Adaptation to climate change of vineyard farms in central Chile: risk preferences, social capital, and technical efficiency

Dissertation

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Enrique Ernesto Alvarado Irias
born in Tegucigalpa, Honduras

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Name of supervisor: Prof. Dr. Bernhard Brümmer

Name of co-supervisor: Prof. Marcela Ibañez Diaz, Ph.D.

Member of Examination Committee: Prof.   Maria Alejandra Engler Palma, PhD

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To my beloved family, Gracia, Enrique, and Raúl who is the light of my life and my greatest inspiration.

To my mom, whom I love with all my heart.

To my grandpa Raúl, whom I will love forever.

Summary

Agriculture is a major economic activity expected to increase its production by 50% to feed a planet of 9 billion people by 2050. The agricultural sector will continue to face many challenges to meet this increasing demand for food, from its vulnerability to scarce water availability and supply to extreme daytime temperatures (~30°C) and extreme climate events (e.g., heavy rainfalls). Agriculture must adapt to climate change to continue providing ecosystem services on which many communities depend. Adaptation is a continuous process of adjustments to known and projected changes in climate and the externalities due to these changes. In the adaptation process, farmers play a central role as they decide on changes in agricultural practices and management styles, among other things. These changes might lead to better outcomes, but for many farmers, there are significant challenges to implementation due to uncertainty and changes in environmental conditions and market prices, difficulties in managing risk, and the increasing competition for land, water, and energy.

Farmers' adaptation patterns can be better understood if we study how farmers react to different levels of risk under measurable uncertainty. Risk preferences are an important factor in a farmer's selection of adaptation options (e.g., technologies and innovative activities). Nonetheless, theoretical, and empirical studies have shown that conventional measures of risk preferences do not fully describe decision behavior. Social capital also plays a significant role in the process of risk management adaptation, particularly through farmers' networks that facilitate the exchange of information and enrich the learning process when adopting new technologies. Generally, it can be said that, given high levels of trust in institutions, the higher the social capital, the less vulnerable farmers are. With this and other factors in mind, adaptation in the agricultural sector should be addressed more coherently. Appropriate policies intended to stimulate efficient transformation should not exclusively rely on the assumption of the rational farmer but take advantage of findings from behavioral economics. This dissertation joins the debate on behavioral economics in climate change adaptation by using survey data and behavioral experiments to understand farmers' adaptation decisions and the effect of these decisions on technical efficiency.

The first paper explores how small farmers' risk preferences and the three forms of social capital: trust, norms, and networking, affect the decision to implement anticipatory (ex-ante) or reactive (ex-post) adaptation options to climate change. Concretely, this paper applies

Cumulative Prospect Theory to determine risk aversion, loss aversion, and the probability weighting function to understand risk preferences beyond risk aversion. We identified four anticipatory and four reactive adaptation options. The risk preferences parameters indicate that vineyard farmers are risk-averse and twice and a half more sensitive to losses than gains and overestimate small probabilities. The main drivers for adaptation are loss aversion, probability weighting, trust, the social norm of conservation, network, frequency of extension services, and shocks.

Our second paper focuses on the effect of adaptation options to climate change (anticipatory or reactive), risk preferences (risk aversion, loss aversion, and probability weighting), and social capital forms (trust, network, and social norms) on technical efficiency. To estimate technical efficiency, we first estimate the production function through a Cobb-Douglas function identifying that capital, the number of vines per main variety, labor, and agrochemicals are the most important inputs. Our sample has a mean technical efficiency index of 0.73, indicating that farms could improve their performance by 27%. We find that from the four anticipatory measures, only irrigation and management significantly affect efficiency. Irrigation contributes positively, while management decreases efficiency. Farmers in our sample overweight small probabilities; therefore, they tend to overuse cultural practices in stages during the unnecessary production process. Overall, we find that adopting reactive adaptation options does not significantly affect technical efficiency, which could be explained by the timing of implementation. Reactive anticipatory measures are implemented after a shock. Therefore, even though they could positively increase the efficiency level, the loss due to the climate-related shock reduces the contribution of the reactive adaptation option. Another key finding regarding social capital is the positive effect of general trust and membership on efficiency. Grape farmers have a solid and well-established organizational structure. If a farmer is a member of a farmer organization is more likely that he could have access to information about prices, weather information, training programs, and even private extension services. Finally, risk aversion negatively influences risk-averse farmers as they tend to avoid changes in technologies or practices, even more when these activities are expensive.

The dissertation provides lessons for designing policies and strategies that focus on facilitating accessibility to exchangeable inputs and promoting the provision of extension services to a broader area. Additionally, facilitate access to irrigation through subsidies and credits, improve trust in programs and networks and develop cooperative enterprises or local and horizontal organizations to share information and services from farmer to farmer. Finally, it is important to generate action plans to improve risk and loss behavior, seize technological and economic opportunities, and not overestimate extreme events.

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Chapter 1. Introduction

1. Climate change effects on small farm agriculture

Agriculture is a major economic activity expected to increase its production by 50% to feed a planet of 9 billion people by 2050 (Alexandratos et al., 2012; Le Mouël and Forslund 2017; Nelson 2010). The agricultural sector will continue to face a multitude of challenges to meet this increasing demand for food, from its vulnerability to scarce water availability and supply to extreme daytime temperatures (~30°C) and extreme climate events (e.g., heavy rainfalls) (Mainuddin et al., 2011; Noble et al., 2014; Smit and Wandel, 2006). Gourdji et al. (2013) suggest that critical high temperatures could lead to losses in production if the variability happens during the reproductive period; it is estimated that around 1-2 percent in crop yields have already been lost due to climate change (Gourdji et al., 2013; Wiebe et al., 2015). Agriculture must adapt to climate change to continue providing ecosystem services on which many communities depend (Feulner 2017; Wiebe et al., 2015; Chen et al., 2016; C et al., 2009).

Adaptation is a continuous process of adjustments to known and projected changes in climate and the externalities due to these changes (Field et al., 2014). In other words, adaptation means that farmers must change how they have traditionally cultivated their crops by changing practices, implementing new technologies, improving their managerial skills, and understanding climatic information to reduce their risk and vulnerability to the potential damages associated with climate change (Smit and Pilifosova, 2003).

Farmers play a central role in the adaptation process as they decide on changes in agricultural practices and management styles, among other things. These changes might lead to better outcomes, but for many farmers, there are major challenges to implementation due to uncertainty and changes in environmental conditions and market prices, difficulties in managing risk, and the increasing competition for land, water, and energy (Godfray et al., 2010; Howden et al., 2007; Mainuddin et al., 2011). Smallholders and subsistence farmers are more vulnerable due to their reliance on agriculture and ecosystem services for their livelihoods (Hannah et al., 2017). Therefore, small farmers will be more strongly affected by weather shocks as they have less capacity and means to adapt (Akter et al., 2016; Sibiko et al., 2018) and because the adaptation process requires resources that could be used for other purposes (Chen et al., 2016; Mendelsohn and Dinar, 1999; Nelson, 2010). Farmers' adaptation patterns can be better understood if we study how farmers react to different levels of risk under measurable uncertainty. Risk preferences are an important factor in a farmer's selection of adaptation options (e.g., technologies and innovative activities), as shown in several risk experiments explaining farmers' risk preferences (Cardenas and Carpenter, 2000; Liu, 2013; Tanaka et al., 2006). Nonetheless, theoretical and empirical studies have shown that conventional measures of risk preferences do not fully describe decision behavior (Lebel and Lebel, 2018; Tversky and Kahneman, 1992).

Social capital also plays a significant role in the process of adaptation in risk management through farmers' networks that facilitate the exchange of information and enrich the learning process when adopting new technologies. Generally, it can be said that, given high levels of trust in institutions, the higher the social capital, the less vulnerable farmers are (Adger, 2003, 2001). With this and other factors in mind, adaptation in the agricultural sector should be addressed more coherently (Howden et al., 2007). Appropriate policies intended to stimulate efficient transformation should not exclusively rely on the assumption of the rational farmer but take advantage of findings from behavioral economics (Osberghaus, 2017). This dissertation joins the debate on behavioral economics in climate change adaptation by using survey data and behavioral experiments to understand farmers' adaptation decisions and the effect of these decisions on technical efficiency.

2. Social capital, risk preferences and technical efficiency when adapting to climate change

We conceptualize decision-making by analyzing small-scale vineyard farmers' behavior when adapting to climate change in central Chile; this means adjusting their practices, management, and processes in response to changes in climate IPCC (2014). There are different typologies of adaptation depending on the intention, the temporal scope (short- or long-term), and the timing of the action (anticipatory (ex-ante) or reactive (ex-post)) (Biagini et al., 2014). Anticipatory adaptation consists of those actions seeking to avoid or reduce the effects of climate change and those facilitating recovery from negative impacts. In contrast, reactive adaptation refers to actions implemented in response to climate-related events that help the farmer handle the negative impacts (Biagini et al., 2014). This dissertation focuses on adaptation depending on the timing of the action; specifically, we use the classification of anticipatory and reactive adaptations as highlighted by Biagini et al. (2014) and identified by Smit et al. (2000).

Concerning the decision-making process Adesina and Baidu-Forson (1995), Adesina and Zinnah (1993), Barlett (2016), Edwards-Jones (2006), and Prokopy et al. (2008) among other scholars identified that farmers' decision-making is determined by a range of aspects such as socioeconomic characteristics, the farmers' context and resources available. Furthermore, Deressa et al. (2009) and Di Falco et al. (2011) identified access to credit, markets, information on climate change, and extension services as key factors influencing the decision to adapt. In the context of climate change, key aspects such as risk preferences and social capital play an important role (see Figure 1. Conceptual framework) since the farmer must invest now to reduce their vulnerability to climate change and to reduce the effect of uncertain negative effects in the future (Bernedo and Ferraro, 2016). Figure 1 provides this dissertation's overall conceptual framework, showing the links among risk preferences and social capital to the farmer's decision-making process (adopt anticipatory and reactive adaptation options) and how these decisions affect the overall performance measured regarding technical efficiency. The effect of risk preferences and social capital are analyzed in the context of a standard agricultural production process, which requires key resources such as land, capital, labor, technologies implemented previously to any climate shock, water, and access to extension services, information, and credit, among others.

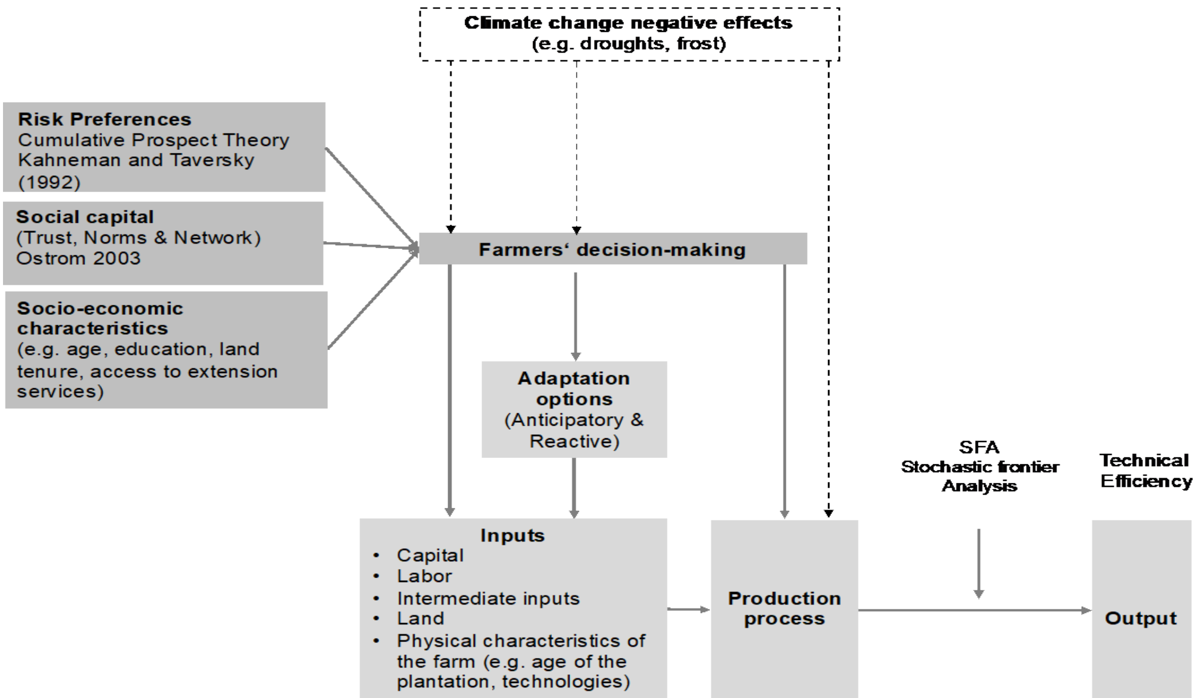

Figure 1. Conceptual framework

In this dissertation, we applied the Cumulative Prospect Theory (CPT) framework to model decisions under risk as proposed by [1]. CPT was preferred over Expected Utility Theory (EUT) (Von Neumann and Morgenstern, 1947) because if climate change is essentially about losses and farmers are loss-averse, the shape of the probability weighting function will influence adaptation decisions. Specifically, in the EUT framework, risk aversion is characterized by a concave utility function and the individuals' aversion to the variability of outcomes. In other words, the EUT framework suggests that a farmer's decision-making process in adopting a technology in response to a climate change shock depends on the technology's effectiveness and the risk associated with future climate change or production risk. However, empirical studies have shown that if this were the case, many farmers would have already bought climate-related insurance against natural disasters. In light of this, we propose that the CPT framework is more suitable for analyzing the role of risk preferences when farmers adapt to climate change because of the following: first, it extends the concept of risk aversion from EUT by allowing preferences to depend on the sign of the outcomes, i.e., gain or losses. Secondly, it will enable the transformation of the cumulative distribution of the objective probabilities so that the outcomes are weighted differently through the probability weighting function (pwf) (Bernedo and Ferraro, 2016b; Osberghaus, 2017; Salazar and Rand, 2016; Tversky and Kahneman, 1992). As Köbberling and Wakker (2005) highlighted when the reference point is considered, the utility and probability weighting functions vary depending on the outcome (gain or loss); thus, the analysis requires separating the basic utility, the probability weighting, and loss aversion.

Concerning social capital, we applied the scientific conceptualization of Ostrom (2007), where social capital is defined as "*an attribute of individuals and of their relationships that enhance their ability to solve problems."* We focus on the three forms of social capital: trust, norms, and networks . In the forms of trust, norms, and networks, social capital is considered a driver of behavior (Adger, 2003, 2001; Narayan and Cassidy, 2001; Ostrom, 2007). Specifically, social capital contributes to the understanding of adaptation to climate change decisions because adaptation is a dynamic process embedded in a social system, in which individual success depends partly on how farmers work together to face the negative effects of climate change

[1] An extended comparison of the theoretical framework to model risk and time preferences is presented in Bernedo and Ferraro (2016).

(Adger, 2003, 2001; Ostrom, 2014). High levels of social capital increase the effectiveness of agricultural trade because this can reduce transaction costs; high levels of trust facilitate the exchange of information (Fafchamps and Minten 2001; Hunecke et al., 2017). According to Narayan and Cassidy (2001), there are variations in how social capital is measured because the concepts are inherently abstract, and their interpretations are diverse.

First, we conceptualized trust following Khalil (2003). Trust is defined as the confidence in the reliability of others; we applied two distinctions: 1) institutional trust is how much the farmer trusts in institutions (Government, extension services), and (2) general trust is how confident the farmer is that he can count on his community members in case of need (Lyon, 2000). Second, norms are informal rules that govern behavior in a community; this is an unobservable form of social capital captured by the farmer's expectation of how he must behave in specific circumstances (Bicchieri and Muldoon 2014; Czajkowski et al., 2017; Elster 2000). In the context of climate change, norms are key when adopting technologies, as the farmer may feel the pressure to adopt certain technologies due to the social norm in the community (Chen et al., 2012; Ibanez 2008). These norms are captured through different statements from the farmer's perspective on how he believes he is expected to act. Third, the network is conceptualized following Maertens and Barrett (2013), who define a social network as the links among individuals through which information, financial resources, goods, or services flow. Networks facilitate adaptation to climate change through their contribution to the learning process of adopting new technologies and reducing transaction costs for the flow of information as farmers learn from their peers (Wollni et al., 2010; Murendo et al., 2017; Foster and Rosenzweig 1995). Networks are especially important in developing countries where extension, financial, and information services are underprovided (Murendo et al., 2017). An extensive social network also helps the farmer manage risk, as he might have access to meteorological information and training on how to use this information (Adger, 2001). Individuals can generate networks over time by building connections to access credit, share information, and train or implement new technologies (Deepa Narayan and Cassidy, 2001).

The decision-making process has implications for the overall output of the farm. Consequently, the analysis of adaptation to climate change is not limited to the determinants of the decision to adapt but also how these decisions and preferences influence performance. To assess producers' performance, we use the notion of Technical Efficiency (TE), which measures the distance to a production frontier (Kumbhakar and Lovell, 2003). By applying TE analysis, it is possible to identify producers operating technically efficiently (operating on their production function) and technically inefficiently (operating below their production frontier). Figure 1 presents the transformation of inputs (e.g., labor, capital) into outputs (measured in Kilograms); in this study, we use the Cobb-Douglas production function as a functional form to estimate the relationship between the inputs and the output. We applied the Stochastic Frontier Analysis (SFA) for the efficiency analysis to assess the stochastic frontier production and the efficiency relative to this frontier (Kumbhakar et al., 2015). The stochastic frontier production function gives the maximum possible level of output (and the model includes a composed error term), which considers technical inefficiency and random error (Kumbhakar et al., 2015; Kumbhakar and Lovell, 2003). Kumbhakar (2002) states that risk plays a key role in input use affecting the output from the process. Kumbhakar (2002) considers production risk and the attitude towards risk in a generalized technical efficiency model. In line with this, we include risk preferences in the model but apply CPT to estimate these risk preferences. According to Reidsma et al. (2010), when adaptation options are considered in the technical efficiency analysis, socioeconomic conditions and farm management are often ignored, but these influence farm performance and adaptation. Technical efficiency is also related to social capital, as the farmer depends on the flow of information and other resources through their network to implement new practices; the literature has shown that high levels of trust in institutions increased adoption levels (Abrahamse and Steg, 2013; Lyon, 2000b; Muange, 2015a; Ostrom, 2007). Therefore, by including risk preferences, the three forms of social capital, and socioeconomic characteristics to explain other sources of inefficiencies, we propose a holistic approach for designing policies that could improve the adaptation process while promoting, at the same time, increases in efficiency.

3. Research problem and objectives

This dissertation joins the debate on behavioral economics in climate change adaptation by using survey data and behavioral experiments to understand farmers' adaptation decisions and the effect of these decisions on technical efficiency. The dissertation proposes a holistic approach to analyzing farmers' adaptation to climate change by combining cross-sectional data with experiments that elicit individual preferences more efficiently.

This thesis aims to understand the role of risk preferences and social capital as determinants of adaptation options and technical efficiency in adapting to climate change in the vineyards of central Chile. Therefore, the following research questions are the core of this dissertation:

- How do small farmers' risk preferences, along with the three forms of social capital: trust, norms, and networking, affect the decision to implement anticipatory (ex-ante) or reactive (ex-post) adaptation options to climate change?
  This research examines farmers' anticipatory and reactive adaptation options and factors such as social capital forms and risk parameters that influence their decisions to adapt. To the best of our knowledge, this is the first study that disentangles how farmers' risk preferences and social capital forms (e.g., trust, norms, and networking) influence anticipatory or reactive adaptation decisions. In this study, we work with vineyards in central Chile, where the principal risk of significant losses is temperature variability and lack of access to water.
- How do adaptation options to climate change (anticipatory or reactive), risk preferences (risk aversion, loss aversion, and probability weighting), and social capital forms (trust, network, and social norms) affect the technical efficiency of small vineyards farmers adapted to climate change in central Chile?
  Empirical evidence shows the key role of adaptation practices, risk preferences, and social capital related to the technical efficiency of productive systems on a one-to-one basis. Therefore, this study combines the analysis of the effect of social capital, risk preferences, and adaptation options on technical efficiency.

Concretely, this dissertation contributes to the literature in three key aspects: 1) we apply Cumulative Prospect Theory to determine risk aversion, loss aversion, and the probability weighting function to understand their effect on technical efficiency; 2) we extend the analysis of the role of social capital by including trust and social norms in addition to social network; 3) we incorporate in the analysis the effect of adaptation options on technical efficiency.

4. Study area and data

This research took place in the two most important regions for the cultivation of grapes in Chile: Region VI of O'Higgins and Region VII of Maule. Region VI of O'Higgins has 34.44% (47,382.07 ha) of the total land under grape cultivation, while Region VII of Maule cultivates 38.88% (53,496.51 ha) of Chile's total grape-growing area (ODEPA, 2017). These areas represent 73.32 % (100,878.58 ha) of the total vineyard area in the country (SAG, 2014)[2].

[2] Chile has an area of 137,592.44 hectares dedicated to the cultivation of vineyards.

Therefore, these regions are critical for studies on the effects of climate change on farmers and their products and the best adaptation options that can be implemented. For data collection, we applied a cross-sectional survey and an artefactual field experiment to elicit risk preferences.

4.1 Cross-sectional survey[3]

We selected farmers based on a database from the University of Talca, Chile. This original dataset was collected from November 2014 through February 2015 and consisted of 452 grape farmers from the Region VI of O'Higgins and Region VII of Maule; it is a cross-sectional dataset with socioeconomic, irrigation systems, production, and social capital variables. From this database, we randomly selected 163 small vineyard farmers distributed proportionally in the regions of O'Higgins and Maule, located in 16 communities.

4.2 Artefactual field experiment[4]

We performed an artefactual field experiment in 16 communities[5] from Region VI of O'Higgins and Region VII of Maule, central Chile. We worked with a team of four interviewers or enumerators on a sample size of 175 farmers who were selected randomly. The main instruments to collect the information were a survey experiment[6] and an exit survey. These experiments were incentivized to reveal risk preferences from grape farmers; in other words, a payoff was given to farmers. We applied the experimental procedure based on Tanaka et al. (2010), Liu (2013), and Ward and Singh (2015). To elicit the risk parameters from the Cumulative Prospect Theory (CPT), we implemented three independent series of lottery-based experiments using a Multiple Price List format. According to Andersen et al. (2006), the Multiple Price List (MPL) format is easier to understand for the participants and provides simple incentives to elicit real choices.

[3] The complete survey is available in Appendix 1.

[4] The complete protocol of the artefactual field experiment is available in Appendix 2.

[5] Specifically, the study was applied in the following communities: Rancagua, Santa Cruz, Palmilla, Peralillo, Requinoa, Chimbarongo, San Vicente, Peumo; from Region VI of O´Higgins; and San Javier, Sagrada Familia, Curico, Villa Alegre, Talca, San Clemente, Maule, Rio Claro (Cumpeo) from Region VII of Maule.

[6] The survey experiment took 40 minutes to complete with each individual.

In this case, vineyard farmers had to choose option A or B in three series. Series 1 and 2 contained 14 choices each and were offered to elicit the risk aversion and probability weighting parameters. For example, in Series 1, the option with less risk was option A with a secure payment of 1,200 Chilean pesos. Option B represented more risk, offering a 10% probability of winning a monotonically increasing payment and a 90% probability of winning a lesser reward of 600 Chilean pesos. Series 2 had the same structure as Series 1 but increased the secure payment in option A. Option B offered a 70% probability of winning an incremental payment and a 30% probability of winning a lesser reward of 500 Chilean pesos. In Series 3, seven different lotteries were offered to estimate the loss aversion parameter λ. Each lottery offered a winning option (with a positive payoff) and a losing option (with a negative payoff), varying the probabilities in each lottery and enabling the estimation of a minimum and maximum loss aversion coefficient. In Series 3, we defined the same probability for winning and losing in each lottery, thus, having the same probability weighting function.

We applied the midpoint method by Tanaka et al. (2010) to estimate the risk, probability weighting, and loss aversion parameters. Further details of the experimental design and procedure are presented in Chapter 2.

4.3 Exit survey

The exit survey collected socioeconomic, sociodemographic, and productive information. In addition, it was used to identify general problems and those related to climate change, the type of adaptation (anticipatory or reactive), and the adaptation options they use in each case, and finally, to identify variables of social capital such as networks, subjective norms, and trust.

5. Dissertation outline

This dissertation is comprised of two essays and is organized as follows. Chapter two presents the first essay, analyzing risk preferences and social capital's causal relation to adaptation behavior. Chapter three presents the second essay, analyzing the effect of risk preferences and social capital on the technical efficiency of small vineyard farmers. Finally, Chapter 4 provides the overall conclusion and discusses implications, limitations, and areas for further research.

Chapter 2. Understanding how risk preferences and social capital affect farmers' behavior to anticipatory and reactive adaptation options to climate change: the case of vineyard farmers in central Chile

Enrique Alvarado [a], Marcela Ibañez [b]

[a] Department of Agricultural Economics and Rural Development, Georg-August-University Göttingen, Germany

[b] Research Centre, Equity, Poverty and Growth, Georg-August-University Göttingen, Germany

Abstract

The potential effects of climate change on global agriculture have been widely studied. However, it is necessary to keep studying the responses that systems and farmers can have to climate change effects. One of these responses is adaptation. In this paper, we have used anticipatory and reactive adaptation because we wanted to know if farmers prefer options to avoid or minimize potential problems or if they prefer to face the straight negative effect of climate change. In this regard, it was necessary to identify the main drivers of farmers' decisions to adapt to climate change. In this context, risk preferences and social capital are essential to the decision-making process. The general objective of this research was to understand how small farmers' risk preferences, along with social capital forms such as trust, norms, and networking, affect the decision to implement anticipatory or reactive adaptation options to climate change. This will provide recommendations to develop policies focusing on adaptation strategies and improving farmers' welfare. This study took place in the two most important regions for the cultivation of vineyards in Chile (O´Higgins and Maule); data were collected through a field experiment and an exit survey from September to December 2016. We conducted a field experiment to elicit the risk preferences of 175 small vineyard farmers; we used the structural and midpoint methods to estimate the Cumulative Prospect Theory (CPT) parameters and social capital variables. Finally, we identify four anticipatory and four reactive adaptation options. The risk preferences parameters indicate that vineyard farmers are risk averse and twice and a half more sensitive to losses than gains and also overestimate small probabilities. The main drivers for adaptation are loss aversion, probability weighting, trust, the social norm of conservation, network, frequency of extension services, and shocks.

Keywords: Adaptation to climate change, Risk preferences, Cumulative Prospect Theory, Social Capital, Vineyard farmers

1. Introduction

The potential effects of climate change on global agriculture have been widely studied , because the agricultural sector is highly vulnerable to changes in rainfall, temperature and to extreme weather events. In this context, agriculture must adapt to climate change, understanding adaptation as a process that reduces vulnerability by implementing changes from different stakeholders at different levels, from the implementation of climate-smart policies to adjustments at the farm level led by the farmers (Noble et al., 2014; Tompkins et al., 2010).

Studies from Bradshaw et al. (2004), Howden et al. (2007), Jianjun et al. (2015), and Niles et al. (2016) highlighted the negative effect on farmers' welfare due to climate change (e.g., increase in diseases and pests, structure and physiognomy of the crops). Therefore, farmers need to increase their resilience[7] to climate variability by implementing adjustments (e.g., processes, practices, structures) at the farm in anticipation or response to positive or negative changes in climate (Noble et al., 2014; Smit and Pilifosova, 2003). Smit et al. (2000) and Biagini et al. (2014) reviewed different types of adaptation, identifying that adaptation could be categorized by (1) the timing of implementation of the action; (2) temporal scope; (3) the intention of the action; (4) the form they take and (5) the spatial scope or institutional extend. In this paper, we use the typology based on the timing of the action, which has two sub-classifications: anticipatory (ex-ante) or reactive (ex-post). Anticipatory adaptation refers to actions to build up resilience at the farm; in other words, the farmer implements actions anticipating a climate-related shock, while reactive adaptation is implemented after a climate change stimuli (Bruin and Chloe, 2011). Based on Smith et al. (1996) and Lecocq and Shalizi (2007), we used the timing of the actions for the following reasons: (1) many anticipatory measures will produce benefits even if the climate does not change; (2) least-cost policy responses to climate change are based on investment in ex-ante (anticipatory) adaptation options (Agrawala et al., 2011); (3) low adaptation rates, changes being made in agriculture are still insufficient to increase production under projected levels of climate change (Thornton et al., 2018); and (4) lack of studies analyzing determinants of adoption of anticipatory adaptation, especially by small farmers. In this regard, it is essential to know what determines the type of adaptation and the adaptation options (set of measures, actions, or activities) that

[7] According to Smit et al. (2000) resilience refers to the degree to which a system can recover from a climate-related stimulus.

farmers implement. Thus, Governments can design effective policies to increase farmers' resilience to climate change.

Thus far, the literature has focused on identifying the determinants of adaptation to climate change in general without making the distinction between the different categories (Deressa et al., 2009; Hassan and Nhemachena, 2008; Smit and Wandel, 2006), concluding that lack of information and financial means, access to markets, extension services, technology and farm assets (labor, land, and capital) are among the main constraints for adaptation. Few studies have distinguished anticipatory and reactive adaptation options applying participatory stakeholder-based approaches. For instance, Reid et al. (2007) performed 25 interviews and four focus groups in Ontario, identifying that non-climatic forces influence the decision-making process to adopt anticipatory options. For instance, those farmers more apprehensive and aware of climate-related risks are more prompt to think in the long-term and to take anticipatory actions; in addition, they found that risk management preferences, cost of the technologies, social capital and access to extension services are relevant to the perceived capacity to face climate change. Nicholas and Durham (2012) provide Insights from winegrowing in Northern California; based on 20 interviews with winegrowers, they showed that farmers make decisions relying heavily on their individual experience and preferences; farmers with longer years of experience adopted anticipatory adaptation options, and they deal with vineyard stresses individually. These studies highlighted the need for further research in causal relationships, with a robust econometric basis analyzing the role of individual preferences and social context on farmers' decisions to anticipate or react to climate change.

