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# ADOPTION OF IRRIGATION SCHEDULING: ROLE OF EXTENSION AND TRAINING IN CENTRAL CHILE

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**Abstract**

This article applies a Logit regression model to examine the factors that contribute to the adoption of irrigation scheduling by small-scale farmers in Central Chile. Socio-economic and productive information was collected from a random sample of 112 small-scale, irrigated farms during the 2010/2011 season. One important feature of this research is the specific extension and training in irrigation scheduling received by some of the farmers. Irrigation scheduling consists of estimating the optimum water application (irrigation timing and frequency) by using information about soil, crop, and climatic conditions. Model results show that training increases the likelihood of adopting irrigation scheduling; however, extension visits show non-significant results. Results also indicate that farm size, production system, access to credit, and use of pressurized irrigation are important variables associated with adopting irrigation scheduling. From a policy standpoint, results show that if pressurized irrigation is adopted (i.e. drip or sprinkler irrigation) scheduling is more likely to be adopted as well. Another relevant policy result is that training is more effective in inducing farmers to adopt irrigation scheduling than an intervention process through extension. It is recommended that extension projects involve intensive training.

*Key words:* Irrigation scheduling, technology adoption, small-scale farmers

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## 1. Introduction

Irrigation has played a major role in increasing food security over the past 50 years (Jensen et al., 1990; Schultz et al., 2005). Moreover, the uncertainty derived from climate change, and its impact on production has resulted in more emphasis on increasing irrigation efficiency (Pathak and Wassmann, 2009; Zhu et al., 2011).

Since irrigation technologies are becoming more relevant in facing the climatic variability scenario, part of the agenda of governments and international organizations (e.g., Food and Agriculture Organization of the United Nations and Inter-American Development Bank) is focused on directing more resources to irrigation development projects (Klop et al., 2008). According to Namara et al. (2007), adoption of irrigation water technologies is promoted worldwide mainly to achieve the following objectives: to avoid water shortage, minimize poverty in vulnerable rural sectors, and improve food security. Modern pressurized irrigation (i.e. drip or sprinkler irrigation) systems have the potential to save large volumes of water; however, their efficiency greatly depends on system design and management (Raine et al., 2000).

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Chile has increased investment in water supply and diffusion of irrigation technologies over the last century, and, by 1970, 1.2 ha were under irrigation. More recently, in 1981, the National Commission of Irrigation (CNR) (Comisión Nacional de Riego, 2007) developed two mechanisms to promote investment in irrigation infrastructure. The first is the Irrigation Development Law (*Ley de Fomento al Riego No 1,123 de 1981),* which provides funding for major investment, including the construction of dams and inter-basin channels. The second is the Investment Irrigation Law (*Ley de Fomento a Obras Menores de Riego No 18,450 de 1985*), which provides farmers with a subsidy for infrastructure and improvement of irrigation (Ríos Brehm and Quiroz, 1995). Between 2005 and 2011, CNR financed approximately 7,000 pressurized irrigation projects for a total investment of US$ 436,366 million. More than 180,000 farmers have been the beneficiaries of this investment, and the agricultural land with projects has reached 115,000 ha.

Despite investment in technology and water supply, complementary assets in extension and research are still needed to improve irrigation efficiency (Cai et al., 2003; Ortega-Farías et al., 2009). The Chilean government, aware of the need for complementary research and extension, has financed several initiatives aiming for a better use of irrigation technology. One of these initiatives is the Irrigation Scheduling Service for Irrigation Water Optimization (SEPOR) (*Servicio de Programación y Optimización del uso del Agua para Riego*), a project whose main objective is developing and promoting an irrigation scheduling system (i.e., appropriate irrigation timing and frequency) (Montoro et al., 2011) among small- and medium-scale producers considered to be the most vulnerable. The project took place in the Central Valley of Chile (Maule Region), an area with high potential for export-oriented food products. The main intervention activities were: (1) direct assistance (extension) to a sample of producers for two years and (2) training activities (courses and seminars). SEPOR was implemented by the Research and Extension Center for Irrigation and Agroclimatology (CITRA) between 2007 and 2010, and was financed by CNR. The evidence of climatic change shows that historical temperature records exhibit an upward trend in the central valley, where this project was developed (Falvey and Garreaud, 2009) and, therefore, adaptation, in which irrigation plays a crucial role, is imperative (Klop et al., 2008; Santibáñez and Santibáñez, 2007). According to Roco et al. (2014), irrigation is one of the top priorities among adaptation practices.

