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Understanding the role of social capital in adoption decisions: An application to irrigation technology

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ABSTRACT

Recently, social capital has gained importance in explaining technology adoption decisions by farmers. In this paper, we examine the impact of social capital on the adoption of irrigation technology and irrigation scheduling among wine producers in Central Chile. We propose three hypotheses: that trust and networks affect positively the adoption of both technologies (H1 and H2) and that trust is positively related to networks (H3). First, we identify seven different components of social capital: general trust, trust in institutions, trust in water communities, norms, formal networks, informal networks, and size of networks. Second, we estimate two Partial Least Squares models using as endogenous variables irrigation technology adoption and adoption of irrigation scheduling. Both models tested confirm the relevance of our interpretation of the use of social capital and its implications in understanding producers' behaviour towards adoption of technologies. The three hypotheses tested positive. Trust in institutions, and formal and informal networks have a positive impact on the adoption of both technologies. General trust has a positive relationship with formal and informal networks. Human capital also has a strong relationship with networks, which allows us to argue that networks are the main catalysts of social capital. As expected, physical and human capital have a positive and significant relationship with adoption. Our results support that extension efforts should consider social networks, not just economic or individual-level predictors, in promoting agricultural innovations.

1. Introduction

Understanding producers' decisions regarding technology adoption has been a major area of agricultural research for several decades. In 1984, Feder & Slade published a widely recognized study of the factors that predict agricultural innovation and adoption to increase productivity, essential to economic growth and development (Doss, 2006; Baerenklau and Knapp, 2007). A standard utility model is commonly used in explaining technology adoption where farmer characteristics (human capital) and farm structure (physical capital) are the main factors affecting the utility of the technology (e.g. Foster and Rosenzweig, 2010; Abdulai et al., 2011; Abdulai and Huffman, 2014; Wossen et al., 2015). Although such studies consider human and physical capital, they address the individual level only, ignoring that individual decisions are embedded within a more complex system corresponding to a community whose shared common interests, activities and concerns lead to individual decisions (Oreszczyn et al., 2010) and shape institutions that must accommodate the physical, economic, and cultural environment of those individuals (Ostrom, 1993). At this point, to build a social capital framework, we break the system concept into individual factors who make decisions as part of their interactions in a social process and within a social environment (Pannell et al., 2006; Aguilar-GAllegos et al., 2015). We will elaborate further on this factor.

Lyda Hanifan first mentioned the concept of social capital in 1916 (Lollo, 2012), but only since the 1990s has it been linked to development and economic growth. As stated by Putnam (1993), social capital enables the formulation of new strategies for development. Although there is no consensus on its definition (Chou, 2006; Sabatini, 2006; Ng'ang'a et al., 2016), social capital is generally explained in the literature as being characterized by networks, norms and trust in social interrelationships that facilitate cooperation and coordination of people to achieve desired goals and mutual benefit (Narayan and Cassidy, 2001; Putnam, 1993). The conceptual vagueness is intensified by the lack of agreement on how to measure social capital (Sabatini, 2006). As social ties, trust and norms are not directly observable (Krishna, 2004), it is necessary to use indirect indicators for measurement (Sabatini, 2006).

Notwithstanding the difficulties in defining social capital, several studies put forward the idea that its main contribution is to facilitate information flows among individuals, which may encourage adoption processes (Läpple and Van Rensburg, 2011; Ramirez, 2013; Micheels

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and Nolan, 2016). According to Micheels and Nolan (2016) the number of adopted technologies has a positive correlation with the farmer social capital. Pannell et al. (2006) refer to adoption as a learning process that occurs through the collection of information and the acquisition of practical skills. Eastwood et al. (2012), going further, also refer to the social nature of learning, considering the adoption of technology to be the tip of the iceberg and that, after adoption, there will be changes in management practices as well as adoption of additional technologies, signaling trust and networks as the main sources of this dynamic. Although this interaction has visible merits, it also can have undesirable effects, such as when bad performance of the technology adopted by some farmers leads to wider rejection of the technology within the community. Moreover, according to Adrianzen (2009), there is a trend among rural households to react more drastically to a bad performance of a new technology than to one that performs well.

As stated above, we argue that social capital components play a relevant role in the adoption decision-making process. However, there is not clear conception on how the social capital components interact to define the behaviour of the producer. Understanding these interactions may shed light on the factors of social capital that can drive decision-making processes towards a specific behaviour. From this statement, two questions arise. What is the relationship of social capital and the behaviour of farmers regarding the use of a technology; and how are social capital components related to each other? As a case study we use irrigation technology adoption and the adoption of irrigation scheduling among medium to small vineyard producers in Chile. We understand irrigation technology not only as the implementation within the farm's irrigation system but also as the adoption of the knowhow to irrigate properly by establishing the time and frequency of irrigation. The adoption of better irrigation practices can benefit the producer by allowing for a higher yield and quality of the products and saving water resources that have been becoming scarcer in the recent years. Henceforth, in this paper we refer to the first process as *irrigation technology adoption* and the second process as *adoption of scheduling*. Although both processes are related, they can be treated as independent decisions and, therefore, we test separate models for irrigation technology adoption and the adoption of scheduling. Having described our study objective and the research context, we now present a literature review on social capital, after which we introduce our research framework and formulate the hypotheses.