In this line of thought, and understanding adaptation as a process partly where the farmer decides on investments now for uncertain negative effects in the future, it is not surprising the influence of risk preferences on the decision to anticipate or react to certain events and innovative especially for small farmers (Bernedo and Ferraro, 2016; Nielsen et al., 2013). Feder (1980) showed that farmers' managerial decisions are influenced by risk preferences, from input used to adopting modern technologies. Nonetheless, he also points out that these risk preferences (risk and risk aversion) should be further analyzed as their effect depends on the region and differences within social systems (e.g., levels of social capital). Empirical studies applied Expected Utility Theory (EUT) to measure risk attitudes; but in this dissertation, we applied the framework of Cumulative Prospect Theory (CPT) to model decisions under risk as proposed by Tversky and Kahneman (1992). CPT was preferred over Expected Utility Theory (EUT) because if climate change is essentially about losses and farmers are loss-averse, the shape of the probability weighting function will influence adaptation decisions, and if a reference point is considered, the utility and probability weighting functions vary depending on the outcome (gain or loss) (Bernedo and Ferraro, 2016; Köbberling and Wakker, 2005). In this regard, the literature has several risk experiments that explain and test different methodologies for the measurement of farmers' risk preferences (Alpizar et al., 2011; Binswanger and Sillers, 1983; Bocquého et al., 2014; Liu, 2013; Tanaka et al., 2010; Ward and Singh, 2015). Jianjun et al. (2015) showed that risk-averse farmers are less likely to adopt adaptation strategies such as planting new crop varieties and adopting new technology, but they are prompt to engage in a weather index crop insurance. The study also highlights the role of socioeconomic characteristics (e.g., education, experience in agriculture) and perception of climate change impacts influencing farmers' adaptation decisions. Liu (2013) applied prospect theory to measure risk preferences; her study shows that adopting an improved variety (Bt cotton) was delayed by risk-averse farmers, while farmers who overweight small probabilities were early adopters of Bt cotton. Building on previous studies, we expand the behavioral literature by analyzing determinants of anticipatory and reactive adaptation options by considering risk preferences and by measuring risk preferences by applying Cumulative Prospect Theory.

Another key factor in farmers' adaptation decisions is social capital, in the forms of trust, norms, and networks, because adaptation occurs in the context of social systems where flows of capital and labor, information, and social capital are interconnected to reduce the individual but also collective vulnerabilities towards climate change (Adger et al., 2005; D. Narayan and Cassidy, 2001; Ostrom, 2007). Farmer's resilience to climate change is partly based on their ability to trust community members, exchange information within their network, and respect the informal rules of behavior within the community; when social capital is high, their vulnerability to a climate-related shock is lower (Adger, 2003). In this sense, for the analysis of the role of social capital, we follow the three forms proposed by Hawkins (2007) and Ostrom (2007): (1) trustworthiness, (2) network, and (3) formal and informal rules of institutions, but studies on technology adoption have focused on the second form of social capital: networks. Hasson et al. (2010) highlighted that high levels of trust enhance cooperation and contribute to increasing adaptation options in the context of adapting to climate change. Still, it will also reduce farmers' vulnerability in case of a shock. In addition, any action in a community is constraint by the social structures, informal rules, and regulatory structures; therefore, the social context influences the individual adaptation behavior (Adger et al., 2005; Akerlof and Kranton, 2005; Lynne et al., 1995). A social network is a form of social capital that facilitates the exchange of information and financial resources and contributes to building self-confidence; strong networks facilitate the response to adverse climate change effects and the establishment of social norms on pro-environmental behavior (Abrahamse and Steg, 2013; Bicchieri and Mercier, 2014; Chow and Chan, 2008). Because of this, it is basic to fully understand how the forms of social capital influence the process of adaptation to climate change.

This research aims to understand how small farmers' risk preferences, along with social capital forms such as trust, norms, and networking, affect the decision to implement anticipatory (ex-ante) or reactive (ex-post) adaptation options to climate change. This will provide recommendations to develop policies focusing on adaptation strategies and improving farmers' welfare. The hypotheses of this study are **H1:** The Cumulative Prospect Theory (CPT) risk preferences parameters, the curvature of the value function (risk aversion), loss aversion, and probability weighting are affected by socioeconomic variables, physical characteristics of the farm, and social capital forms; **H2:** Risk and loss averse farmers will implement anticipatory adaptation options against negative effects of climate change (i.e., scarcity of water, frost, diseases and pests effect), but risk and loss lovers farmers will implement reactive adaptation options; and **H3:** Farmers with low confidence in institutions, poor networking, and strong negative social norms, along with high levels of risk and loss aversion are less likely to adopt anticipatory options. This research examines farmers' anticipatory or reactive adaptation options and factors such as social capital forms and risk parameters that influence their decisions to adapt. In this study, we work with vineyards farmers of central Chile, in the two most important regions for the cultivation of vineyards because they represent 73.32% of the national production (SAG, 2014), and where the principal risk of large losses is due to temperature variability and lack of access to water. To the best of our knowledge, this is the first study that disentangles how farmers' risk preferences and social capital forms (e.g., trust, norms, and networking) influence anticipatory or reactive adaptation decisions with a robust econometric analysis.

This paper is structured as follows: Section 2 presents the theoretical framework for adaptation to climate change, risk preferences, and social capital. Section 3 describes the study area and methodology, including experimental design and econometric model, and Section 4 presents the preliminary results and Section 5 conclusions.

2. Theoretical framework

2.1 Adaptation to climate change: typologies, options, and determinants

Adaptation is when groups, governments, and individuals implement changes in management styles, technologies, policies, norms, and general behavior in response to climate change. These changes aim to minimize people's vulnerability to the adverse effects of climate change (Bradshaw et al., 2004; Smit and Wandel, 2006). In agriculture, adaptation occurs when adjustments are in response to a climate-related stimulus[8]. reviewed the literature identifying that adaptation can be typified depending on: a) The intention of the action in response to a stimulus (planned or spontaneous; b) The timing of the action, whether it occurs ex-ante (anticipatory) or ex-post (reactive) to a climate-related stimulus; c) The timeframe of the action, depending if it is a plan for short-term or longer-term benefits; d) the coverage of the action if it is localized or widespread; and e) The form that the action takes, which could imply changes in behavior, the flow of information, techniques used for the production or institutional arrangements.

The strong emphasis on adaptation raised questions, especially about how and what type of adaptation should be supported by policymakers concerning regulations and allocation of funds. In this regard, the precise definition of the type of adaptation is most relevant. Lecocq and Shalizi (2007) emphasize that to balance the allocation of funds among the many strategies concerning mitigation and adaptation, it is essential to define which strategies will provide the highest returns regarding reducing vulnerability and increasing resilience. They have pointed out the anticipatory measures provide the highest positive effects even if a climate-related shock does not happen. Also, some anticipatory options do not require as high investments as mitigation or reactive options, mainly because they focus on lowering the costs of coping ex-ante. In this sense, this research focuses on the timing of the action. Anticipatory adaptation refers to actions aiming at minimizing or considerably reducing the effects of adverse effects of climate change. While reactive adaptation refers to those actions implemented after a climate-related shock has occurred (Bruin and Chloe, 2011; Smith et al., 1996).

[8] Climate-related stimuli refers to changes in temperature or precipitation (e.g. droughts, long-term trends)., but it also considers isolated extreme events (Smit and Wandel, 2006).

To provide a clear understanding of anticipatory and reactive options, it is necessary to identify which options help farmers to be less vulnerable to climate change. Field et al. (2014) identifies three categories of adaptation options: structural/physical, social, and institutional. *Structural/physical options* include a) Engineering and Built Environment (e.g., water storage, pump storage, and improved drainage); b) Technological options (e.g., modern irrigation and fertilization methods, new crop varieties, rainwater harvesting); c) Adaptation based on ecosystems (e.g., afforestation and reforestation, bushfire reduction and prescribed fire, green infrastructure, and ecological corridors); and d) Service options (e.g., water and sanitation and vaccination programs). On the other hand, *social options include* a) Educational options (e.g., extension services, sharing local and traditional knowledge); b) Informational options (e.g., vulnerability assessment, risk modeling); and c) Behavioral options (e.g., livelihood diversification, planting dates, exchange of information within the social network). Finally, *institutional options include* a) Economic options (e.g., taxes and subsidies, insurance, payments for ecosystem services, and water tariffs); b) Laws and regulation options (e.g., record and sharing procedures of meteorological data, regulation for water use, protected areas declarations); and c) Government policies and programs (e.g., national, and regional adaptation strategies, warning systems, vulnerability assessments, emergency response plans, and sector plans).

Literature has analyzed which adaptation options are most used in agriculture. For instance, Bryan et al. (2009) and Deressa et al. (2009) identified that farmers most commonly adapt by using different crop varieties, changing planting dates (early and late planting), irrigation, planting trees, and soil conservation. However, Di Falco et al. (2011) explain that soil conservation is one of the most critical adaptation strategies, while Hassan and Nhemachena (2008) identified crop and livestock management practices and water conservation as the most used adaptation options.

Regarding the determinants of adaptation options, literature has studied adaptation more generally, concerning the determinants of adaptation options by the farmers without specifying any typology. Several studies support the role of socioeconomic characteristics (e.g., age, sex, education), access to extension services, credit, market, information on meteorological data, access to fertile land, wealth, social capital, type of agriculture (e.g., subsistence) as determinants of adaptation measures (Bryan et al., 2009; Deressa et al., 2009; Di Falco et al., 2011; Hassan and Nhemachena, 2008; Lynne et al., 1995; Niles et al., 2016). Only a few have distinguished between anticipatory and reactive adaptation using participatory approaches describing how and what the farmers have identified as the reasons to adopt specific measures. Bryan et al. (2009) and Hassan and Nhemachena (2008) identified that previous experience with a climate-related shock facilitates the adoption of farm-level adaptation strategies. Also, Nicholas and Durham (2012) describe that winegrowers from Northern California relied primarily on their personal experience and trusted personal contacts; then, they rely on information from the public (university and government), and lastly, they benefit from information coming from private sources including consultants and grower associations. Reid et al. (2007) describe that farmers in Ontario decide to implement anticipatory adaptation options if they have had previous experience with a climate-related shock; farmers with more experience with the crop are also more like to be open to investments that will provide benefits in the long-term.

2.2 Adaptation to climate change and risk preferences

According to Errington (1995), farmers confront different types of uncertainty related to a) Natural hazards (this refers to the unpredictable impact on the output of climate, pests and diseases, and other natural calamities); b) Market fluctuations or market risk (price uncertainty, lack of information, imperfect markets); c) Social uncertainty (caused by differences of control over resources, i.e., high level of uncertainty concerning land access or behavior of the moneylender); and d) State actions and wars (decisions by agencies of the state may chop and change from one moment to the next, or insecurity and armed struggle). Farmers face these types of uncertainty and risks (when probabilities are known), but as described in the previous section, previous experience with adverse effects from climate change influences adopting adaptation practices (Bryan et al., 2009; Reid et al., 2007). Understanding adaptation as a process partly where the farmer decides on investments now for uncertain negative effects in the future, individual preferences become more relevant, especially those related to risk, on the decision to anticipate or react to certain events, and innovation, especially for small farmers (Bernedo and Ferraro, 2016; Nielsen et al., 2013). Feder (1980) showed that farmers' managerial decisions are influenced by risk preferences, from input used to adopting modern technologies. Alpizar et al. (2011) have also highlighted that to understand adaptation patterns truly, it is necessary to explore how farmers react to different levels of risk. Alpizar et al. (2011) and Kumbhakar (2002) have identified that risk and risk aversion are essential when the farmer decides regarding technology and inputs for the production in its farms. There are different behavioral patterns according to the differences in regions (i.e., cultural, social, economic), and therefore risk and risk aversion must be analyzed considering the characteristics of the social system where the farmer is embedded . In this context, it is necessary to investigate which factors drive farmers' decisions to adopt anticipatory and reactive measures to climate change.

Several behavioral experiments explain the measurement of risk aversion or risk attitudes of farmers to explain differences in input use and rates of adoption of modern technologies by heterogeneous farmers in terms of size (Alpizar et al., 2011; Binswanger and Sillers, 1983; Bocquého et al., 2014; Cardenas and Carpenter, 2008; Kumbhakar, 2002). Jianjun et al. (2015) implemented a study in China to analyze risk aversion when Chinese farmers decide on which adaptation strategies to adopt. She used the risk aversion parameter in the econometric analysis and identified that more risk-averse farmers (or those that preferred the safe option more times) were less likely to adopt new technologies or plant new crop varieties; nonetheless, risk-averse farmers were more likely to engage in the acquisition of a weather index crop insurance.

Bocquého et al. (2014), Liu (2013), Tanaka et al. (2010), and Ward and Singh (2015) are among the few studies that have applied Cumulative Prospect Theory (CPT) as proposed by Tversky and Kahneman (1992), this approach differs from the Expected Utility Theory (EUT) as it proposes that the shape of the utility function is determined simultaneously by risk aversion, loss aversion and nonlinear probability weighting (pwf). Loss aversion refers to the farmers' sensitivity to loss compared to gain, while the pwf refers to the farmers' tendency to overweight small (large) probabilities and underweight large (small) probabilities) (Liu, 2013). Liu (2013) applies the framework to Chinese farmers in the decision to adopt Bt cotton, finding that Chinese farmers are more sensitive to loss than gain, meaning that risk-averse farmers delayed adopting Bt cotton, while farmers that overweighed small probabilities of adopting Bt cotton earlier.

Farmers face the risk of losses due to the adverse effects of climate change. Therefore, it is essential to analyze the determinants of anticipatory and reactive adaptation options by applying an approach in which we can account for farmers' loss aversion, risk aversion, and farmers' tendencies to weight probabilities. The Cumulative Prospect Theory (CPT) is the approach that we consider better fits the analysis of risk preferences under climate change. Section 3 describes in detail the design and procedure to elicit the parameters of CPT.

2.3 Adaptation to climate change and social capital

Social capital is a relevant concept in the discussion of adaptation to climate change. The literature has shown that farmers with high social capital are: 1) less vulnerable and more resilience to changes in climate; 2) prompt and self-confident when adopting new technologies; and 3) establish strong mechanisms of communication through the social network, allowing the flow of resources (e.g., information, financial) more effectively (Adger, 2003; Barr et al., 2011; Carpenter et al., 2004; Di Falco et al., 2011; Newman et al., 2014; Ostrom, 2007).

Social capital is an attribute that reveals the connection of an individual with his social surrounding (network). Thus, the farmer's level of trust in his colleagues and friends allows him to feel confident that he can rely on his network in case of need, but he also feels pressure to behave according to his colleagues and friends (Chow and Chan, 2008; D. Narayan and Cassidy, 2001; Ostrom, 2007). Although social capital has shown to be a valuable capital in rural development, it is not always easy to measure as it is considered an abstract construct not directly observable in the field and requires elicitation of individual perception, values, and beliefs (Maertens and Barrett, 2013; D. Narayan and Cassidy, 2001). In this regard, literature has proposed different dimensions or forms of social capital that provide guidance and how to approach social capital in the field. Narayan and Cassidy (2001) proposed seven dimensions of social capital: 1) group characteristics, 2) generalized norms, 3) togetherness, 4) everyday sociability, 5) neighborhood connections, 6) volunteerism, and 7) trust. Although these dimensions provide a deep understanding of social capital, it is not always feasible (concerning cost and openness from the farmers to share details of their connections) to get the detailed information required to measure each dimension.

On the other hand, Hawkins (2007) and Ostrom (2007) proposed three specific forms of social capital: trust, norms (formal and informal), and network, which are the basis of analysis in this paper. Trust refers to how much the farmer believes that the people around him care and is there for him in case of need (Berg et al., 1995; Carmeli and Spreitzer, 2009). Trust also applies to institutions; if the farmers have high levels of trust and believe that the government is promoting a beneficial policy or technology, then the farmer is more likely to support the policy and adopt the technology. Patt and Gwata (2002) identified that for farmers to believe and use weather forecast data, the forecast communicator must have had a track record of being right; otherwise, it is unlikely that the communicator will be trusted. Also, Grothmann and Patt (2005) identified that trust is associated with risk perceptions and that if farmers are risk averse and have low levels of trust in the weather forecast, forecasts are likely to have little observable value. Cassar et al. (2017) identified that after a climate change shock, the level of risk aversion is higher, and the levels of trust in the community are higher. Lastly, Smith and Mayer (2018) show that high levels of trust contribute to positive behavior and policy support.

The second form of social capital is social norms, formal and informal rules that govern behavior in a community (Ostrom and Ahn, 2003). As Jones (2015) and Ostrom (2009) highlighted, social norms could promote or constrain adaptation, as individuals' actions and behaviors adjust depending on the norms and rules established in the social system. Grothmann and Patt (2005) identified that one of the main determinants when adapting to climate change is social norms if the norm is to implement practices that reduce vulnerability. Lo (2013) shows that individual judgment is influenced by his expectation of what he believes key referrals expect from him; it does influence his behavior regarding what is right and wrong. Norgaard (2006) identifies that social denial or collective nonresponse to climate change is a barrier to adopting adaptation measures if there is collective economic interest. In this regard, if the social norm ignores the effects of climate change, this could influence how individuals weight the probabilities of occurrence of negative effects due to climate change, promoting anti-climate behavior patterns and delaying adaptation (Gifford, 2011; Jones, 2015). Trust is related to social norms; If people behave according to the social norm, this is viewed as trustworthiness which increases trust in other people (Richards, 2013).

The third form of social capital, a social network, refer to the individual links within and outside the community through which information, money, goods, or services flow (Maertens and Barrett, 2013). A social network can be seen as a mechanism to reduce transaction costs that facilitates the adoption of new technologies and, at the same time, facilitates the learning process as individuals learn from their peers, neighbor, and friends . In developing countries, with asymmetric information and where information and financial resources are limited, having a strong social network facilitates the process of adaptation (Adler and Kwon, 2002). Gifford (2011) states that social networks can induce the establishment of anti-climate or pro-climate social norms if there is a high level of trust. The characteristics of the network of the farmer are relevant because the individual reflects on his past experiences for making decisions concerning the adoption of adaptation measures (Nicholas and Durham, 2012), and behavioral economics has shown that individual experiences affect preferences related to risk and time (Cassar et al., 2017). Social networks are an essential source of information and arguably more necessary and relevant when managing risk. Local organizations, farmer groups, and environmental committees have an influence when managing weather-related risks. In some cases, these local organizations are responsible for establishing a co-management agreement for fisheries, forests, and irrigation systems. The agreements can be formal or informal; in some contexts, it is a social norm that specific institutions establish a mechanism to resolve disputes and allocate benefits, enhancing the resilience of both social and natural systems (Adger, 2001; Adger et al., 2005). Thus, in its three forms, trust, network, and social norms, social capital is relevant when analyzing the decision-making process towards the adoption of anticipatory and reactive adaptive options.

3. Methods

3.1 Area of study

Chile is divided into regions, provinces, and communes (ODEPA, 2017). This research took place in the two most important regions for the cultivation of vineyards in Chile: Region VI of O´Higgins and Region VII of Maule.

Figure 2. Map of Chile and administrative regions of interest.

For instance, Region VI of O'Higgins owns 34.44% (47,382.07 ha) under cultivation of vineyards, while Region VII of Maule owns 38.88% (53,496.51 ha). These areas represent 73.32 % (100,878.58 ha) of the area destined for vineyards in the country (SAG, 2014)[9].

Therefore, these regions are critical for studies on the effects of climate change on the farmers and their production and the best adaptation options that can be implemented. Specifically, the study was applied in the following communities: Nancagua, Santa Cruz, Palmilla, Peralillo, Requinoa, Chimbarongo, San Vicente, Peumo; from Region VI of O´Higgins; and San Javier,

[9] Chile has an area of 137,592,44 hectares dedicated to the cultivation of vineyards.

Sagrada Familia, Curico, Villa Alegre, Talca, San Clemente, Maule, Rio Claro (Cumpeo) from Region VII of Maule.

3.1 Methodology

3.1.1 Data collection

For this study, we collected the data through a field experiment and an exit survey with vineyard farmers in central Chile. We selected farmers based on a database from the University of Talca, Chile. This original database was collected from November 2014 through February 2015 and consisted of 452 vineyard farmers from the Region VI of O'Higgins and Region VII of Maule; it is a cross-sectional data with socioeconomic, irrigation systems, and production.

As mentioned in the theoretical framework, we consider the three forms of social capital in the analysis. We followed the guidelines from Narayan and Cassidy (2001) and Maertens and Barrett (2013) and included specific survey questions to measure social capital. With regards to trust, we include General and Institutional Trust. General trust was measured using the statement *"I can trust the people around me without* being too cautious,"; and institutional trust was measured by requesting farmers to express their level of trust towards agricultural associations, municipalities, public institutions, and the State of Chile using a Likert scale (from 1 to 5, 1=strongly disagree and 5 being strongly agreed). The social network was measured in two ways: 1) farmers' participation in a local organization (including water, environmental, farmer, or agricultural-related organizations), and 2) the size of the network. The network size is the number of farmers known by the participant that has implemented a specific anticipatory or reactive adaptation option (Table 2 presents the list of anticipatory and reactive options as specified by the IPCC (2012)). With regards to the social norm, we measured how committed the farmer is to follow the rules in the community by asking his opinion using a Likert scale (from 1 to 5, with 1 strongly disagree and 5 being strongly agreed) with regards to the following statement "*I always obey the laws and regulations (labor, transit, tax, etc.)*."

We randomly selected 204 small vineyard farmers from the regions mentioned above from this database because of their importance for vineyard cultivation. Afterward, we contacted these farmers by phone to determine their willingness to participate in the new research[10]. Of these 204 vineyard farmers, 22 were excluded because they no longer cultivate vineyards, and another 19 were excluded because we identified inconsistencies in the data. In the end, the study's sample size was 163 small vineyards farmers distributed proportionally in the regions of O'Higgins and Maule among a total of 16 communities.

Data were gathered from a face-to-face field experiment and an exit survey with vineyard farmers from September to December 2016. The exit survey collected socioeconomic, sociodemographic, and productive information. In addition, it was used to identify general problems and those related to climate change, the type of adaptation (anticipatory or reactive), and the adaptation options they use in each case, and finally, to identify variables of social capital such as networks, subjective norms, and trust. There were four interviewers or enumerators from the study area, and therefore they were familiar with the language, culture, and customs of small vineyard farmers.

3.1.1 Anticipatory and reactive adaptation options to climate change

The literature review identified anticipatory and reactive adaptation options, which experts enriched through semi-structured interviews. We validated the information through the exit survey (after each experiment), asking about the farmer's adoption levels regarding each option. The dependent variable was dichotomous, with the value of one when farmers adopted the anticipatory or reactive option (measure or activity).

3.1.2 Artefactual field experiment: risk preferences

To elicit risk preferences, we conducted a field experiment with 163 small vineyard farmers of two central regions of Chile (O´Higgins and Maule). The experiment was designed as an artefactual field experiment which means that the intervention took place in real life, in this case in farms with vineyard farmers, applying the scientific method and avoiding controlled conditions as in a lab (but the same quality). Also, the subjects of interest (farmers) understood that they were participating in an experiment.

[10] We did not mention that this was a field experiment and an exit survey to avoid selection bias.

3.1.3 Design of the experiment

The design of the experiment follows Ward and Singh (2015), who implemented a variation of the methodology originally proposed by Tanaka et al. (2010) and then replicated by Bocquého et al. (2014), Liu (2013), and Ward and Singh (2015)[11]. The design of the experiment simplified the choices faced by the participants and the estimation of risk premium by proposing choices between lotteries or fixed payment and a risky prospect (Ward and Singh, 2015); it is based on eliciting parameters from Cumulative Prospect Theory (CPT). CPT defines three essential parameters that have an influence on farmers' decisions under risk and that jointly describe an individual's valuation of risk prospects; these parameters are: 1) risk aversion (σ), 2) probability weighting (γ), and 3) loss aversion (λ) (Bocquého et al., 2014; Liu, 2013; Tanaka et al., 2010; Ward and Singh, 2015). Our experimental design considers a case of a risky prospect with two outcomes, x, and y, which will occur with probabilities p and q = 1- p, respectively. In this case, and based on Tanaka et al. (2010), the utility of the prospect can be expressed as:

$$U_{(x,y;p,q,\sigma,\gamma,\lambda)} = \begin{Bmatrix} v(y) + w(p)[v(x) - v(y)] & for\ x > y > 0\ or\ x < y < 0 \\ w(p)v(x) + w(q)v(y) & for\ x < 0 < y \end{Bmatrix} \quad (1)$$

where:

$$v(x) = \begin{Bmatrix} x^{\sigma} & for\ x > 0 \\ -\lambda(-x)^{\sigma} & for\ x < 0 \end{Bmatrix} \quad (2)$$

and w(p) is a probability-weighting function[12]:

$$w(p) = \exp[-(-\ln p)^{\gamma}] \text{ for } 0 < \gamma \leq 1 \quad (3)$$

Risk aversion (σ) is dictated by the concavity in the curvature of the prospect value function in the gains domain; this means that if σ < 0.5, the individual shows strong risk aversion; if 0.5< σ <0.9 implies moderate risk aversion; if σ =1 implies risk neutrality; and σ >1 implies risk-seeking behavior. This value can never be less than zero (Bocquého et al., 2014). The probability weighting (γ) parameter captures the degree to which low-probability outcomes are

[11] This design maintains the structure of the experiments from Tanaka et al. (2010), we calibrated payouts and simplify it to increase the understanding of the probabilities.

[12] Ward and Singh (2015) used the axiomatically derived weighting function proposed by Prelec (1998) and also implemented by Tanaka et al. (2010) and.

disproportionately weighted by an individual when valuing risky prospects. In other words, γ captures whether a farmer distorts probabilities of unlikely events. The standard interpretation of the value is that if γ<1, the individual overweighs low probability outcomes and underweight high probability results, expressing an inverse s-shape form. The value of γ=1 means that the individual does not distort probabilities expressing a straight line. Lastly, when γ>1 indicates that individuals underweight extreme events, the function takes an s-shape form (Tanaka et al., 2010). Loss aversion (λ) characterizes farmers' sensitivity to losses. Literature refers that farmers are more sensitive to losses than gains if λ >1; if λ <1, then they are less sensitive to losses; and λ =1 suggests that farmers are indifferent. If the probability weighting and loss aversion parameters equal 1, then risk aversion is the only parameter that defines the preferences, and the model is reduced to Expected Utility Theory (EUT) (Ward and Singh 2015).

3.2 Procedure of the experiment

Vineyard farmers played three series of lotteries with a total of 35 rounds. Specifically, series one involves 14 rounds; series two involves 14 rounds, and series 3 involves seven rounds; each round is equivalent to a selection between a riskless option A and a risky option B. These experiments were incentivized to persuade the vineyard farmers to reveal their risk preferences; in other words, a payoff was made to farmers.

For this experiment, we implemented a Multiple Price List (MPL) format as in other studies in the literature (Bocquého et al., 2014; Tanaka et al., 2010; Ward and Singh, 2015) because the format is easy to understand for farmers and allows to use incentives when eliciting choices. Farmers were presented with two bags, one black and one white; the black bag had 35 numbered balls, and the white bag had ten colored balls (green and red). Specifically, the white bag had ten green and red balls representing the probabilities of each series; for instance, three green balls represented a 30% chance of winning in option B, and seven red balls represented a 70% chance of losing in the same option. Then, at the end of the 35 rounds, we took the black bag with 35 numbered balls; each one was equivalent to one of the 35 rounds of series three. It was explained to farmers that after the 35 rounds, they had to bring out one numbered ball from the black bag, which represented the round that would be played; then, they had to bring out one ball from the white bag if the farmer had chosen option A it was a fixed payment, but if the farmer had chosen option B they got a payoff according to the probability represented by the colored ball (green for winning and red for losing).

Table 1. Payoff schedule for the three series of the experiment (parameters α and σ)[*$]

Round	Option A		Option B		Expected value difference
Series 1	Probability =1		Probability = 0.1	Probability = 0.9	
1	1200		3100	600	350
2	1200		3400	600	320
3	1200		3850	600	275
4	1200		4300	600	230
5	1200		4900	600	170
6	1200		5650	600	95
7	1200		6700	600	-10
8	1200		7600	600	-100
9	1200		8650	600	-205
10	1200		10200	600	-360
11	1200		12500	600	-590
12	1200		16000	600	-940
13	1200		21750	600	-1515
14	1200		33600	600	-2700
Series 2	Probability = 1		Probability = 0.7	Probability = 0.3	
1	4000		5600	500	-70
2	4000		5700	500	-140
3	4000		6000	500	-350
4	4000		6200	500	-490
5	4000		6500	500	-700
6	4000		6900	500	-980
7	4000		7300	500	-1260
8	4000		7700	500	-1540
9	4000		8200	500	-1890
10	4000		8700	500	-2240
11	4000		9500	500	-2800
12	4000		10500	500	-3500
13	4000		11900	500	-4480
14	4000		13700	500	-5740
Series 3	Probability = 0.5	Probability = 0.5	Probability = 0.5	Probability = 0.5	
1	10000	-2000	12000	-8500	2250
2	2000	-2000	12000	-8500	-1750
3	500	-2000	12000	-8500	-2500
4	500	-2000	12000	-6800	-3350
5	500	-4000	12000	-6800	-4350
6	500	-4000	12000	-5900	-4800
7	500	-4000	12000	-4650	-5425

[*] Design adapted from Tanaka et al. (2010), Liu (2013), Bocqueho et al. (2014) and Ward and Singh (2015). The original values from Tanaka were proportionally changed to Chilean Pesos through a conversion factor, as Carcamo (2017), but with a difference in the values of option A, round 4 from series 3 in order to follow the original values proportions from Tanaka et al. (2010).

