted June 2022, available online August 2022

ABSTRACT

Agricultural production is a challenging business in Argentina due to output variability, unfavorable government policies, and the absence of public risk management programs. Based on probit modeling and information surveyed from producers farming in the Humid Pampa, this paper studies the influence of (a) risk attitudes, (b) risk perceptions, and (c) socioeconomic factors on the probability of choosing five different risk management strategies. Besides confirming that some results previously found in the literature apply to the Argentine case, we find that local farmers have a particular understanding of specific risk management strategies. Some strategies usually applied to reduce risks, such as the use of futures markets or vertical integration are perceived by Argentine farmers as risk-increasing. Cost control is the preferred strategy for risk-averse farmers. Policymakers and companies providing services should take into consideration the particular way in which Argentine farmers perceive and manage risks to build a common language.

Keywords: *Argentine farmers; risk management strategies; risk perceptions; risk attitudes; behavioral economics*.

1 Introduction

Agricultural production is a risky business, and managing different risks is challenging for farmers. Weather conditions affect plants and animals; price volatility, trade barriers, legal disputes, and human resources conflicts are other significant risk sources associated with commercial and business management issues (Crane et al., 2013; Kahan, 2013). Moreover, farm risks have been growing in the last few years, fueled by new sources, including (but not limited to) climate change[1], new environmental regulations, political conflicts, social instability, animal welfare issues, changes in consumers' preferences, new breeding technologies, rising concentration in the input markets, and pricing dynamics (Boehlje et al., 2011; Weaver et al., 2020).

In developing countries, risk management is of special concern since the available information for forecasting is limited (Aditto et al., 2012). Furthermore, country-specific issues may contribute to an increase in risks. For example, in the case of Argentina, farmers are used to enduring substantial doses of volatility derived from political and institutional factors which increase the normal level of farming risks.

Agricultural production is of major importance to the Argentine economy. Approximately 55% of the country's exports are linked to farming which also supplies almost all the food that is consumed in the domestic market. Agriculture in the Humid Pampa, the main producing area in the country, has undergone substantial changes in the last 20 years due to new crop technologies, new farm practices, and changes in land use (Anton et al., 2019). These changes have contributed to boosting agricultural output, but yields still show a considerable annual variability (Hubbs et al., 2016; Hubbs et al., 2017), primarily due to the absence of irrigation systems (Gallacher et al., 2011).

The variability of output is further aggravated due to Argentine agricultural policies which have been subject to abrupt shifts and have moved in the opposite direction compared to policies in the United States or Europe. While the United States and the European Union provide assistance and cash transfers, Argentina has burdened the agri-food sector with export taxes over most of the last two decades (Anton et al., 2019). Moreover, there have been no programs encouraging farmers to get insurance coverage or schemes to stabilize incomes (Lema et al., 2018).

The combination of (a) high volatility in output and yields, (b) macroeconomic and political instability, and (c) the absence of public programs to tackle risk have created a hostile environment for Argentine farmers, who need resilience to survive and remain in business. While many papers study risk management strategies (see Table 1 and Table 2), not many address the role of farmers in such an adverse context. A deeper understanding of Argentine farmers' risk management strategies may provide valuable information for insurance and trading companies and help them design better-tailored solutions for the sector. Furthermore, government institutions may be interested in working on public insurance plans or support programs towards helping farmers tackle risks.

This paper aims at analyzing the factors that influence different risk management strategies implemented by Argentine producers farming in the *Humid Pampa*, using a local farm-level survey. Building on a literature review that is presented in section 2, in section 3 we define the two main variables employed in the study: risk attitudes and risk perceptions, and summarize the methods used for studying how these variables affect farmers´ risk management behavior. In section 4 we detail our findings, and in Section 5 we present our conclusions and the main policy and business implications of our work.

2 Literature review and theoretical framework

The concept of risk comprises a potentially unfavorable outcome and the losses that may come after (Wang et al., 2010; Wolff et al., 2019). Risk is intrinsic to every decision: economic agents typically make choices without knowing the outcomes. Economics has mainly relied on the Expected Utility Theory framework to represent behavior in a context of uncertainty (Loubergé, 1988). The idea of rational choice under uncertainty was generalized by the seminal work of John Von Neumann and Oskar Morgenstern (1944). The authors propose an axiomatic system in which agents' preferences are represented through choices among lotteries or gambles that produce an outcome with a determined probability. If the person chooses the secure outcome over any risky lottery that provides the same expected value, it is considered risk-averse (Resnik, 1987).

Nevertheless, recent research has demonstrated that behavior in real life may not follow theoretical predictions. People show biases and follow more straightforward paths to shape their beliefs about uncertain events. For example, people assign different weights to gains and losses (Kahneman and Tversky, 1979) or ponder risks according to how vividly they portray the outcomes of an adverse event, regardless of the probabilities (Tversky and Kahneman, 1974). Even past

[1] See, for example, in Mesfin and Bekele (2018) the adoption of different risk management and adaptation strategies of smallholder farmers in Ethiopia.

experiences matter, since people rate higher those risk sources they have been exposed to previously (Öhman, 2017). Hence, shaping risk perceptions and attitudes is much more complex than theoretical models; it is influenced by economic agents' contexts, experiences, and beliefs. Understanding this is essential since these attitudes and perceptions will ultimately impact how agents decide to manage risk.

Risk management strategies help economic agents to avoid, transfer or reduce risks, or even to accept some and cope with the consequences. Managing risks requires identifying and assessing risk sources, and then choosing a combination of activities that reduce the possibility of an adverse event while maximizing returns (Beal, 1996; Harwood et al., 1999). Thus, the optimal risk management strategy should balance potential profit and losses following the economic agent's risk preferences (Crane et al., 2013).

2.1 Risk management in agriculture

Risk management strategies cannot be understood without addressing farmers' context and beliefs since farm managers tend to react to their circumstances. In this setting, the risk management strategies they adopt should match their personal risk preferences (Meuwissen et al., 2001). Different theoretical models suggest that risk management strategies depend mainly on farmers' beliefs about risk. These beliefs are a combination of risk attitudes and risk perceptions plus a group of socioeconomic variables that directly affect strategies or are mediated through attitudes and perceptions (Sitking and Weingart, 1995; Sitking and Pablo, 1992).