2. Background on social and human capital

The factors determining the adoption or non-adoption of a certain technology in agriculture continue to draw research attention. Profitability of the technology to be adopted is usually considered as the key factor (Foster and Rosenzweig, 2010; Wossen et al., 2015), in which economic aspects, such as the availability of labour, crop price, price of resources or access to credit, are also ranked among the most relevant (Arellanes and Lee, 2003; Baumüller, 2012; Noltze, 2012; Genius et al., 2013; Abdulai and Huffman, 2014). Besides economic factors, other determinants are also considered. Traditional studies on technology adoption use socio-economic characteristics like age, gender and experience of the farmer, educational level, household size or income, to represent human capital (Arellanes and Lee, 2003; Foster and Rosenzweig, 2010; Abdulai et al., 2011; Genius et al., 2013; Handschuch et al., 2013; Ramirez, 2013; Abdulai and Huffman, 2014), and farm characteristics like farm size, land ownership, soil quality, machinery, type of crops or livestock as proxies for physical capital (Isham, 2002; Arellanes and Lee, 2003; Abdulai et al., 2011; Baumüller, 2012; Noltze, 2012; Handschuch et al., 2013; Ramirez, 2013). In addition to these established variables, several authors have emphasized social and institutional variables, thereby effectively turning the focus to social capital in addition to human and physical capital (Isham, 2002; Arellanes and Lee, 2003; Foster and Rosenzweig, 2010; Noltze, 2012; Abdulai and Huffman, 2014; Wossen et al., 2015; Aguilar-Gallegos et al., 2015).

As already mentioned, social capital has been conceptualized in various ways in the literature. It has been described as a valuable asset (Bolino et al., 2002), often created as a by-product of social activities (Putnam, 1993; Beugelsdijk and Smulders, 2003). Narayan and Cassidy (2001), Putnam (1993) and Woolcock (1998) define social capital as social interrelationships that facilitate cooperation and coordination of people to achieve desired goals and mutual benefit through norms, trust and networks. For Bourdieu (1980), social capital is a function inherent in the social structure and relationships among actors. In a more structured form, van Rijn et al. (2012) distinguish between cognitive and structural social capital, in which cognitive social capital is associated with norms, values and trust, while structural social capital is associated with either vertical or horizontal networks, in other words intra-community ties (Woolcock and Narayan, 2000; van Rijn et al., 2012). Social norms are hierarchical and not spontaneously developed (Fukuyama, 2001), and they influence the individual's preferences for respecting constraints. Norms combined with trust enable collective action (van Rijn et al., 2012). In contrast, structural social capital is associated with networks or inter-community ties, known as bonding social capital (Woolcock and Narayan, 2000), that could be horizontal and include informal ties that bridge different communities or organizations, such as family and friends, formal or open networks, or vertical relationships.

Evidence shows that social capital leads to an increase in economic growth and facilitates economic and community development (Narayan and Cassidy, 2001; Knack and Keefer, 1997; Woolcock and Narayan, 2000). Hence, creating and strengthening social capital has been seen as relevant for local economies. Factors like homogeneity, such as belonging to the same ethnic group and having the same language or religion (Chou, 2006), reinforce social capital because they lead to similarity in interests and values (Lollo, 2012). According to Lollo (2012), a second important determinant of social capital is clear rules and a sufficient flow of information expressed by an explicit hierarchy that, in the socio-technological landscape, is not influenced directly by the individuals but drives changes (Hermans et al., 2013). In other words, being a member of the group is necessary for the individual's creation of social capital (Lollo, 2012). Further determinants for building social capital are the frequency and repetition of interactions as well as opportunity and motivation for participation in a group (Lollo, 2012) and at least a basic level of education (Cramb, 2004).