[$] Series 1 and 2 were used to estimate σ and γ, and series 3 to estimate λ.

[&] Expected value difference = expected value of option A – expected value of option B

For instance, in series one, option A was the riskless option with a fixed payment of 1,200 Chilean pesos. In contrast, option B represented more risk offering a 10% probability of winning a monotonically increased payment, obtaining a losing award with a 90% probability of 600 Chilean pesos. Series two is parallel to series one; the difference is the higher fixed payment in option A. Option B offered a 70% probability of winning an incremental payment and a losing award with a 30% probability of 500 Chilean pesos. Because we have a fix payment in the less risky option and a fixed payment of the losing award, we expect farmers to change from option A (riskless option) to option B (risky option) at some point in the lottery. Series one and two were used to elicit σ and γ. In series three of the experiment, farmers played seven rounds, each with options A and B, but both options were risky, with a winning and losing draw. This series was useful to elicit λ. The payoff schedule for this experiment is shown in Table 1.

3.3 Estimation of risk preferences parameters

According to the literature, there are two methods for estimating the Cumulative Prospect Theory (CPT) risk preferences parameters, the structural and the midpoint method. The structural method uses the Maximum Likelihood Approach in STATA to maximize the farmers´ utility function (Andersen et al., 2006; Bocquého et al., 2014; Harrison and Ng, 2016; Harrison and Rutström, 2009). In this approach, it is possible to elicit the parameters for each participant, and it is only necessary to choose a specific group of covariates as determinants; nevertheless, this could lead to a great amount of variation.

In this research, we used the midpoint method; following Tanaka et al. (2010), Liu (2013), and Ward and Singh (2015), we take the switching points of series 1 and 2 to elicit the parameters of risk aversion (σ) and probability weighting (γ) simultaneously when valuing risky prospects. For example, if one farmer changes from Option A to B in round 7 in series one and round 20 in series 2, we should fulfill the next inequalities:

From Series 1,

$$1200^{\sigma} > 600^{\sigma} + \exp[-(-\ln 0.1)^{\gamma}]\,(5650^{\sigma} - 600^{\sigma})$$
$$1200^{\sigma} < 600^{\sigma} + \exp[-(-\ln 0.1)^{\gamma}]\,(6700^{\sigma} - 600^{\sigma})$$

From Series 2,

$$4000^{\sigma} > 500^{\sigma} + \exp[-(-\ln 0.7)^{\gamma}]\,(6500^{\sigma} - 500^{\sigma})$$
$$4000^{\sigma} < 500^{\sigma} + \exp[-(-\ln 0.7)^{\gamma}]\,(6900^{\sigma} - 500^{\sigma})$$

A range of combinations of σ and γ will fulfill the four inequalities, and therefore we estimate the upper and lower bounds of both parameters that together satisfy this criterion. We use Tanaka et al. (2010) approximations by using the interval's midpoint to one decimal place for σ and γ. The changes in series 3 define the λ.

For instance, if a farmer switches from Option A to B in round 33, we infer the utilities derived from Option A and B in round 33 are the same. Finally, the λ values are based on a function of σ (Ward and Singh 2015):

$$\lambda_{33}(\sigma) = \frac{500^{\sigma}_{33} - 12{,}000^{\sigma}_{33}}{(-4000_{33})^{\sigma} - (-6{,}800_{33})^{\sigma}}$$

We estimate the interval of λ using the lower and upper bound of σ, and then we take the midpoint of intervals to obtain λ. In the numerator, we have the winning values for the round evaluated (in this case, round 33), which correspond to Option A and Option B. In the denominator, we have the losing payoffs for Option A and B correspondently.

3.4 Econometric model and estimation strategy

As mentioned in section 3.2.2, we first identified from the literature review and through semi-structured interviews with experts that anticipatory and reactive adaptation options are crucial for the cultivation of grapes. Therefore, we were able to collect data in terms of the adoption of individual anticipatory and reactive options; afterward, we aggregated the number of anticipatory options and the number of reactive options to estimate an index of anticipatory (Y_A) and an index of reactive (Y_R) adaptation as follows:

$$Y_{Ai} = \frac{Number\ of\ anticipatory\ options\ adopted}{Total\ number\ of\ anticipatory\ options\ available} \quad (4)$$

$$Y_{Ri} = \frac{Number\ of\ reactive\ options\ adopted}{Total\ number\ of\ reactive\ options\ available} \quad (5)$$

To analyze the effect of risk preferences and social capital on anticipatory or reactive behavior, we define the index of anticipatory and reactive adaptation as a dependent variable. In this sense, we assume that disturbances are uncorrelated across observations but correlated across equations; consequently, we estimate a seemingly unrelated regressions (SUR) model with two equations and express it as follows:

$$y_{Ai} = \beta_0 + \beta_1 X + \beta_2 RP + \beta_3 SC + \beta_4 SH + \varepsilon_1 \quad (6)$$

$$y_{Ri} = \beta_0 + \beta_1 X + \beta_2 RP + \beta_3 SC + \beta_4 SH + \varepsilon_1 \quad (7)$$

Y_{Ai} and Y_{Ri} are the dependent variables that can take the value of 0, 0.25, 0.5, and 1. X is a vector of socioeconomic characteristics: education (in years), wealth (land value used as a proxy), frequency of extension services (number of visits per year) and quality of the main variety (=1 if the main variety is premium). RP is a vector that includes risk preferences parameters: risk aversion, probability weighting, and loss aversion estimated using the midpoint method, as explained in section 3.3. SC is a vector that includes social capital variables: membership (=1 if a member of a farmer, water organization), the norm of conservation (expectation of the farmer to comply with the norm to conserve natural resources), size of the network (number of people known by the farmer who has adopted at least one adaptation option), general trust (using the statement "I can trust the people around me without being too cautious" measured using a Likert scale being one the strongly disagree and 5 strongly agree), and institutional trust (factor variables based on four statements indicating farmer's level of trust in agricultural associations, municipalities, public institutions and the State of Chile). We assume strict exogeneity of X, SC, and RP in each equation. So far, both equations have the same variables for vector X, RP, and SC. The difference between the two equations is on vector SH, which includes shocks that the farmer has experienced concerning climate change. For instance, the vector in Eq. (6) includes two variables coded as dummies: 1) if the farmer has been affected by a shock due to low precipitation (=1 if yes), and 2) if the farmer has been affected by a pest shock (=1 if yes). Eq. (7) shows that the SH vector includes climate-related shocks, specifically from diseases and frost.

To disentangle the effect of risk preferences and social capital on the adoption of each specific anticipatory and each reactive adaptation technology, we applied a multivariate probit model (MVP). MVP is a natural extension of the probit model that allows more than one equation with correlated disturbances (Greene, 2012).

In this case, our dependent variable is a dummy that takes the value of one if the farmer has adopted an anticipatory or reactive technology. Therefore, the general specification of the equation system model would be:

$$y_m^* = X_m'\beta_m + +RP_m\,\beta_m + SC_m\beta_m + SH_m\beta_m + \varepsilon_m, \;\; m = 1, \dots, M \qquad (8)$$
$$y_{im} = 1 \text{ } if \text{ } y_{im}^* > 0, \text{and } 0 \text{ } otherwise,$$

$\epsilon_{im}, m = 1, \dots, M$ the error terms are distributed as multivariate normal, each with a mean of zero, and variance-covariance matrix V, where V has values of 1 on the leading diagonal and correlations $\rho_{jk} = \rho_{kj}$ as off-diagonal elements. Where M is the number of anticipatory (4) and reactive (4) adaptation measures (Table 2). We estimate the model using the simulated maximum likelihood by Cappellari and Jenkins (2003). We include in the model the same vector variables as in Eq. (6) and Eq. (7) for the analysis of each dummy variable listed in Table 2.

4 Results

4.1 Anticipatory and reactive adaptation options

In this paper, we focus on the following options classified by type of adaptation: anticipatory or reactive; problems that solve water access, frost, diseases, and pests; and in their category: technological, behavioral, or economic. In this regard, the options are organized as follows:

Table 2. Types of adaptation (based on the timing of the action) and its options.

Type of adaptation*	Adaptation options	Problems that solve	Category of options*
Anticipatory adaptation	Modern irrigation (drip)	Water access	Technological
	Water management techniques**	Water access	Technological
	Pheromone diffusers	Pests	Technological
	Changing practices/management	Frost, diseases, pests	Behavioral
Reactive adaptation	Heating systems	Frost	Technological
	Agrochemicals - D	Diseases	Technological
	Agrochemicals - P	Pests	Technological
	Weather insurance	Frost, diseases, pests	Economic

Source: own calculation.
* Based on IPCC (2014) and IPCC (2012).
** Or water saving technologies (harvesting techniques, tanks, and other reservoirs).

On the one hand, we identified four anticipatory adaptation options, three technological and one behavioral; from these, two are to solve water access problems, one to solve pest problems, and one to solve frost, disease, and pest problems. On the other hand, we also identified four reactive adaptation options, three technological and one economical (to solve frost, diseases, pests, and water access).

4.2 Descriptive statistics

The average age of the farmers was 55, and 89% of the participants were male, with 24 years of experience working in vineyards (Table 3). The participants had, on average, ten years of education, achieving a secondary or middle education. Of the total participants, 83% were married.

Table 3. Descriptive statistics.

Variable	Description	Mean	Std. dev
Age	Farmers age in years	55.10	13.692
Gender	= 1 if the farmer is male	0.90	0.30
Education	Number of years of formal education	10.28	4.155
Experience	Years of experience working in vineyards	24.36	15.468
Marital status	= 1 if the farmer is marriage	0.83	0.373
Region	= 1 if Maule	0.73	0.444
Advisor	= 1 if access to advisor/ extension services	0.30	0.458
Production System	= 1 if intensive	0.25	0.431
Vines value	Value of vines per ha	6,135,000	870,592
Off farm income	= 1 if yes	0.53	0.500
Time	Time to closest market in minutes	16.25	11.405
Density	Number of vines per ha	4,046.43	2,317.45
Modern irrigation	= 1 if it is a drip irrigation system	0.25	0.431
Water management	= 1 if the farmer uses water management techniques	0.22	0.417
Prevention of pests	= 1 if the farmer uses pheromone diffusers	0.69	0.465
Management	= 1 if the farmer uses cultural practices	0.67	0.469
Mitigation of frost	= 1 if farmer implements heating activities	0.22	0.417
Mitigation of diseases	= 1 if farmer applies agrochemicals	0.75	0.431
Mitigation of pests	= 1 if farmer applies agrochemicals	0.22	0.417
Weather insurance	= 1 if farmer has a weather insurance	0.12	0.325
Trust	Confidence in the reliability of others	3.45	1.187
Institutional trust	Trust in institutions	3.64	1.120
Network	Number of farmers who adopted technologies	3.78	4.396
Norm of conservation	Farmers from the network encourage to adapt	4.19	1.075
Frequency services	Number of visits by the extension agent per year	8.55	9.871
Farm organization	= 1 if farmer participates in farmer organization	0.41	0.493
Wealth	Proxy for wealth in Dollars	614,783	1,070,721
Variety quality	= 1 if the grape is premium	0.77	0.417
Water tax	Water tax per ha in Chilean Pesos	20,750	25,415
Low precipitation	= 1 if shocks because of low precipitation	0.57	0.497
Pests shocks	= 1 if shocks because of pests	0.39	0.4888
Diseases shocks	= 1 if shocks because of diseases	0.42	0.50
Frost shocks	= 1 if shocks because of frost	0.59	0.493
Clima	= 1 if the farmer has a negative perception of the effects of climate change	0.88	0.319

Source: own calculation.

In addition, 52% of the farmers belong to Region VII of Maule, and 30% had access to extension services. 25% of the production systems are intensive, and the value of total vines per ha was 6,135,000.

The results show that 53% of farmers had an additional source of income from a part-time job in urban areas, and the time to the closest market in minutes was 16.25. On average, the density or number of vines per ha is 4,046.43. Modern irrigation (drip) has been adopted by 25% of farmers; regarding water management techniques, 22% of the farmers implemented this adaptation option. Whereas pheromone diffusers and management practices (cultural activities) are well-established adaptation options, about 69% and 67% of the vineyard farmers implement these options on the farm.

A reactive adaptation option in economic terms is related to the acquisition of weather insurance; 12% of the participants had weather insurance. In the case of frost, only 22% of farmers used heating systems. 75% of the participants used agrochemicals to control diseases, and 22% used agrochemicals to control pests.

Regarding social capital forms, farmers have moderate trust in other people (3.45 out of 5); also, farmers have moderate institutional trust (3.64 out of 5), e.g., trust in agricultural organizations, municipalities, public institutions, and the state of Chile.

On average, the number of farmers in the respondent network that has adopted any adaptation option is 4, and there are moderate norms of reciprocity (3.2 out of 5) to preserve the environment. The number of visits by the extension agent per year was 9. Furthermore, the average participation in a farmer organization was 41%.

On average, the wealth of farmers, as a proxy of land value, was US$ 614,783. Variety quality was premium at 77%. At the same time, water payment ranges widely due to market prices; on average, the participants pay 20,750 Chilean pesos per hectare per year (~US$30). Regarding shocks, low precipitation problems were in 57%, pest shocks in 39%, diseases shocks in 42%, and frost shocks in 59%. Finally, the perception of the negative effects of climate change is 88%.

4.3 Risk preferences

Using the midpoint method, we estimated the risk preferences parameters (σ, λ, and γ). Then we presented the socioeconomic, farm, and social capital determinants of these parameters (Appendix 4) has the estimation of these parameters through the structural method).

4.3.1 Estimation of parameters

From the total farmers of the sample (175), we estimate the Cumulative Prospective Theory (CPT) risk preferences parameters (σ, λ, and γ) (Table 4). We obtained parameters according to the midpoint method and similar results as Tanaka et al. (2010), Liu (2013), Bocquého et al. (2014), and Ward and Singh (2015). For instance, σ =0.59 indicates risk aversion among the farmers. Regarding loss aversion, λ =2.44, so we can assume that vineyard farmers are two and a half times more sensitive to losses than gains. Finally, the value of probability weighting is γ=0.79 which means that vineyard farmers tend to overestimate small probabilities.

Table 4. Risk preferences parameters using the structural method (maximum likelihood).

Parameter	Value	Std. Err.	β_0= 1
Curvature of value function (Risk aversion) (σ)	0.59***	0.039	0.000
Loss Aversion (λ)	2.44***	0.160	0.000
Probability weighting (γ)	0.79***	0.023	0.000
Observations	175		
Clusters	0		

Source: own estimation

Note: *p < 0.1, ** p < 0.05, *** p < 0.01.

We used results from the midpoint method because they are more consistent in the models; the structural method (explained by covariates) turns out to be weak or less solid with many variations.

4.3.2 Determinants of parameters

Table 5 presents the determinants for the Cumulative Prospective Theory (CPT) risk preferences parameters (σ, λ, and γ). For this estimation, we used an OLS regression model.

Analyzing the curvature of the value function (σ), the results suggest that male vineyard farmers are more risk averse; moreover, farmers from Region VII of Maule are more risk averse than those from Region VI of O'Higgins and farmers with access to advisors are also more risk averse. In this regard, it will be imperative to understand why farmers with an advisor are averse to risk when they should be with more knowledge and skills to manage risk.

Table 5. Determinants of the risk preferences parameters (midpoint method).

Variable	Curvature (σ)	Loss aversion (λ)	Probability Weighting (γ)
Gender (male)	-0.35042***	0.14396	0.02289
Experience	0.00019	0.02082**	-0.00296*
Region	-0.21228**	0.82544**	-0.07963
Advisor	-0.16253**	0.27413	-0.06527
Production system	0.04006	0.33202	0.07884**
Vines value	2.27e-08	-6.65e-07***	3.96e-08
Off farm income	-0.08255	0.46249	0.04758
Constant	0.92381***	4.26421***	0.49549**
Observations	175		
Clusters	0		
Prob > Chi2	0.000		

Note: *p < 0.1, ** p < 0.05, *** p < 0.01.

Regarding loss aversion (λ), results show that farmers with more experience are more loss averse; maybe the reason is related to the type and quality of experience; it could be possible that the knowledge is only empiric and without strong managerial skills. In addition, farmers from Region VII of Maule are more loss averse than those from Region VI of O'Higgins; this could be explained by the proximity of O'Higgins to the metropolitan area of the country where they could have access to better education and services. In the case of farmers with a great value in vineyards (premium + area), we can infer that this kind of wealth helps to face aversion behavior.

Finally, results indicate that farmers with more experience tend to overweight small probabilities. This is the same case as loss aversion because the experience could be empirical or only related to agricultural practices and not focus on improving managerial skills. Lastly, we have those farmers with intensive production systems who do not overweight small probabilities.

4.4 Econometric and empirical results

This section presents the results of the seemingly unrelated regressions (SUR) to identify tendencies and drivers for anticipatory or reactive behavior. SUR was applied as we identified correlations between the errors of individual equations or models. Then we used the multivariate probit to identify the drivers of each technology or adaptation option that is part of the anticipatory or reactive type of adaptation.

4.4.1 Drivers of anticipatory and reactive options – SUR Model

The seemingly unrelated regressions (SUR) model was used with a system of two equations with continuous dependent variables and correlated error terms. It is feasible to use the SUR model when we have at least two equations, each with its dependent variable. Furthermore, we need to have a different set of regressors or independent variables in each equation; otherwise, a simple OLS model would be necessary.

In this regard, we have two linear equations with different dependent variables Y_A = dependent variable for the whole group of anticipatory options when people behave anticipatorily (continuous variable with these possible outcomes 0, 0.25, 0.50, 0.75, 1, according to the number of anticipatory adaptation options implemented from the total options); and Y_R = dependent variable for the whole group of reactive options when people behave reactive (continuous variable with these possible outcomes 0, 0.25, 0.50, 0.75, 1, according to the number of reactive adaptation options implemented from the total options).

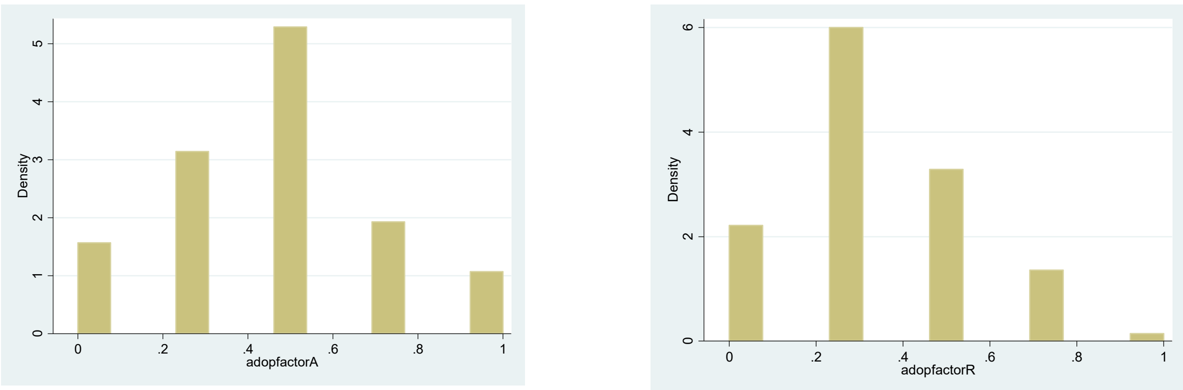

Figure 3. Distributions of anticipatory and reactive adaptation options.

As shown in Table 6, the sigma parameter or curvature of the value function cannot explain an anticipatory or reactive behavior for implementing one of these types of adaptation. However, we can infer that farmers less sensitive to losses implement anticipatory adaptation options; also, farmers who underweight small probabilities tend to use this option.

Table 6. Determinants of anticipatory and reactive adaptation options – SUR Model.

Determinants	Anticipatory options	Reactive options
Sigma	0.014	-0.014
	(0.035)	(0.033)
Lambda	-0.015*	-0.002
	(0.009)	(0.008)
Gamma	0.226***	-0.062
	(0.056)	(0.053)
Institutional trust	-0.019	-0.004
	(0.039)	(0.037)
Norm of conservation	-0.092	0.117*
	(0.065)	(0.061)
Network	0.009**	-0.006
	(0.004)	(0.004)
Frequency services	0.005***	0.003*
	(0.002)	(0.002)
Farm organization	-0.097***	-0.024
	(0.037)	(0.038)
Education	0.001	-0.005
	(0.005)	(0.004)
Wealth	0.000***	0.000
	(0.000)	(0.000)
Variety quality	0.062	-0.023
	(0.044)	(0.043)
Water tax	0.000*	
	(0.000)	
Low precipitation shocks	0.004	
	(0.036)	
Pests shocks	0.063*	
	(0.038)	
Clime perception	-0.002	0.025**
	(0.012)	(0.012)
Density		-0.000*
		(0.000)
Frost shocks		0.058*
		(0.035)
Diseases shocks		0.057*
		(0.033)
Constant	0.224*	0.224*
	(0.116)	(0.116)
Observations	175	
Clusters	0	
Prob > Chi2	0.000	

Source: own calculation

Note: *p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses

Regarding social capital, we identified that conservation norms have a positive effect on adopting reactive adaptation. Thus, if we want to foster this adaptation, we could institutionalize this type of norm in the area.

On the contrary, networks contribute to the use of the anticipatory option; this leads us to the question of what kind of technologies, knowledge, or information flow through this group of interconnected farmers. Surprisingly, the more frequency of technical assistance, the more implementation of both types of adaptation, maybe because the extension services do not differentiate between the types of adaptation.

Then, we have that being part of a farm organization positively affects the implementation of anticipatory options; this is similar to networks. It is imperative to understand how these organizations work or what kind of information they have and spread around their members. Finally, in the context of anticipatory options, we identified that wealth, water tax payments, and pest shocks increase the use of these technologies and behavior. Finally, on the side of reactive options, we can infer that shocks and perceptions about climatic conditions drive the implementation of these actions. We used the "Breusch-Pagan test of independence" for each model to test the independence of the error in the two equations.

4.4.2 Drivers of anticipatory and reactive options as groups (heterogeneous effects)

As we mentioned in the methodology, to unravel the effect of risk preferences and social capital on each technology part of the group of anticipatory or reactive adaptation options, we applied a multivariate probit model (MVP). We applied this model because we identified that the error terms of the equations were correlated.

In this regard, as shown in Table 7, we tried to identify the drivers for each technology part of the group of anticipatory adaptation options. As we mentioned, we could not find effects from the gamma parameter. Still, loss averse has an important role in implementing these technologies as loss averse farmers implement modern irrigation, but farmers less sensitive to losses tend to implement pheromone diffusers to solve pest problems and implement cultural practices (management) also to solve this problem and diseases.

In the case of gamma, we identified that farmers who underweight small probabilities tend to implement the whole group of anticipatory options.

Table 7. Determinants of anticipatory adaptation options into groups.

Panel A	**Anticipatory options**			
Determinants	Modern irrigation	Water management	Prevention of pests	Management
Sigma	0.235	0.172	-0.099	0.036
	(0.272)	(0.248)	(0.217)	(0.216)
Lambda	0.141**	0.065	-0.145**	-0.146**
	(0.061)	(0.057)	(0.058)	(0.061)
Gamma	0.809*	0.721*	0.840**	1.327***
	(0.443)	(0.384)	(0.380)	(0.440)
General trust	-0.198*	0.058	0.090	-0.237**
	(0.114)	(0.102)	(0.100)	(0.102)
Institutional trust	0.084	-0.100	-0.225**	0.155
	(0.119)	(0.111)	(0.114)	(0.110)
Norm of conservation	-0.440	-0.602	-0.298	0.005
	(0.424)	(0.418)	(0.442)	(0.405)
Network	0.060**	0.076***	0.046	-0.028
	(0.030)	(0.027)	(0.032)	(0.029)
Frequency services	0.022*	0.020*	0.019	0.002
	(0.012)	(0.011)	(0.012)	(0.012)
Farm organization	-0.240	0.294	-0.592**	-0.536**
	(0.283)	(0.259)	(0.244)	(0.265)
Education	0.071**	-0.027	-0.005	0.009
	(0.033)	(0.031)	(0.030)	(0.033)
Wealth	0.000***	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Variety quality	0.596	-0.220	0.112	0.449
	(0.373)	(0.298)	(0.278)	(0.287)
Water tax	-0.000	0.000*	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Low precipitation shocks	0.426	0.013	-0.402*	0.134
	(0.272)	(0.242)	(0.236)	(0.244)
Pests shocks	0.105	-0.023	0.231	0.898***
	(0.287)	(0.260)	(0.259)	(0.274)
Constant	-3.334***	-1.500*	0.865	-0.725
	(0.995)	(0.872)	(0.772)	(0.749)
Observations	175			
Prob > Chi2	0.000			
LRT chi2(6) = 40.7022	Prob > chi2 = 0.0000			

Source: own calculation

Note: *p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses

Regarding social capital, trust in other farmers has a negative effect on the implementation of modern irrigation and management; one possible answer to this situation is related to bad experiences when people rely on others.

This situation is similar to the institutional trust that has a negative effect on the prevention of pest through the use of pheromones diffusers, maybe because the government is who promote these technologies. It is necessary to analyze the strategy to encourage the implementation of prevention measures.

In the case of network, it has a positive effect on the implementation of modern irrigation and water management as well as the frequency of extension services and wealth on the same technologies. On the contrary, being part of a farmer organization has a negative effect on the adoption of prevention of pests and management. Still, pest shocks increase the use of cultural practices to solve this problem.

We identified the determinants necessary for implementing reactive adaptation technologies in Table 8 the most important. In essence, we focused on risk preferences and social capital forms but also on shocks because we have identified that the presence of these events has a direct impact on reactive behaviors.

Table 8. Determinants of reactive adaptation options into groups.

Panel B	**Reactive options**			
Determinants	Mitigation of frost	Mitigation of diseases	Mitigation of pests	Weather insurance
Sigma	-0.295	-0.012	-0.193	0.099
	(0.253)	(0.223)	(0.237)	(0.313)
Lambda	-0.154**	0.075	-0.035	0.086
	(0.069)	(0.061)	(0.058)	(0.073)
Gamma	-0.394	-0.065	-0.333	0.164
	(0.388)	(0.350)	(0.370)	(0.483)
Institutional trust	0.810*	-0.172	-0.105	-0.130
	(0.460)	(0.377)	(0.377)	(0.630)
Norm of conservation	-0.275	0.745*	0.411	3.998
	(0.441)	(0.393)	(0.470)	(115.577)
Network	-0.039	-0.032	-0.051*	-0.064
	(0.031)	(0.026)	(0.031)	(0.051)
Frequency services	0.025**	0.003	-0.008	0.038**
	(0.012)	(0.012)	(0.013)	(0.015)
Low precipitation shocks	-0.139**	0.008	0.080	0.058
	(0.062)	(0.056)	(0.058)	(0.074)
Frost shocks	0.118*	0.080	0.073	0.086
	(0.064)	(0.056)	(0.058)	(0.078)
Diseases shocks	0.109	0.112	-0.062	-0.054
	(0.074)	(0.073)	(0.076)	(0.096)
Pest shocks	-0.067	0.031	0.083	0.186**
	(0.065)	(0.066)	(0.063)	(0.082)
Marital status	0.990**	0.032	0.182	-0.088
	(0.405)	(0.291)	(0.316)	(0.408)
Wealth	0.000***	0.000*	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-1.786**	-0.805	-1.205	-6.522
	(0.834)	(0.703)	(0.738)	(115.582)
Observations	175			
Prob > Chi2	0.00			
chi2(6) = 15.3522 Prob > chi2 = 0.0177				

Source: own calculation
Note: *p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses

In the case of social capital, only institutional trust positively affects the implementation of the same technology to solve problems because of the frost. Norms of conservation also have a positive effect on the use of agrochemicals to mitigate disease problems, and the network has a negative effect on the use of agrochemicals to control pests, maybe because in the networks, there is awareness about the use of agrochemicals and because the government has programs to promote the use of pheromones (anticipatory option).

In regard to mitigating frost through heating systems, we also identified that frequency of extension services, frost shocks, marital status, and wealth have a positive effect on the adoption of these technologies; on the contrary, low precipitation shocks have a negative impact. Finally, in the case of weather insurance, the frequency of extension services which technicians promote credits and insurance, and pest shocks, one of the most important problems in the cultivation of grapes, both have a positive effect on the adoption of this economic option to face the negative effects of climate change.

5. Conclusions

Over time, the agricultural sector has been impacted by climate change and other external shocks (e.g., by variations in market prices, credit constraints, and lack of access to technology). These negative effects represent losses in production or revenues. Therefore, it was important to deeply understand the responses that systems and farmers can have to climate change's negative effects. One of these responses is the process of adjustment to climate change or adaptation.

In this paper, we wanted to identify the effect of risk preferences and social capital on the implementation of adaptation options to climate change, but under an approach of adaptation based on the timing of the action (when the actions occur): anticipatory (ex-ante) or reactive (ex-post). In this regard, we identified four anticipatory adaptation options (modern irrigation (drip), water management techniques, pheromone diffusers, and changing practices/management): and identified four reactive adaptation options (heating systems, agrochemicals against diseases, agrochemicals against pests and weather insurance).

Regarding the risk preferences, we used the Cumulative Prospect Theory (CPT) to estimate the parameters, we used the structural and midpoint method, but we focused on the last because it is more consistent.