Risk attitudes reveal or indicate to which extent a person is willing to take risks or prefers to avoid them; attitudes go from risk aversion to risk pursuing (Sitking and Weingart, 1995). Research has demonstrated that risk attitudes tend to be contextual and may change through time (Dohmen et al., 2011). Risk attitudes will influence the type and intensity of risk management strategies: the more risk-prone the agent is, the less willing he/she will be to implement risk reduction strategies (van Winsen et al., 2016; Meuwissen et al., 2001).

On the other hand, *risk perceptions* reflect the economic agents' subjective viewpoints on how they characterize activities as more or less risky (Slovic et al., 1982; Bishu et al., 2018). Therefore, risk perceptions will influence farmers' choices when designing their risk management strategies and when selecting one over the other. According to Sulewski and Kloczo-Gajewska (2014, p. 140) "*appropriate risk perception can be seen as a prerequisite for choosing an effective risk-coping strategy because a farmer that is not aware of the risks faced is clearly unable to manage them effectively*".

But, as previously stated, not only risk perceptions and attitudes affect the design of risk management strategies. Farmers from different socioeconomic backgrounds (age, education, culture, income, farming practices, etc.) follow different decision-making processes (Duong et al., 2019). The variables related to a farmer's socioeconomic background may directly affect his/her strategies (Sherrick et al., 2004; Kaczala and Wisniewska, 2015) or be mediated by perceptions and attitudes (Meuwissen et al., 2001; van Winsen et al., 2016; Boggess et al., 1985). Table 1 summarizes the socioeconomic variables that have been identified in the literature.

Table 1.

Literature Review. Socioeconomic variables that affect risk management strategies.

Author	Age	Education	Gender	Farm size	Land tenure	Farm type	Region
Aditto et al (2012)		x	x	x			x
Bergfjord (2009)				x			
Bishu et al (2018)			x	x			x
Boggess et al (1985)	x			x		x	x
Duong et al (2019)							
Kaczala and Wisniewska (2015)	x	x		x		x	x
Meuwissen et al (2001)	x					x	
Pellegrino (1999)				x			
Pennings and Garcia (2001)							
Sherrick et al (2004)	x	x		x	x		
Van Asseldonk et al (2016)				x			

2.2. Risk management strategies

There is a broad range of risk management strategies available to farmers. Some are more traditional, like crop insurance (Sherrick et al., 2004; Meuwissen et al., 2001) or future contracts (Huirne et al., 2000). Other strategies are associated with farm management activities, like controlling costs, maintaining financial reserves, seeking off-farm income, introducing better technology, seeking productive diversification, using government credit or subsidies programs, seeking vertical integration, or resorting to professional consultants to make decisions.

Table 2 summarizes the main strategies identified in the relevant literature.

Table 2.
Literature Review. Synthesis of risk management strategies identified in the literature.

	Use of future and options contracts for output	Financial buffer / Prioritize solidity	Vertical integration	Use professional advice	Cost control / Process optimization	Diversify activities	Use of production contracts	Buy insurance	Obtain off farm income	Use govt loans & cash programs
Van Winsen et al (2016)	X	X			X	X	X		X	
Huirne et al (2009)	X	X			X	X		X	X	
Hardwood et al (1999)	X	X	X			X	X		X	
Aditto et al (2012)	X	X			X	X			X	
Meuwissen et al (2001)	X					X		X	X	
Wilson et al (1988)	X			X	X					
Sulewski and Kloczko-Gajewska (2014)	X	X				X				
Kaczala and Wisniewska (2015)										
Bergford (2009)			X	X	X					
Theuvsen (2013)		X		X	X	X				
Boggess et al (1985)		X								X
Bishu et al (2018)					X	X				
Sherrick et al (2004)								X		

This paper intends to test one main hypothesis, that farmers' risk management strategies are influenced by (a) risk attitudes (the extent to which farmers are willing to take risks), (b) risk perceptions (the risk sources that are subjectively considered most relevant) and (c) socioeconomic factors, as shown in Figure 1. The goal is to evaluate the influence and relationships between variables in general, not to make specific hypotheses about the expected direction of the variables.

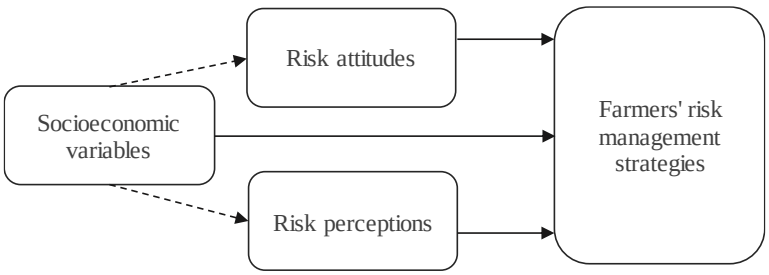

Figure 1. Model of analysis: factors affecting risk management strategies.

Based on available data, this paper tests five different strategies: 1) use of futures; 2) crop storage[2]; 3) plans for vertical integration; 4) use of professional advisory services and 5) preference for cost control.

3 Model & Data

3.1 Model

We use a response model to determine the probability of choosing a specific risk management strategy. In particular,

$$P(y_s = 1|x) = G(x\beta) \quad (1)$$

Where $y_s = 1$ is the election of a strategy s, x is a row vector of K explanatory variables, β is a column vector of parameters. This model is generally called an index model because the function G(.) maps the index into the response probability (Wooldridge, 2002). As any probability is between 0 and 1, we choose a function G(.) that ensures that condition. In this case, the standard normal density function. In other words, we use the probit model to estimate β for each strategy s:

y_1: Using futures
y_2: Storing crops
y_3: Plans for vertical integration
y_4: Use of professional advice in decisions
y_5: Preference for cost control

[2] In the Argentine case, storing crops may be interpreted as a way of financial buffering since producers tend to save crops (mainly in silo-bags) to wait for better prices or to sell later to cover cash shortages.

As we are interested in what determines the probability of choosing a specific strategy, we focus on vector β. However, the interpretation of estimated parameters is not straightforward in probit models, because the partial effect of each covariate on $P(y_s = 1|x)$ is affected by the nonlinear function G(.). In order to obtain a comprehensive interpretation, there are two possible approaches: estimating the partial effect at the mean (PEA), or the average partial effect (APE). The former means estimating the partial effect at the level of the "average farmer in the sample". This can be misleading in the case of discrete variables (just as most of the variables in our dataset). On the other hand, the APE is more intuitive for binary covariates. For each observation, the probability of success is calculated when one of the binary covariates $x_k = 1$ and when $x_k = 0$, holding the other covariates constant. The difference would be the conditional effect of x_k on y_s for each farmer. Then, we average this effect across farmers and we obtain the APE, which is the way we show results in Section 4 (Wooldridge, 2013).