The benefits of social capital are numerous. Generally speaking, social capital promotes collective work, reduces transaction costs and increases transaction ability (Isham, 2002; Fukuyama, 2001; Sabatini, 2006; Chalupnicek, 2010; van Rijn et al., 2012). Strong network ties lead to more effective and efficient work, along with an effective way to cope with risk. van Rijn et al. (2012) and Ng'ang'a et al. (2016) found that due to the reduction in transaction costs, social capital aids farmers in coping with risk, in which social capital can be seen as a mutual insurance. Trust enables exchange and responsibility among individuals to protect themselves against risks and shocks. The main advantage of social capital is seen in the information flow provided by networks and trust (Bolino et al., 2002; Bouma et al., 2008; Eastwood et al., 2012). According to Fisher (2013), trust constitutes the catalyst that promotes the transformation of information into usable knowledge. Networks, in contrast, provide the environment for the exchange of information as they can "bridge the gap between supply of new technologies and the firms who may adopt" (Micheels and Nolan, 2016). Not only does the amount of information increase and become more accessible (Adler and Kwon, 2002), but the information in the network is also filtered, concentrated and legitimated (Burt, 1997; Chalupnicek, 2010). Adopters can be distinguished by not only having more information, but also because they actively collect more information (Läpple and Van Rensburg, 2011). The main sources of information are extension agents and other farmers (Isham, 2002; Eastwood et al., 2012). Although extension agents are seen as the primary source, Foster and Rosenzweig (2010) also postulate that "even without the intervention of extension agents, farmers learn from their social interactions with other farmers" (see also Genius et al., 2013) It has also been shown that farmers' membership in an agricultural group has a positive impact on the adoption decision (Abdulai et al., 2011; Abebaw and Haile, 2013; Ramirez, 2013; Abdulai and Huffman, 2014).

In line with the extant literature we hypothesize that social capital has a positive relation with irrigation technology adoption and the adoption of scheduling, although it has been reported that social capital may also create negative externalities. For example, social ties have to be constantly renewed and reconfirmed; otherwise, they can be destroyed easily (Adler and Kwon, 2002). But too strong ties can also lead to distrust, intolerance or even violence against outsiders (Fukuyama, 2001), or, in the case of homophilic networks, could potentially impose social norms and cut sources of information (Newman and Dale, 2007). Furthermore, closed networks are often negatively connected with lobbies or criminal organizations like the Mafia (Fukuyama, 2001), which are only acting for their own benefit. Even if the impacts are less extreme, closed networks can isolate themselves (Woolcock and Narayan, 2000; Adler and Kwon, 2002) and lose their incentives to acquire new ideas and information (Beugelsdijk and Smulders, 2003). On the other hand, just as the flow of beneficial information can spread easily through networks, this is also true for negative information. Adrianzen (2009), for example, illustrates that the bad performance of the technology adopted by some farmers led to a "complete rejection of the technology" in the community. He observes that "rural households tend to react more drastically to bad news than to good news about new technology".

As seen in the literature review, social capital is a catalyst for technology adoption and economic growth, regardless of the negative impacts that it could have in certain contexts. Most of the literature agrees that social capital creates a virtuous circle that makes information and technology available to the community and, in particular, individuals. Although the evidence shows that the main components of social capital—norms, trust and networks—influence the decision to adopt, less attention has been placed on identifying and estimating the relationships among norms, trust and networks. We claim that these three components are interrelated and that understanding their interactions may better explain the influence of social capital on people's behaviour.

Along with social capital we cannot overlook human capital as a component in the adoption decision process (Wozniak, 1984; Arellanes and Lee, 2003; Abdulai et al., 2011; Ramirez, 2013; Genius et al., 2013). Human capital is created individually (Burt, 1997) and can be understood as economically utilisable knowledge, skills, abilities and other characteristics that individuals create and maintain through education and training (Schultz, 1981; Becker, 1993; Armstrong, 2006). Kaasa (2009) proposes that social capital is a component of human capital, and Burt (1997) confirms that human capital is useless without social capital. Likewise, Chou (2006) claims interdependence between both kinds of capital.

3. Research hypotheses and methodology

3.1. Research hypotheses

To summarize briefly, social capital and its specific components, namely networks, trust and norms, influence the adoption of technologies mainly by creating an environment that has more availability and search capacity for information. The literature also recognizes that networks are the main catalyst to explain this process of technology adoption, but networks also require trust to validate information. Norms, on the other hand, represent the rules or landscape for expressing the other components and transforming them into benefits. Accordingly, we define three main hypotheses about the relationship of social capital to irrigation technology adoption and the adoption scheduling, and among the components of social capital. The hypotheses are established as follows (see Fig. 1):

H1. Trust is positively related to irrigation technology adoption and adoption of scheduling (e.g. Pavlou, 2003).

H2. Networks are positively related to irrigation technology adoption and adoption of scheduling (Maertens and Barrett, 2013; Venkatesh et al., 2012).

H3. Trust is positively associated with networking (e.g. Lobb et al., 2007).

According to the figure and the hypotheses, trust and physical and human capital are exogenous variables, while networks and the adoption of irrigation of irrigation technology and scheduling are endogenous.

3.2. Case study description

The wine sector in Chile provides a good case study for testing our hypotheses. Chile has become a major player in the wine market, as the fifth largest wine exporter in the world (OIV, 2015), with an export value of 1.8 billion US$ in 2013 (ODEPA, 2014). The planted area of vineyards in 2012 was 128,638 ha (ODEPA, 2014), and the irrigated land for wine production is estimated at 81% (Census, 2007). More important to the subject of this paper is that water stress management and other management practices are necessary to obtain a high quality grape (Ojeda-Bustamente et al., 2004; Pellegrino et al., 2005; Ezzhaouani et al., 2007), which is crucial to increasing the competitiveness of the vineyards.