According to Maraseni et al. (2012), higher levels of water savings are possible not only with a proper design but also with training and better irrigation system management. Given the characteristics of farmers included in the project, the approach to implementing extension and training is a high-interest topic for the Chilean government. Our research question is: How effective were extension and training efforts, or more specifically, was irrigation scheduling adopted after the intervention? If it was not adopted, what were the factors preventing its use? Our aim is to contribute to the discussion regarding policy design to improve overall irrigation water use efficiency in order to reduce the adverse effects that are likely to evolve from increasing climatic variability.

## 2. Methodology and data

### *2.1. Model description*

According to the approach taken by Adesina and Zinnah (1993) and Rahm and Huffmann (1984), we assume that farmers maximize utility and adopt technologies when the anticipated utility from adoption exceeds that of non-adoption. Although not directly observed, utility $U_{ij}$ for a given farmer $i$ using a particular technology $j$ can be expressed as a function of a vector of explanatory variables $X_i$, for example, farm size or cropping system.
The underlying $U$ function of the $i^{th}$ farmer, expressed in terms of farm and farmer-specific attributes, $X$, and a disturbance term with a mean of 0, can be written as Eq. (1):

$$U_{ij} = \beta_i(\mathrm{X}_i) + \varepsilon_{ij}, \quad j = 1,0, \quad i = 1,2,\ldots,n \tag{1}$$

where, $X_i$ is a vector of explanatory variables and $\beta_i$ is a vector of parameters. Adoption of the new technology ($j=1$) by the $i^{th}$ farmer occurs when $U_{i1}>U_{i0}$. Models can be expressed as a binary choice of observable adoption or non-adoption, which implies using a Probit or Logit model (e.g., Feder et al., 1985; Foltz, 2003; Jara-Rojas et al., 2013; Lapar and Pandey, 1999). In this article, we use a binary regression model (Logit) to evaluate the factors that contribute to the adoption of irrigation scheduling.

The estimated Logit model can be derived from an underlying latent variable model (Greene, 2008) (Eq. 2):

$$y^* = \beta_0 + \mathrm{X}\beta + \varepsilon, \quad y = 1[y^* > 0] \tag{2}$$

where, $y^*$ is the unobserved or latent variable, $X$ denotes a set of explanatory variables, $\beta$ are the parameters to be estimated, ε is the error term, and 1[y*>0] defines the binary outcome where $y = 1$ if a farmer adopts irrigation scheduling and 0 otherwise. The binary models are not linear regressions and $\beta$ parameters do not have a direct interpretation; therefore, marginal effects are usually computed at the mean of each variable. The marginal effect for the $j^{th}$ continuous variable is Eq. (3) (Greene, 2008):

$$\frac{\partial P(y=1)}{\partial X_j} = \Lambda(x'\beta)\{1-\Lambda(x'\beta)\}\beta_j \tag{3}$$

where, $\Lambda$ is the cumulative distribution function (CDF) of the logistic distribution. The marginal effect is interpreted as the percentage change in the probability of adopting irrigation scheduling given a one unit increase in the continuous independent variable of interest and setting the other variables at their mean values. The marginal effects for a binary variable are calculated as Eq. (4):

$$\Delta P(y=1) = \Lambda(\beta_1) - \Lambda(\beta_0) \quad (4)$$

Thus, the marginal effect is calculated as the dummy variable equal to 1 minus the result of the same dummy at 0 and setting all other variables at their mean values.

### *2.2. Area under study and empirical model*

The area under study includes the second section of the Cachapoal River (O'Higgins Region), North Maule River (Maule Region), and Longaví River (Maule Region); all these areas are located in the Chilean Central Valley. The sample size for this study was 112 farmers, selected from among members of water associations (104 valid questionnaires) and geographically distributed as follows: 49 farmers from Cachapoal River, 26 farmers from North Maule River, and 37 farmers from Longaví River. The sample included 55 producers who received training and/or extension and 49 who did not receive the intervention. The participation of producers in the program was determined directly by the water association representatives and/or by voluntary participation, creating a possible selection bias. To avoid bias, the sample was randomly selected from the water association producer lists. Information for the study was captured in an in-person survey conducted between May and August 2010. Producers in the sample exhibited a wide range of crops, such as fruits trees, horticulture, cereals, and grasses. Despite crop diversity, all the systems could be treated by irrigation scheduling. The intervened farmer was one who received direct extension or training through courses or workshops. The empirical Logit model used in this study is estimated with maximum likelihood methods and can be expressed in general terms as Eq. (5):