3.2 Data

This paper's main source of information is a survey on farmers' purchasing habits and managing behavior called "Needs of the Argentine Agricultural Producer 2017". A total of 818 surveys were carried out among agricultural producers from the *Humid Pampa* (covering the provinces of Buenos Aires, Santa Fe, Córdoba, and Entre Ríos). Approximately 85% of the soybean national production (considering an average from 2012/13 to 2015/16) is grown in the surveyed area. The survey includes agricultural producers, defined as the physical or legal persons dedicated to the production of soybeans, wheat, corn, etc. on owned and/or leased land. The fieldwork was conducted during June and July 2017. This is the only survey in Argentina that is aimed at understanding farmers' strategies and purchasing behavior.

3.2.1 Risk attitudes

The survey includes a section to study farmers' risk profiles, with three self-assessment questions. Question number 32 inquires about risk attitudes: *"How willing are you, as a businessman, to take risks with the aim of making a profit? (1 = not very willing; 9 = very willing)"*. This question shows a structure similar to that proposed by Dohmen et al. (2011) but is constrained to the producer's risk attitudes "as a businessman". When analyzing the responses given, the mean of the 818 responses is 6.03.

Most farmers were very cautious in their answers; as shown in Figure 2, responses around the mean –options 5, 6, and 7– capture 57.2% of the total, representing approximately quintiles 2 to 4. The riskiest selections, values 8 and 9, fall approximately in the last quintile of the sample (22.6%), while the most conservative responses (values 1 to 4) are in the first quintile. Based on these results, two dummy variables were defined and included in the model, one for the last quintile (risk takers) and one for the first (risk-averse).

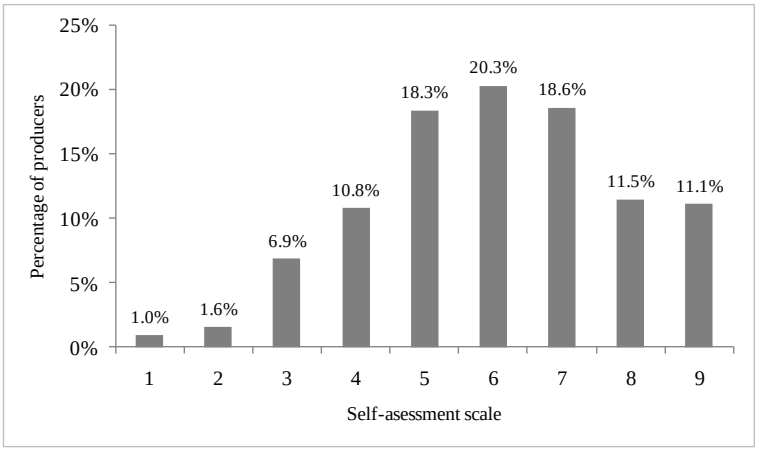

Figure 2. Histogram of the 'willingness to take risks' variable.

3.2.2 Risk perceptions

To explore farmers' risk perceptions, in question number 30 they are requested to rank the following risks from 1 to 5, 1 being the most important and 5 the least important: *production risk; climate risk; marketing risk; financial risk; legal risk* and *human risk.* For a better interpretation, the responses were characterized in clusters that help to determine risk perception groups. This approach is similar to Thompson et al. (2019).

Cluster analysis is a statistical methodology that allows dividing a finite set of individuals into groups. Those individuals in the same group are similar, and those in different groups are dissimilar. Most of the various grouping algorithms

proposed in the literature are framed in two differentiated classes, non-hierarchical (or partition methods) and hierarchical methods (James et al., 2013).

This paper uses the *k-means* method, which belongs to the non-hierarchical type. In this method, the data set is partitioned in *k* distinct, not overlapping clusters, trying to minimize the variability within each cluster, $W(C_k)$. The most common measure to define cluster variation is based on the Squared Euclidean Distance (James et al., 2013):

$$W(C_k) = \frac{1}{|C_k|} \sum_{i,i' \in C_k} \sum_{j=1}^{p} \left(x_{ij} - x_{i'j}\right)^2 \quad (2)$$

Where $|C_k|$ is the number of observations in the *k*th cluster and p is the total number of pairwise squared Euclidean distances between observations x_{ij} in a particular cluster.

Using the algorithm (5), we obtain three different groups of farmers[3], following an approach similar to Thompson et al. (2019). Table 3 summarizes the characterization of each cluster in terms of risk perceptions for the six different risk sources evaluated in the survey.

Table 3.
Cluster analysis. Risk perceptions by cluster.

	Cluster 1	Cluster 2	Cluster 3	All	F-statistic ANOVA	Pairwise comparison
Climate risk	1.537	5.170	1.433	2.002	1160.25	*** Cluster 2 is different from 1 and 3
Productive risk	2.236	2.241	4.162	2.894	263.94	*** Cluster 3 is different from 1 and 2
Financial risk	3.586	2.482	3.726	3.482	41.08	*** Cluster 2 is different from 1 and 3
Commercial risk	3.414	2.786	4.018	3.533	44.99	*** All clusters are different from each other
Legal risk	5.243	3.777	2.130	3.979	898.81	*** All clusters are different from each other
Human risk	4.983	4.545	5.531	5.110	33.82	*** All clusters are different from each other
Observations	423	112	277	812		
% of sample	52.1%	13.8%	34.1%	100.0%		

Pairwise comparison test with Bonferroni correction, α=0.1

ANOVA test for differences in multiple means *** p<0.01, ** p<0.05, * p<0.1

Note: Rate according to preference, where: 1 = the most important and 6 = the least important

The first group is the largest one, with more than half of the respondents in the sample (52.1%). For modeling purposes, this will be the benchmark group. These farmers are the closest to the average or 'typical' Argentine farmer, in terms of risk perception. Members of this group are mainly output-centered and consider climate and production risks to be the most important. Financial and commercial risks come third and fourth, while risks from legal or human aspects are the least valued. These are young producers farming in the core area, they are mid-sized, and operate a high share of rented land.