In Chile, two major incentives are in place to promote the efficient use of water resources. The first is the Irrigation Development Law (*Ley de Fomento al Riego No 1123 de 1981*), which provides funding for major investment, and the second is the Investment Irrigation Law (*Ley de Fomento a Obras Menores de Riego No 18,450 de 1985*), which provides farmers a subsidy for infrastructure and for increasing adoption of irrigation technology. Chile has a solid institutional structure for managing water for irrigation. There are three different levels of associations considered in the Chilean Water Code of 1981: (a) Monitoring Committees (Juntas de Vigilancia), which are supervisory committees in charge of monitoring the use of natural sources of water or rivers; (b) Channel Associations (Asociaciones de Canalistas),

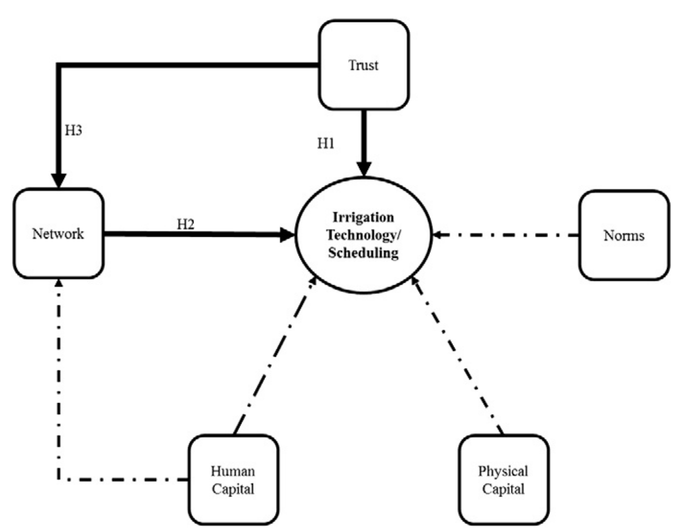

Fig. 1. Research model and hypotheses. H1 and H2 indicate that trust and networks are associated with the adoption of irrigation technology and the adoption of scheduling, in this order. H3 indicates a positive association between trust and networks.

which are associations of water channel users in charge of administering primary infrastructure such as main artificial irrigation channels and dams; and (c) Water Communities (Comunidades de Agua), which are responsible for secondary infrastructure or distribution channels.[1] At this level, farmers make decisions on how to manage the channel and the distribution of water, hence it is where farmers decide to take collective actions towards better outcomes, such as more security in water access, lower rate of conflicts among farmer and better access to policy incentives. The water code was introduced in 1981 to provide a secure environment of water rights that sustain the structure, which generally are proportional to a variable flow or quantity of water and is administrated by the three levels of associations. In Chile the water resource policy assigns water rights to individual users who can trade these freely. Evidence shows that the water market has traded a low volume of water rights, except for certain regions where water is scarce and has high economic value (Donoso, 2006). The area under study does not show high rates of scarcity at the moment; however, water availability is becoming an issue leading to the need to incorporate technologies to cope with it, maintaining quality and productivity if the vineyard.

3.3. Methodology and data collection

For testing the hypotheses, a Structural Equation Model (SEM) was chosen, which allows the identification of the interconnection among endogenous and exogenous variables. We estimated two models using as endogenous variables the adoption of irrigation technology and adoption of scheduling. To better understand the difference between irrigation technology (drips and sprinklers) and scheduling, we can say that the technology corresponds to the hardware of the irrigation system and scheduling to the "know how". Irrigation scheduling is a concept used in the irrigation community to define the quantity of water to apply in a certain period to satisfy plant requirements, based on soil characteristics, meteorological conditions and physiological plant processes (Backeberg, 2014; Chartzoulakis and Bertaki, 2015). Producers who have furrow irrigation can still determine their requirements for water. Although both practices are related, the choice of adopting one or the other is not bounded; hence, we preferred to estimate both models separately to see if the social capital structure in the two decisions still holds. We consider this issue relevant since the primary objective of the article is not to understand factors of adoption per se but rather the role of social capital in the process.

For our study we used a Partial Least Squares (PLS)-SEM model because it performs better in non-parametric analysis, which is mostly the case of the scale-type variables that we are using in the model (Weiber and Mühlhaus, 2014; Huber et al., 2007). Further, as fewer difficulties with multicollinearity occur, it is especially appropriate for studies with intricate causal relationships between the constructs (Haenlein and Kaplan, 2004).

The irrigation technology adoption variable is binary and takes the value 1 when the producer adopts drips or sprinklers and the value 0, otherwise. The variable adoption of scheduling is not directly observable; hence, we used the use of instruments to schedule irrigation as a proxy, understanding instruments as tools that allow for measurement of irrigation needs. There are several instruments,[2] from less to more accurate and sophisticated. The use of at least one of them can be considered to indicate adoption of scheduling. This variable takes the value 1 if at least one of the instruments is adopted and 0, otherwise.