We found that the curvature of the value function is σ =0.59, indicating risk aversion among the farmers. Regarding loss aversion, λ =2.44, so we can assume that vineyard farmers are two and a half times more sensitive to losses than to gains. Finally, the value of probability weighting is γ=0.79 which means that vineyard farmers tend to overestimate small probabilities.

Finally, we identified the effect of these risk preferences parameters and social capital forms (trust, social norms, and network) on the anticipatory and reactive group of adaptation options and the technologies in each group. We found that loss aversion and probability weighting have a key role in the implementation of these technologies, as well as some forms of social capital as norms of conservation, network, trust, frequency of extension services, and shocks.

Chapter 3. Technical efficiency, risk preferences and social capital: an overarching approach for small vineyard farmers adapted to climate change in central Chile

Enrique Ernesto Alvarado Irias [a], Bernhard Brummer [a], Marcela Ibañez[b]

[a] *Department of Agricultural Economics and Rural Development, Georg-August-University Göttingen, Germany*

[b] *Research Centre, Equity, Poverty and Growth, Georg-August-University Göttingen, Germany*

Abstract

Climate change can be seen as a shock that decreases the value of economic activities and production functions. Therefore, this study estimates technical efficiency as an integrated approach with risk preferences and social capital for small vineyard farmers adapting to climate change. Empirical evidence shows the key role of adaptation, risk preferences, and social capital related to technical efficiency on a one-to-one basis, but not as an overarching analysis. This study occurred in central Chile's O'Higgins and Maule regions; data were collected through a field experiment and an exit survey from September to December 2016. We conducted an artefactual field experiment to elicit risk preferences from 175 small vineyard farmers; we used the midpoint method to estimate the Cumulative Prospect Theory (CPT) parameters, which indicate vineyard farmers are risk averse, sensitive to losses, and tend to distort probabilities. Then we applied a stochastic frontier analysis to the main variety area of vineyards. Results showed that the influence of capital (0.55) and the number of vines (0.32) is higher, whereas labor (0.13) and intermediate inputs (0.11) are also important but relatively low. The scale elasticity is 1.11, showing a Constant Returns to Scale (CRS). On average, technical efficiency was 0.73, meaning farmers could improve their performance by 27%.

Additionally, results suggest that experience and education positively influence efficiency, contrary to age, gender, region, and density, whereas access to extension services and irrigation increases efficiency. Also, general trust and membership in farmer organizations increase efficiency; and risk aversion and probability weighting decrease it. In this regard, it is necessary to design policies focused on facilitating accessibility to exchangeable inputs and the promotion of extension services, facilitating access to irrigation through subsidies and credits, improving trust in programs and networks, and developing organizations to share information and services. **Keywords:** technical efficiency, stochastic frontier analysis, cumulative prospect theory, risk preferences, social capital, adaptation to climate change, and vineyard farmers.

1. Introduction

Climate change is an alteration of weather conditions over a period, normally more than two decades, and has a negative or positive effect on human societies or natural ecosystems. In the case of negative effects, changes in weather patterns (e.g., because of changes in temperature or rainfall) can stimulate an increase in pests and disease pressure, droughts, or flooding, among other events that could lead to damage to infrastructure and production systems. Climate change means an immediate technological shock that decreases the value of economic activities over time (Kelly et al., 2005); indeed, climate change can affect the deterministic and stochastic parts of a production function (Alpizar et al., 2011; Kelly et al., 2005). Thus, one process to face climate change effects is adaptation.

Regarding agriculture, adaptation is a method by which institutions and farmers adjust farms' activities to minimize the adverse effects of climate change or seize on its potential benefits. Consequently, farmers have been implementing adaptation options or activities that help to adjust their systems to the negative effects of climate change and to analyze the implication of adaptation on the variability of crop production, agricultural outputs, or productivity (Bryan et al., 2009; Deressa et al., 2009; Di Falco et al., 2011; Hassan and Nhemachena, 2008; Tesfahunegn et al., 2016).

Specifically, various studies point out that implementing relevant adaptation options increases crops' productivity or technical efficiency by reducing the negative effects of climate change (Khanal et al., 2018; Roco et al., 2017; Wossen et al., 2015). Accordingly, it is necessary to integrate the effect of adaptation options into technical efficiency analysis. However, it is important to conduct this analysis considering the type of adaptation, in this case, when the action occurs, i.e., anticipatory (ex-ante) or reactive (ex-post). By considering the type of adaptation, the analysis supports the policy design process, mainly when deciding which adaptation option is more relevant to promote depending on the time of the shock and the effect on efficiency.

To improve the analysis of technical efficiency in the face of climate change, it is important to include farmers' risk preferences. On the one hand, adaptation and risk preferences are related because adaptation is a decision under the influence of risk, as it is necessary to decide about implementing a technology or economic option today with two possible results: unknown profits or additional costs in the short, medium or long term (Bernedo and Ferraro, 2016). On the other hand, technical efficiency and risk preferences are related because risk is essential for the decision-making process, particularly for small producers in less developed countries (Nielsen et al., 2013). Risk is an important part of the decision-making process concerning the utilization of inputs, and consequently output provision, production variance, and as a determinant of inefficiency (Kumbhakar, 2002; Tiedemann and Latacz-Lohmann, 2013; Villano and Fleming, 2006), and also it explains levels of inefficiency (Lien et al., 2017). Nonetheless, the majority of literature regarding the analysis of risk preferences and technical efficiency applied Expected Utility Theory (EUT) (Kumbhakar, 2002; Lien et al., 2017; Tiedemann and Latacz-Lohmann, 2013; Tong et al., 2018; Villano and Fleming, 2006). However, EUT does not explore the effects of risk aversion, loss aversion, and probability weighting, which are key elements of Cumulative Prospect Theory (CPT). CPT is a behavioral economic theory that describes a model of decision-making under the influence of risk, understanding how subjects make decisions over weighted options that implicate a risk (known possibilities). According to the CPT, subjects decide based on the possibility of gains or losses, using heuristics instead of valuing the ending outcome (Tversky and Kahneman, 1992). Under the CPT we estimate three parameters that represent: the curvature of the value function in the gains domain (states risk aversion), the sensitivity to losses (loss aversion), and how subjects distort probabilities (probability weighting).

Technical efficiency is also related to social capital because the farmer depends on the flow of information and other resources through their network to implement new practices, which then influences the decision regarding using exchangeable inputs and variable outputs. In this regard, the literature has shown that high levels of trust in institutions increased adoption levels (Abrahamse and Steg, 2013; Lyon, 2000; Muange, 2015; Ostrom, 2007). Additionally, social networks positively affect efficiency (Muange, 2015). Still, there is a gap in the literature concerning the role of social norms and other forms of trust and membership in this technical efficiency analysis.

Overall, empirical evidence shows the key role of adaptation options, risk preferences, and social capital related to the technical efficiency of productive systems on a one-to-one basis. Therefore, this study focuses on technical efficiency analysis of small vineyard farmers who have implemented adaptation to climate change[13], where the main determinants of efficiency

[13] Which means that these farmers have implemented one of two types of adaptation options, based on the timing of the action: anticipatory (ex- ante) or reactive (ex-post).

are technologies and economical options to face climate shocks, risk preferences (risk aversion, loss aversion, and probability weighting) and social capital forms (trust, network, and social norms). We also consider socioeconomic characteristics such as experience, age, gender, education level, land ownership, household size, and physical characteristics of the farm, such as area, type variety, and training system, among others, to explain efficiency levels.

We contribute to the literature in three key aspects: 1) we apply Cumulative Prospect Theory determining risk aversion, loss aversion, and the probability weighting function to understand their effect on technical efficiency; 2) we extend the analysis of the role of social capital by including trust and social norms in addition to social network; 3) we incorporate in the analysis the effect of anticipatory and reactive adaptation options. This study was implemented in the O'Higgins and Maule regions of central Chile, home to 80% of the total grape production in the country, where around 60% of the farmers are small. Therefore, this study will provide policy recommendations to improve small farmers' efficiency levels. Data were collected through a field experiment and an exit survey from September to December 2016. Specifically, we conducted an artefactual field experiment to elicit risk preferences from 175 small vineyard farmers. We used the midpoint method to estimate the risk preference parameters. We apply a stochastic frontier analysis to the main variety of grapes produced in the vineyard, allowing us to appraise individual farmer capacities compared to a frontier.

The rest of the paper is structured as follows: Section 2 presents the theoretical framework, section 3 presents empirical evidence with regards to technical efficiency, adaptation, risk preferences, and social capital, section 4 provides details on the methods, and section 5 presents the results, and in section 6 the conclusions of the analysis are presented.

2. Theoretical framework

2.1 Technical efficiency and stochastic frontier analysis

Frequently in popular media, the terms productivity and efficiency are considered synonyms. However, it is important to note the distinct differences between these terms for the interests of this research. Whereas productivity is simply a measure of the output produced by a firm concerning the input it uses (normally, it is measured as a ratio or percentage), technical efficiency is essentially the maximum level of productivity given fixed technology (Coelli et al., 2005). In simple terms, technical efficiency can be defined as the maximum achievable output considering a certain group of inputs. Since the seminal work of Farrell (1957), the theoretical term of technical efficiency has been operationalized by calculating a so-called frontier production function based on the observed outputs of firms, as opposed to the earlier method of calculating theoretical functions (Farrell, 1957). This technique was further developed into the stochastic frontier production function, presented by Aigner et al. (1977) and Meeusen and van Den Broeck (1977).

This stochastic frontier analysis (SFA) allows us to appraise individual farmer capacities compared to a frontier. Deviations from the frontier can be explained by the error term made up of two components: a) the statistical error term due to measurement errors and other uncontrollable effects, and b) the technical inefficiency error term resulting from a number of human errors, including lack of information, adjustment costs and managerial errors (Meeusen and van Den Broeck, 1977). Consequently, we can specify the stochastic frontier model as:

$$\ln\, y_i = lnf\,(X_i;\beta) + \varepsilon_i \qquad (9)$$
$$\varepsilon_i = v_i - u_i$$

Where Y_i is the scalar of outputs produced by farms, X_i is a vector of all the inputs, β is a vector of unknown parameters, $\varepsilon_i l_t$ is the composed error term, with v_i being the symmetric component distributed as N (0; $\sigma^2{}_v$), and u_i, a non-negative random term, interpreted as the technical inefficiency, i.e., the shortfall in production from the technically efficient frontier. Both terms are independent of X_i and from each other.

Originally, Aigner et al. (1977) specified the underlying distribution of u_i as N^+ (0; $\sigma^2{}_u$). Nevertheless, various researchers have proposed a simultaneous estimation of the efficiency effect and the production frontier under the assumption of adequate distributional properties (Kumbhakar et al. 1991; Caudill and Ford 1993; Simar et al. 1994; Battese and Coelli 1995; Caudill et al. 1995; Wang and Schmidt 2002).

Consequently, and taking into account that production functions based on cross-sectional data vary according to the size of farms, we assume that the u_i term of the composed error of the model could be heteroscedastic (Caudill and Ford, 1993), thus allowing u_i to be dependent from some covariates (Wang and Schmidt 2002). In this context, and according to Greene (1990), Caudill et al. (1995), and Wang and Schmidt (2002), in this study, we assume a general model based on this distribution:

$$\ln\, y_i = lnf\,(X_i;\beta) + (v_i - u_i) \qquad (10)$$
$$v \approx N(0, \sigma_u^2)$$

$$u \approx N^{+}(0, \sigma_u^2) \quad \sigma_u = \exp(z\delta)$$

Where equation (2) has the same specification as equation (1), the v_i component error term is normally distributed (N (0; σ^2_v)), and the u_i component error term or inefficiency shows a half-normal distribution (N^+ (0; σ^2_u)), but σ_u = exp (zδ), where z is a vector of variables and δ is a vector of unknown parameters. Caudill et al. (1995) and Wang and Schmidt (2002) have implemented and argued in favor of this model with so-called scaling properties, in which the parameters of the distribution of the technical inefficiency error term u_i are dependent on the efficiency effects.

As mentioned before, and in this case, the stochastic frontier analysis (SFA) is applied with production functions. One is the Cobb-Douglas production function, a functional form used to estimate the relationship between two or more inputs and the output produced. The advantages of this function are a relatively easy estimation and interpretation, and it applies to small samples (Douglas, 1976).

However, it imposes very strong assumptions. The Cobb-Douglas functional form forces the properties of restrictive scale and substitution on the frontier, which can lead to the issue of non-constant scale elasticity and nonunitary substitution elasticities being mistakenly associated with inefficiency (Fried et al., 1993).

Now, the translog production function presents an opportunity to overcome some of the rigid requirements of the Cobb-Douglas functional form. This class of models relaxes the restrictions of the Cobb-Douglas model concerning demand elasticities and elasticities of substitution (Greene, 2008).

Translog models allow for passage from a linear relationship between the output and production factors to a nonlinear one (Greene 2008). However, this class of models can be quite complex for estimation and assuring the appropriate curvature with this model can be challenging (Fried et al. 1993; Greene 2008). The translog functional form also does not assume perfect substitutability between production factors or perfect competition on the market for production factors.

2.2 Risk preferences

There is extensive theoretical literature about risk and risk preferences (Von Neumann and Morgenstern 1947; Kahneman and Tversky 1979; Binswanger 1980; Tversky and Kahneman

1992; Harrison et al. 2007; Andersen et al. 2008; Harrison 2008; Harrison and Rutström 2008; Harrison and Rutström 2009; Tanaka et al., 2010; Andreoni and Sprenger 2012; Attanasio et al. 2012; Liu 2013; Nielsen et al., 2013; Cardenas and Carpenter 2013; Ward and Singh 2015). Thus, it is important to present this topic's main ideas, terms, and theories.

People continuously face uncertainty and risk (when probabilities are known) when making decisions about any necessary process or circumstance. Risk has been widely studied in agriculture because it is essential for production and has an important role in farmers' decision-making process (Bocquého et al., 2014). In general, the expected utility theory (EUT) has been the common framework for modeling decisions under risk (Von Neumann and Morgenstern, 1947). Under expected utility theory (EUT), risk aversion refers to farmers' aversion to the variability of the end outcomes. It is captured by the curvature of the utility function (Bernedo and Ferraro, 2016). The expected utility theory (EUT) specification assumes a Constant Relative Risk Aversion (CRRA) utility function[14] (Harrison and Rutström, 2009), and it is possible to conduct it straightforwardly. When we estimate a CRRA utility function, we constitute a utility of an income outlined by:

$$\mathrm{U}\ (\mathrm{x}) = X^r \tag{11}$$

Where x is the prize from the lottery and the unknown parameter to be estimated is r; in expected utility theory, the probabilities for outcomes k are those induced by the researcher, p_k. In this regard, expected utility is the probability-weighted utility for every outcome in every lottery i, (p_k*u_k) (Harrison and Rutström, 2009).

Nevertheless, now its application is questionable because it has been proven that subjects do not necessarily behave according to the essential assumptions of expected utility theory (EUT); basically, we can state this: under expected utility theory, the risk aversion levels for small bets are inconsistent with regards to high bets (Allais, 1953; Rabin, 2000), farmers neither distinguish between gains and losses nor do they take into account the valuation of outcomes to objective probabilities (Bocquého et al., 2014), and alternative theories have shown better results and explanations for the decision-making process under risk (Kahneman and Tversky 1979; Tversky and Kahneman 1992; Quiggin 1981, 1982; Tanaka et al., 2010; Bocquého et al., 2014). Non-expected utility theories include Cumulative Prospect Theory

[14] Utility function outlined over the end prize when a lottery is played (Harrison and Rutström 2008)

(CPT) developed by Tversky and Kahneman (1992), rank-dependent utility theory (RDU), and rank- and sign-dependent theory (Bernedo and Ferraro, 2016; Quiggin, 1982, 1981; Schmidt and Zank, 2008).

Cumulative prospect theory (CPT) arises as an alternative to expected utility theory (EUT). Under CPT, a prospect, represented by P = (p_1,x_1; … ;p_n, x_n), refers to a finite probability distribution p_j over a group of outcomes x_j, described monetarily. In practice, these probabilities are a set of real numbers sum to one and are non-negative (Schmidt and Zank 2008). Additionally, outcomes are understood as changes from the reference point (in this case, zero) (Schmidt and Zank 2008), these outcomes are categorized as gains or losses regarding the reference point, and farmers can behave differently in each of these domains (losses for (-) domain and gains for (+) domain) (Bocquého et al., 2014).

Nowadays, CPT is used in several studies to explain the decision-making process under risk better because these three parameters jointly determine the utility function: the curvature of the utility function (σ, which can be seen as a measure of risk aversion), loss aversion (λ, measures sensitivity to loss compared to gain) and nonlinear probability weighting (γ, the tendency for overweighting small (large) probabilities and underweighting large (small) probabilities)(Schmidt and Zank, 2008). All these parameters affect how farmers assess risky outcomes, which successively changes their behavior. Hence, assessing farmers' risk preferences with CPT instead of EUT might help explain farmers' decision-making process (Bocquého et al., 2014). Considering a standard case of a risky prospect with two outcomes, x and y, and probabilities p and q = 1- p, respectively. The value or utility of the prospect function can be expressed as:

$$U_{(x,y;p,q,\sigma,\gamma,\lambda)} = \begin{Bmatrix} v(y) + w(p)[v(x) - v(y)] & for\ x > y > 0\ or\ x < y < 0 \\ w(p)v(x) + w(q)v(y) & for\ x < 0 < y \end{Bmatrix} \quad (12)$$

where:

$$v(x) = \begin{Bmatrix} x^{\sigma} & for\ x > 0 \\ -\lambda(-x)^{\sigma} & for\ x < 0 \end{Bmatrix} \quad (13)$$

and w(p) is a probability-weighting function[15]:

[15] Probability weighting function showed in Prelec (1998)

$$w(p) = \exp[-(-\ln p)^{\gamma}] \text{ for } 0 < \gamma \leq 1 \quad (14)$$

As we can observe, under Tversky and Kahneman's (1992) cumulative prospect theory (CPT), we have a final utility function, a power utility function (explained on the gain or positive domain and the loss or negative domain), and the probability weighting function (Harrison and Rutström, 2009).

There are different methods to elicit risk preference parameters. Still, the model originally proposed by Tanaka et al. (2010) and then replicated by Liu (2013), Bocquého et al. (2014), and Ward and Singh (2015) is the easiest to understand for farmers from developing countries. Moreover, this methodology allows researchers to elicit the Cumulative Prospect Theory (CPT) parameters easily. As we stated before, three parameters characterize individual behavior under this theory. The parameter σ captures the curvature of the prospect value function in the gains domain, and it can be considered as a measure of risk aversion: if $\sigma < 1$ indicates a concavity in the curvature of the prospect value function, this indicates risk aversion, $\sigma = 1$ indicates risk neutrality and $\sigma > 1$ suggests risk-loving behavior. Generally, σ cannot be negative (Bocquého et al., 2014). The parameter λ characterizes loss aversion. In other words, λ indicates farmers' sensitivity to losses: if $\lambda >1$, farmers are more sensitive to losses than gains; if $\lambda <1$, farmers are less sensitive to losses than gains and if $\lambda = 1$, farmers show indifference. Together, these three parameters jointly characterize the valuation of risky prospects (Tanaka et al., 2010; Liu, 2013; Bocquého et al., 2014; and Ward and Singh, 2015). The parameter γ refers to farmers' inclination to distort objective probabilities (how small probabilities are weighted disproportionately at the moment to value risky prospects). In other words, γ indicates whether farmers distort probabilities of unlikely events: if $\gamma < 1$, the probability weighting function has an inverse s-shape form, so farmers overweigh small probabilities, if $\gamma = 1$, there is no distortion (the probability weighting function is a straight line), if $\gamma > 1$, the probability weighting function has an s-shape form and farmers tend to underestimate small probabilities (Tanaka et al., 2010; Liu 2013; Bocquého et al., 2014).

2.3 Social capital

Social capital refers to individuals' attributes and their relations that improve the ability to solve problems in a collective way (Ostrom and Ahn, 2003), and highlights the importance of using social connections and social relations in achieving goals (Lin, 2002). Putnam (2001) explains social capital as the "features of social organization, such as networks, norms, and trust that facilitate coordination and cooperation for mutual benefit." Generally, social capital is generated when a group shares it (Narayan and Cassidy 2001).

Generally, there is consistency in the concept of social capital; however, at the practical level, the procedures for measuring social capital are diverse, leading to various explanations. For instance, social capital involves abstract social constructs that need subjective interpretation to become operatives (Narayan and Cassidy 2001). As Ostrom and Ahn (2003) and Ostrom and Walker (2003) pointed out, social capital is not as easy to measure, find or see as physical capital. Moreover, Adger (2003) mentioned the difficulties in measuring social capital as it relies on other forms of capital. In addition, social capital does not depreciate and does not involve future and present trade-offs.

Regarding the forms of social capital, Narayan and Cassidy (2001) identified seven forms: a) characteristics of a group (memberships, resource contribution, etc.), b) norms (equity, kindness, or reliability), c) fellowship between people (if subjects get along), d) sociability in everyday life, e) connections within neighborhoods (help, sharing information, etc.), f) volunteerism (yes or no, expectations or critiques, etc.) and, g) trust (in family, neighbors, clans, social class, business firms, municipalities, state, providers, and others). Whereas Hawkins (2007) and Ostrom (2007) proposed three general forms: a) trust, b) network and c) institutions' formal and unwritten rules. Trust refers to confidence in others, specifically in their reliability. For instance, general trust is the trust that subjects have in others, and institutional trust is the trust in providers, banks, police, municipalities, the state, etc. (Knack and Keefer 1997). Network refers to a social linkage with individuals and the frequency of their interaction through which resources and information flow (Maertens and Barrett, 2013). Finally, social norms are the equivalent of unwritten or informal rules. For instance, norms of reciprocity, i.e., when someone helps others and expects to receive help if needed (Fountain, 1998). Another social norm could be cooperation or civic norms, referring to those norms that comply within the community without having a regulatory framework (Dakhli and Clercq, 2004).

3. Technical efficiency, adaptation, risk preferences, and social capital: empirical evidence

Empirical studies show that key inputs of farms are land, labor, machinery, and capital (Battese and Coelli, 1995; de Sousa Henriques et al., 2009; Khanal et al., 2018; Lien et al., 2017; Nguyen et al., 2018). One of the most recent studies analyzing wine production by Piesse et al. (2018) applied a stochastic frontier inefficiency model to compare well-established wine-growing regions with new ones in South Africa. For the frontier production, they utilized the following inputs: land, labor (temporary and permanent), pesticide and herbicide costs, fertilizer, electricity, and fuel, all of which are in constant values. In this case, the land was the most important input, followed by labor and pesticides. Considering which variables describe deviations from the stochastic frontier, the study highlighted that more supervision and permanent labor decrease inefficiency. They also include viticulture practices to explain deviations from the production frontier: these are the application of inorganic fertilizers, quantitative relationship between the modern and old trellising, ratio of total area with or without drip irrigation, the proportion of total planting area with old vines and proportion of total planting area with red varieties.

Some of these viticulture practices are associated with adaptation to climate change but were not associated in this study. Nonetheless, it is important to highlight that the use of drip irrigation increases efficiency, and the use of inorganic fertilizer decreases efficiency levels.

Another study analyzing important determinants of technical efficiency in vine systems is by Moreira et al. (2011), who analyzed the productive technical efficiency of vineyard farmers in Chile. The study applied a Cobb Douglas production function and used the structure established by Battese and Coelli (1992). The study shows that block size (an area with one variety and a certain management), labor, and machinery are the most influential inputs. The study could not further specify improvements needed for farms' technical efficiency.

In general, stochastic frontier analysis studies relate levels of efficiency with socioeconomic variables (age, experience, education, household size, and off-farm work) and physical characteristics of the farm (area, irrigation, market distance, credit and extension services) (de Sousa Henriques et al., 2009).

Despite the richness of empirical studies analyzing technical efficiency, only a few focus on the effects of adaptation options to climate change on technical efficiency. For instance, Khanal et al. (2018), using stochastic frontier analysis, evaluated the effect of farmers' adaptation strategies on technical efficiency in Nepal. The study measures the value of production (Rupees) for three crops: rice, maize, and wheat. For the production function, the study includes the following inputs: area, labor, fertilizers (kilograms), and capital (seeds and pesticides in Rupees). For the inefficiency model they included: education, experience, distance to market, irrigated land, the adaptation index (total of weighted adaptation options), and membership. Results show that adaptation is a key factor in explaining inefficiency;

adopters on a larger scale are more efficient (13%) than adopters on a smaller scale. In addition, membership positively affects technical efficiency (members share information about markets, technologies, and production issues); however, no further analysis of social networks and norms was included. In the same research approach, Roco et al. (2017) emphasize the role of adaptation options concerning irrigation technologies and meteorological information, concluding that farmers who use these options have higher levels of technical efficiency.

Thus far, risk preferences, estimated under cumulative prospect theory (CPT), have not been included in the combined analysis of technical efficiency and adaptation. Still, empirical evidence shows how risk behavior, estimated under expected utility theory, affects efficiency levels directly. As Kumbhakar (2002) stated, risk plays a key role in decisions about inputs and outputs. This author generalized an efficiency model to combine production risk and farmers' risk behavior. The model was applied to Norwegian salmon farms, finding that production risk increases with feed, decreases with labor and capital and that farmers show risk-averse behavior (Kumbhakar and Tveterås, 2003). To the best of our knowledge, no studies to date apply cumulative prospect theory to estimate risk preferences and explain its relationship with technical efficiency.

As we mentioned earlier in this section, empirical studies have shown that social capital plays a key role in understanding sources of inefficiency (efficiency). Specific literature analyzes the role of social capital through the effect of social networks and membership as mechanisms to access finance, information, and other resources. In this context, Muange (2015) investigated the effect of networks on the efficiency of small cereal farmers in Tanzania through a stochastic frontier analysis. The model was applied to plot-level data of cereals (maize and sorghum), and the results show that network effects on technical efficiency are different for each crop. Specifically, social networks increase efficiency in the case of sorghum, but there is no effect on maize. The bridging dimension of social capital, measured through the connections of the farmer with actors outside the community (extension advisors), has a positive effect on the efficiency of maize.

Binam et al. (2004) emphasize the role of social capital in technical efficiency analysis among small farmers in Cameroon. They explained differences in technical efficiency by the following variables: extension services, social capital, credit, distance to road, and fertility of the soil. The study reveals the relationship between club membership and inefficiency, highlighting how social capital provides incentives for efficient production. When farmers are members of an association, they can share information about technologies and production activities and increase their access to extension services: all of these improve market access and incomes.

Empirical evidence highlights the key role of adaptation practices, risk preferences, and social capital related to the technical efficiency of productive systems. Most commonly, the analysis of risk preferences related to technical efficiency is based on expected utility and not prospect theory. In the present study, we jointly determined risk aversion and risk seeking by the value function and cumulative weighting functions. Therefore, this study contributes to the literature by combining the analysis of the effect of adaptation options, risk preferences, and social capital on technical efficiency. As a case study, we apply the framework to vineyard farms in Central Chile.

4. Methods

4.1 Area of study

Chile is divided into 15 administrative regions, which are also divided into provinces and communities (INE, 2017). This research took place in the two most important regions for the cultivation of vineyards in Chile: Region VI of O´Higgins and Region VII of Maule. For instance, Region VI of O'Higgins contains 34.44% (47,382.07 ha) of the total area in Chile under grape cultivation, while Region VII of Maule contains 38.88% (53,496.51 ha). These areas represent 73.32 % (100,878.58 ha) of the country's total land area in vineyards (SAG 2014)[16]. Therefore, these regions are important for studies on technical efficiency and its determinants.

Figure 4. Map of Chile and administrative regions of interest.

[16] Chile has an area of 137,592.44 hectares dedicated to the cultivation of vineyards (SAG 2015).

Specifically, the study was applied in the following communities: Nancagua, Santa Cruz, Palmilla, Peralillo, Requinoa, Chimbarongo, San Vicente, Peumo; from Region VI of O´Higgins; and San Javier, Sagrada Familia, Curico, Villa Alegre, Talca, San Clemente, Maule, Rio Claro (Cumpeo) from Region VII of Maule.

4.2 Data

4.2.1 Sample data

In general, the data for this study were collected through a field experiment and an exit survey with vineyard farmers of central Chile. We selected farmers based on a database from the University of Talca, Chile. This original database was collected from November 2014 through February 2015 and consisted of 452 vineyard farmers from the Region VI of O´Higgins and Region VII of Maule. It is cross-sectional data with socioeconomic, irrigation systems, production, and social capital variables.

We randomly selected 204 small vineyard farmers from the regions mentioned above from this database because of their importance for vineyard cultivation. Afterward, we contacted these farmers by phone to determine their willingness to participate in the research. Of these 204 vineyard farmers, 22 were excluded because they no longer cultivate vineyards, and another seven were excluded because we identified inconsistencies in the data. In the end, the sample size for this study was 175 small vineyard farmers distributed throughout the regions of O'Higgins and Maule in a total of 16 communities.

Data were collected from September to December 2016 with vineyard farmers, and, as we mentioned before, we used a face-to-face survey field experiment that includes the following sections: Section I: Introduction, Section II: sociodemographic and socioeconomic information of the farm owner, and Section III: the artefactual field experiment (risk preferences). The exit survey includes the following sections: Section I: climate change (perception and issues), technological, behavioral, and economic adaptation options, Section II: productive information, and Section III: social capital. In addition, the exit survey was used to identify general problems and those related to climate change. There were four interviewers or enumerators from the study area, and therefore they were familiar with the language, culture, and customs of small vineyard farmers. Usually, the survey experiment and exit survey took 40 minutes to complete with each individual. Each respondent was informed that they were free to refuse to participate and that they did not need to answer any question sensitive to them. Also, an alternate respondent replaced those who declined to participate.