$$\begin{aligned} Scheduling_i &= \alpha_i + \beta_1 Age_i + \beta_2 Educ2_i + \beta_3 Educ3_i +, \\ &\beta_4 Major.fruits_i + \beta_5 Minor.fruits_i \\ &+ \beta_6 F.size_i + \beta_7 Irr.tech_i + \beta_8 Sepor.tr_i +, \\ &\beta_9 Sepor.ex_i + \beta_{10} Cred.pri_i + \beta_{11} Cred.gov_i \\ &+ \beta_{12} M.north_i + \beta_{13} M.south_i + \varepsilon_i \end{aligned} \quad (5)$$

where, the dependent variable *Scheduling* has a value of 1, if the *ith* farmer adopts irrigation scheduling adhering at least two of the following agronomic criteria:

1. If the farmer uses climatic information to perform irrigation scheduling,
2. If the farmer uses soil information to perform irrigation scheduling,
3. If the farmer uses crop information to perform irrigation scheduling.

In accordance with the definition of adoption used in this study, 41% of farmers adopted irrigation scheduling (n=46). The rest of farmers (n=58) also performed irrigation scheduling, but they did not use climatic, soil, and crop information; as a consequence, an overuse of irrigation water was expected.

### *2.3. The data*

The independent variables used in the Logit model are described in Table 1. These variables are related to natural, social, human, physical, and financial capital associated with the farm and the farmer (Boyd et al., 2000) and were obtained from the literature about irrigation technology adoption. See Bjornlund et al., (2009) on the financial and physical farm conditions; Caswell and Zilberman (1985) on type of crop and location; Namara et al., (2007) on the use of credits; and Negri et al., (2005) and Shrestha and Gopalakrishnan (1993) on farm size.

**Table 1.** Definition of variables used in the econometric model

| ***Variable*** | ***Type*** | ***Description*** |
|---|---|---|
| **Dependent** | | |
| *Irrigation scheduling* | Dummy | 1 if farmer adopts irrigation scheduling, 0 otherwise. |
| **Independent** | | |
| *Age* | Continuous | Age of head of household in years. |
| *Educ1* | Dummy | 1 if the farmer has incomplete elementary school, 0 otherwise (omitted variable) |
| *Educ2* | Dummy | 1 if the farmer has completed elementary school but incomplete secondary school, 0 otherwise |
| *Educ3* | Dummy | 1 if the farmer has completed elementary school and higher education |
| *Major.fruits* | Dummy | 1 if the farm has major fruit trees (apples, kiwifruits) as a main crop, 0 otherwise. |
| *Minor.fruits* | Dummy | 1 if the farm has minor fruit trees (berries) as a main crop, 0 otherwise. |
| *Crops* | Dummy | 1 if the farm has annual crops or vegetables as a main crop, 0 otherwise (omitted variable). |
| *F.size* | Continuous | Farm size in hectares. |
| *Irr.tech* | Dummy | 1 if the farm has pressurized irrigation, 0 otherwise. |
| *Sepor.tr* | Dummy | 1 if the farmer received training from SEPOR, 0 otherwise. |
| *Sepor.ex* | Dummy | 1 if the farmer received extension from SEPOR, 0 otherwise. |
| *Cred.pri* | Dummy | 1 if the farmer used private credit, 0 otherwise. |
| *Cred.gov* | Dummy | 1 if the farmer used government credit, 0 otherwise. |
| *M.north* | Dummy | 1 if the farm is located in northern Maule watershed, 0 otherwise. |
| *M.south* | Dummy | 1 if the farm is located in southern Maule watershed, 0 otherwise. |
| *Cachapoal* | Dummy | 1 if the farm is located in the Cachapoal watershed, 0 otherwise (omitted variable). |

Table 2 shows a summary of descriptive statistics of the variables used. Mean sample farm size was 15.1 ha and ranges from 0.5 to 160 ha. The top three crops declared as the main source of farm income were fruits (peaches, apples, and kiwifruit), berries, and vegetables, with 35.6%, 32.7%, and 16.1% of responses, respectively. The mean age of the head of the household was 56 years, which is consistent with the widely held view that young people tend to migrate from rural to urban areas. In the sample, 17% of the farmers were 46-50 years old and 24% were older than 65. According to INE (2007), it was estimated in the last agricultural census that 34% of the rural population was over 65 years old. Educational level is usually a constraint in technology adoption (Asfaw and Admassie, 2004). In the present study, 29.8% of farmers had not completed elementary school (less than 8 years of education), 25% had incomplete secondary education, and 45.2 % had completed secondary education or higher (≥ 12 years). The average educational level of the sample was 3.4 years, and this hindered adoption of new technologies.