The second group's assessment of productive risk is similar to that of the base group. However, it does not consider climate as important and gives the highest weight to financial and commercial risks. These farmers are more focused on business and commercial issues and, on average, their size is the largest. This second group accounts for 13.8% of the sample.

Finally, the third group (34.1% of the sample) values climatic risk similarly to the base group and estimates every risk less than the other two groups (except for legal risks). This group is the one that gives more value to risks coming from legal sources. These farmers see that weak property rights and an adverse institutional environment as risks. On average, these farmers are the oldest. They are traditional, small-scale Humid Pampa landowners.

Appendix 2 includes a characterization of each cluster based on the variables introduced in the models. Appendix 3 briefly describes each cluster.

3.2.3 Risk management strategies and socioeconomic variables.

The survey questionnaire let us distinguish different risk management strategies adopted by farmers.

[3] 812 out of the total 818 farmers that make up the sample were classified since six did not answer question number 30. Therefore, these 812 farmers will be our base group for modelling purposes.

Appendix 1 lists and defines the risk management strategies included, as well as the socioeconomic variables. Table 4 summarizes some descriptive statistics for the main variables.

Table 4.
Summary statistics for socioeconomic and management strategies variables.

Variable	Observations	Mean	sd	min	max
Age (years)	818	45.785	12.357	19	84
Male	818	0.935	0.246	0	1
Graduate studies	818	0.601	0.490	0	1
Core area	818	0.421	0.494	0	1
Livestock area	818	0.323	0.468	0	1
Farm size (hectares)	818	2,168.35	7,215.20	310	190,000
Land tenure	818	0.472	0.500	0	1
Mixed farmers	818	0.315	0.465	0	1
Operate with future markets	818	0.355	0.479	0	1
Crop storage	796	0.274	0.446	0	1
Vertical integration	818	0.414	0.493	0	1
Decides with professionals	818	0.544	0.498	0	1
Cost control	818	0.331	0.471	0	1

Source: Needs of the Argentine Agricultural Producer 2017 survey

4 Results

Table 5 details the results for each probit model, expressed as Average Partial Effects (APE)[4], as explained in Section 3.1. The model shows that farmers' risk beliefs, attitudes, and perceptions, significantly affect their adoption (or not) of risk management strategies.

4.1 Risk attitudes

The first striking aspect is that risk attitudes operate in a different direction than expected. One would anticipate that risk aversion positively correlates with the use of risk-reducing strategies, as reflected by van Winsen et al. (2016), Theuvsen (2013), and Meuwissen et al. (2001).

Nevertheless, those Argentine farmers that declare themselves as more willing to take risks are more likely to use futures (9.6%) and store crops (8.7%) compared to the base group. On the contrary, being part of the group self-declared as risk-averse implies being less likely of using futures (-7%) and integrating vertically (-12%) compared to the base group. In addition, risk aversion significantly and positively relates to a preference for cost control (this result is as expected).

Futures and options are not popular among Humid Pampa producers as shown by Leavy and Allen (2015). It does not necessarily imply that farmers are unaware of the need to manage price risks. Results from the previous survey (Needs of the Argentine Agricultural Producer 2012) indicated that 74% of respondents stated they were not trading in futures markets, but at the same time, 55% of them reported they were using forward contracts. Producers argued information and knowledge issues that add to the high costs of trading in futures markets (Mac Clay et al., 2020). Local producers' lack of information causes them to consider agricultural derivative markets as speculative rather than as a price coverage option. Franken et al. (2014) obtained a similar result among Illinois farmers, where risk aversion increases the proportional use of forward contracts, but not futures and options.

A similar explanation can be drawn over vertical integration. Farmers may see vertical integration not as a risk management strategy but, on the contrary, as a risk-increasing decision. Argentine macroeconomic instability and cyclical policies may discourage farmers from integrating forward or backward in businesses when they are not well informed and may expose them to additional market fluctuations, government regulations, or unions' pressures. Therefore, farmers see vertical integration as risky, whereas in normal contexts it may be considered risk-reducing.

[4] Partial Effects at the Means were also calculated, with no substantial differences with APE.

Table 5.
Probit regression models. Average Partial Effects (APE) Summary

	MANAGEMENT STRATEGIES				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Use of futures	Crop storage	Vertical integration	Profesional advice	Cost control
Risk attitude					
Risk-averse	-0.070*	0.016	-0.120***	-0.032	0.134***
	(0.041)	(0.040)	(0.041)	(0.040)	(0.042)
Risk-takers	0.096**	0.087**	0.055	-0.033	0.018
	(0.039)	(0.039)	(0.040)	(0.038)	(0.037)
Risk perceptions					
Cluster #2 (Business-commercial)	-0.206***	-0.006	0.113**	0.046	0.063
	(0.039)	(0.043)	(0.049)	(0.048)	(0.046)
Cluster #3 (Legal/Property risks)	-0.065*	-0.159***	-0.154***	-0.152***	0.257***
	(0.036)	(0.034)	(0.040)	(0.039)	(0.039)
Socioeconomic variables					
Age (40-54)	0.042	-0.005	-0.053	0.001	0.131***
	(0.037)	(0.035)	(0.038)	(0.037)	(0.036)
Age (55-69)	-0.010	-0.028	0.003	-0.018	0.207***
	(0.046)	(0.044)	(0.048)	(0.046)	(0.047)
Age (70+)	-0.038	-0.060	-0.049	-0.099	0.275**
	(0.101)	(0.098)	(0.104)	(0.106)	(0.107)
Gender	-0.086	-0.031	-0.072	-0.108*	-0.024
	(0.062)	(0.063)	(0.063)	(0.055)	(0.064)
Education (Undergraduate)	-0.035	-0.038	-0.076**	0.032	0.090***
	(0.035)	(0.034)	(0.036)	(0.035)	(0.033)
Education (Graduate)	0.131*	-0.098*	-0.040	0.128**	0.144**
	(0.073)	(0.055)	(0.066)	(0.060)	(0.065)
Size	0.114***	0.008	0.052**	0.169***	-0.070***
	(0.018)	(0.018)	(0.020)	(0.021)	(0.025)
Land tenure	-0.149***	-0.091***	-0.106***	-0.199***	0.085**
	(0.034)	(0.033)	(0.035)	(0.034)	(0.033)
Farm type	0.031	0.084**	0.144***	0.065	0.006
	(0.039)	(0.039)	(0.041)	(0.040)	(0.039)
Region (Core area)	0.000	0.160***	0.041	0.006	0.006
	(0.040)	(0.040)	(0.041)	(0.039)	(0.039)
Region (Livestock area)	0.066	0.080*	0.002	-0.059	0.083**
	(0.041)	(0.045)	(0.044)	(0.041)	(0.040)
Observations	812	790	812	812	812