Since PLS models are not suitable for binary variables, as the estimation procedure uses ordinary least squares, we use transformed variables for both irrigation technology and scheduling. Kupek (2006) proposes four methods for transforming the binary into a suitable variable for PLS. One of the recommended approaches is to estimate the probability of adoption using a probit or logit model. Using a probit model, we estimated the expected value (EV) of irrigation technology and scheduling adoption to implement the PLS models. Models specification and results are presented in Annex C.

The exogenous variables in the models are the social capital components, namely norms, trust and networks; human capital, measured as educational level in years of schooling; and physical capital as a control variable, measured as size of the farm in hectares. Although the measurement of human and physical capital is not simple, in technology adoption models physical capital is usually measured in terms of size of the farm (Abdulai and Huffman, 2014; Jara-Rojas et al., 2012). Education performed better than other related variables, such as experience and training, for measuring human capital in a regression model.

Data were collected using a standardized questionnaire based on statements found in the literature and adapted to the context of the study using the advice of psychometric experts.[3] The survey requested information about respondent characteristics, farm structure, irrigation technology adoption and adoption of scheduling, and social capital. To measure social capital, a list of statements, reduced through a factor analysis to the components explained above, was presented to the producers, who were asked to rate them on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree).

The survey was applied in Central Chile, specifically in O'Higgins and Maule Regions. These regions were chosen because they comprise 73% of the national territory under cultivation and because, in both regions, wine production is one of the most important agricultural activities. In 2014, together they produced >880 million litres of wine (ODEPA, 2014). The sample size of the study was 452 vineyards distributed proportionally in both regions among a total of 16 municipalities. The distribution was done according to the Wine Growing Cadastral 2012 of the Agriculture and Livestock Service. The O'Higgins and Maule region comprise a total of 85,843.25 ha of irrigated land (our target was only irrigated land), representing 75% of the national surface of irrigated land of vineyards. Our sample surveyed a total of 8315.01 ha of vineyards corresponding to 9.7% hectares of both regions.

Since we did not have a list of producers for a random sampling procedure, in order to ensure diversity in the sample at least one kilometre distance was kept between respondents. The respondents were visited in person to administer the survey. The questionnaire was pre-tested with 10 farmers to ensure that it was well structured and clear, especially with respect to the statements used in the social capital section.

As mentioned, we used PLS to estimate both models. The first step was the analysis and construction of the components of social capital. As proposed by von Meyer-Höfer et al. (2013), in order to elicit the components, we use an exploratory factor analysis in SPSS Statistics. This preliminary step allows for using these components as basic constructs in PLS. These estimations were done using SmartPLS Version 3 (Ringle et al., 2015). To test for reliability of the PLS constructs, we used indicator reliability (factor loading), convergence criteria (composite reliability, AVE) and discriminant validity (Fornell-Larcker criterion). The goodness of fit of the PLS was tested with the R^2, and the significance of the path coefficients with *t*-test for the hypothesis that the coefficient is equal to zero.

4. Results

4.1. Data description

The sample shows a high diversity of producers and vineyards. The size of the farms ranges from 0.25 ha to 1600, with an average

[1] "The Market for Water Rights in Chile: Major Issues (Paperback) by Monica Rios Brehm, Jorge Quiroz: World Bank Publications, United States 9780821333075 Paperback - The Book Depository", s. f.)

[2] Instruments include meteorological station, soil or plant sensors, and pan evaporation.

[3] Experts on psychometric from the Faculty of Phycology of the University of Talca.

81.62 ha. Still, 47.6% have <25 ha. The average area planted with vineyards is 36.1 ha, with a range of 0.5 to 810 ha. Of the vineyards, 43.1% have adopted irrigation technology, while the remaining 56.9% continue with furrow irrigation. As stated above, to define the adoption of scheduling variable, we use as a proxy having or not having an instrument to measure water requirements. Using this definition, we found that 23.0% use scheduling and that the most used instruments[4] are pan evaporation (9.7%) and meteorological stations (11.1%). It is also important to note that 33.2% of respondents declare that they have water limitations, which could explain the moderate rate of adoption of irrigation and scheduling. We interviewed owners (45.8%) and managers (54.2%) as decision makers in the vineyard regarding agricultural management. >90% of those interviewed were males, ranging in age from 23 years to 89 years, with an average age of 56.9 years. As for educational attainment, 37.6% of the producers had reached secondary school and 34.1% higher education.

4.2. Components of social capital

This section analyses the components of social capital and the relationships found by means of the estimated parameters of structural equations. To compare the structure of relationships among components, we used the irrigation technology adoption and adoption of scheduling models separately to analyse, as it were, two distinct decisions, which yielded highly consistent results that identified the same components and the same statements included in each component.