Regarding adoption of irrigation technologies and despite the high percentage of fruit production as a main crop (68.3%), only 14.4% of farmers have pressurized irrigation. However, adoption of irrigation scheduling is still possible through gravitational irrigation. Inefficiencies associated with water use have shown that these affect agricultural production revenue (Yilmaz and Harmancioglu, 2007). Wang (2010) gives evidence that wheat farmers could produce the same quantity of wheat with the same quantity of inputs but with 69.35% less water. Financial capital variables, such as access to credit, have been positively associated with the adoption of technologies, especially those that require more investment, such as new irrigation systems (Abdulai et al., 2011; Alcon et al., 2011). In the present study, 24% of the sample received credit from a government institution called INDAP (National Institute for Agricultural Development) and 33.7% from private financial institutions. Finally, 32.7% of the sample received training and 46.7% extension.

## 3. Results and discussion

### *3.1. SEPOR description*

The main objective of SEPOR was to increase the efficiency of water use by developing and promoting an irrigation scheduling system. The specific aims of the project were to give direct assistance (extension) to a sample of producers, to train producers and professionals (via course and seminars), and to train water organizations in the use of technologies, meteorological instruments and climatic information. (One activity of the project was to implement meteorological stations in different areas to provide information to farmers. This activity was crucial to making irrigation programming possible).

SEPOR was financed by CNR and implemented by the Research and Extension Center for Irrigation and Agroclimatology (CITRA) between 2007 and 2010 with three water associations that serve producers in the three geographic areas mentioned in section 3.2, which are all located in the Chilean Central Valley. Producers participating in the extension program were selected by the three irrigation organizations' representatives, who aimed to include lead producers in each sector. To engage more interested producers, the associations also used their communication networks, such as meetings, periodic publications and web pages, to promote SEPOR.

**Table 2.** Descriptive statistics of variables used

| *Variable* | *Mean (for continuous variables)* | *SD* | *Percentage (for categorical variables)* |
|---|---|---|---|
| ***Dependent variable*** | | | |
| *Irrigation scheduling* | | | 41.3 |
| ***Independent variables*** | | | |
| *Age* | 56.4 | 11.9 | 35 |
| *Educ1* | | | 29.8 |
| *Educ2* | | | 25.0 |
| *Educ3* | | | 45.2 |
| *Major.fruits* | | | 35.6 |
| *Minor.fruits* | | | 32.7 |
| *Crops* | | | 31.7 |
| *F.size* | 15.1 | 26.7 | |
| *Irr.tech* | | | 14.4 |
| *Sepor.tr* | | | 32.7 |
| *Sepor.ex* | | | 46.2 |
| *Cred.pri* | | | 33.7 |
| *Cred.gov* | | | 24.0 |
| *M.north* | | | 22.1 |
| *M.south* | | | 33.7 |
| *Cachapoal* | | | 44.2 |

The extension activity consisted of visiting a participating farm once a week during the irrigation season to check program implementation and results of crop water use, growth, yield, and quality. Overall, extension consisted in giving basic recommendations to improve water use efficiency as well as training in irrigation scheduling. At first, the SEPOR team in charge of extension was oriented only toward advising on the use of irrigation technology; however, they observed that producers had management problems, which if not solved would make the use of water inefficient and, thereby, jeopardize the project results. The SEPOR team adjusted the methodology and also started advising on overall management practices. This change of strategy suggests that SEPOR engaged in a more participatory approach once the project was underway, but not from its beginning. It is important to note that around 35% of the participating farmers changed over time; therefore, it was not possible to have a continuous record of their performance.

The training modules, both courses and seminars, were open to the community of small- and medium-scale farmers and professionals and technicians who were working with each irrigation association. Producers could attend one or more courses and seminars without restriction. As expected, small- and medium-scale farmers with low levels of education, investment, and training tended not to participate, and, therefore, the SEPOR team identified a barrier to this activity.

### *3.2. Model Results*

The estimated model correctly predicts and classifies 84.6% of farmer choices (see Table 3). The Log-likelihood value is -41.35; along with the percentage of correct predictions, it indicates that the model has good explanatory power. Moreover, eight of 13 estimated parameters are significant at least at 10% confidence.