Note: The model includes two new interactions: size and land-tenure; size and farm type. They are all dummy variables except size. Robust standard errors in parenthesis.
*** p<0.01, ** p<0.05, * p<0.1

4.2 Risk perceptions

We find risk perceptions do explain part of the risk management strategies used. Therefore, the model now includes two of the three groups obtained via cluster analysis; the first group is the benchmark. Risk perception group #2 (the more business-oriented group that values commercial and financial risks the most) is negatively associated with the probability of using futures (-20.6%), which is explained by the fact that Argentine farmers believe that derivative markets are a risky choice. Also, group #2 membership is significant to explain vertical integration (11.3% average increase in probability).

Risk Group #3 (the group that values every risk source less but values legal risks the most compared to the other two groups) is significant to explain the probability of using all the assessed risk management strategies. As expected, membership in this group reduces the probability of using four out of five risk management strategies (except for cost control).

4.3 Socioeconomic variables

Including socioeconomic variables in the model was useful. The probability of preference for cost control activities increases with age when compared to the base group (the youngest farmers). This seems reasonable given that cost control is a very traditional way of managing risk in agriculture —even though it is not a risk management tool per se.

Gender is significant to explain the strategy of involving professionals in decisions: being a man reduces, on average, the probability of resorting to professionals (-10.8%) in the decision-making process. This means that women show a higher preference for professional advice, which is interesting since women are a small part of the sample (around 6%). So, differences in means should be strong to reject the null hypothesis. Several studies show that women tend to be more risk-averse, and therefore, more prudent in their decisions than their male counterparts (Donkers et al., 2001; Charness and Gneezy, 2012).

Education positively correlates with using most of the strategies. Having an undergraduate or graduate degree is positively associated with a preference for cost control. There is a positive association between a graduate degree, the use of futures and the inclusion of professionals in the decisions. The more educated the farmer, the more he or she understands the need for professionalized management, and the greater their knowledge of more sophisticated price risk tools. These results are in line with the findings from Aditto et al. (2012), Kaczala and Wisniewska (2015), and Sherrick et al. (2004).

As expected, farm size is positively associated with the probability of using futures, vertical integration, and professional advisory services in the decision-making process. These results are in line with the findings from Van Asseldonk et al. (2016) and Aditto et al. (2012). Size, though, is negatively associated with the preference for cost control. One explanation is that farm size may probably 'relax' some cost-control-oriented activities: the larger the size, the easier it is to cover some inefficiencies. Another explanation, as Bergfjord (2009) states, is that size reduces the use of more traditional strategies and increases the importance of more sophisticated tools.

Concerning land tenure, owning 75% or more of the land is negatively associated with the probability of using four out of the five strategies under analysis. Being a farmer who rents less than a quarter of the land under production decreases the probability of using every strategy if compared to farmers with a higher share of rented land (cost control being the exception). It is reasonable since owning a higher share of the main productive asset makes farmers feel relatively safer with their operations and decreases the need for risk management strategies. As Sherrick et al. (2004) state, greater reliance on farmland ownership versus leasing often reflects greater stability of land control and a better wealth position for farmers.

Regarding farm type, it is interesting to verify that mixed farms are associated positively with the probability of storing crops (8.4%) and vertical integration (14.3%). These results work in the expected direction since the livestock business relies on saving crops as input for the cattle; in terms of vertical integration, one may say that these farms already show a degree of vertical integration. Kaczala and Wisniewska (2015), Meuwissen et al. (2001) and Boggess et al. (1985) also find connections between farm type and risk strategies.

Finally, in terms of regions, producing in the core agricultural area is positively associated with the probability of storing crops, while producing in a more livestock-oriented area is positively associated with storing crops and the preference for cost control (in both cases, as expected). Aditto et al. (2012), Boggess et al. (1985), Kaczala and Wisniewska (2015) and Bishu et al. (2018) find a relationship between location and risk strategies.

5 Conclusions

Previous studies on farm risks in Argentina (Pellegrino, 1999; Gallacher et al., 2016) have not addressed how farmers tackle risk in this highly hostile macroeconomic and political context. This paper intends to offer broader insights into on-farm risk management in adverse country contexts. Agricultural production is a challenging business in Argentina due to output variability, unfavorable government policies, and the absence of public risk management programs.

This paper makes three main contributions. The first is that both risk attitudes (willingness to take risks) and risk perceptions (the risk sources that farmers consider the most important) affect farmers' probability of choosing different risk management strategies. Some studies indicate that risk attitudes are the main factor that conditions the type of strategies adopted, while risk perceptions show low explanatory power over risk strategies (Meuwissen et al., 2001; Aditto et al., 2012; van Winsen et al., 2016). On the other hand, other studies claim that both, risk perceptions and attitudes, affect strategy selection (Wilson et al., 1988; Bishu et al., 2018; Sulewski and Kloczko-Gajewska, 2014; Sitkin and Weingart, 1995; Sherrick et al., 2004). The results in this paper go in line with the last group, as findings reveal that risk attitudes and perceptions influence the management strategies chosen.

Second, Argentine farmers' socioeconomic profiles help to predict the probability of adopting different risk management strategies. This is in line with previous evidence (Sherrick et al.,2004; Kaczala and Wisniewska, 2015).

Social variables (e.g., education, age, or location) and economic variables (e.g., farm size, land tenure regime, or farm type) are significant to explain the probability of choosing one or more of the assessed strategies.

Finally, some idiosyncratic characteristics of the Argentinean case were found. Literature shows that the higher the risk aversion, the higher the use of risk management strategies (van Winsen et al., 2016; Theuvsen, 2013; Meuwissen et al., 2001). However, Argentine farmers show an inverse relationship. In other words, farmers self-declared as risk-tolerant present a higher probability of using futures and storing crops, while farmers self-declared as risk-averse are associated with a reduced probability of using futures and integrating vertically. These counter-intuitive results make sense in the specific context of Argentine agricultural producers. In the matter of futures, for example, Argentine farmers mention informative and knowledge issues regarding agricultural derivative markets: they tend to see these markets as speculation tools rather than as coverage tools. Something similar happens with the possibility of vertical integration.