For both models seven components were elicited, in which the lowest factor loading among all statements is 0.601, which is above the 0.6 considered as threshold (Huber, 2012). The models meet the criteria of convergence, and in both cases the AVE criteria and composite reliability ability are greater than or at least in the case of the adoption of scheduling model, the threshold value (Otter et al., 2014). The variance inflation factor (VIF), which measures the presence of multicollinearity, presents values close to 1, which largely meets the critical value of 10. Finally, discriminant validity is tested with the Fornell-Larcker criterion (Tables 2 and 4 of Annexes A and B), also meeting the threshold values corresponding to a greater AVE.

As expected, the results in both models reveal seven components that can be grouped in the three traditional components of social capital: networks, trust and norms. For trust, no single component was identified but, rather, three different levels that could affect behaviour differently. The first component is trust in the surrounding society (family, friends and colleagues), which we named general trust; the second is trust in institutions. Both can be found in previous literature as common components of social capital (Knack and Keefer, 1997; Narayan and Cassidy, 2001; Krishna, 2004; Chou, 2006; van Rijn et al., 2012). However, as a third and more specific level of trust, we extracted trust in water communities as a unique component due to the structure of the water supply in Chile. Water communities are organizations that manage the use of water in an irrigation channel, so they appear as a specific component in our models. Analysing the concept behind water community, it can be said that it also represents trust in institutions but at a more specific level.

Network is also subdivided into three components: formal and informal networks and size of the network. Formal and informal networks, known as structural social capital, are separated into informal groups such as networks of close neighbours, family and friends, while formal network is represented by the farmers` participation in associations, and hence to access to new and vital information via events and exchange with professional and experts. This result contrasts with the distinction between horizontal and vertical networks, known as bonding and bridging networks, often discussed in the literature (Beugelsdijk and Smulders, 2003; Cramb, 2004; Chou, 2006; Adrianzen, 2009; van Rijn et al., 2012). Also, size of network, which we construe as breadth of the network, has been identified by a factor called number of ties in order to measure the number of relationships as an element of social capital (Teilmann, 2012). The statements that we can consider as the most specific definition of the context of the classical components of social capital are almost identical in both models. This result is relevant in understanding social capital because it strengthens the stability of the main definitions of the social capital. The number of statements included in the survey was originally 31, but this was reduced to 20 after the factor analysis in PLS for the irrigation technology adoption model, and to 19 for the adoption of scheduling. The only differences in number of statements were found in trust in institutions and norms; however, given the nature of the statements, the difference only affected the number of statements, not the meaning of the component. A curious result of the analysis is that in the component norms, the statements that prevail were those related to social norms related to good practices as a neighbour or boss (see Tables 1 and 3 of Annexes A and B); even though we included statements regarding compliance with legal requirements, such as laws or voting in elections. This reveals the primacy of compliance with norms that affect the surrounding society over adherence to rules that should be obeyed to avoid legal problems. As pointed out by Newman and Dale (2007), close and homophile networks can create the effect of increasing compliance with social norms inside the network.

After extracting the components, we can observe the interrelations among them, shown in Figs. 2 and 3. Here we focus only on the connections among the seven components of social and human capital. In PLS, the estimated path coefficients can be interpreted as an analogue of the OLS regression coefficients (Huber, 2012) and, as seen in Figs. 2 and 3, both models show high similarity in results.

In hypothesis 3 (H3), we expected to find a correlation between trust and networks, which is supported by the results. General trust is positively related to formal (0.157) and informal (0.339) networks. The same happens in the model of adoption of scheduling, which even exhibits almost the same estimated coefficients. In contrast, trust in institutions and in water communities was not found to have an association with networks, meaning that only general trust, which corresponds to trust in people close by, plays a role in establishing networks. It is also relevant to note that trust and informal networks have a stronger relationship compared to formal networks, reaching almost twice the value of the coefficient. This result is expected since trust here is related to family, friends and colleagues.

Also relevant, human capital is positively related to all components of networks, with the strongest relation being the size of the network. This can be explained by the principle that a higher educational level allows for establishing more complex and broader networks.

According to our findings, the components of networks are endogenous variables in the model; these results indicate that trust and human capital generate the possibility to create networks. It can then be further argued that the main catalyst of social capital is networks, which in turn are fed by trust and human capital. This is an important and novel result, since studies traditionally consider these components as independent antecedents of the individual decision-making process (Cramb, 2004; van Rijn et al., 2012).

Contrarily with what we expected, norms, in our case social norms, were not found to be related to the other components of social capital. Only in combination with trust and networks can norms produce concrete benefits (Bolino et al., 2002; Bandiera and Rasul, 2006; Bouma et al., 2008).

4.3. Irrigation technology adoption model

The model analyses the factors affecting the adoption of irrigation technology, in which human capital is measured in years of education and physical capital in terms of farm size in hectares. In this model the

[4] Producers may use more than one instrument.