By analyzing the effect of each variable on the adoption of irrigation scheduling, it can be seen that age has a significant and negative influence. This was expected and evidenced in related literature that shows that younger farmers are likely to be more innovative and have a higher rate of technology adoption (Cramb, 2006; Lapar and Pandey, 1999; Lichtenberg, 2001; Norris and Batie, 1987). In this study, the marginal effect was -0.013, which indicates that for each additional year, the probability of adopting technology decreases by 1.3%.

Several studies also show that the educational level of the householder is a relevant variable in determining irrigation technology adoption (Cramb, 2006; Namara et al., 2007; Sanginga et al., 2007). Although the parameters of the dummy variables are positive (the omitted category is low education), neither is significant in the econometric model. The low level of significance might be explained by the high concentration of the educational level in the sample. A total of 54.8% of the farmers had only incomplete secondary education or less.

Farmers who use pressurized irrigation technology had a higher probability of adopting scheduling with a marginal effect that increased up to 59.6%. The high impact of this variable was also expected, because the large investment in irrigation technology should be accompanied by investment in its proper use. Regarding to access to credit, several studies (Foltz, 2003; Namara et al., 2007) reported that cash availability was used as proxy to facilitate capital to farmers and could be critical in adopting technologies involving initial investment in irrigation technologies, such as sustainable activities, in which irrigation efficiency is relevant (Caviglia-Harris, 2003, 2004).

**Table 3.** Estimates of Logit regression model and semi-elasticities (*Robust standard errors*[†] *in italics*)

| ***Variables*** | ***Logit for irrigation scheduling*** | | ***Semi-elasticities*** | |
|---|---|---|---|---|
| *Age* | -0.052* | *0.028* | 0.013* | *0.007* |
| *Educ1* | 0.200 | *0.852* | 0.049 | *0.211* |
| *Educ2* | 0.017 | *0.863* | 0.041 | *0.212* |
| *Major.fruits* | 1.890** | *0.901* | 0.440** | *0.181* |
| *Minor.fruits* | 0.067 | *1.037* | 0.017 | *0.256* |
| *F.size* | 0.056** | *0.024* | 0.014** | *0.006* |
| *Irr.tech* | 3.202** | *1.388* | 0.596*** | *0.127* |
| *Sepor.tr* | 3.046*** | *1.164* | 0.635*** | *0.161* |
| *Sepor.ex* | -1.360 | *1.165* | -0.303 | *0.224* |
| *Cred.pri* | -2.078*** | *0.807* | -0.445*** | *0.146* |
| *Cred.gov* | 1.854** | *0.809* | 0.429*** | *0.157* |
| *M.north* | -0.380 | *0.975* | -0.091 | *0.229* |
| *M.south* | -1.828* | *1.054* | -0.401** | *0.189* |
| *Constant* | 0.635 | *2.178* | | |
| % correct predictions | 84.6% | | | |
| Log-likelihood | -41.35 | | | |
| N | 104 | | | |

**P* < 0.1; ***P* < 0.05; ****P* <0.01*

*†: Breusch-Pagan/Cook-Weisberg test and results show the presence of heteroscedasticity. Therefore, robust standard errors were computed with STATA 11 (commands: logit, robust).*

In fact, Abdulai et al. (2011) reported a marginal effect of access to credit of up to 41%, which is similar to our results. The estimated marginal effect on adopting scheduling is positive and approximately 43%. Although irrigation scheduling does not require a high level of investment, it involves irrigation technology that does require investment. It is also interesting to note that public and private credit generates mixed results. While public credit increases the probability of adoption, private credit reduces significantly the probability of adopting irrigation scheduling.

As previously mentioned, the main crop was also significant in estimating the incorporation of irrigation scheduling; major fruit crops have a positive effect on irrigation scheduling as compared with annual crops and grasses. This was predictable, as cultivating fruit requires more sophisticated technology, not only in irrigation but also in mechanization and other inputs, which could promote innovation in the orchard as a whole. The marginal effect of having major fruit orchards was 44%, which implies a large increase in the probability of adopting scheduling. Although minor fruit crops, mainly raspberries, had a positive impact on the probability of adoption as compared with cereals and grasses, they were not significant. Raspberry production is in the hands of small-scale farmers (96% of all raspberry producers in the country), and those producers invested less in irrigation. Our results also show a positive relationship between size and irrigation scheduling adoption that is equivalent to a 1.4% increase per additional hectare. The literature has also reported that farm size is significant in irrigation technology adoption (Shuck et al., 2005; Skaggs, 2001).