4.2.2 Stochastic frontier specification and variable selection

Small vineyard farmers from Region VI of O´Higgins and Region VII of Maule (central Chile) show different proportions of the area allocated to vines, a large range of vine varieties, different technologies, management, and market orientation, which means different scales of the vineyards' production. In this regard, the stochastic frontier analysis (SFA) allows us the opportunity to appraise individual farmer capacities in comparison to a frontier (Meeusen and van Den Broeck 1977), where the composed error term explains deviations from the frontier: the statistical error term or random noise (v_i) distributed as N (0; σ^2_v), and the inefficiency error term (u_i) distributed as N^+ (0; $\sigma^2_{u,i}$) (Aigner et al., 1977), as we explained in section 2 of the theoretical framework. Nevertheless, as we used a production function based on cross-sectional data where farms vary in size, among other factors, we can expect that the inefficiency error term (u_i) is heteroscedastic (Caudill and Ford 1993; Caudill et al., 1995: Wang and Schmidt 2002) and can be dependent on a group of covariates (Wang and Schmidt 2002). In this research, we applied the model developed by Wang and Schmidt (2002) due to the differences in the area for vines, vine varieties, technologies, management, and market orientation, thus we anticipated variation at the efficiency level.

We have chosen the Cobb-Douglas function form for the production frontier and tested it against the more flexible translog form. The likelihood Ratio Test (LRT) confirms the selection of the Cobb-Douglas form at a 1% significance level. We also performed the LRT to select the input variables to avoid omitted or overestimated variable bias.

The Cobb-Douglas production function as an empirical model has an easy interpretation and assumes equal production elasticities, scale elasticities, and unitary substitution for firms (Coelli and Sanders, 2013; Greene, 2008), and in general, the coefficients can be interpreted as output elasticities. Fundamentally, the general model is:

$$\ln\, y_i = \beta_0 + \beta_1 lnK_i + \beta_2 lnL_i + \beta_3 lnIM_i + \beta_4 lnNV_i + \beta_5 PA_i + (v_i - u_i) \qquad (15)$$

$$v_i \approx N(0, \sigma_u^2)$$

$$u_i \approx N^+(0, \sigma_u^2) \quad \sigma_u = \exp(z\delta)$$

Where the output (y_i) is the value of the total production of grapes in tons from the main variety area, the inputs are capital stock (k_i) explained by the value of vineyards in the main variety area plus one-time investments such as irrigation and training system[17] and labor (L_i) is the total labor days per year to apply agrochemical (fertilizer, acaricide, herbicide, insecticide, and fungicide) and carry out management activities (pruning, harvesting, disbudding, and toping). Intermediate inputs (IM_i) are defined as the total value or cost of agrochemicals (fertilizer, acaricide, herbicide, insecticide, and fungicide) and water rights, the number of vines (NV_i) per area of the main variety, and the plantation age (PA_i). In addition, we included variables that might shift the production frontier: a dummy variable for variety quality (low or high) and training system (parrón or espaldera). All these variables were selected to generate a constant flow of services across the farmers and avoid multicollinearity. Furthermore, these variables were scaled by their mean, and then we took logarithms to converge the function better.

Then, we analyzed the determinants of technical efficiency to explain deviations from the frontier accordingly to Wang and Schmidt (2002) and the scaling function defined as $(z_i,) =$ exp (z'):

$$h(z_i, \delta) = \exp(\delta_1 + \delta_2 Ex_i + \delta_3 Ag_i + \delta_4 Ed_i + \delta_5 Ge_i + \delta_6 Ti_i + \delta_7 Re_i + \delta_8 De_i + \delta_9 Ad_i + \delta_{10} Ir_i + \delta_{11} Pp_i + \delta_{12} Pd_i + \delta_{13} Ma_i + \delta_{14} Hs_i + \delta_{15} Md_i + \delta_{16} In_i + \delta_{17} Tr_i + \delta_{18} Nt_i + \delta_{19} Nr_i + \delta_{20} M_i + \delta_{21} Ra_i + \delta_{22} La_i + \delta_{23} Pw_i) \quad (16)$$

Where Ex_i is experienced in vineyards (years), Ag_i is the age of farmers (years), Ed_i is level of education (years), Ge_i is gender (male), Ti_i is the distance to market (minutes), De_i is density (number of vines per ha), Ad_i is advisor, Ir_i is the type of irrigation (drip or furrow), Pp_i is the prevention of pests through pheromone diffusers (yes or no), Pd_i is the prevention of diseases (yes or no), Ma_i is management (conservation practices), Hs_i is mitigation of frost (heating systems), Md_i is mitigation of diseases (chemical), In_i is insurance (yes or no), Tr_i is general trust (yes or no), Nt_i is the network (number of farmers who adopted technologies), Nr_i is the norm of reciprocity (organization of agricultural events to improve knowledge), M_i is membership in agricultural organizations (yes or no), Ra_i is risk aversion, La_i is loss aversion, and Pw_i is probability weighting (distortion or not of probabilities).

[17] For this one time investments, we use the straight line depreciation to estimate the current value.

Finally, we use Battese and Coelli (1988) for the estimation of technical efficiency (TE_i) of each farmer, as shown in Kumbhakar and Lovell (2000):

$$TE_i = E\,[e^{-u_i} |\, \varepsilon_i] \tag{17}$$

4.2.3 Adaptation to climate change: anticipatory and reactive adaptation options

The information was collected from experts through semi-structured interviews and farmers through the exit survey (after each experiment). Then, the information was classified by the type of adaptation, anticipatory or reactive, and validated according to the IPCC (2012). Each adaptation option was a dichotomous dependent variable with a value of 1 when farmers adopted the option. We focused on adaptation to climate change based on water access, frost, diseases, and pest problems or shocks.

4.2.4 Risk preferences: experimental design, procedure, and parameters estimation

We conducted a field experiment to estimate the risk preferences of 175 small vineyard farmers in two central regions of Chile (O´Higgins and Maule). The experiment was designed as an artefactual field experiment which means that the intervention took place in real life, in this case in farms with vineyard farmers, applying the scientific method and avoiding controlled conditions as in a lab (but with the same quality). Also, the subjects of interest (farmers) understood that they were participating in an experiment.

As we mentioned in the theoretical framework, the design of the experiment follows the methodology originally proposed by Tanaka et al. (2010) and then replicated by Liu (2013), Bocquého (2014), and Ward and Singh (2015) to elicit the cumulative prospect theory (CPT) risk preference parameters (sigma (σ) is the curvature of the utility function seen as a measure of risk aversion, where lambda (λ) is loss aversion and gamma (γ) is derived from a probability weighting function to analyze distortion of probabilities). We focused on Ward and Singh's (2015) design, a variation of Tanaka et al. (2010). This design is easy to implement in developing countries with small farmers. A complete explanation of the design, procedure, and parameter estimation can be seen in Appendix 3.

4.2.5 Social capital: variables selection

The social capital variables that we consider for this study are illustrated in Table 9.

Table 9. Social capital variables.

Explanatory variables	Description
Trust	
General trust	It is an observed independent variable based on the farmer's rating of the following statement: “I trust the farmers in my community.” Measured using a Likert scale: 1=Strongly disagree, 2=disagree, 3=Neutral, 4=Agree, 5=Strongly agree
Institutional trust	It is a continuous latent variable based on four statements indicating farmers’ level of trust in agricultural associations, municipalities, public institutions, and the state. Measured using a Likert scale: 1=Strongly disagree, 2=disagree, 3=Neutral, 4=Agree, 5=Strongly agree
Social network	
Network	It is an observed independent variable measured by asking the number of individuals that the subject knows that have implemented at least one adaptation option
Member of an organization	It is an observed independent binary variable. It takes the value of 1 if the farmer has participated in community-based organizations, including water, environmental, and farmer organizations, and 0 otherwise
Social norms	
Norms of reciprocity	It is a continuous latent variable measured by three statements "I organize meetings with producers and consultants to acquire new knowledge in agriculture"; "When attending agricultural events, I actively participate"; and "My opinion is considered in agricultural associations to which I belong" (KMO: 0.62, Cronbach alpha of 0.6). From these statements, we construct one variable. These items were measured using a Likert scale: 1=Strongly disagree, 2=disagree, 3=Neutral, 4=Agree, 5=Strongly agree. This variable captures the extent to which farmers see themselves as providing value to their organization through knowledge sharing.

Source: own calculation.

5. Results

5.1 Descriptive statistics

In total, 175 farmers from two different regions in Central Chile (Maule and O'Higgins) participated in this study. Table 10 presents the descriptive statistics for the output and inputs of the production function and the variables that might shift the production frontier. On average, the total grape production from a single variety, denoted by the “main variety of the vineyard,” is 59.92 tons, whereas the main variety area is 4.56 hectares. Capital stock (value of vineyards in the main variety area plus one-time investments such as irrigation and training system) is around 28,000,000 Chilean pesos. Total labor per main variety area is 224.31 days.

Regarding intermediate inputs (costs of agrochemicals and water rights), the value is 1,687,652.00 Chilean pesos. The number of vines per main variety area is 16,699.87 plants. Plantation age is equivalent to 22.25 years. Regarding the quality of variety, only 11% produce for special markets (premium), and training systems are almost 19% “parron” style, increasing quantity but less quality.

Table 10. Descriptive statistics for production function variables.

Variable	**Description**	**Mean**	**Std. dev**
Total production mv	Total tons per main variety area	59.92	51.12
Capital	Chilean Pesos per main variety area (vines value)+irrigation systems+ training systems	2.80e+07	2.05e+07
Total labor mv	Chilean Pesos per main variety area	3,364,661.00	2,863,663.00
Total labor two mv	Number of days per main variety area	224.31	192.171
Intermediate inputs	Chilean Pesos per main variety area	1,687,652.00	1,652,612.00
Number of vines	Total of vines per main variety area	16,699.87	13,530.99
Main variety area	Hectares of the main variety	4.56	3.213
Plantation age	Number of years of the main variety	22.25	14.622
Variety quality	Low or high-quality of the grape	0.11	0.311
Training system	Method to assist canopy management	0.19	0.396

Source: own calculation.

Additionally, we have analyzed the descriptive statistics for the determinants of the inefficiency model (Table 11). The average age of farmers was 55 years, and 90% were male, with an average of 24 years of experience working in vineyards. The participants had, on average, ten years of education, achieving a secondary or middle education.

Table 11. Descriptive statistics for the main determinants of inefficiency.

Variable	**Description**	**Mean**	**Std. dev**
Age	Respondent age in years	55.10	13.692
Gender	= 1 if the respondent is male	0.90	0.30
Education	Respondent's years of formal education	10.28	4.155
Experience	Years of experience working in vineyards	24.36	15.468
Time	Time to closest market in minutes	16.25	11.405
Density	Number of vines per ha	4,046.43	2,317.45
Advisor	= 1 if access to advisor/ extension services	0.30	0.458
Irrigation type	= 1 if it is furrow	0.75	0.431

Variable	Description	Mean	Std. dev
Prevention of pests	=1 if the farmer uses pheromone diffusers	0.69	0.465
Prevention of diseases	=1 if the respondent uses specific practices	0.91	0.289
Management	=1 if the farmer uses cultural practices	0.67	0.469
Mitigation of frost	=1 if the farmer implements heating activities	0.22	0.417
Mitigation of diseases	=1 if the farmer applies agrochemicals	0.75	0.431
Weather insurance	=1 if the farmer has a weather insurance	0.12	0.325
Trust	Confidence in the reliability of others	3.45	1.187
Network	Number of farmers who adopted technologies	3.78	4.396
Norm of reciprocity	organization of events to improve knowledge	2.42	1.431
Membership	= 1 if the farmer participates in a local organization	0.86	0.350

Source: own calculation.

On average, the time to the closest market was 16 minutes. The density of vines per ha is 4,046.43, which is comparable to the literature, as, generally, the density is around 3,000 vines per ha. Still, it depends on whether farmers want more quality (less density) or more quantity (more density) (SAG 2015). From the total, only 30% of the participants have access to extension services to discuss specific production topics.

Regarding anticipatory adaptation options, furrow irrigation has been adopted by 75% of the interviewed farmers, and pheromone diffusers, as a prevention of pests, are a well-established adaptation option; about 70% of the vineyard farmers implement this option on the farm. However, disease-prevention practices, such as a collection of damaged fruits, among others practices, have been adopted by 91% of the farmers from the sample. Changing management practices (cultural activities) have been implemented by 67% of the participants; these practices include pruning, and disbudding, among others. Whereas reactive adaptation options, as a response to an external shock due to climate change such as frost, disease, or pests, have, in general, a lower rate of implementation, leading us to conclude that farmers are risk and loss averse. The potential reactive options include mitigating frost through heating activities and soil flooding, yet only 22% of the farmers used these options; also, 75% of the participants used agrochemicals to control for diseases. A reactive adaptation option in economic terms is related to the acquisition of weather insurance, 12% of the participant farmers have weather insurance, and 41% of the participants are interested and willing to purchase weather insurance.

As we mentioned before, in the case of social capital, farmers have moderate trust in other people (3.45 out of 5). Regarding networks, on average, the number of farmers in the respondent network that has adopted any adaptation option is 4. Furthermore, there are moderate norms of reciprocity (2.42 out of 5) at the moment to help others. Finally, the average participation in any local organization is 86%.

5.2 Risk preferences parameters

From the total farmers of the sample (175), we estimate the Cumulative Prospective Theory (CPT) risk preferences parameters (σ, λ, and γ) (Table 12). Our estimations are consistent with estimations in the literature (see section 2.2)—for instance, σ =0.84, which indicates risk aversion among the farmers. Regarding loss aversion, λ =2.98, we can assume vineyard farmers are three times more sensitive to losses than gains. Finally, the value of probability weighting is γ=0.75, which means that vineyard farmers tend to overestimate small probabilities.

Table 12. Risk preference parameters using the midpoint method (inequalities).

Parameter	Value	Std. Err.	β_0= 1
Curvature of the value function (Risk aversion) (σ)	0.84***	0.034	0.000
Loss Aversion (λ)	2.98***	0.286	0.000
Probability weighting (γ)	0.75***	0.013	0.000
Observations	175		
Clusters	0		

Source: own calculation.

Note: *p < 0.1, ** p < 0.05, *** p < 0.01.

To estimate the parameters of risk aversion, probability weighting, and loss aversion for each observation (each farmer), we follow the midpoint method established by Tanaka et al. (2010) and applied by Liu (2013); Bocquého et al. (2014); and Ward and Singh (2015).

5.3 Functional form: parameters of the production function and determinants

As we stated, this research occurred in Region VI of O´Higgins and Region VII of Maule, central Chile. In these regions, the vineyard production is well explained by a Cobb –Douglas Stochastic Frontier production function; we choose this functional form after testing it against the translog production function. We performed the Likelihood Ratio Test (LRT) to confirm our selection at a 1% significance level (p-value=0.055). This is consistent with the literature; for example, Moreira et al. (2011) analyzed the technical efficiency of Chilean grape farmers in central Chile through a Cobb –Douglas production function.

In our production model, capital, number of vines per main variety, labor, and intermediate inputs are the most important inputs. The coefficients of this group of inputs are all significant and positive and were estimated through the Maximum Likelihood (ML) approach. Other studies in grapevine production indicate that the most influential inputs are block size (an area with one variety and a certain management), labor and machinery (Moreira et al., 2011), and also that land, labor, and agrochemicals (pesticide, herbicide, and fertilizer) are the most imperative inputs (Piesse et al., 2018). These results are similar, as we included the land value in the capital to a certain extent. We used the number of vines per main variety instead of the area to avoid multicollinearity among the variables. In addition, our model includes intermediate inputs such as agrochemicals (pesticide, herbicide, and fertilizer) but includes water rights.

According to the literature, the influence of capital (0.55) and the number of vines (0.32) is high enough, whereas labor (0.13) and intermediate inputs (0.11) are also important but relatively low (Table 13). Finally, the sum of these exchangeable inputs or the scale elasticity is 1.11, showing a Constant Returns to Scale (CRS); we confirm this condition by the Wald-test (p=0.8507). This Constant Returns to Scale (CRS) means that output increases by the same proportional change as all inputs change. Regarding the variables that might shift the production frontier, the age of vines is negative, as we expected, but not significant. In contrast, variety quality is negative and significant, which makes sense because generally, the higher the quality, the less productive. The training system ("parrón") is positive and significant, which means this trellising system helps to improve production.

All these variables were selected to generate a constant flow of services across the farmers and avoid multicollinearity. Furthermore, these variables were scaled by their mean, and then we took logarithms to converge the function better.

Table 13. Estimated coefficients for the stochastic production frontier.

Parameter	Value	Std. Err.
Intercept	0.29***	0.091
Capital	0.55***	0.164
Labor	0.13*	0.073
Intermediate inputs	0.11*	0.058

Parameter	Value	Std. Err.
Number of vines	0.32***	0.087
Age of vines	-0.004	0.002
Variety quality	-0.44***	0.104
Training system	0.50***	0.133
Observations	175	
Chi2	441.41	
P	0.0000	

Source: own calculation.

Note: *p < 0.1, ** p < 0.05, *** p < 0.01.

Efficiency

The mean Technical Efficiency index is 0.73 (73%) with a standard deviation of 0.17, which indicates that farms could improve their performance by 27% (Figure 5).

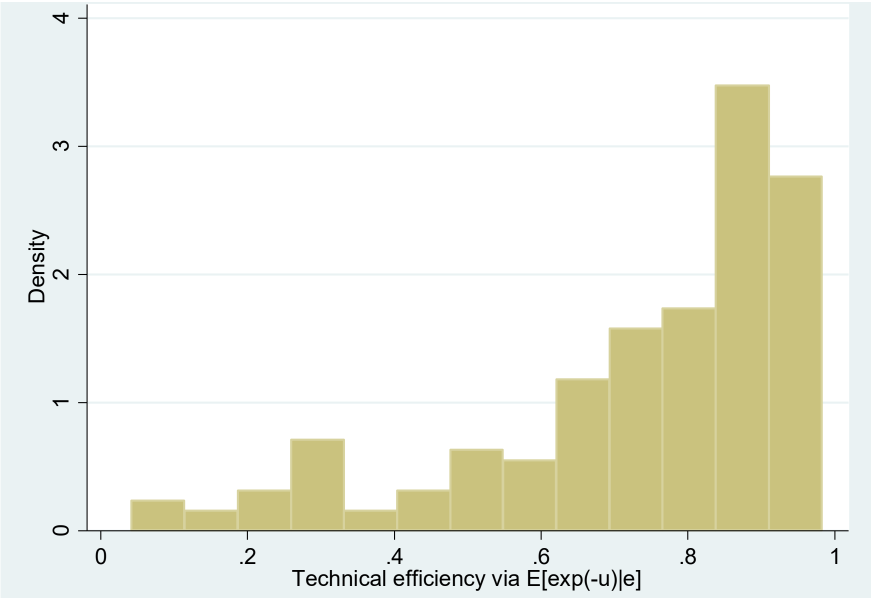

Figure 5. Technical efficiency of vineyard farmers in central Chile.

Source: own calculation.

Deviations from the frontier could be explained by socioeconomic, technological, social capital, and behavioral determinants, as we can see in Table 14. As mentioned in the theoretical framework and methodology, the inefficiency model has a half-normal distribution. In general terms, it is possible to see and understand the effect of socioeconomic variables, adaptation options, social capital forms, and risk preference parameters on the technical efficiency of small vineyard farmers of central Chile.

Table 14. Determinants of technical efficiency.

Variable	Coefficient	Std. Err.	Effect on TE	Marginal Effects
Experience	-0.04***	0.015	+	-0.004
Age	0.04**	0.020	-	0.002
Education	-0.08	0.057	+	-0.544
Gender	1.91**	0.812	-	0.015
Time to market	0.02	0.019	-	0.004
Region	2.01***	0.752	-	0.013
Density	0.001***	0.001	-	0.002
Advisor	-1.27**	0.560	+	-0.001
Irrigation	-0.99**	0.530	+	-0.003
Prevention of pests (pheromone diffuser)	-0.06	0.662	+	0.004
Prevention of diseases	-0.98	0.808	+	0.015
Management	1.90***	0.664	-	0.016
Mitigation of frost	-0.67	0.513	+	-0.007
Mitigation of diseases	-0.10	0.468	+	0.015
Weather insurance	-0.58	0.765	+	0.005
General trust	-0.60**	0.254	+	-0.003
Network with adaptation	0.43	0.568	-	0.005
Norm of reciprocity (events)	0.34*	0.198	-	0.046
Membership	-0.90*	0.533	+	-0.002
Risk aversion	0.76**	0.454	-	0.003
Loss aversion	0.25	0.413	-	0.003
Probability weighting	2.88*	1.628	-	0.019
Observations	175			
Chi2	441.41			
P	0.0000			

Source: own calculation.

Note: *p < 0.1, ** p < 0.05, *** p < 0.01.

As we expected, experience in vineyard production positively affects technical efficiency (-0.04) at a significance level of 1% because more experience can lead to better decision-making when farmers face production problems. In the case of age decreases efficiency (0.04) and is significant at a 5% level, which is, in some cases, an expected result because we can assume that old farmers are not interested in changing or improving their production system.

On the contrary, young farmers could show more willingness to participate in extension services programs, adopt new technologies, improve or make changes to their systems to have better revenues, etc. Gender (=1 if male) also has a negative effect (1.34) on efficiency at a significance level of 5%; this could be interpreted as female farmers being generally better decision-makers. The distance to the closest market in minutes also has a negative effect on technical efficiency (0.02); this could be interpreted as the farther from the market, the less efficient, because more distance implies more logistics and costs to deliver the grapes, also those farmers that are further away from the market have less access to information and services (prices, technologies, extension services, credits, insurance, etc.).

In the case of the region, we identified that these variable decreases efficiency (2.01) with a significance level of 1%, indicating that farmers from Region VII of Maule are less productive than those from Region VI of O´Higgins. To confirm this, we compared the yields of each region. It turns out that farmers from Region VII of Maule have an average yield of 11.95 tons per ha, whereas farmers from Region VI of O´Higgins have an average yield of 15.37 tons per ha. This may be due to the proximity of Region VI of O´Higgins to the metropolitan region of the country, which means better access to markets, information, and services. An interesting determinant is a density (vines per ha) because this decreases efficiency (0.01) and is significant at a 1% level. Nevertheless, this could be interpreted as the small vineyard farmers being more interested in high-quality levels of grapevines which implies fewer vines per ha.

Regarding access to extension services, we identified that this has a positive effect on technical efficiency (-1.27) at a significance level of 5%, which could be interpreted as the extension services from the Government and ministries being well structured with enough quality to solve problems. In the case of irrigation (furrow), this increases efficiency (-0.99) and is significant at a 5% level. This could lead us to believe that farmers do not have problems with water access; of course, they paid for water rights, but once they have access, there are no problems with the amount; this could explain why so few adopt modern irrigation. Moreover, management decreases efficiency (1.90) at a significance level of 1%. This could be due to an overuse of cultural practices such as pruning, disbudding, and topping. It would be interesting to analyze the effectiveness and costs of each activity. About other technologies or adaptation options that help to face the negative effects of climate change (prevention of pests, prevention of diseases, mitigation of frost, mitigation of diseases), we found that these could positively affect technical efficiency, but they are not significant.

Regarding social capital forms, as we mentioned before, empirical studies have shown that social capital plays a key role in understanding sources of inefficiency – efficiency (Binam et al., 2004; Muange, 2015). Concretely, we found that general trust makes farmers more efficient or increases efficiency (-0.60) at a significance level of 1%: maybe farmers are more willing to cooperate or engage in productive interactions, and they can learn from others from extension services. More trusting farmers may be more open to receiving and sharing information and services.

In the case of the norm of reciprocity, it has a negative effect on technical efficiency (0.34); this is significant at a 10% level. This result could be explained as such: more time invested in organizing events to share knowledge could lead to less time to make decisions about products or to be involved in key production activities on the farm, or perhaps the effect of these agricultural events is not as expected.

Membership (-0.90) increases efficiency at a significant level of 1%; this could be explained by farmers being more exposed to information, services, shared experience, and having access to technologies or adaptation options. Muange (2015) reports similar findings; he analyzed the effect of social networks and membership as mechanisms to access finance, information, and other benefits. Binam et al. (2004) emphasize the role of social capital on technical efficiency; basically, they analyzed the relationship between membership and inefficiency, highlighting how social capital provides incentives for efficient production. They explained that member farmers of an association could share information about technologies and production activities and increase their access to extension services. All of these effects improve market access and incomes.

Regarding risk preferences, in agriculture, risk plays an essential role in production decision-making (Bocquého et al., 2014). Moreover, it has an important effect on decisions concerning inputs and outputs (Kumbhakar 2002). However, thus far, risk preferences, estimated under cumulative prospect theory (CPT), have not been included in the combined analysis of technical efficiency, social capital, and adaptation. For these reasons, we included the risk-averse, loss-averse, and probability weighting variables to understand their effect on efficiency. In this case, we use these parameters as dummy variables because, as Liu (2013) stated, these parameters show some grade of correlation that could lead to a misinterpretation of the results.

Under cumulative prospect theory (CPT), farmers exhibit risk-averse behavior (0.76), which is significant at a 5% level. This variable negatively affects technical efficiency, as risk-averse farmers tend to avoid changes in technologies or practices even more, when these activities are expensive. Finally, the probability weighting variable (2.88) decreases efficiency at a significance level of 1%. This is because farmers who distort probabilities try to avoid changes in production systems.

6. Conclusions

This study took place in central Chile, in the two most important regions for the cultivation of grapes, Region VI of O´Higgins and Region VII of Maule, because these jointly represent 73.32 % (100,878.58 ha) of the country's cultivation area for this crop. Consequently, it is imperative to understand the main inputs for production and identify the determinants of technical efficiency to design better strategies and policies to help farmers improve their production systems. In this regard, farmers specified that the main problems in their regions are related to pests, frost, and diseases. Whereby they have implemented adaptation options in their vineyards without knowing the efficiency of these practices.

This study estimates technical efficiency as an integrated approach, including risk preferences and social capital for small vineyard farmers adapting to climate change. Empirical evidence shows the key role of adaptation options, risk preferences, and social capital related to the technical efficiency of productive systems on a one-to-one basis; however, up to this point, there has been no overarching analysis. This study focuses on Stochastic Frontier Analysis to estimate technical efficiency and its determinants: adaptation options to face climate shocks, risk preferences (risk aversion, loss aversion, and probability weighting), and social capital forms (trust, network, and social norms). We also control for socioeconomic variables and physical characteristics of the farm. It is important to highlight that we estimate risk preference parameters under cumulative prospect theory (CPT) (curvature of the function as a measure of risk aversion, loss aversion, and probability weighting) because, to date, the majority of literature regarding the analysis of risk and technical efficiency has been based on expected utility theory (EUT), which cannot capture how farmers make decisions based on the possibility of gains or losses and how farmers distort probabilities.

We used a Cobb – Douglas production function with a sample of 175 small vineyard farmers. Results showed that the influence of capital (0.55) and the number of vines (0.32) is relatively high. In comparison, labor (0.13) and intermediate inputs (0.11) are also important but relatively low. The scale elasticity is approximately 1.11, showing a Constant Returns to Scale (CRS); in other words, output increases by the same proportional change as all inputs change.

On average, technical efficiency was 0.73, meaning farmers could improve their performance by 27%. Results suggest that experience and education positively influence the technical efficiency of vineyard systems, as opposed to age, gender, region, and density. Access to extension services and irrigation increases technical efficiency. Additionally, general trust and membership in farmer organizations increase technical efficiency. Finally, as we expected, risk aversion and probability weighting (distortion of objective probabilities) negatively influence technical efficiency.

In light of our findings, it is necessary to design policies that facilitate small farmers' access to a wide range of exchangeable inputs to take advantage of the Constant Returns to Scale. In addition, it is necessary to promote strategies and policies with an emphasis on more extension services with greater action areas, facilitating access to irrigation through subsidies and credits, and improving trust in programs, projects, and networks. It is also necessary to develop cooperative enterprises or local and horizontal organizations to share information and services from farmer to farmer and generate action plans to promote a better risk and loss behavior to seize technological and economic opportunities and not overestimate extreme events.

Chapter 4. Concluding remarks

Agriculture is a significant driver of climate change but, at the same time, is one of the most vulnerable economic sectors due to changes in precipitation patterns and the highest incidence of extreme weather events (Clapp et al., 2018). Around 2.5 billion people depend on agriculture, concentrated mainly in Less Developed Countries (LDC), where over 60% of the population is affected due to its dependence on agricultural production. Consequently, the agricultural sector must implement adaptation options that will reduce its vulnerability and increase the resilience of rural areas to face the unavoidable negative impacts due to past emissions (Fischer et al., 2002; FAO, 2007; van Meijl et al., 2017). Adaptation refers to policies, practices, and projects aiming to moderate damage from climate change's negative effects (Di Falco et al., 2011). Small farmers are frequently affected by droughts or crop diseases/pests due to changes in precipitation patterns and temperatures; nonetheless, adoption rates of adaptation measures are still low (Ali and Erenstein, 2017; Isinika et al., 2016; Menike and Arachchi, 2016). In this dissertation, we analyzed adaptation based on the timing of the action (anticipatory and reactive adaptation) following the typology proposed by Smith et al. (2000). Anticipatory adaptation is when the farmer implements actions to avoid a loss in the future due to a climate-related shock. Reactive adaptation is when the farmer implements an action in response to a climate-related shock. Lecocq and Shalizi (2007) identified that by promoting the adoption of anticipatory options, the Government could balance limited financial resources among mitigation, adaptation, and recovery. This dissertation aims to understand the role of risk preferences and social capital as determinants of adaptation options and technical efficiency in adapting to climate.