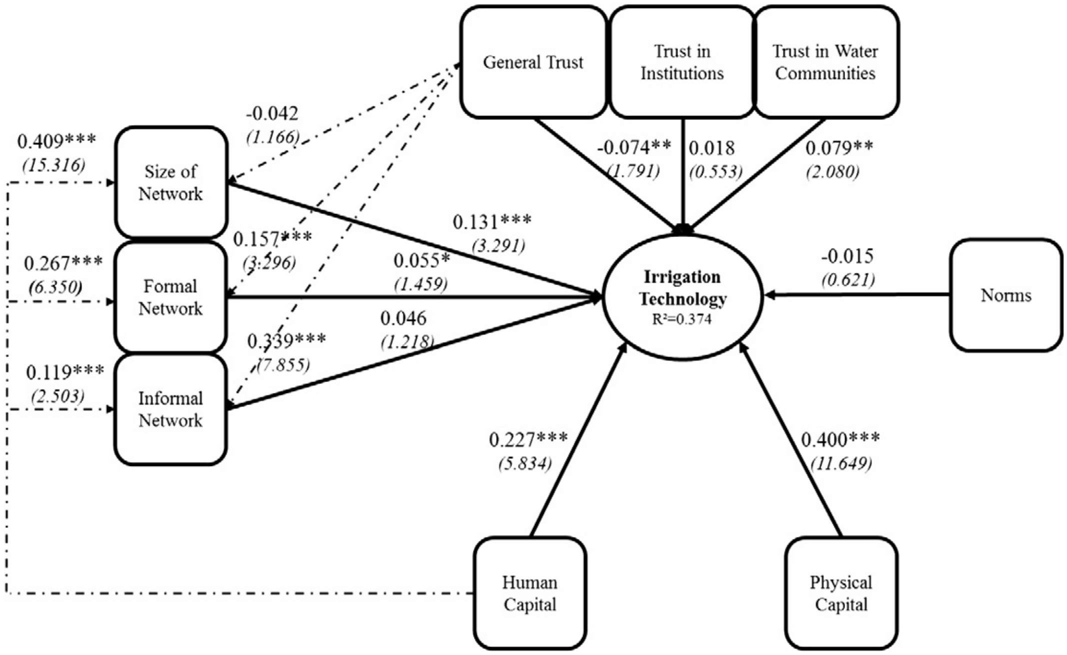

Fig. 2. Partial Least Squares model estimation for irrigation technology adoption. Significance level: ***: P < 0.01, t-value > 2.33; **: P < 0.05, t-value > 1.66; *: P < 0.1, t-value > 1.29. t-values are in parenthesis.

R^2 is 0.374, which can be considered good given the complexity of model and variables (Huber, 2012). According to the results, 11 out of 15 path coefficients are statistically significant in the model.

Following H1, trust presents contradictory results for the adoption of irrigation technology, but since there are three components of trust, the behaviour of each can produce different effects. Trust in water communities has a positive and significant impact on the probability of adoption, meaning that one unit-change in the standardized trust in water communities index derives in a 7.9% change in the probability on irrigation technology adoption. General trust is negative and significant whereas trust in institutions is not significant although positive. Water communities are self-organized and, as recognized by Ostrom (1993), regardless of their design or organization, this characteristic can have a positive impact on successful irrigation projects. In the Chilean context, water communities are in charge of managing water access at the farm level distribution, therefore we argue that as long as trust in these organizations is high, producers have the perception of a safer environment to invest in irrigation. In contrast, general trust captures the individual behaviour in the surrounding environment. Looking at the statements that operationalize general trust we can observe that most respondents tend to agree that trusting in neighbours will not harm them in their own benefit and do not think they need to be cautious