The findings presented in this paper are useful to several value chain actors. First, commercial intermediaries and trading companies need to consider how deficiencies in information and knowledge affect farmers' perception of the use of future markets. A more direct communication strategy may reduce information gaps and help farmers to refine their commercialization strategies. Second, banks and insurance companies should consider that farmers tend to develop a defensive approach to manage their business in economically and politically unstable environments (like Argentina). Credit or insurance products should specifically address the particularities of the farming business, and foster farmers to venture into value-adding activities that are normally seen as risky (such as vertical integration). Finally, policymakers need to account for the fact that persistent policy instability discourages investments and undermines farming perspectives. Long-term and consistent policies contribute to building a predictable business environment and reducing the number of risk sources that farmers have to manage.

In a context of rapid changes in the agricultural sector and a particularly adverse country context, Argentine farmers are forced to be resilient to remain in business. This paper has explained the factors that influence their choice of strategies to mitigate or transfer risks. Our work presents some limitations since the survey that provided most of the information that we used is very rich, but not specifically oriented to risk management. The approach to risk management strategies is built indirectly, resorting to some of the questions. Therefore, the scope of the evaluated strategies leaves aside some other important strategies, such as insurance coverage or off-farm rents. Further analysis should be oriented to (a) incorporate other strategies not assessed here; (b) study farmers' needs and willingness to spend money on specific risk programs, in line with Lema et al. (2019), and (c) gain deeper knowledge on the relationship between farmers and ag derivative markets.

Acknowledgments

The authors declare not to have received any special financial support for this research.

References

Aditto, S., Gan, C., Nartea, G. (2012). Sources of risk and risk management strategies: the case of smallholder farmers in a developing economy. In: Nerija Banaitiene (ed.), Risk Management–Current Issues and Challenges.

Anton, J., Cervantes-Godoy, D., Bossard, F., Guerrero, S. (2019). Review of Agricultural Policies in Argentina. OCDE Report. Available at: https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=TAD/CA(2018)9/FINAL&docLanguage=En (Accessed on July 27, 2020).

Beal, D.J. (1996). Emerging issues in risk management in farm firms. *Review of Marketing and Agricultural Economics*, **64**(3): 336-347.

Bergfjord, O.J. (2009). Risk perception and risk management in Norwegian aquaculture. *Journal of Risk Research*, **12**(1): 91-104.

Bishu, K.G., O'Reilly, S., Lahiff, E., Steiner, B. (2018). Cattle farmers' perceptions of risk and risk management strategies: evidence from Northern Ethiopia. Journal of Risk Research, **21**(5): 579-598.

Boehlje, M., Roucan-Kane, M., Broring, S. (2011). Future Agribusiness Challenges: Strategic Uncertainty, Innovation and Structural Change. *International Food and Agribusiness Management Review*, **14**(5): 1-29.

Boggess, W.G., Anaman, K.A., Hanson, G.D. (1985). Importance, causes, and management responses to farm risks: evidence from Florida and Alabama. *Journal of Agricultural and Applied Economics*, **17**(2): 105-116.

Charness, G., Gneezy, U. (2012). Strong evidence for gender differences in risk taking. *Journal of Economic Behavior and Organization*, **83**(1): 50-58.

Crane, L., Isaacs, S., Jose, D. Sharp, R. (2013). *Introduction to risk management*. Extension Risk Management Education Agency, United States Department of Agriculture (USDA). Available at http://extensionrme.org/pubs/introductiontoriskmanagement.pdf (Accessed June 27, 2020).

Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., Wagner, G. (2011). Individual risk attitudes: Measurement, determinants, and behavioral consequences. *Journal of the European Economic Association*, **9**(3): 522-550.

Donkers, B., Melenberg, B., Van Soest, A. (2001). Estimating Risk Attitudes Using Lotteries: A Large Sample Approach. *Journal of Risk and Uncertainty,* **22**:165–195.

Duong, T., Brewer, T., Luck, J., Zander, K. (2019). A global review of farmers' perceptions of agricultural risks and risk management strategies. *Agriculture*, **9**(1): 1-16.

Franken, J., Pennings, J., Garcia, P. (2014). Measuring the effect of risk attitude on marketing behavior. *Agricultural Economics,* **45**(5): 525-535.

Gallacher, M. (2011). Production variability in Argentine agriculture. Anales de la Asociación Argentina de Economía Política. Available at https://aaep.org.ar/anales/works/works2011/Gallacher.pdf (Accessed June 24, 2020).

Gallacher, M., Lema, D., Gastaldi, L., Galetto, A. (2016). Climate variability and agricultural production in Argentina: the role of risk-transfer mechanisms. *Revista Ensayos de Política Económica*, **2**(4). Available at: https://repositorio.uca.edu.ar/handle/123456789/1864

Harwood, J., Heifner, R.G., Coble, K.H., Perry, J.E, Somwaru, A. (1999). Managing Risk in Farming: Concepts, Research, and Analysis. *Agricultural Economics Reports 34081, United States Department of Agriculture, Economic Research Service.* Available at https://ageconsearch.umn.edu/bitstream/34081/1/ae990774.pdf (Accessed June 24, 2020).

Hubbs, T., Good, D., Irwin, S. (2016) "Assessing Argentine Corn Yield Risk: Historical Deviations from Trend." *farmdoc daily* (6):234, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, December 15, 2016.

Hubbs, T., Irwin S., Good D. (2017). "Assessing Argentina Soybean Yield Risks: Historical Deviations from Trend." *farmdoc daily* (7):14, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, January 26, 2017.

Huirne, R.B.M., Meuwissen, M.P.M., Hardaker, J.B., Anderson, J.R. (2000). Risk and risk management in agriculture: an overview and empirical results. *International Journal Risk Assessment and Management*, **1**(1-2), p. 125-136.

James, G., Witten, D., Hastie, T., Tibshirani, R. (2013). An introduction to statistical learning with applications. New York: Springer.

Kaczała, M., Wiśniewska, D. (2015). Risks in the farms in Poland and their financing-research findings. In: Research Papers of the Wroclaw University of Economics (381), edited by Krzysztof Jajuga and Wanda Ronka-Chmielowiec.