4.1 Main findings

In the first chapter, we analyzed how small farmers' risk preferences and the three forms of social capital: trust, norms, and networking, affect the decision to implement anticipatory (ex-ante) or reactive (ex-post) adaptation options to climate change. In doing so, we applied Cumulative Prospect Theory (CPT) to consider that, in addition to risk aversion, farmers might be more sensitive to losses than gains and that they might under-or-overweight probabilities affecting their adaptation decisions. This approach is relevant to the success of the implementation of any adaptation strategy.

Our first chapter explores how small farmers' risk preferences and the three forms of social capital: trust, norms, and networking, affect the decision to implement anticipatory (ex-ante) or reactive (ex-post) adaptation options to climate change. Concretely, this paper applies Cumulative Prospect Theory to determine risk aversion, loss aversion, and the probability weighting function to understand risk preferences beyond risk aversion. We find that farmers in our sample are main risk averse (σ =0.59), three times more sensitive to losses than to gains (λ =2.44), and tend to overestimate small probabilities (γ=0.79); confirming our selection of approach of using CPT over EUT. Finally, we identified the effect of these risk preferences parameters and social capital forms (trust, social norms, and network) on the anticipatory and reactive group of adaptation options and the technologies in each group. We found that loss aversion and probability weighting have a key role in implementing these technologies and some forms of social capital as norms of conservation, network, trust, frequency of extension services, and shocks.

Our second chapter focuses on how adaptation options to climate change (anticipatory or reactive), risk preferences (risk aversion, loss aversion, and probability weighting), and social capital forms (trust, network, and social norms) affect the technical efficiency of small vineyards in central Chile. To estimate technical efficiency, we first estimate the production function through a Cobb-Douglas function identifying that capital, the number of vines per main variety, labor, and agrochemicals are the most important inputs. Notwithstanding, capital and number of wines are the highest elasticities with 0.55 and 0.32, respectively. Our sample has a mean technical efficiency index of 0.73, indicating that farms could improve their performance by 27%.

We find that from the four anticipatory measures, only irrigation and management significantly affect efficiency. Irrigation contributes positively, while management decreases efficiency. The positive contribution of furrow irrigation to efficiency could be because it is a practice that many farmers (85% of the sample) have and that, in case of a problem, they can easily solve the issue by asking their network fellows. In addition, to incentivize adoption of furrow irrigation the government covers up to 75% of the total investment with subsidies. In addition, there are no extreme water limitations in the Maule and O' Higgins Regions, and the amount of water that grape cultivation requires is fulfilled by furrow irrigation. Furrow irrigation is not as efficient as pressurized irrigation (only 25% of the farmers have pressurized irrigation), but it requires less initial investment, training, and maintenance. According to Hunecke et al. (2016), one of the main drivers to switching to more efficient irrigation systems is experience with water limitations. Regarding the anticipatory adaptation measure of management, the effect is negative. This finding can be explained because farmers overweight small probabilities and overuse cultural practices in production processes. Overall, we find that adopting reactive adaptation options does not significantly affect technical efficiency, which could be explained by the timing of implementation. Reactive anticipatory measures are implemented after a shock. Therefore, even though they could positively increase the efficiency level, the loss due to the climate-related shock could reduce the contribution of the reactive adaptation option (Khalil, 2003).

Another key finding regarding social capital is the positive effect of general trust on efficiency. This could be due to the extensive experience that the farmers have; on average, in our sample, a farmer has 24 years of cultivating grapes. Trust is built over time (Wreford et al., 2017), which makes us believe that the high levels of trust from our sample result from working together during all these years involved in the cultivation of grapes. Membership's positive and significant effect reinforces this finding; specifically, grape farmers have a strong and well-established organizational structure. If a farmer is a member of a farmer organization it is more likely that he could have access to information about prices, weather information, training programs, and even private extension services. Surprisingly, we find a negative effect from norms of reciprocity; this could be due to the vertical (top-down) organization structure, which does not allow ample participation for small farmers. Although small farmers receive the member benefits, they can feel their participation is a burden if decision-makers do not consider their opinion in the organization. Finally, risk aversion negatively influences technical efficiency because risk-averse farmers tend to avoid changes in technologies or practices even more, when these activities are expensive.

4.2 Policy implications

Small farmers have many constraints, so public policy should provide appropriate support to enhance resilience and reduce the vulnerability of small farmers by adjusting management, production methods, and farm structure. The role of the Government has been most commonly on the generation and sharing of information. Nonetheless, when the costs of adaptation are high but provide public benefits, the government should consider proving a financial contribution .

The policy implications from our findings imply interventions at different levels. At the national level, we recommend that when preparing a national adaptation plan and strategies, the government should consider agricultural risk and not focus only on promoting adaptation technologies. Still, we include risk management strategies as part of the extension services. Results show that in the context of Chile, the extension services have a positive effect, and the farmers are open to receiving advice from the extension agents. This opens an opportunity to incorporate in the extension program a set of risk management strategies and competencies in terms of perceived risk so the farmer could make a due diligent decision.

In a broader context than Chile, according to the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework on Climate Change (UNFCC), each country must design strategies and action plans to reduce vulnerabilities. These plans are too general and do not differentiate between the type of adaptation options. As Smith et al. (2000) identify, adaptation could be categorized depending on the 1) timing, 2) intention, 3) scale, and 4) short vs. long term. Defining a category will help countries create competencies for extension agents to know which options should be implemented before or after a shock to get the highest benefit. In this dissertation, we describe that if reactive technologies are implemented before a shock, it could increase costs and be less effective.

In our analysis of the effect on technical efficiency, we believe it is necessary to design policies and strategies focused on: facilitating accessibility to interchangeable inputs and promoting the provision of extension services to a wider area. Additionally, facilitate access to irrigation through subsidies and credits, improve trust in programs and networks and develop cooperative enterprises or local and horizontal organizations to share information and services from farmer to farmer. Finally, it is important to generate action plans to promote better risk and loss behavior, seize technological and economic opportunities, and not overestimate extreme events.

4.3 Limitations and ideas for further research

This research has some limitations that should be acknowledged and suggest areas for further research. First, the analysis in both chapters relies on an artifactual field experiment that uses Cumulative Prospect Theory to elicit risk aversion, probability weighting, and loss aversion. The type of questions and lotteries measured risk in general terms; further research could investigate risk applied to different negative effects of climate change through a randomized control trial. In terms of experimental design, we recommend using monotonicity in answers, as Liu (2013) forced the participants to change within the lotteries to avoid inconsistencies. In addition, further research could provide insights regarding the design of the experiment (e.g., Harrison vs. Liu) to provide recommendations or general guidelines on when each design is more appropriate.

Second, both studies relied on cross-sectional data for social capital and production-related data. Applying the holistic approach with panel data could provide a complete assessment of changes in preferences, vulnerabilities, and resilience towards climate change due to adaptation. Although we identified a positive effect of irrigation as an anticipatory adaptation option, further research analyzing the effectiveness and cost of the activity will guide the allocation of funds efficiently. Third, the inclusion of time preferences can enhance the understanding concerning adopting adaptation measures. The decision to invest now to receive a possible benefit in the future is closely linked with time preferences

Fourth, our analysis shows no effect of adopting reactive adaptation on technical efficiency; as we mentioned before, this could be explained because the effect is neutralized depending on the climate-related shock. Nonetheless, a further application could be targeted at farmers that have not adopted any adaptation option.

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Appendices

Appendix 1. Survey – Adoption of irrigation technologies by small farmers in the Maule and O'Higgins Region.

UNIVERSIDAD DE TALCA

Fondecyt Fondo Nacional de Desarrollo Científico y Tecnológico

AGRONOMÍA UNIVERSIDAD DE TALCA

ENCUESTA PROYECTO FONDECYT Nº 1140615

**"ADOPCIÓN DE TECNOLOGÍAS DE RIEGO ENTRE PEQUEÑOS Y MEDIANOS AGRICULTORES DE LA REGIÓN DEL MAULE Y O'HIGGINS:
EL ROL DEL CAPITAL SOCIAL"**

Toda información proporcionada tendrá carácter confidencial, donde el manejo de datos solo será de tipo estadístico y NO se facilitará a terceros. La información personal solicitada tiene por único fin el poder fiscalizar el correcto proceso de toma de encuestas.

Dr. Alejandra Engler Palma, Investigador responsable

Nombre del encuestador		Fecha			

INFORMACIÓN GENERAL DEL PRODUCTOR

1.		2. Coord. Lat. S	

Número de identificación			Coord. Long. O		
3. Tipo de empresa	Unipersonal	Sociedad	4. Comuna		
5. Área total cultivada	_____________hectáreas		6. Tiempo de viaje predio – ciudad	___________________minutos	
7. Superficie propia /otra	________ha / ________ha		8. Cargo del contacto	Dueño	Administrador
9. Teléfono del contacto			10. Nombre de la empresa		
11. Edad del contacto	_________________años		12. Género del contacto	M	F
13. N° de hijos del contacto			14. Estado Civil del contacto	Casado/ convive	Soltero
15. Experiencia agríc. del contacto	_________________años		16. Existe ingreso adicional (dueño)	SI	NO

17. Años de educación	BASICA	MEDIA	SUPERIOR	POSTGRADO
	1 2 3 4 5 6 7 8	9 10 11 12	13 14 15 16 17	18 19 20 21 22 23

TECNOLOGÍAS DE RIEGO EN VIÑAS

18. ¿Recibe recomendaciones de riego de parte de algún asesor?

☐ Sí ☐ No

"Si la respuesta es NO sáltese a la pregunta 24"

19. ¿A qué entidad pertenece el asesor que realiza dichas recomendaciones de riego? *(puede marcar más de una)*

☐ Privado ☐ Asociación agrícola ☐ Indap– Prodesal ☐ Proveedor de insumos

☐ GTT ☐ Bodega- Comprador ☐ Otro ________________ ☐ Otro ________________

20. ¿Qué tipo de asesor realiza las recomendaciones de riego?

☐ Asesor general de cultivos ☐ Asesor especialista en riego

21. ¿Cómo califica la calidad de la asesoría que recibe?

a) Responsabilidad						
1	2	3	4	5	6	7

b) Conocimientos						
1	2	3	4	5	6	7

22. ¿Cuántas visitas realiza el asesor en el año? N°___________________

23. ¿Cuál es el costo por visita del asesor? $____________________

"Sáltese a la pregunta 28"

24. ¿Quién decide cuánto y cuándo regar?

☐ Propietario	☐ Administrador-Gerente agrícola	☐ Asesor	☐ Trabajador

25. ¿Dicha persona ha recibido capacitación formal en riego?

☐ Sí	☐ No

"Si la respuesta es NO sáltese a la pregunta 28"

26. ¿Quién realizó o dictó esta capacitación formal (la última realizada)?

☐ Empresa de riego	☐ Universidad- Centro de investigación	☐ Otro_________________

27. ¿Cuántas capacitaciones formales ha tenido en los últimos 3 años?
N°_________________

28. ¿En base a qué fuente de información riega sus cultivos?
(puede marcar más de una)

☐ Instrumentos propios	☐ Instrumentos de otros	☐ Medios masivos (diario, web, TV)	☐ Criterio personal

"Si responde INSTRUMENTOS pase a la pregunta 29, de lo contrario sáltese a la 30"

29. ¿Qué clase de instrumentos se utilizan para definir cuánto y cuándo regar?
(puede marcar más de una)

☐ Sensores de planta	☐ Sensores de suelo	☐ Estaciones meteorológicas	☐ Bandeja de evaporación	☐ Otros menores

30. ¿Qué entiende por programación de riego?

____
_

31. ¿Su comunidad de aguas le provee información sobre requerimiento hídrico de cultivos?

☐ Sí, frecuentemente	☐ Sí, ocasionalmente	☐ No, Nunca	☐ No aplica, No pertenece

32. ¿Obtiene información sobre requerimiento hídrico de alguna otra organización? Especifique

☐ No	☐ Sí	____

33. ¿ A través de qué medios de comunicación obtiene información meteorológica?
(puede marcar más de una)

☐ Internet	☐ Televisión	☐ Radio	☐ Diario	☐ Amigos

34. ¿A través de qué medios obtiene información sobre seminarios, charlas, capacitación o nuevas tecnologías y técnicas de producción agrícola?
(puede marcar más de una)

☐ Asesores	☐ Colegas / Amigos	☐ Proveedores de insumos	☐ Indap / SAG / CNR

☐	☐	☐	☐ Otra similar
☐ Universidades	☐ Ninguna	☐ Otro ____________	☐ Otro ____________

35. ¿Tiene limitaciones de agua para regar?

☐ Sí ☐ No

"Si la respuesta es NO sáltese a la pregunta 38"

36. ¿Cuán frecuentes han sido estas limitaciones de riego en los últimos 3 años?

☐ Muy frecuentes ☐ Frecuentes ☐ Poco frecuentes ☐ Muy poco frecuentes

37. ¿A qué motivos atribuye estas limitaciones?
(puede marcar más de una)

☐ Cambio climático ☐ Gestión de la comunidad agua ☐ Falta de obras de riego ☐ Uso no-agrícola del recurso

38. ¿Ha participado en algún proyecto de transferencia tecnológica en riego?

☐ Sí ☐ No

"Si la respuesta es NO sáltese a la pregunta 43"

39. ¿Qué tipo de participación tuvo en el proyecto?
(puede marcar más de una)

☐ Ensayos en el predio ☐ Asesoría directa ☐ Cursos formales (medio año o más) ☐ Otro:______________

40. ¿Qué entidad organizó el proyecto? ____________________

41. ¿Cuánto tiempo ha participado o participó en dicho proyecto (años)? ____________________

42. ¿Qué nota le pondría al apoyo recibido (de 1 a 7)? ____________________

43. Indique el "tiempo de riego por hectárea si tiene riego tecnificado" ó el "número de riegos por hectárea si tiene riego gravitacional" en cada mes de la temporada. Si practica ambos sistemas contesta ambas filas.

	Septiembre	**Octubre**	**Noviembre**	**Diciembre**	**Enero**	**Febrero**	**Marzo**	**Abril**	**Mayo**
Cantidad (N°)									
Tiempo (horas)									

44. Si se arrienda agua en su sector, ¿Cuál es el valor de un día de agua ó del metro cúbico?

$__________________/día $__________________/$m^3$

45. ¿Cuenta con riego tecnificado en su predio?

☐ Sí	☐ No

"Si la respuesta es SI sáltese a la pregunta 47"

46. ¿Por qué motivos no cuenta con riego tecnificado?
(puede marcar más de una)

☐ No conozco la tecnología	☐ Tengo agua en abundancia	☐ La inversión es muy alta	☐ No aumenta los ingresos

"Esta sección de la encuesta terminó"

47. ¿Quién realizó la instalación de su sistema de riego tecnificado?

☐ Empresa - personal externo	☐ Propietario - personal interno

"Si la respuesta es PROPIETARIO - PERSONAL INTERNO sáltese a la pregunta 49"

48. ¿Cómo califica la calidad de la empresa o personal que realizó la instalación del sistema de riego?

a) Responsabilidad						
1	2	3	4	5	6	7

b) Conocimientos						
1	2	3	4	5	6	7

49. ¿Ha recibido subsidios de inversión al riego?

☐ Sí	☐ No

"Si la respuesta es NO sáltese a la pregunta 51"

50. ¿Qué porcentaje de bonificación recibió?
Si cuenta con más de un sistema, indique el promedio
____________________%

51. ¿Qué clase de mantenciones realiza al sistema de riego anualmente?
(puede marcar más de una)

☐ Ninguna, no se realizan	☐ Limpieza de boquillas- goteros	☐ Limpieza de filtros	☐ Chequear uniformidad de descarga de agua

"Si la respuesta es NINGUNA esta sección de la encuesta terminó"

52. ¿Quién realiza las mantenciones al sistema de riego?

☐ Empresa - personal externo	☐ Propietario - personal interno

"Si la respuesta es PROPIETARIO - PERSONAL INTERNO esta sección de la encuesta terminó"

53. ¿Cómo califica la calidad del servicio que recibe?

a) Responsabilidad						
1	2	3	4	5	6	7

b) Conocimientos						
1	2	3	4	5	6	7

RENTABILIDAD DEL VIÑEDO

54. Complete el siguiente cuadro para las 4 cepas más relevantes en su predio, listadas en orden de superficie.
Información debe ser de temporada anterior. Indique la fila con mayor superficie al final de esta página.

Cepa	Nombre		Tipo de Conducción y Destino	Área (ha)	Rdto. (t/ha)	Año plant.	Marco plant. (m x m)	Precio ($/Kg)	* Sist. Manejo	* Sist. Riego	Número de Got-Asp/ ha	Caudal (L/Hr)
1			Espaldera Reserva									
			Espaldera Varietal									
			Parrón Reserva									
			Parrón Varietal									
2			Espaldera Reserva									
			Espaldera Varietal									
			Parrón Reserva									
			Parrón Varietal									
3			Espaldera Reserva									
			Espaldera Varietal									
			Parrón Reserva									
			Parrón Varietal									
4			Espaldera Reserva									
			Espaldera Varietal									
			Parrón Reserva									
			Parrón Varietal									

*** Sistema de manejo: 1) Convencional 2) Orgánico 3) Biodinámico 4) Otro**
*** Sistema de riego: 1) Goteo 2) Aspersión 3) Cinta- Californiano 4) Surco- Tendido**

Escriba la fila con mayor superficie (cepa, conducción y destino) para responder preguntas 55 y 56: ______________________

55. Complete costos de insumos incurridos por hectárea en la temporada anterior

Información debe ser de la fila con mayor superficie identificada en el cuadro anterior.

"Si el encuestado no tiene a mano el precio del producto basta con anotar claramente el nombre "

Item		Nombre	Número aplicac.	Forma aplicac. (JH - JM - FR)	Cant. por aplicación	Unidad (Kg, g – L, cc)	Precio ($/L - $/Kg)
Abonos	A)						
	B)						
	C)						
Malezas	A)						
	B)						
	C)						
Arañitas	A)						
	B)						
	C)						
Insectos	A)						
	B)						
	C)						
Hongos	A)						
	B)						
	C)						

56. Complete "costos de labores" ó "cantidad de trabajo incurrido" por hectárea en la temporada anterior

Aquellas labores realizadas con maquinaria propia se responden como Número de Jornadas Máquina

Labores	Mano de obra			Maquinaria		
	Costo total ($)	Cantidad (N°)	Unidad (JH - JM)	Costo total ($)	Cantidad (N°)	Unidad (JH - JM)
A) Poda y amarre						
B) Cosecha						
C) Desbrote						
D) Chapoda						
E) Control malezas						
E) Resto labores						

CAPITAL SOCIAL

Respond in scale from 1 to 5 according to their level of agreement with the following statements.
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

	Confianza		**1**	**2**	**3**	**4**	**5**
57.	I can trust the people around me without the need to be cautious						
58.	Farmers are reliable people						
59.	I believe that other farmers would not harm me for their own benefit						
60.	The people of the neighborhood works together to solve problems of water availability						
61.	In the last five years it has increased confidence among producers who belong to the Water Community	N/A					
62.	I could lean on friends if I require not too large amounts of money						
63.	Agricultural associations work for the welfare of farmers and the agricultural sector						
	Indique su grado de confianza en:		**1**	**2**	**3**	**4**	**5**
64.	Municipalities						
65.	Public Institutions						
66.	Th estate of Chile						
67.	Water Communities	N/A					
68.	Channel Association	N/A					
69.	Supervisory Council	N/A					
	Normas		**1**	**2**	**3**	**4**	**5**
70.	Always I obey the laws and regulations (labor, transit, tax, etc.)						
71.	When the people around me have a hard time whenever I help them						
72.	I always vote in presidential and municipal elections						
73.	I disapprove when farmers receive benefits that do not qualify						
74.	My workers have better working conditions than other farms						
75.	I always pay my workers and service providers timely						
	Redes formales		**1**	**2**	**3**	**4**	**5**
76.	I go to all the meetings of the associations to which I belong (except for emergencies)	N/A					
77.	My opinion is considered in agricultural associations to which I belong	N/A					
78.	I attend lectures, conferences or seminars related to agriculture						
79.	When attending agricultural events, my participation is usually more active than others						
80.	I know and I am linked regularly with professionals and experts of agriculture						
81.	Organizations interact to improve the service and information they provide to farmers						
82.	I have participated in non-agricultural voluntary organizations (religious, cultural, political, community, etc.)						
	Redes informales		**1**	**2**	**3**	**4**	**5**
83.	In the work field, I often communicate with neighboring farmers						
84.	I spend time with my friends because I consider important to share with them						
85.	I always support my farming neighbors when they have a problem						

86.	I maintain frequent contact with representatives of the water community	N/A					
87.	I organize meetings with producers and / or consultants to acquire new knowledge in agriculture						

COMPORTAMIENTO PLANIFICADO

Respond in scale from 1 to 5 according to their level of agreement with the following statements.
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

	Actitudes		1	2	3	4	5
88.	The irrigation technology improves crop management						
89.	Investing in irrigation technology is profitable						
90.	The irrigation technology increase yields						
91.	Investment in irrigation technology is relatively low for farmers						
92.	The irrigation technology is the solution to address problems of water shortage						
93.	The irrigation systems promotes soil conservation						
	Normas sociales y personales		**1**	**2**	**3**	**4**	**5**
94.	The water community which I belong expect or expected me to adopt modern irrigation systems	N/A					
95.	Other farmers see or saw good I adopt modern irrigation						
96.	I adopted or I would adopt irrigation technology because it helps to conserve water resources						
97.	The nearby community perceives me as a farmer who cares about the environment						
98.	I share information with other farmers about management techniques to improve agricultural production						
	Control percibido		**1**	**2**	**3**	**4**	**5**
99.	I have enought funds to invest in irrigation technology (consider subsidies)						
100.	I count with people or companies in which I could lean to implement modern irrigation						
101.	I have knowledge to successfully operate a modern irrigation system						
102.	I am able to program an irrigation system						
103.	I can effectively implement a modern irrigation system						
104.	I consider that the operation of a technology irrigation system is easy						
	Intención conductual		**1**	**2**	**3**	**4**	**5**
105.	Within this or next year I have planned to adopt modern irrigation systems						
106.	I'm planning to incorporate instruments for the determination of water requirements						
107.	I would be willing to borrow money to adopt modern irrigation systems on the farm						
108.	I have the intention to be trained in irrigation systems this year						
109.	I have the intention to hire a consultant to improve planning and maintenance of irrigation system						

110.	I have the intention to offer to be part of the leadership of the water community	N/A					

NETWORKING

111. Respecto a sus relaciones comerciales, de colegas y amistades indique:

Grupo	Número con los que se relaciona	Cercanía de relación promediada (Alta/ Media / Baja)
Proveedores de insumos		
Compradores de uva		
Entidades financieras		
Empresas certificadoras		
Colegas		
Amigos		

112. Indique su participación en las siguientes entidades, en hasta 3 asociaciones agrícolas y en hasta 3 asociaciones no agrícolas a las que pertenezca (considere hobbies o pasatiempos).

Entidad	Participa (Sí/No)	Desde cuándo (Año)	Asistencia (%)	Ha tenido rol direct. (Sí/No)	Particip. personal (B-R-M)	Beneficios de participación (B-R-M)
Comunidad de aguas						
Asociación de Canalistas						
Junta de Vigilancia						
A. Agrícola 1 ____________________						
A. Agrícola 2 ____________________						
A. Agrícola 3 ____________________						
A. No-agrícola 4 _______________						

113. De los productores de viñas que conoce, cuántos SI tienen riego tecnificado N°_________

114. De los productores de viñas que conoce, cuántos NO tienen riego tecnificado
N°________

Appendix 2. Artefactual experiment: instructions and lotteries

UNIVERSIDAD DE TALCA
Proyecto Adaptación de la Agricultura al Cambio Climático (A2C2)
HERRAMIENTA DE CAPTURA DE INFORMACIÓN
Aspectos socioeconómicos, cambio climático y capital social

DATOS GENERALES

<table>
<tr><td>Número de la encuesta:</td><td></td><td rowspan="7">NOTA
Información establecida por el encuestador/investigador</td></tr>
<tr><td>Nombre del encuestador:</td><td></td></tr>
<tr><td>Fecha:</td><td></td></tr>
<tr><td>Región:</td><td></td></tr>
<tr><td>Provincia:</td><td></td></tr>
<tr><td>Comuna:</td><td></td></tr>
<tr><td>Coordenadas de la propiedad:</td><td>X:
Y:</td></tr>
</table>

SECCIÓN I: Introducción

Muy buenos días/tardes, mi nombre es: ________________________. Yo trabajo con la Universidad de Talca, en un estudio sobre cambio climático.

Opción A: Si ya se concertó cita	**¿Podría hablar con:** ____________________________**?**	***Nota:*** *Recordarle que hace unos días nos comunicamos vía teléfono para confirmar esta reunión*
Opción B: Si no se concertó cita	**¿Podría hablar con:** el jefe del hogar o persona que toma las decisiones sobre los viñedos**?**	***Nota:*** *Si preguntan ¿Para qué?, explicarles con base en el siguiente cuadro*

SI	NO
¡¡¡MUY AMABLE!!! Nuevamente, muy buenos días/tardes, como le mencioné anteriormente mi nombre es____________________ y trabajo para un proyecto de investigación de la Universidad de Talca que desea conocer cómo es la adaptación al cambio climático entre los productores de uva de la región. Debido a lo expuesto, y a que usted es un productor reconocido en su comuna, quisiera realizáramos un experimento y una pequeña entrevista. Este es un estudio académico, le garantizo que la información que usted nos brinde será utilizada de forma confidencial. Si tiene alguna duda puede contactar a la Dra. Alejandra Engler de la Universidad de Talca al teléfono: (56 – 71) 2200210 y/o al correo: mengler@utalca.cl Está de acuerdo en que continuemos SI ⬇ NO ➡	**¡¡¡MUCHAS GRACIAS POR SU COLABORACIÓN!!!**

SECCIÓN II: Datos generales

Antes de iniciar, podría conocer: ¿Cuál es su nombre completo? _________________________

SECCIÓN III. Decisiones ante el riesgo

3.1 Primera parte

En esta primera parte usted va a tener la posibilidad de ganar dinero. La cantidad de dinero que usted gane va a depender de sus respuestas y éste le será pagado al final de la encuesta. A continuación le brindaré las instrucciones generales:

- *Le voy a presentar una serie de escenarios donde usted tendrá que decidir entre dos opciones de pago (una "Opción A" y una "Opción B").*
- *La "Opción A" representará un valor de ganancia fijo.*
- *La "Opción B" representará un valor de ganancia que va depender de la suerte. En esta bolsa negra vamos a colocar 10 bolas. Algunas son de color verde y otras de color rojo. Al final de la actividad usted debe sacar una bola. Sus pagos dependen de la bola que saque.*

Veamos un ejemplo.

- *El escenario tiene una "Opción A" y una "Opción B" y usted debe elegir una de ellas.*
- *La "Opción A", ofrece un pago fijo de 3,000 Pesos.*
- *La "Opción B", en cambio ofrece un pago de 6,000 Pesos si saca una de las tres bolas verdes que hay en la bolsa negra o un pago de 1,000 Pesos si saca una de las siete bolas rojas que hay en la misma bolsa.*

Ejemplo:

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
16	3,000 Pesos	6,000 Pesos si sale una de las bolas de color verde: ●●● (3 verdes)	1,000 Pesos si sale una de las bolas de color rojo:☐ ●●●●●●● (7 rojas)

Su tarea consiste en decidir qué prefiere. *En esta actividad no hay respuestas correctas o incorrectas, todo depende de sus preferencias.*

Cabe aclarar que no es posible pagar todas las decisiones que se realizarán, sólo una será seleccionada para pago. Para decidir cuál decisión se pagará, usted debe sacar una bola de la **bolsa blanca** que contiene bolas numeradas del total de escenarios. Donde cada número representa una de las decisiones. El número que saque va a determinar la decisión a pagar.

No existe la opción de cambiar las respuestas. Así que piense cuidadosamente cuál opción prefiere.

.

¿Tiene preguntas?
¡Vamos a empezar!

LISTA DE DECISIONES No. 1

Instrucciones específicas para esta sección:

- En las decisiones 1 a 14, vamos a colocar 1 bola color verde y 9 bolas color rojo en la bolsa negra.
- Por favor díganos qué opción prefiere.

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
1	1,200 Pesos	3,100 Pesos si sale una bola de color verde: ● (1 verde)	600 Pesos si sale una de las bolas de color rojo: ●●●●●●●●● (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra

2	1,200 Pesos	3,400 Pesos si sale una bola de color verde: (1 verde)	600 Pesos si sale una de las bolas de color rojo: (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
3	1,200 Pesos	3,850 Pesos si sale una bola de color verde: (1 verde)	600 Pesos si sale una de las bolas de color rojo: (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
4	1,200 Pesos	4,300 Pesos si sale una bola de color verde: (1 verde)	600 Pesos si sale una de las bolas de color rojo: (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
5	1,200 Pesos	4,900 Pesos si sale una bola de color verde: (1 verde)	600 Pesos si sale una de las bolas de color rojo: (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
6	1,200 Pesos	5,650 Pesos si sale una bola de color verde: (1 verde)	600 Pesos si sale una de las bolas de color rojo: (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
7	1,200 Pesos	6,700 Pesos si sale una bola de color verde: (1 verde)	600 Pesos si sale una de las bolas de color rojo: (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
8	1,200 Pesos	7,600 Pesos si sale una bola de color verde: (1 verde)	600 Pesos si sale una de las bolas de color rojo: (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
9	1,200 Pesos	8,650 Pesos si sale una bola de color verde: ● (1 verde)	600 Pesos si sale una de las bolas de color rojo: ●●●●●●●●● (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
10	1,200 Pesos	10,200 Pesos si sale una bola de color verde: ● (1 verde)	600 Pesos si sale una de las bolas de color rojo: ●●●●●●●●● (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
11	1,200 Pesos	12,500 Pesos si sale una bola de color verde: ● (1 verde)	600 Pesos si sale una de las bolas de color rojo: ●●●●●●●●● (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
12	1,200 Pesos	16,000 Pesos si sale una bola de color verde: ● (1 verde)	600 Pesos si sale una de las bolas de color rojo: ●●●●●●●●● (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
13	1,200 Pesos	21,750 Pesos si sale una bola de color verde: ● (1 verde)	600 Pesos si sale una de las bolas de color rojo: ●●●●●●●●● (9 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
14	1,200 Pesos	33,600 Pesos si sale una bola de color verde: ● (1 verde)	600 Pesos si sale una de las bolas de color rojo: ●●●●●●●●● (9 rojas)

LISTA DE DECISIONES No. 2

Instrucciones específicas para esta sección:

- En las decisiones 15 a 28, vamos a colocar siete bolas verdes y tres bolas rojas en la bolsa negra.
- Por favor díganos qué opción prefiere.