The results for SEPOR training and extension show that training through courses and seminars had a positive impact, increasing by 63.5% the probability of adoption, while direct intervention (extension) in the field did not have a significant impact. The questions now are why direct intervention was not effective, and why training, which is not as intensive as direct intervention, had such a high impact on adoption. We offer two possible explanations. The first is circumstantial and refers to the rotation of producers along the project time frame, which was mentioned in section 4.1. The fact that some producers receiving extension services dropped out of the program and new producers were incorporated might reduce the percentage of producers adopting scheduling. Dropping the program constituted a clear signal of not being interested in scheduling. The producer attending a course or seminar has to learn how to implement the technology and then apply it, using the learning by doing approach, which is a signal of more interest. A second explanation could be the strategy used for the extension intervention. At the beginning, the intervention was done only in irrigation practices, and, as explained in the description of SEPOR, only later it was recognized that a broader, more participatory intervention was needed. Lisson et al. (2010) argued that flexibility in project plans with participatory approaches to transferring technologies increases the likelihood of adoption. They recognized the importance of learning by experimentation; therefore, household participation is needed throughout the whole process of generating intervention plans, their implementation and evaluation, understanding the dynamics of the farming cycle, and farmer-to-farmer contact. A participatory approach that includes public-private partnerships (PPP) also creates greater opportunities, although the commitment of the different agents participating in the partnership enhances the effectiveness of the mechanisms and programs to be implemented and increases social capital among producers, thereby reinforcing adoption (Wellens et al., 2013). Participatory approaches included flexibility to adapt the project activities to the participants' reality. Furthermore, high frequency of contact between extensionists and the farmers and farm trial implementation enhanced social capital formation among project participants, which could increase success in adoption and impact of project objectives (Lisson et al., 2010; Wellens et al., 2013).

The results lead us to suggest policy implications of increasing water use efficiency. In Chile, the institutions related to water distribution and use in agricultural production, that is, the Ministry of Agriculture, CNR, and INDAP, are certainly aware of the appropriate use of water resources and the low rate of irrigation technology adoption. This has resulted in increased irrigation subsidies as well as the implementation of several programs and projects to improve efficiency at the farm level. The results presented in this study show that the adoption of pressurized irrigation is low and highly correlated with water use efficiency through irrigation scheduling. Although scheduling can be implemented with gravitational irrigation, it is less likely to produce a high effect in optimizing the use of water because gravitational irrigation *per se* generates more water losses. Being aware of the correlation between scheduling, pressurized irrigation and the characteristics of gravitational irrigation, public institutions can more effectively target resources toward subsidies, training, and extension. Consequently, if subsidies and other incentives to increase irrigation technology adoption continue, they will also imply a higher probability of water use efficiency.

A surprising result of this research is the effectiveness of training, which appears to be a mechanism that not only disseminates knowledge but also identifies farmers who are really motivated to incorporate the technology. Therefore, the selection of farmers to participate in such a project should be delayed until participants declare their willingness to take part, instead of identifying them *a priori*.

## 4. Conclusions

The aim of this article was to understand the factors that determine the adoption of irrigation scheduling among medium- and small-scale farmers in central Chile. Water use efficiency will be crucial in the near future because of the uncertainty of its availability, due to the variability caused by climatic change and the increase in water demand from different economic sectors.

Water use efficiency at the farm level is determined by the farmer's use of irrigation technology and also by a scheduling program that is adjusted to plant needs. A Logit model was estimated using irrigation scheduling as a dependent variable and training and extension as key independent variables. Results show that farm size and credit availability have a strong effect in increasing the probability of adopting irrigation scheduling. This is also true in the case where farmers have pressurized irrigation. After investing in high technology for irrigation, there is a higher probability that producers will adopt an efficient use of this technology.

The key variables of the study, training and extension, generated an unexpected result. Training had a positive and high impact on adoption, while extension (direct intervention) had a minor effect. This result emphasizes the need for an adequate methodology to transfer knowledge and know-how to producers so that they can effectively use public resources. Extension projects should incorporate research, training, and extension as a dynamic participatory process with a strong partnership between the different agents involved in the project. Therefore, to maximize impact, funding institutions should provide flexibility to finance projects than can develop into methodology, timing, and processes.

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