Kahan, D. (2013). Managing risk in farming. Rome, Italy: Food and Agriculture Organization of the United Nations.

Kahneman, D., Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, **47**(2): 263-291.

Leavy, S., Allen, B. (2015). Comercialización de soja: Mercado disponible vs. Mercado a término, período 1994-2014. Revista de Investigaciones de la Facultad de Ciencias Agrarias-UNR, **25**: 019-026.

Lema, D., Gallacher, M., Yerovi, J.J.E., De Salvo, C.P. (2018). Analysis of Agricultural Policies in Argentina 2007–2016, **695**. Inter-American Development Bank. Available at: https://repositorio.inta.gob.ar/xmlui/handle/20.500.12123/4779.

Lema, D., Gastaldi, L., Gallacher, M., Galetto, A. (2019). Willingness to pay for weather-based index insurance in milk production. *Revista de Investigación en Modelos Financieros*, **8**(1), 52-69.

Loubergé, H. (1988) Uncertainty in Macroeconomics and the Microeconomics of Uncertainty. *The Geneva Papers on Risk and Insurance - Issues and Practice volume,* **13**: 96–99.

Mac Clay, P., Accursi, F.M., Feeney, R. (2020). Risk attitudes between Argentine farmers: what determines willingness to take risks? *International Journal of Risk Assessment and Management*, **23**(3-4): 255-273.

Mesfin, A.H., Bekele, A. (2018). Farmers perception on climate change and determinants of adaptation strategies in Benishangul-Gumuz regional state of Ethiopia. *International Journal on Food System Dynamics* **9**(5): 453-469.

Meuwissen, M.P., Huirne, R.B.M., Hardaker, J.B. (2001). Risk and risk management: an empirical analysis of Dutch livestock farmers. *Livestock production science*, **69**(1): 43-53.

Öhman, S. (2017). Previous experiences and risk perception: The role of transference. *Journal of Education, Society and Behavioural Science*, **23**(1): 1-10.

Pellegrino, J.M. (1999). Risk management in agriculture: Argentine evidence of perceived sources of risk, risk management strategies and risk efficiency in rice farming. Master Theses. Lincoln, New Zealand: Lincoln University. Available at https://core.ac.uk/download/pdf/35462514.pdf (Accessed June 17, 2020).

Resnik, M.D. (1987). Choices: An introduction to decision theory. University of Minnesota Press.

Sherrick, B.J., Barry, P.J., Ellinger, P.N., Schnitkey, G.D. (2004). Factors influencing farmers' crop insurance decisions. *American Journal of Agricultural Economics*, **86**(1): 103-114.

Sitkin, S.B., Weingart, L.R. (1995). Determinants of risky decision-making behavior: A test of the mediating role of risk perceptions and propensity. *Academy of management Journal*, **38**(6): 1573-1592.

Sitkin, S.B., Pablo, A.L. (1992). Reconceptualizing the determinants of risk behavior. *Academy of management review*, **17**(1): 9-38.

Slovic, P., Fischhoff, B., Lichtenstein, S. (1982). Why study risk perception? *Risk analysis*, **2**(2): 83-93.

Sulewski, P., Kłoczko-Gajewska, A. (2014). Farmers' risk perception, risk aversion and strategies to cope with production risk: an empirical study from Poland. S*tudies in Agricultural Economics*, **116**(3): 140-147.

Theuvsen, L. (2013). Risks and risk management in agriculture. Problems of World Agriculture/*Problemy Rolnictwa Światowego*, **13**(28). 162-174.

Thompson, N.M:, Bir, C, Widmar, N.J.O. (2019). Farmer perceptions of risk in 2017. *Agribusiness*, **35**: 182– 199.

Tversky, A., Kahneman, D. (1974). *Judgment under Uncertainty: Heuristics and Biases*. Science, New Series, Vol. 185, No. 4157, pp 1124-1131.

Van Asseldonk, M., Tzouramani, I., Ge, L., Vrolijk, H. (2016). Adoption of risk management strategies in European agriculture. *Studies in Agricultural Economics*, **118**(3): 154-162.

Van Winsen, F, de Mey, Y., Lauwers, L., Van Passel, S., Vancauteren, M., Wauters, E. (2016). Determinants of risk behaviour: effects of perceived risks and risk attitude on farmer's adoption of risk management strategies. *Journal of Risk Research*, **19**(1): 56-78.

Von Neumann, J., Morgenstern, O. (1944). Theory of Games and Economic Behavior. Princeton: Princeton University Press.

Wang, Y., Robin Keller, L., Simon, J. (2010). Descriptive models of perceived risk. *Wiley Encyclopedia of Operations Research and Management Science*. John Wiley & Sons, Inc.

Weaver, R.D., Moon, Y.D. (2020). Pricing perishables: robust price assurance. *International Journal on Food System Dynamics,* **11**(1): 39-51.

Wilson, P.N., Luginsland, T.R., Armstrong, D.V. (1988). Risk perceptions and management responses of Arizona dairy producers. *Journal of Dairy Science*, **71**(2): 545-551.

Wolff, K., Larsen, S., Øgaard, T. (2019). How to define and measure risk perceptions. *Annals of Tourism Research*, **79**: 102759.

Wooldridge, J.M. (2002). Econometric analysis of cross section and panel data. The MIT Press, 4th Ed.

Wooldridge, J.M. (2013). Introductory Econometrics. A modern approach. CENGAGE Learning, 5th Ed.

Appendix 1. List and definition of the variables included in the models.