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
15	4,000 Pesos	5,600 Pesos si sale una de las bolas de color verde: ● ● ● ● ● ● ● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ● ● ● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
16	4,000 Pesos	5,700 Pesos si sale una de las bolas de color verde: ● ● ● ● ● ● ● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ● ● ● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
17	4,000 Pesos	6,000 Pesos si sale una de las bolas de color verde: ● ● ● ● ● ● ● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ● ● ● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
18	4,000 Pesos	6,200 Pesos si sale una de las bolas de color verde: ● ● ● ● ● ● ● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ● ● ● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
19	4,000 Pesos	6,500 Pesos si sale una de las bolas de color verde: ● ● ● ● ● ● ● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ● ● ● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
20	4,000 Pesos	6,900 Pesos si sale una de las bolas de color verde: ●●●●●●● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ●●● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
21	4,000 Pesos	7,300 Pesos si sale una de las bolas de color verde: ●●●●●●● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ●●● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
22	4,000 Pesos	7,700 Pesos si sale una de las bolas de color verde: ●●●●●●● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ●●● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
23	4,000 Pesos	8,200 Pesos si sale una de las bolas de color verde: ●●●●●●● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ●●● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
24	4,000 Pesos	8,700 Pesos si sale una de las bolas de color verde: ●●●●●●● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ●●● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
25	4,000 Pesos	9,500 Pesos si sale una de las bolas de color verde: ●●●●●●● (7 verdes)	500 Pesos si sale una de las bolas de color rojo: ●●● (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	

26	4,000 Pesos	10,500 Pesos si sale una de las bolas de color verde: (7 verdes)	500 Pesos si sale una de las bolas de color rojo: (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
27	4,000 Pesos	11,900 Pesos si sale una de las bolas de color verde: (7 verdes)	500 Pesos si sale una de las bolas de color rojo: (3 rojas)

Decisión	☐ **Opción A** Usted ganaría un pago fijo de:	☐ **Opción B** Usted ganaría según el color de la bola que saque de la bolsa negra	
28	4,000 Pesos	13,700 Pesos si sale una de las bolas de color verde: (7 verdes)	500 Pesos si sale una de las bolas de color rojo: (3 rojas)

3.2 Segunda parte

En esta segunda parte las opciones son un poco distintas. A continuación le brindaré las instrucciones generales:

- *Le voy a presentar siete escenarios donde usted tendrá que decidir entre dos opciones de pago (una "Opción A" y una "Opción B").*
- *La "Opción A" y la "Opción B" representarán un valor de ganancia que va depender de la suerte. En esta bolsa negra vamos a colocar 10 bolas. Algunas son de color verde y otras de color rojo. Al final de la actividad usted debe sacar una bola. Sus pagos dependen de la bola que saque.*

Si al final de la actividad usted selecciona una de las decisiones de esta lista (decisiones 29 a 35), le vamos a dar 8.500 Pesos independientemente de la opción que seleccione.

Las decisiones son además un poco distintas,
- *En la bolsa negra vamos a colocar 5 bolas verdes y 5 bolas rojas.*
- *Tanto los pagos de la "Opción A", como los de la "Opción B" van a depender de la suerte.*
- *Además en estas decisiones si selecciona la bola roja existe la posibilidad de perder parte o la totalidad de los 8.500 pesos que le hemos dado.*

Por favor, elija la opción que prefiera cuidadosamente ya que al final una de éstas decisiones puede ser seleccionada para ser pagada.

Ejemplo:

Decisión	☐ **Opción A** Usted ganaría:	Usted perdería:	☐ **Opción B** Usted ganaría:	Usted perdería:
34	100 Pesos si sale una de las 5 bolas de color verde: (5 verdes)	2,000 Pesos si sale una de las 5 bolas de color rojo: (5 rojas)	6,000 Pesos si sale una de las 5 bolas de color verde: (5 verdes)	3,000 Pesos si sale una de las 5 bolas de color rojo: (5 rojas)

Explicación de resultados:

- *Supongamos que se selecciona la Decisión 34.*
- *En ese caso usted automáticamente recibe 8.500 pesos*

- *En la "Opción A" si usted saca una de las 5 bolas verdes usted ganaría 100 pesos. En cambio, si saca una de las cinco bolas perdería 2.000 pesos. Este valor se descuenta de los 8.500 que acaba de recibir.*
- *En la" Opción B" si usted saca una de las cinco bolas verdes usted ganaría 6.000 pesos. En cambio, si saca una de las cinco bolas perdería 3.000 pesos. Este valor se descuenta de los 8.500 que acaba de recibir.*

¿Todo está claro? **SI** **NO** Le explicaré nuevamente con ejemplos

LISTA DE DECISIONES No. 3

Instrucciones específicas para esta sección:

- En las decisiones 29 a 35, vamos a colocar 5 bolas color verde y 5 bolas color rojo en la bolsa negra.
- Por favor díganos qué opción prefiere.

Decisión	**☐ Opción A** Usted ganaría:	Usted perdería:	**☐ Opción B** Usted ganaría:	Usted perdería:
29	10,000 Pesos si sale una de las bolas de color verde: (5 verdes)	2,000 Pesos si sale una de las bolas de color rojo: (5 rojas)	12,000 Pesos si sale una de las bolas de color verde: (5 verdes)	8,500 Pesos si sale una de las bolas de color rojo: (5 rojas)

Decisión	**☐ Opción A** Usted ganaría:	Usted perdería:	**☐ Opción B** Usted ganaría:	Usted perdería:
30	2,000 Pesos si sale una de las bolas de color verde: (5 verdes)	2,000 Pesos si sale una de las bolas de color rojo: (5 rojas)	12,000 Pesos si sale una de las bolas de color verde: (5 verdes)	8,500 Pesos si sale una de las bolas de color rojo: (5 rojas)

Decisión	**☐ Opción A** Usted ganaría:	Usted perdería:	**☐ Opción B** Usted ganaría:	Usted perdería:
31	500 Pesos si sale una de las bolas de color verde: (5 verdes)	2,000 Pesos si sale una de las bolas de color rojo: (5 rojas)	12,000 Pesos si sale una de las bolas de color verde: (5 verdes)	8,500 Pesos si sale una de las bolas de color rojo: (5 rojas)

Decisión	**☐ Opción A** Usted ganaría:	Usted perdería:	**☐ Opción B** Usted ganaría:	Usted perdería:
32	500 Pesos si sale una de las bolas de color verde: (5 verdes)	2,000 Pesos si sale una de las bolas de color rojo: (5 rojas)	12,000 Pesos si sale una de las bolas de color verde: (5 verdes)	6,800 Pesos si sale una de las bolas de color rojo: (5 rojas)

Decisión	☐ **Opción A** Usted ganaría:	Usted perdería:	☐ **Opción B** Usted ganaría:	Usted perdería:
33	500 Pesos si sale una de las bolas de color verde: ● ● ● ● ● (5 verdes)	4,000 Pesos si sale una de las bolas de color rojo: ● ● ● ● ● (5 rojas)	12,000 Pesos si sale una de las bolas de color verde: ● ● ● ● ● (5 verdes)	6,800 Pesos si sale una de las bolas de color rojo: ● ● ● ● ● (5 rojas)

Decisión	☐ **Opción A** Usted ganaría:	Usted perdería:	☐ **Opción B** Usted ganaría:	Usted perdería:
34	500 Pesos si sale una de las bolas de color verde: ● ● ● ● ● (5 verdes)	4,000 Pesos si sale una de las bolas de color rojo: ● ● ● ● ● (5 rojas)	12,000 Pesos si sale una de las bolas de color verde: ● ● ● ● ● (5 verdes)	5,900 Pesos si sale una de las bolas de color rojo: ● ● ● ● ● (5 rojas)

Decisión	☐ **Opción A** Usted ganaría:	Usted perdería:	☐ **Opción B** Usted ganaría:	Usted perdería:
35	500 Pesos si sale una de las bolas de color verde: ● ● ● ● ● (5 verdes)	4,000 Pesos si sale una de las bolas de color rojo: ● ● ● ● ● (5 rojas)	12,000 Pesos si sale una de las bolas de color verde: ● ● ● ● ● (5 verdes)	4,650 Pesos si sale una de las bolas de color rojo: ● ● ● ● ● (5 rojas)

¡¡¡FIN DE LA ACTIVIDAD!!!

Ahora iniciaremos el procedimiento para definir el pago que usted recibirá.

Primero vamos a seleccionar cuál decisión vamos a pagar.

- **Por favor selecciona una bola de esta bolsa blanca.**
- **En la decisión ______ usted seleccionó la opción _______.**
- **Si la opción que seleccionó es un pago fijo, eso es lo que recibirá__________.**
- **Si la opción que seleccionó es un pago que depende del azar, entonces revisemos la bolsa negra que corresponde a la lista con ___ bolas verdes y ___ bolas rojas.**
- **Por favor selecciona una bola de la bolsa negra.**
- **Seleccionó una bola _______. Su pago es ___________.**

Ahora sólo quisiera realizarle unas cuantas preguntas más y después proceder a pagarle

El pago que le corresponda deberá registrarse en un recibo de pago y en una lista.
SECCIÓN IV. Información sobre problemas generales, cambio climático y capital social

Finalmente, pediría su colaboración para realizarle unas cuantas preguntas sobre sus problemas de producción, el clima y sobre las organizaciones que integra. ¿Iniciamos?

1. ¿Podría conocer el área total de su propiedad? (en hectáreas)

______ has

NOTA
Área total de la finca, agrícola y ganadera, en hectáreas (has)

2. ¿Podría conocer cuántas hectáreas de su propiedad dedica al cultivo de viñedos?

NOTA

	______ has Área de cepa principal ______has. Nombre de la cepa___________ Área de cepa secundaria ____has. Nombre de la cepa___________	*Área total de todas las variedades o cepas, en has*
3.	¿Cuántos años de experiencia tiene en el cultivo de viñedos? ______ años	***NOTA*** *Años de experiencia en vinicultura*
4.	¿Podría indicar, en orden de importancia, cuáles son las **cinco principales** causas de problemas para el cultivo de viñedos? __ Las variaciones del clima (heladas, falta o exceso de lluvia, entre otras) __ Bajos precios por la uva __ Falta de acceso a fuentes de agua para riego __ Plagas y/o enfermedades __ Falta de acceso a mercados __ Falta de acceso a créditos agrícolas __ Otros: ____	***NOTA*** *Leer la pregunta y opciones* *Deben elegir 5 en orden de importancia (siendo 1 el más importante y 5 el menos importante)*
5.	¿Cómo calificaría usted los efectos negativos que las constantes variaciones del clima (como las heladas en invierno o la falta de lluvias en verano) le causan a los viñedos? Siendo 1:Nada grave, 4: Grave y 7: Extremadamente grave[18] **1 2 3 4 5 6 7**	***NOTA*** *Leer la pregunta y las opciones (marcar una opción)*
6.	¿Podría indicar, del 1 al 7, que tanto fueron afectados sus viñedos por cada uno de los siguientes eventos climáticos **el año pasado**? (del 1: Efecto mínimo o nulo; 4: Efecto medio, a 7: Efecto extremo)	***NOTA*** *Leer la pregunta y mostrar las opciones* *Deben elegir la magnitud del 1al 7*

1	Heladas	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2	Falta de lluvias (sequías o sequías extremas)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3	Exceso de lluvias[19]	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4	Falta de acceso a fuentes de agua[20]	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5	Desarrollo enfermedades (moho gris/oídio)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6	Desarrollo de plagas (polilla del racimo)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	Otros: ____________	**1**	**2**	**3**	**4**	**5**	**6**	**7**

7.	¿En los últimos 5 años, ha invertido en tecnologías que ayudan a **prevenir** los efectos negativos de los eventos climáticos (heladas, falta de lluvia, entre otros) en sus viñedos? (tecnologías contra heladas/sistemas de riego, entre otras) Si____ No ___, Por qué:____ ¿Tiene idea de que tanto dinero ha invertido? __________________ Pesos	***NOTA*** *Leer la pregunta al entrevistado* ***Prevenir: antes de que llegue el daño***

[18] La escala completa es: 1: Nada grave, 2: No muy grave (leve), 3: Moderadamente grave, 4: Grave, 5: Bastante grave, 6: Muy grave, y 7: Extremadamente grave.

[19]Las tormentas o inundaciones pueden ser "Eventos Climáticos o Meteorológicos Extremos" que son eventos raros o muy poco frecuentes de un ***lugar*** y ***época del año*** en particular (una probabilidad máxima del 10%). IPCC, 2013.

[20] Bajo caudal de ríos, quebradas o canales.

8.	¿En los últimos 5 años, aproximadamente cuánto ha invertido en cada una de las siguientes tecnologías o actividades para **prevenir** los daños o efectos negativos de las **heladas** y así mejorar su cosecha e ingresos? Fertilización adecuada (suelos y foliares) __________________ Pesos Variedades resistentes _________________________________ Pesos Manejo (eliminación de malezas, podas) ___________________ Pesos	***NOTA*** *Leer la pregunta y las opciones al entrevistado* ***Prevenir: antes de que llegue el daño***
9.	¿Cuáles de estas tecnologías implementa para **disminuir o aliviar** los daños o efectos negativos de las **heladas** y así mejorar su cosecha e ingresos? ☐ Inundación de terrenos (↑capacidad calórica del suelo) ☐ Mezcla mecánica del aire (hélices) ☐ Calentamiento del aire (quemadores, tarros o agitadores) ☐ Aspersión de agua (liberación de calor al congelarse el agua) ☐ Manejo del cultivo (eliminación de brotes para salvar planta) ☐ No implementa ninguna tecnología o actividad	***NOTA*** *Leer la pregunta y las opciones al entrevistado.* *Puede marcar más de una.* ***Disminuir o aliviar: una vez que ha ocurrido el daño***
10.	¿En los últimos 5 años, aproximadamente cuánto ha invertido en tecnologías que ayudan a **disminuir o aliviar** los efectos negativos de las **heladas** en sus viñedos? ___________________ Pesos	***NOTA*** *Basado en tecnologías de pregunta anterior*
11.	¿Usted implementa riego en sus viñedos? Si____ No ___ pero anteriormente utilizó ¿Hace una o dos cosechas? (si/no)_______	***NOTA*** *Si: Continuar* *No: Pasar a pregunta 14*
12.	¿Qué tipo de riego tiene en sus viñedos?	***NOTA*** *Leer la pregunta y las opciones al entrevistado* *Puede marcar más de una opción*

	Tipo	En que cepas (las 2 principales)	Área de cepa (has)
☐	Goteo		
☐	Aspersión		
☐	Surco		
☐	Californiano		

13.	¿En los últimos 5 años, aproximadamente cuánto ha invertido en sistemas de riego para disminuir el efecto de la sequía y/o mejorar el ingreso en sus viñedos? ___________________ Pesos	
14.	¿Podría saber cuánto paga al año por los derechos de agua para su finca? ___________________ Pesos,	***NOTA*** *Los valores podrían estimarse si se conocen las has para viñas*
15.	¿Usted posee sistemas de almacenamiento de agua (tanques, represas, pozos) Si____, ¿Qué capacidad tiene? ____________________M3 No ___, Por qué:____	
16.	¿Cómo combate los problemas por exceso de lluvias (inundaciones)? ☐ Canales de drenaje ☐ Otros_________________ ☐ No tengo ese problema	***NOTA*** *Leer la pregunta y las opciones al entrevistado*

17. ¿En los últimos 5 años, aproximadamente cuánto ha invertido en canales de drenaje para disminuir el efecto de las inundaciones en sus viñedos?

___________________ Pesos

18. ¿Usted implementa tecnologías o actividades para **prevenir o disminuir** los daños o efectos negativos de las enfermedades (Moho gris (*Botrytis cinerea*) - Oídio (*Uncinula necátor*)) y así mejorar su cosecha e ingresos?

NOTA
Leer la pregunta y las opciones al entrevistado

Puede marcar más de una opción

☐ Control químico curativo (fungicidas)
☐ Control químico preventivo (adecuada fertilización)
☐ Variedades resistentes
☐ Control cultural (buen drenaje, podas, entre otras)
☐ Otras: ____
☐ No implemento ninguna tecnología o actividad, Por qué: __________________

19. ¿Usted implementa tecnologías o actividades para **prevenir o disminuir** los daños o efectos negativos de las plagas (Polilla del racimo (*Lobesia botrana*)) y así mejorar su cosecha e ingresos?

NOTA
Leer la pregunta y las opciones al entrevistado

Puede marcar más de una opción

☐ Control químico curativo (plaguicidas)
☐ Control químico preventivo (adecuada fertilización)
☐ Variedades resistentes
☐ Control biológico (uso de otros insectos, entre otras)
☐ Control cultural (trampas, barreras vivas, buen drenaje, podas, entre otras)
☐ Otras: ____
☐ No implemento ninguna tecnología o actividad, Por qué: __________________

20. ¿Posee el seguro agrícola contra riesgos climáticos promovido por el INDAP?

NOTA
Leer la pregunta y las opciones
SI: pasar a pregunta 22

☐ Si:de qué aseguradora:____
☐ No, Por qué:____
Qué cambiaría para tenerlo_____________________________________

21. ¿Desearía tener un seguro agrícola contra problemas climáticos como las heladas, el exceso o falta de lluvias y/o viento, el cual le permitiría asegurar toda el área de viñas que desee y que le podría cubrir hasta 2/3 (casi el 70%) del rendimiento que usted espera tener de la cosecha (con un deducible entre el 20 y 30%)?

NOTA
Leer la pregunta

Si____, Por qué no había pensado tomarlo antes: _________________________
No ___, Por qué:____

22. ¿En el futuro, como quisiera evitar los problemas causados por los eventos climáticos negativos (por ejemplo: heladas o falta de lluvia)?

NOTA
Leer la pregunta y las opciones

☐ Invertir en un seguro agrícola contra riesgo climático
☐ Invertir en tecnologías (__riego tecnificado, __control de heladas)
☐ Invertir en ambas opciones: tecnologías + seguro agrícola
☐ Ninguna. Porqué ____

23. ¿Si usted tuviera que decidir entre tecnologías que **previenen** el efecto negativo del clima en sus viñedos o **aliviar** el daño causado una vez que ha ocurrido, qué prefiere? 1. Prevenir, 7. Aliviar una vez que ha ocurrido

1 2 3 4 5 6 7

Capital social

Networking e institucionalidad

24. ¿Podría decirme a que organizaciones locales o regionales pertenece?

☐ Organizaciones de productores. No1:_____________ No2:_______________
☐ Organizaciones ambientalistas o de gestión del riesgo.
☐ __Comunidad de agua, __asociación de canalistas,__ juntas de vigilancia
☐ Otras: ____

NOTA *Leer la pregunta y las opciones Puede marcar más de una opción*

25. ¿Aproximadamente, cada cuanto tiempo conversa o recibe asesoría de extensionistas? (puede ser a nivel formal, informal o social)

☐ Mensualmente. Número de veces________
☐ Semestralmente. Número de veces_______
☐ Anualmente. Número de veces___________

NOTA *Dato aproximado Mencionar opciones Sólo marcar una opción*

26. ¿Cuántos productores que usted conoce **SI** han implementado alguna tecnología o actividad para **prevenir** los efectos negativos del clima?

Cantidad:_______

NOTA *Si es cero, pasar a la pregunta 28*

27. ¿De la cantidad de productores que mencionó anteriormente, podría mencionar el nombre de algunos? (preferiblemente de los que más confianza tiene)
Puede ser el nombre, apodo o una forma de identificarlo, una inicial o número

NOTA *Puede ser el primer nombre o inicial*

Nombre	¿Cuándo usted requiere información sobre el clima y como contrarrestarlo, consulta a este productor? **Nota:** Si ó No	¿Cada cuánto tiempo conversa con este productor sobre el clima y/o de las prácticas para contrarrestarlo?	¿Este productor es familiar, amigo y/o vecino? **Nota:** Pueden ser todas las opciones	¿Esta persona trabaja para institución pública o privada?
1.		❒ Mensual.# veces__ ❒ Anual.# veces____	❒ Familiar ❒ Amigo ❒ Vecino	❒ PU ❒ PRI ❒ Ninguna
2.		❒ Mensual.# veces__ ❒ Anual.# veces____	❒ Familiar ❒ Amigo ❒ Vecino	❒ PU ❒ PRI ❒ Ninguna
3.		❒ Mensual.# veces__ ❒ Anual.# veces____	❒ Familiar ❒ Amigo ❒ Vecino	❒ PU ❒ PRI ❒ Ninguna
4.		❒ Mensual.# veces__ ❒ Anual.# veces____	❒ Familiar ❒ Amigo ❒ Vecino	❒ PU ❒ PRI ❒ Ninguna
5.		❒ Mensual.# veces__ ❒ Anual.# veces____	❒ Familiar ❒ Amigo ❒ Vecino	❒ PU ❒ PRI ❒ Ninguna
6.		❒ Mensual.# veces__ ❒ Anual.# veces____	❒ Familiar ❒ Amigo ❒ Vecino	❒ PU ❒ PRI ❒ Ninguna
7.		❒ Mensual.# veces__ ❒ Anual.# veces____	❒ Familiar ❒ Amigo ❒ Vecino	❒ PU ❒ PRI ❒ Ninguna

28. ¿Cuántos productores que usted conoce **NO** han implementado alguna tecnología o actividad para **prevenir** los efectos negativos del clima?

Cantidad: ______

NOTA *Aproximado Primero definir cuantos conoce*

Normas

29. ¿Me podría dar su opinión sobre las siguientes declaraciones, marcando entre 1 y 7, donde 1 es la opción menos importante y 7 es la más importante?

NOTA

Mostrar el cuadro

	Normas	**1**	**2**	**3**	**4**	**5**	**6**	**7**
A	Considera usted que la mayoría de los miembros de su **organización agrícola (ambiental o de manejo de agua)** piensa que usted debe implementar actividades, prácticas o tecnologías para contrarrestar los efectos negativos del clima							
B	Las personas que son importantes para mí piensan que debo implementar tecnologías o actividades para contrarrestar los efectos negativos del clima							
C	Yo hago lo que la mayoría de personas que son importantes para mí piensan que debo hacer							
D	Usted siente la obligación de implementar tecnologías o actividades para contrarrestar los efectos negativos del clima							
E	De 1 a 7 cuánto calificaría usted su deseo de implementar tecnologías o actividades para contrarrestar los efectos negativos del clima							

Appendix 3. Artefactual experiment: experimental design, procedure and parameters estimation of the experiment

3.1 Experimental design

As we stated before, the design of the experiment follows the methodology originally proposed by Tanaka et al (2010) and then replicated by Liu (2013), Bocquého (2014) and Ward and Singh (2015) to elicit the cumulative prospect theory (CPT) risk preference parameters. We focused on the Ward and Singh (2015) design, which is a variation from Tanaka et al (2010). Fundamentally, this experiment involves choices between two options: Option A is equivalent to a fixed payment and Option B is equivalent to a risky option in each of the 35 rounds presented to farmers (Ward and Sing 2015). The utility function is as follows[21]:

$$U_{(x,y;p,q,\sigma,\gamma,\lambda)} = \begin{Bmatrix} v(y) + w(p)[v(x) - v(y)] & for\ x > y > 0\ or\ x < y < 0 \\ w(p)v(x) + w(q)v(y) & for\ x < 0 < y \end{Bmatrix}$$

where:

$$v(x) = \begin{Bmatrix} x^{\sigma} & for\ x > 0 \\ -\lambda(-x)^{\sigma} & for\ x < 0 \end{Bmatrix}$$

and w(p) is a probability-weighting function[22]:

$$w(p) = \exp[-(-\ln p)^{\gamma}] \text{ for } 0 < \gamma \leq 1$$

3.2 Procedure

In this stage, vineyard farmers played 3 series of lotteries with a total of 35 rounds. Specifically, series 1 involves 14 rounds, series 2 involves 14 rounds, and series 3 involves 7 rounds, each round involves a selection between a riskless option A and a risky option B. In order to

[21] We explain these equations and parameters in more detail in the theoretical framework.

[22] This is the weighting function showed in Prelec (1998).

persuade the vineyard farmers to reveal their risk preferences, these experiments were incentivized; in other words, a payoff was made to farmers.
For this experiment, we implemented a Multiple Price List (MPL) format as other studies in the literature have also done (Tanaka et al 2010; Liu 2013, Bocquého 2014; Ward and Singh 2015), as the format is easy to understand for farmers and allows the use of incentives when eliciting choices.

Basically, we followed a procedure by putting 35 numbered balls in a black bag and 10 colored balls (green and red) in a white bag. Specifically, the white bag had 10 green and red balls representing probabilities for each series; for instance, 3 green balls represented a 30% chance of winning in option B and 7 red balls represented 70% chance of losing in the same option. Then, at the end of the 35 rounds, we took the black bag with 35 numbered balls in which each ball was equivalent to one of the 35 rounds of the 3 series. It was then explained to farmers that after the 35 rounds they had to select one numbered ball from the black bag, which represented the round that will be played. Participants then had to select at random one ball from the white bag. If the farmer chose option A they received a fixed payment, but if the farmer chose option B they got a payoff according to the probability represented by the colored ball (green for winning and red for losing).

For instance, in series 1 option A was the riskless option with a fixed payment of 1,200 Chilean pesos. While option B represented more risk, offering a 10% probability of winning a monotonically increasing payment, yet with a 90% probability of receiving the losing amount of 600 Chilean pesos.

Series 2 is similar to series 1, however, with the difference that there is a higher fixed payment for option A, while Option B offered a 70% probability of winning an incremental payment and a 30% probability of receiving a losing payment of 500 Chilean pesos. Because we have a fixed payments in the less risky option and a fixed payment for the losing amount, we expect farmers to change from option A (riskless option) to option B (risky option) at some point of the lottery. These 2 first series were useful to elicit σ and γ.

In series 3 of the experiment, farmers were presented with 7 rounds, each with option A and B, but both options are risky, with a winning and losing draw. This series was useful to elicit λ. The payoff schedule for this experiment is shown in Table A. 1.

Table A. 1. Payoff for the three series of the experiment*$&

Round	Option A		Option B		Expected value difference
Series 1	Probability =1		Probability = 0.1	Probability = 0.9	
1	1200		3100	600	350
2	1200		3400	600	320
3	1200		3850	600	275
4	1200		4300	600	230
5	1200		4900	600	170
6	1200		5650	600	95
7	1200		6700	600	-10
8	1200		7600	600	-100
9	1200		8650	600	-205
10	1200		10200	600	-360
11	1200		12500	600	-590
12	1200		16000	600	-940
13	1200		21750	600	-1515
14	1200		33600	600	-2700
Series 2	Probability = 1		Probability = 0.7	Probability = 0.3	
1	4000		5600	500	-70
2	4000		5700	500	-140
3	4000		6000	500	-350
4	4000		6200	500	-490
5	4000		6500	500	-700
6	4000		6900	500	-980
7	4000		7300	500	-1260
8	4000		7700	500	-1540
9	4000		8200	500	-1890
10	4000		8700	500	-2240
11	4000		9500	500	-2800
12	4000		10500	500	-3500
13	4000		11900	500	-4480
14	4000		13700	500	-5740
Series 3	Probability = 0.5	Probability = 0.5	Probability = 0.5	Probability = 0.5	

1	10000	-2000	12000	-8500	2250
2	2000	-2000	12000	-8500	-1750
3	500	-2000	12000	-8500	-2500
4	500	-2000	12000	-6800	-3350
5	500	-4000	12000	-6800	-4350
6	500	-4000	12000	-5900	-4800
7	500	-4000	12000	-4650	-5425

* Design adapted from Tanaka et al (2010), Liu (2013), Bocqueho et al (2014) and Ward and Singh (2015). The original values from Tanaka were proportionally changed to Chilean Pesos through a conversion factor, as Carcamo (2017), but with a difference in the values of option A, round 4 from series 3 in order to follow the original values proportions from Tanaka et al (2010).

$ Series 1 and 2 were used to estimate σ and γ, and series 3 to estimate λ.

& Expected value difference = expected value of option A – expected value of option B

3.3 Estimation of parameters

According to the literature, there are two methods for the estimation of the Cumulative Prospect Theory (CPT) risk preference parameters, the structural and the midpoint method. The structural method uses the Maximum Likelihood Approach in STATA to maximize the farmers´ utility function (Andersen et al 2008; Harrison 2008; Harrison and Rutström 2009; Bocqueho et al 2014; Harrison et al 2016). In this approach, it is possible to elicit the parameters for each participant, it is only necessary to choose a specific group of covariates as determinants; nevertheless, this could lead to a great amount of variation.