Variable	Type	Description
Age	Socioeconomic	Four age groups: 18-39; 40-54; 55-69 and 70+
Gender	Socioeconomic	Male=1 Female=0
Education	Socioeconomic	Undergrad (finished undergraduate studies)=1 Rest=0 Graduate (finished graduate studies)=1 Rest=0
Location	Socioeconomic	Core Area = North of Buenos Aires; South of Córdoba & South of Santa Fe (core agricultural area in Pampa Húmeda with share of corn above the mean). Livestock Area = West, Southeast and Center of Buenos Aires Provinces (this region captures more than 65% of cattle heads in the sample) Rest = Center of Córdoba; North of Santa Fe; West of Entre Ríos & East of Entre Ríos.
Farm Size	Socioeconomic	Overall production area (in hectares)
Land Tenure	Socioeconomic	Land Tenure = 1 if 25% or less of the operated land was rented. Land Tenure = 0 if more than 25% of the operated land was rented.
Farm Type	Socioeconomic	Farm Type = 1 for mixed farmers, if farmer has area dedicated to livestock (dairy, beef or swine) Farm Type = 0 for farms dedicated only to agriculture.
Willingess to take risks	Risk Attitudes	How willing are you, as a businessman, to take risks with the aim of making a profit? (1=not very willing; 9= very willing) Risk Averse = 1 to 4 Base group = 5 to 7 Risk takers = 8 and 9
Most important sources of risk	Risk Perceptions	When considering the risks you face as an agricultural producer, which of the following areas of risk do you consider to be the most important when managing your farm business? Rate according to preference, where: 1 = the most important and 6 = the least important Productive risk; Climate Risk; Financial Risk; Commercial Risk; Legal Risk; Human Risk. *Simplified in 3 groups via cluster anaylsis.*
Future markets	Strategies	Use of futures = 1 if the farmer declares that usually operates with future markets.
Crop Storage	Strategies	Crop Storage = 1 if farmer stored any percentage of his production in the last harvest season, no matter what the mode of storage was.
Vertical Integration	Strategies	Vertical Integration = 1 if the farmer is planning to expand vertically either in the next 12 months or in the next 5 years, self-employed or associated.
Decides with professionals	Strategies	Professional Advice = 1 if the farmer uses professional advisory services to make decisions
Cost Control	Strategies	Cost Control = 1 if the farmer chose Managing/Controlling Costs as the most important activity for success

Appendix 2. Characterization of each cluster in terms of the main variables introduced in the models.

		Cluster 1	Cluster 2	Cluster 3	All	F-statistic ANOVA		Pairwise comparison
Socioeconomic	Age (18-39)	0.463	0.339	0.144	0.337	41.87	***	All clusters are different from each other
	Age (40-54)	0.366	0.518	0.491	0.430	7.46	***	Cluster 1 is different from 2 and 3
	Age (55-69)	0.149	0.125	0.329	0.207	19.97	***	Cluster 3 is different from 1 and 2
	Age (70+)	0.021	0.018	0.036	0.026	0.89		No differences between clusters
	Gender	0.934	0.955	0.928	0.935	0.50		No differences between clusters
	Education (Undergrad)	0.556	0.670	0.646	0.602	4.13	**	Cluster 1 is different from 2 and 3
	Education (Graduate)	0.054	0.071	0.101	0.073	2.72	*	Cluster 3 is different from 1
	Avg. Size (in hectares)	2028	4440	1455	2165	7.04	***	Cluster 2 is different from 1 and 3
	Land Tenure	0.366	0.473	0.632	0.472	25.02	***	Cluster 3 is dfferent from 1 and 2
	Farm Type	0.355	0.384	0.217	0.312	9.19	***	Cluster 3 is dfferent from 1 and 2
	Region (Core Area)	0.482	0.313	0.375	0.422	7.23	***	Cluster 1 is different from 2 and 3
	Region (Livestock Area)	0.279	0.518	0.307	0.321	12.10	***	Cluster 2 is different from 1 and 3
Risk Attitudes	Risk Attitude (Risk averse)	0.203	0.107	0.238	0.202	4.29	**	Cluster 2 is different from 1 and 3
	Risk Attitude (Risk takers)	0.243	0.232	0.191	0.224	1.33		No differences between clusters
Risk Management	Use of futures	0.430	0.205	0.292	0.352	13.50	***	Cluster 1 is different from 2 and 3
	Crop storage	0.353	0.315	0.127	0.271	22.77	***	Cluster 3 is dfferent from 1 and 2
	Plans for vertical integration	0.485	0.580	0.231	0.411	32.15	***	Cluster 3 is dfferent from 1 and 2
	Use of profesional advisory services	0.631	0.661	0.361	0.543	30.24	***	Cluster 3 is dfferent from 1 and 2
	Preference for cost control	0.191	0.268	0.574	0.333	65.26	***	Cluster 3 is dfferent from 1 and 2
	Observations	423	112	277	812			
	% of sample	52.1%	13.8%	34.1%	100.0%			

Pairwise comparison test with Bonferroni correction, α=0.1

ANOVA test for differences in multiple means *** p<0.01, ** p<0.05, * p<0.1

Appendix 3. Brief description of each cluster.

	Cluster 1	Cluster 2	Cluster 3
Risk Perception	This is the average cluster in terms of perception. It represents the 'typical' Argentine farmer. This group will be used as benchmark for modelling purposes. Farmers in this group put focus on productive aspects. They tend to be output-oriented, and give more importance to climate and productive risks. In second place come financial and commercial risks. The least valued sources of risk by this group are those coming from legal and instutional aspects.	This is the group that gives the least importance to climatic risks. Compared with the other two clusters, this group of farmers gives the highest rank to commercial and financial risks. This is a group less centered in output and more focused on economic or business aspects.	This group see that main risks come from institutional and property right aspects, and not from the rest of the sources.
Socioeconomic characteristics	Farmers in this group show the lowest average age. These are young farmers, that mainly produce in the core area, focused on agriculture. These farmers are mid-sized compared with the other two groups. These farmers produce mostly on rented land.	These are the farmers that show the largest size. Aproximately half of these farmers rent 25% or less of the land they explote. This group produces mainly in the area with the highest number of livestock cattle. Low age average (but not the lowest).	These are the oldest farmers, and show slightly higher education level compared with the other two groups (mainly in term of graduate education). These are traditional land-owners, with the smallest size compared with the other two groups. Productive profile more oriented to agriculture.
Risk Management Strategies	Almost 43% of these farmers use futures. This is the group with the highest rate of use of this strategy, compared with the other two clusters.	With the exception of the use of futures, this group do not show differences with the base group in terms of risk management strategies.	This group show differences with the other two groups in terms of four out of five strategies. This is the gruop with the highest rate of application of cost control (57,4% of farmers use this strategy). Since this group is mainly composed by older farmers that are landowners, it is expected for them to use a very "traditional" form of risk management such as cost control. As expected, this group is the one with the least rate of adpotion of strategies such as crop storage, vertical integration and use of professionals in decisions. This is expected since this group value the least every risk compared to the other two groups (except for legal risks). They see risks in a more general way, associated with the institutional environment.
Observations	423	112	277
% of sample	52.1%	13.8%	34.1%