In this research, we used the midpoint method, following Tanaka et al (2010), Liu (2013) and Ward and Sing (2015); we take the switching points of series 1 and 2 to elicit simultaneously the parameters of risk aversion (σ) and probability weighting (γ) when valuing risky prospects. For example, if one farmer changes from Option A to B in round 7 in series 1 and in round 20 in series 2, the following inequalities should be fulfilled:

From Series 1,

$$1200^{\sigma} > 600^{\sigma} + \exp[-(-\ln 0.1)^{\gamma}]\,(5650^{\sigma} - 600^{\sigma})$$

$$1200^{\sigma} < 600^{\sigma} + \exp[-(-\ln 0.1)^{\gamma}]\,(6700^{\sigma} - 600^{\sigma})$$

From Series 2,

$$4000^{\sigma} > 500^{\sigma} + \exp[-(-\ln 0.7)^{\gamma}]\,(6500^{\sigma} - 500^{\sigma})$$

$$4000^{\sigma} < 500^{\sigma} + \exp[-(-\ln 0.7)^{\gamma}]\,(6900^{\sigma} - 500^{\sigma})$$

A range of combinations of σ and γ will fulfill the four inequalities and therefore we estimate upper and lower bounds of both parameters that together satisfy this criterion. We use Tanaka et.al (2010) approximations by using the midpoint of the interval to one decimal place for σ and γ. The λ is defined by the changes in series 3.

For instance, if a farmer switches from Option A to B in round 33, we infer the utilities derived from Option A and B in round 33 are the same. Finally, the λ values are based on a function of σ (Ward and Singh 2015):

$$\lambda_{33}\,(\sigma) = \frac{500_{33}^{\sigma} - \;12{,}000\,_{33}^{\sigma}}{(-4000_{33})^{\sigma} - (-6{,}800_{33})^{\sigma}}$$

In the numerator, we have the winning values for the round evaluated (in this case, round 33), which correspond to Option A and Option B; and in the denominator, we have the corresponding losing payoffs for Option A and B respectively. We estimate the interval of λ using the lower and upper bound of σ and then we take the midpoint of intervals to obtain λ.

Appendix 4. Risk preferences parameters (structural method)

We used the structural method, through Maximum Likelihood (ML) approach, to estimate the average values for the risk preferences parameters (σ, λ and γ) without including covariates (Table 15). In general, we obtain parameters according to literature ((Tanaka et al 2010; Liu 2013; Bocquého et al 2014; Ward and Singh 2015). For instance, σ =0.35 which indicates risk aversion among the farmers. Regarding loss aversion, λ =2.00 so we can assume that vineyard farmers are two times more sensitive to losses than to gains. Finally, the value of probability weighting is γ=1.01 which means that vineyard farmers tend to overestimate small probabilities, but this value is not different from 1.

Table 15. Risk preferences parameters using the structural method (maximum likelihood).

Parameter	**Value**	**Std. Err.**	**β_0= 1**
Curvature of value function (Risk aversion) (σ)	0.35***	0.008	0.000
Loss Aversion (λ)	2.00***	0.044	0.000
Probability weighting (γ)	1.01***	0.013	0.459
Noise	0.73**	0.331	
Observations	6,125		
Clusters	175		

Note: *p < 0.1, ** p < 0.05, *** p < 0.01.

Appendix 5. Curriculum Vitae

ENRIQUE ERNESTO ALVARADO IRIAS

Environmental socioeconomics - Agricultural economist – Behavioral economist

+49 162 2579425 ealvarado79@gmail.com ealvarado79

Nationality: Honduran Id: 0801-1979-03902 Passport: C746382

OBJECTIVE

Develop and apply scientific knowledge to achieve equilibrium between natural resources protection and socioeconomic progress of the nations.

EDUCATION:

2014 to 2019	**PhD Program in Agricultural Economics** Research area: Behavioral economics, climate change, technology adoption, technical efficiency of agricultural systems University of Göttingen, Germany www.uni-goettingen.de
2004 - 2005	Environmental Socioeconomic Graduate Program **(Honorable Mention Award)** Tropical Agricultural Research and Higher Education Center (CATIE) Turrialba, Costa Rica, C.A. Best graduated, 2do average of the promotion of masters www.catie.ac.cr
2000	Agronomic Engineer Program with specialization in: Agricultural Economics – Agribusiness Management Panamerican School of Agriculture - Zamorano El Zamorano, Honduras, C.A. www.zamorano.edu
1997 - 1999	Agronomic Program Panamerican School of Agriculture - Zamorano El Zamorano, Honduras, C.A. www.zamorano.edu
1985- 1995	Primary education, High School Degree in Sciences Instituto Salesiano San Miguel Tegucigalpa, Honduras, C.A.

EXPERIENCE:

2017-To date	Göttingen University, Germany Research assistant Main activities: • Participation in research projects • Preparation of scientific /research papers
2016	Universidad de Talca, Chile Research assistant Main activities: • Implementation of a artefactual field experiment • Participation in seminars • Participation in research project
2014-2015	Göttingen University, Germany Research assistant Main activities: • Participation in research projects • Preparation of scientific /research papers
2013	Inter-American Development Bank (BID) www.iadb.org Nordic Development Fund (NDF) www.ndf.fi Position-BID: Assistant - Country Representative; NDF: Climate Change Long-Term Consultant, management, implementation and oversight of projects about climate change, gender and indigenous populations. Main activities: • Identify and design projects to adapt to and mitigate climate change (AMCC); sustainable development and environmental management. • Raise non-reimbursable funds for Honduras. • Oversight and/or implement technical and administrative actions of "Indigenous Populations Program – Afro Hondurans and Climate Change". Solutions of the AMCC in Infrastructure and agriculture and education management. • Development of communication outreach: press conferences, public discussions among key stakeholders.
2007-2013	Consulting and research In the area of economy and environmental management: • Preparation of the Strategy to Implement a Payment for Environmental Services Scheme (PSA) in 12 Green Municipalities of the influence area of Rio Mocal Sub watershed in Honduras –El Salvador (FAO, October, 2012-January, 2013). • Update the Management Plan of the Protected Area Habitat/Species Chismuyo Bay with a territorial, gender and climate change approach (Proyecto Eco Pesca/Adt, 2012).

	• Estimation of the carbon stored in the forests of the Department of Atlántida (Foundation VIDA/ PROCORREDOR, 2011). • Assessment of the bioethanol, biogas and bio fertilizer production from coffee residues in Honduras (Biomass Research, the Netherlands, August-September, 2012). • Definition of a baseline on energy consumption and greenhouse gas emissions of two coffee cooperatives in western Honduras (SNV, 2011). • Implementation of two Payment for Environmental Services systems (PES) in micro watersheds of the Sierra de Agalta National Park and El Refugio de Vida Silvestre la Muralla (TNC, 2011). • Updating of the management plan of the Sierra de Agalta National Park (coauthor, TNC, 2010-2011). • As Market Specialist and biodiversity advisor for the preparation of a proposal to participate in a full and open competition for the USAID/PROPARQUE project (IRG, 2011). • Updating of the management plan of Jeannette Kawas National Park (Foundation PROLANSATE/ PROCORREDOR, 2011). • Trainer in the workshop "Business plans with emphasis on business tourism or eco-tourism in protected areas" (Foundation Vida/ PROCORREDOR, 2011). • Design of an Early Warning System to address socio-economic drought and adapt to climate change in the departments of Valle and Choluteca (COPECO – PMDN, 2010). • Development of strategies for the implementation of Payment for Environmental Services (PES) in two Micro watersheds of the Sierra de Agalta National Park and El Refugio de Vida Silvestre la Muralla (TNC, 2010). • Economic valuation of natural assets of the National Protected Areas System of Honduras (SINAPH) and its importance to society and the Honduran economy (NISP Alliance: TNC – DIBIO – GTZ –ICF, 2010) • Preparation of the strategy to implement a Payment for Environmental Services system, based on the water resource services and secondary products in the La Tigra National Park (Foundation Amitigra – FORCUENCAS, 2010) • Development of the study of "Economic valuation of water environmental services of the watershed Suyatal – Algodonal (Alternativas S.A. – FORCUENCAS, 2010). • Development of the study of "Economic valuation of water environmental services of the watershed Cerro Azul" (SECOAGRO – FORCUENCAS, 2009). • Development of the study of "Economic valuation of water environmental services of the watershed El Águila" (SECOAGRO – FORCUENCAS, 2009). • Preparation of the industrial waste inventory of Honduras (coauthor, CNP+LG, 2009). • Preparation of the "Second Inventory and Characterization of the Actions on Payments for Environmental Services in Honduras (PBPR – SAG – DGA/SERNA, 2007 - 2008).

	• Field coordinator and writer of the baseline study of the project Promoting Integrated Management of Ecosystems and Natural Resources in Honduras, Ecosystems Project (ANED Consultants– PNUD/GEF, 2007). • Editing and thematic document enrichment: key environmental problems of Honduras • Editing and thematic document enrichment: key environmental problems of Honduras (Zamorano – World Bank, 2007). In the area of socioeconomic development: • Institutional Reforms and investments for the Extension Services in Central America: Honduras Case Study (FAO, September-October 2013). • Preparation of the analysis and action plan of the value chain of horticulture, flowers and strawberries in the La Tigra National Park with gender as cross-cutting (USAID/ProParque; November, 2012-January, 2013). • Update of the Institutional Strategic Plan of the National Association of Cacao Producers of Honduras (APROCACAHO, Oct-Dec., 2012). • Preparation of the analysis and action plan of the value chain of livestock in the Sierra de Agalta National Park (USAID/ProParque, 2012). • Preparation of the pre feasibility study for the production of organic cacao in the Sico-Paulaya Valley (SAG, 2012). • Preparation of the analysis and action plan of the value chain of livestock in the Colibri Esmeralda National Park (USAID/ProParque, 2012). • Preparation of the Strategic Plan for CODDEFFAGOLF (CODDEFFAGOLF, 2012). • Preparation of the Strategic Plan for La Coordinadora de Mujeres Campesinas de La Paz (COMUCAP) (OXFAM, 2011). • Adviser to the Association of Cocoa Producers of Honduras (APROCACAHO) in the area of value chain, competitiveness and business management (Cacao Centro America Project – CATIE, 2010). • Feasibility study for the processing of cocoa in Honduras (financial and market analysis for the purchase of a cocoa processing plant in the country) (FHIA, 2010). • Preparation of a feasibility study, market assessment and a marketing strategy for the cultivation of cocoa in the basin of the Patuca River (Asociación Patuca – FORCUENCAS, 2010). • Preparation of a booklet on the supply of environmentally friendly cocoa (Cocoa AB) and/or its derivatives in Honduras and El Salvador) (CATIE – CAMBio Project – BCIE, 2010). • Socioeconomic characterization of the communities within the protected areas of Los Delgaditos, Isla del Tigre and Bahía de Chismuyo of the south region of the country (Fonseca Gulf) (CODDEFFAGOLF – Amigos de la Tierra, 2009).

	• Development of a strategy for socio-economic development and environment and its plan of action for communities within the protected areas of Los Delgaditos, Isla del Tigre and Bahía de Chismuyo (CODDEFFAGOLF – Amigos de la Tierra, 2009-2010). • Strategic analysis and business assessment of two small producers companies of African oil palm of Honduras and preparation of project proposals (SNV, 2009). • Definition and analysis of the supply and demand of environmentally friendly cocoa (cocoa AB) and/or its derivatives in Honduras and El Salvador (CATIE – CAMBio Project – BCIE, 2009). • Preparation of the project proposal for the development of three collection centers of cacao in the northern part of the country (CATIE – Mesoamerican Environmental Program, 2009). • Development of the Strategic Plan 2009-2013 for APROCACAHO, revision of its statutes and organizational structure, definition of its business and analysis of special cocoas value chains (CATIE – Central American Cacao Project, 2009). • Preparation of an assessment of the performance of APROCACAHO with regards to their services and impacts (CATIE – Central American Cacao Project, 2009). • Preparation of the administrative, accounting and personnel manuals of APROCACAHO; in addition, preparation of the internal procedure regulation and its marketing manual (CATIE – Central American Cacao Project, 2009). • Technical review and final edition of 4 project profiles and business plans in sustainable agriculture, agroforestry, forestry and organic fertilization on the Sub-basin of the Manchaguala River, northern zone of the Country (Zamorano, 2009). • Preparation of the business plan of the Industrial Residues Bag of Honduras (CNP+LG, 2008). • Preparation of the methodological proposal of the “Cluster Strategy for Coffee with Marcala´s Origin Denomination” (ANED Consultores, 2008). • Evaluation of a baseline of the resilience and action project in the South of Honduras "SHARP" (ANED Consultants – World Vision, 2008). • Preparation of the technical proposal for “disaster reduction management and strengthening of local structures in the response to emergencies (ANED Foundation – TROCAIRE, 2008). • Systematization of the pilot phase of the Central America cocoa Project in its component of productive chains (CATIE, 2008). • Systematization of the bi-national Agro ecotourism development project between Ocotepeque and Chalatenango (Bi-national Program- Zamorano, 2008). • Preparation of the course: financial sustainability of protected areas (CATIE - CCAD, 2007). • Edition of the report: mid-term evaluation of the program to Support subsistence farmers (ANED Consultants – ADRA, 2007). • Preparation of the final report of the pilot phase of the Cocoa Central America project in Honduras (APROCACAHO, 2007).

2007 - 2009 (06/07 – 31/11)	International Resources Group (IRG) – USAID/ Honduras Integrated Management of Environmental Resources Project (MIRA) Environmental Socioeconomic Specialist www.irgltd.com www.mirahonduras.org Activities in the area of Biodiversity and Policy: • Design a methodology to develop a eco touristic value chain in the fishing area in the marine coastal of the north of the country and define guidelines to coordinate its implementation. • Coordinate the elaboration of the valuation study of the supply and demand of the water environmental service in the micro watershed of West End, Roatán, and Bay Islands. • Coordinate the induction of the consultancy team that develops the economic valuation of the water environmental service in the watersheds of Danlí and Choluteca. • Design the methodology and terms of reference to prepare the National Wetland Inventory of Honduras. • Revision and follow-up of the preparation process of the National Wetland Inventory. • Member of the technical committee to review the National Wetland Policy. Activities in the area of Productivity and Development: • Coordinate the preparation of the Best Environmental Practices Guides (GBPA) for eight productive sectors in the country (biodiesel, textil, tilapia, tourism, poultry, swine production, sugar cane processing, forestry (primary sector) and for the construction in the marine coastal zones. These guides will be used to simplify the environmental licensing process in the country. - Selection of sector with COHEP and SERNA - Definition of the methodology of the guides (content, approach of impact matrices and prevention, mitigation, correction and compensation measurements, etc). - Supervision, edition and technical revision of the guides. - Coordination of socialization and validation workshops. • Coordinate the preparation of eight Cleaner Production Guides (GP+L) in the mentioned sector: - Selection of sector with COHEP and SERNA - Definition of the methodology of the guides (content, preparation of tools, rapid evaluations of P+L in the enterprises, etc.). - Supervision, edition and technical revision of the guides. - Coordination of socialization and validation workshops.

	• Coordinate the preparation of the National Cleaner Production Strategy and its action plan: - Design the content and coordinate with the consultant team. - Participative construction of the action plan. - Coordination of socialization and validation workshops. • Coordinate the implementation of Cleaner production practices in 13 hotels in the fisher zone – coastal area in the north coast of the country: - Hotel selection. - Selection and validation of the tools. - Systematization of the results.
2006 - 2007 (06/06- 06/07)	Tropical Agricultural Research and Higher Education Center (CATIE) Position: Project manager/ researcher/ professor assistant www.catie.ac.cr Activities: • Assessment of the Farmer Association of Cacao Producers in Honduras “APROCACAHO”. • Characterization of the cacao value chain in Honduras. • Evaluation of the role of the government and educative institutions in the cacao sector of Honduras. • Technical formulation of proposal for international projects. • Rise financing for projects and programs. • Systematization of local, regional and international projects. • Systematization of information for technical and financial reports. • Management, preparation and implementation of an inter-enterprise diagnosis manual – auto assessment of the performance of the agricultural enterprises through the use of participatory methodologies. • Management and preparation of institutional strengthening for second level organizations of the Ecuadorian cacao sector and Central America coffee sectors. • Professor assistant of the “Rural Economy” class. • Supervision of program of international internships. • Conferences concerning enterprise capacity and international course of “Modernization of the Latin American Cacao culture”. • Design, preparation and implementation of the training manual “Economic valuation of environmental goods and services for the Mesoamerican Biological Corridor (CBM)”. • Preparation of the training manual “Collective action and designed of management local institution of the common resources. • Trainer of the international course “Economic Valuation of environmental goods and services for national decision makers of the CBM. • Development of socioeconomics and econometrics research • Preparation of scientific articles for international magazines.

2006 (01/06 – 06/06)	Pan-American School of Agriculture "El Zamorano" www.zamorano.edu Position: Coordinator of the project "Bi-national Agro Eco touristic Development between Ocotepeque, Honduras and Chalatenango, El Salvador". Activities: • Development of a Local Economy local Strategy based on rural tourism. • Coordinate the participative formation of 4 municipal committees of tourism and a regional committee for municipalities in the Department of Ocotepeque, Honduras. • Develop an inventory of touristic attractions and services in Ocotepeque, Honduras and Chalatenango, El Salvador. • Develop diagnosis of the necessities of training and designed a training plan in the touristic and environmental education areas for a mancomunity of municipalities. • Institutional strengthening of an association of municipalities (support in the preparation of the work plan, technical platform, common responsibilities agenda and economic sustainability). • Other activities: preparation of operative plans, technical reports, memories, personnel management and monitoring. • Articulate the Technical Cooperation Platform of AMVAS.
2004 – 2005	Tropical Center for Research and Education (CATIE) (www.catie.ac.cr) Research: • Design, construction and analysis of the structures of costs for the cattle producers of the north coast of Honduras. • Adaptation of the methodology to evaluate the business capacity of cattle producers. • Design and adaptation of a methodology to evaluate the capacity of enterprising of youth in rural areas. • Analysis of livelihood of organic rural producers. • Analysis of the productive chain of furniture in Turrialba, C.R. • Analysis of the demand for the protection of water resources through a system of payment for environmental services. • Analysis of forestry and cattle investments.
2002 – 2003	Committee for the Protection and Development of Flora and Fauna in the Fonseca Gulf, Honduras (CODDEFFAGOLF), ONG.

	Project Coordinator: RED MANGLAR for the defense of Coastal Ecosystems and Community well-being Activities: • Elaboration of the financial proposal for the development of a project (which was presented to an international organization (HIVOS of Netherlands) and was approved) • Elaboration of the annual budget and operative plan (POA's) • Coordination and development of seminars concerning environment, protection of marine-coastal resources and community development. • Coordination of local and regional forums in Proof Sustainable Development and Protection of Maritime-Coastal Resources. • Elaboration and presentation of technical and financial reports. • Representative of the NGO in American Networks • Execution of the annual operative plan • Coordination of the elaboration and distribution of educational material, socialization/consciousness (brochures, manuals, books) • Lobby agent in Municipalities, Ministers, environmental organizations and others. Honduran Representative for the Action Network in Pesticides and Alternatives for Central America (RAPAC) Activities: • Development of informative workshops with NGO's, decision makers, politicians and others, concerning the unification in the registration of pesticides at the Centro American Customs Union • Coordination of a National Campaign to forbid the use of the 12 most dangerous pesticides (according to the OPS) • Support in the elaboration of the study: Social Costs of Pesticides use • Coordinator in the exchange of information with the main Central American actors related with the efforts to decrease the use of pesticides and to find alternatives • Promoting the efforts to reduce the use of pesticides to involve new actors • Celebration of National and International events promoting the no-use of pesticides. • Promulgation of information to educate and increase consciousness concerning the use of pesticides • Coordination of educational forums about the impacts of pesticides • Coordination of the organization of the Environmental Teachers Network • Support in the consciousness of the media

	Department of Project and Financial Management, Director Activities: • Elaboration of development projects proposal for international donors (in the areas of: micro irrigation, protected areas management, watershed management, sustainable agriculture, institutional capacity, community development) • Maintenance of inter-institutional relation with the donors. Director of the Program: Training and Environmental Management Activities: • Coordination and elaboration of trainings in environmental issues and sustainable development (environmental education, mangroves, nursery, reforestation, fire control, agro forestry, family gardens, horticulture, grain bank, soil conservation, organic compost, integrated pesticide management, pesticides impact, rational use of agrochemicals, organization, role of administrative boards, leadership, parliamentary norms, rural credit, administration, etc. • Elaboration of memories and reports. • Development of micro enterprises with mix groups of women and artisans fisherman (rural banks, handcrafts, bank grain, poultry, and recollection centers). Control and Follow-up of the following projects: • Together to Sustainable Development. • Re-construction of 40 houses destructed by the tide. • Education and promotion of environmental management, gender and sustainable development in Municipalities of the coast in the Fonseca gulf. Other activities: • Participation as lecturer in inter-institutional meetings. • Organization of environmental and sustainable development forums. • Design and implementation of a greenhouse for 20,000 plants. • Establishment of forest plantations/energetic forest. • Reforestation of watersheds. • Establishment of fruit trees. • Technical assistance to producers of watermelon, casaba and others. • Technical assistance to poultry producers.
2001 – 2002	Committee for the Protection and Development of Flora and Fauna in the Fonseca Gulf, Honduras (CODDEFFAGOLF), ONG.

	Coordinator of the Project: Elaboration of Management Plan for three protected areas in the Fonseca Gulf. Activities: • Coordination of more than 15 training events of "Validation of management plans in three protected areas in the Fonseca gulf, in which were present the industry, local government, civil society and other environmental organizations in the area. • Implementation of 10 micro projects of sustainable development as: establishment of 4 houses for poultry production, one store of natural medicine, one handcraft store, and one store for basic grains (beans, rice, corn), one store for common goods. • Coordination and development of trainings on the following topics: organization, parliamentary norms, leadership, gender, farmer to farmer methodology, eco-tourism, environmental legislation, family gardens, integrated pesticide management, soil conservation, water intake systems, animal sanitation, agro forestry, food processing and conservation, basic principles of administration, basic marketing and formation and administration of micro enterprises, between many others. • Elaboration of annual budgets and operational plans (POA's) • Elaboration and presentation of technical and financial reports. • Lobby agent in Municipalities, Ministers, environmental organizations and others. • Design of the methodology to evaluate the performance of the projects
2000 - 2001	Pan-American School of Agriculture "Escuela Agrícola Panamericana" • Development of an analytical methodology for the management of rural credit catalogue managed by a saving and credit association. • Control and verification of rural loan • Elaboration and field working of interviews in the rural area, to determine the impact of the use of credit and the reasons why the customers of a cooperative retired from a credit program. • Assistant of Guillermo Berlioz professor in charge of the Marketing area. • Assistant of MSc. Miguel Avedillo, professor in charge of the accounting, statistical and administration courses.
1997 - 1999	Pan-American School of Agriculture "Escuela Agrícola Panamericana, under the philosophy of "Learn by doing" • Development of field work and laboratory in the following areas: forestry, intensive crops, irrigation, aquiculture, poultry, milk and meat livestock, horticulture, in vitro production. • Development of projects in food processing plants, (milk, meat and fruits processing). • Practical participation of the economical modules of: human resources management, accounting, total quality administration and marketing.

	• Coordination of the project: Management of auto development in the community of Cuesta grande, Valle del Yegüare.
1995	Movimiento Juventud Financial commission Instituto Salesiano San Miguel Tegucigalpa, Honduras. C.A.

PUBLICATIONS:

Alvarado, E.; Ibañez, M.; Brümmer, B. 2018. Understanding how risk preferences and social capital affect farmers' behavior to anticipatory and reactive adaptation options to climate change: the case of vineyard farmers in central Chile (forthcoming).

Alvarado, E.; Brümmer, B.; Ibañez, M. 2018. Determinants of technical efficiency in vineyard systems of central Chile when adapting to climate change: the role of risk preferences and social capital (forthcoming).

Alvarado, E. 2018. Technical and environmental efficiency of vineyard farmers in central Chile (forthcoming).

Alvarado, E.; Vargas, E. 2006. Herramientas de gestión pecuaria: modelo de optimización económica para fincas de ganado de doble propósito. Working Paper.

Vargas, E.; Alvarado, E.; Alas, M, 2006. Determinantes de la eficiencia técnica para la producción de hortalizas en invernaderos. Working Paper.

Alvarado, E. 2005. Modelo de Optimización Económica para el Análisis y la Simulación de la Innovación Tecnológica en Sistemas de Producción de Ganado de Doble Propósito de la Región Nororiental de Honduras. Tesis.

Alvarado, E. 2000. Diagnóstico Empresarial de una Asociación de Ahorro y Crédito y Evaluación del Impacto del Micro-crédito en su cartera de clientes. Tesis.

INTERNATIONAL CONFERENCES

SABE/IAREP 2018 Conference.

The Society for the Advancement of Behavioral Economics (SABE)/ the International Association for Research in Economic Psychology (IAREP). Middlesex University, London, UK. July19-22, 2018

Contribution: Oral presentation.

ICAE 2018 Conference

30th International Conference of Agricultural Economists (ICAE). Vancouver, Canada. July 28 - August 2, 2018.

Contribution: Oral presentation.

AERNA Conference

VIII Conference of the Association of Environmental and Resource Economists (AERNA), Madrid, Spain; September 3 - 5, 2018.

TROPENTAG 2018 Conference

Ghent University, Belgium.

September 17-19, 2018

Contribution: Poster

ACKNOWLEDGEMENTS

- Travel Grant for early career scholars to participate in the 30th International Conference of Agricultural Economist, Canada, 2018.
- Research Grant from the Graduate School of Social Sciences, University of Göttingen Germany, 2018.
- Scholarship-Loan from HONDUFUTURO for the Doctoral Program, Honduras, 2016.
- Scholarship from Katholischer Akademischer Ausländer-Dienst (KAAD) to pursue a Doctoral Program, Germany, 2016 – 2018.
- Scholarship from the University of Los Andes for economic studies.
- Honorable mention for the studies of master in science in environmental socioeconomic of CATIE.
- Best graduated and speaker of the promotion of master of CATIE.
- Full scholarship for the Master Program in Environmental Socioeconomic granted by the Exterior Relations Ministry of the Norwegian Republic (NORAD) and CATIE.
- Scholarship for the Agronomic Engineer in Zamorano, granted by the Agricultural and Livestock Secretariat (SAG) and Fondo Dotal de Honduras.
- Diplomas of honor in Zamorano.
- Diplomas of honor in the primary and secondary studies.

SKILLS:

- Software: excellent management of basic processor and statistical programs (Office, Infostat, etc.).
- Languages: English level – mid -high, TOEFL 84.
- Excellent ability to write and analysis capacity.
- Capacity to maintain good inter institutional relations (donors, ONGs, etc.).
- Deep knowledge in the preparation of proposal and project management with a gender approach and under logic framework schemes.
- Capacity to systematize projects, prepare scientific reports and develop research using econometrics techniques (lineal programming, regressions, etc.).

COMPLEMENTARY EDUCATION:

2013 2 months	Project Management for Results (PM4R) Course Inter-American Institute for Economic and Social Development (INDES) Inter-American Development Bank (BID) www.iadb.org
2013 1 week	Diploma in Biostatistics CATIE, Turrialba, Costa Rica, C.A. www.catie.ac.cr
2013 3 days	Communication skills ADEN Business School- BID
2012-2013 2 months	Diploma on Gender Equity and Community Development. CODDEFFAGOLF, Honduras. www.coddeffagolf.org
2012 Two weeks	VII International Course on Tools for the Monitoring of Carbon Sequestration in Land Use Systems CATIE-Universidad de Tolima (UT); Ibague, Colombia www.catie.ac.cr www.ut.edu.co
2011 2 weeks	First Central American Regional Training on "Economics on Environment and Natural Resources" Latin American and Caribbean Environmental Economics Program www.laceep.org
2010 2 months	International Course on Sustainable Tourism Universidad of North Texas (UNT), Denton, Texas www.unt.edu
2009 3 months	Specialization course Environmental Impact Assessment- Strategic Environmental Evaluation Latin-American Center of Long Distance Education (CLADEAD) Virtual platform: www.cladead.com
2008 3 months	Specialization course Measurement of the Local Economy Bolivian Center of Multidisciplinary Studies (CEBEM) Virtual platform: http://cvirtual.cebem.org/

2007 3 months	Specialization course Management of Public Policies for Rural Areas Formulation and Evaluation of Programs and Projects of Development FAO/ Project FODEPAL Virtual platform: www.rlc.fao.org/proyecto/fodepal/
2006 4 months	Specialization course The Territorial Approach of Regional Development FAO/ Project FODEPAL **Outstanding** Virtual platform: www.rlc.fao.org/proyecto/fodepal/

PERSONAL REFERENCES

a) Ing. Juan Barahona (COMRURAL) Cel: 9970 7408
b) Ing. Gerardo Santos (Seguros HSBC) Cel: 99 02 31 54
c) Lic. Dina Morel (CODDEFFAGOLF) Tel: 99274367 dinaemorel@yahoo.com

PROFESSIONAL REFERENCES

a) Ph.D. Eliécer Vargas (Funcionario CATIE) Tel: (506) 25582218 evargas@catie.ac.cr
b) Ph.D. Juan Carlos Flores (Profesor EAP, El Zamorano) Cel: 9981-5093 jcflores@catie.ac.cr
c) M. Sc. Hector Santos (Funcionario USAID/Honduras) Tel: 22369320 hsantos@usaid.gov
d) M. Sc. Martha Cálix (Funcionaria, EAP “El Zamorano”) mcalix@zamorano.edu
e) M.Sc. Rubén Gallozzi (Asesor SNV) Tel 33906323 rmgallozzi@snvworld.org
f) Ing. Cesar Flores (DGA/SERNA) Tel: 99064659 psa_dga2004@yahoo.com.mx
g) Ing. Ana Patricia Martínez (Consultora International Resources Group) apat_afe@yahoo.com