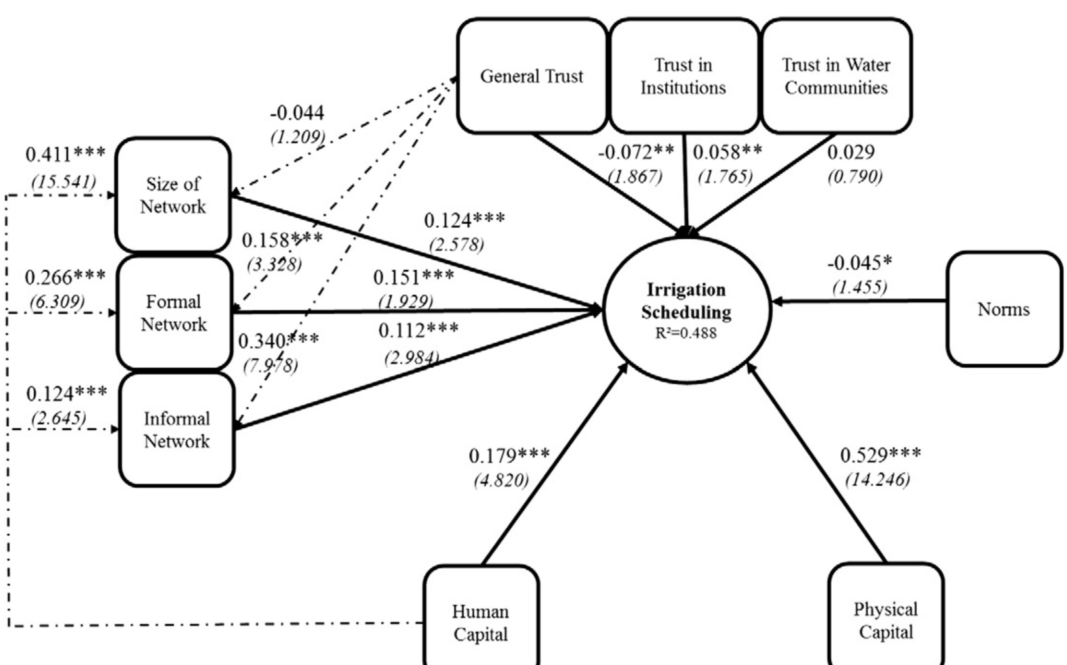

Fig. 3. Partial Least Squares model estimation for the adoption of scheduling. Significance level: ***: P < 0.01, t-value > 2.33; **: P < 0.05, t-value > 1.66; *: P < 0.1, t-value > 1.29. t-values are in parenthesis.

(see Annex A). The statements relate to cooperation and the possibility of fewer conflicts among producers, hence as long as trust in neighbours is low the perception of uncertainty of water supply will be high and might translate into the need to use technologies to make the use of water more efficient.

Two of the three components of networks (H2) have a positive and significant impact on the probability of adoption: size of the network (0.131) and formal networks (0.055), allowing us to accept H2.

The remaining variables show the expected associations. The human capital coefficient is positive and significant, with an estimated value of 0.227, and physical capital, at 0.400, is highly significant. It is interesting to note that in terms of coefficients, these two have the highest values in the model. However, this is not surprising since both variables represent two relevant components of the decision, whereas social capital is diluted into seven components. Norms, in contrast, are not significant in the model.

4.4. Adoption of scheduling model

The adoption of scheduling model has greater explanatory power than the irrigation technology adoption model ($R^2 = 0.488$), exhibiting an even higher performance with respect to the model of irrigation technology adoption. Also, 13 out of 15 coefficients are statistically significant in this model. These statistics show a good fit of the model and give us confidence that the results are reliable.

In this model, as well as in the first model, the component trust has contradictory results. On one hand, trust in water communities, although still positive, is no longer significant but trust in institutions is, with an estimated value of 0.058. Again, the impact of general trust is negative and significant (−0.072), with a value that is almost the same as in the irrigation technology adoption model. This suggests that the conclusion offered for the first model still holds. This result is attributed to the direct effect of general trust; however there is also an indirect effect through informal and formal networks that in turn are positively related to adoption in both models. Summing up both effects, we found that in the case of irrigation technology adoption the total effect is −0.050 while in the case of the adoption of scheduling is −0.014 allowing us to reject H1. As for trust in institutions, its impact in both models is positive and we can argue that higher trust in the government may lead to the perception of a safer investment horizon.

In the adoption of scheduling model, the three components of networks are significant and, as expected, positive. Size of network and formal and informal networks exhibit estimated coefficients of 0.124, 0.158 and 0.340, respectively; informal networks, once again, have a higher impact on the probability of adoption compared to the other two components.

Contrary to the results of the first model, norms were found to have a significant and negative impact on the adoption of scheduling. Although unexpected, the value of the coefficient (−0.045), and the fact that it is only significant a 10% confidence, is not a strong indicator of the relevance of norms in the probability of adoption. However, van Rijn et al. (2012) also mentioned that norms might have negative results on adoption, as they could be an indicator of risk aversion. As a possible explanation, we can argue that the concept of norms found in our work could be tied to general trust since its components are related to social norms, reinforcing its negative impact on adoption.

The influence of human capital, as well as physical capital, on the probability of adoption confirms expectations. Both variables again show a highly positive and significant impact in the model.

5. Discussion and conclusions

Both models validate the importance of our interpretation and the use of social capital and its implications in understanding producers' behaviour towards adoption of technologies. The models show substantially comparable outcomes and, although each concerns a distinct decision, provide converging results that give support to the assertion that models are strong predictors of farmers' adoption behaviour.

We proposed three main hypotheses: the influence of trust (H1) and networks (H2) on adoption of irrigation technology and scheduling, and the influence of trust on networks (H3). For the three hypotheses, we found similar results and conclusions across both models. Trust in institutions and water communities play a positive role in investing in irrigation technology, probably stemming from the fact that trust may function as a mechanism to decrease or overrule perceptions of risk. At the same time, general trust resulted in a negative and statistically significant impact. In particular, the role of trust in water communities allows for a positive environment for investing in irrigation. In the case of general trust, we can offer at least three different explanations for this counterintuitive result. One being that, as Fukuyama (2001) and Newman and Dale (2007) pointed out, trust inside communities might prevent members from looking for outside information, thereby creating a disincentive to adoption. A second explanation is that farmers and neighbours do not have a good experience with the technology and pass this information inside the network. Another explanation, linked to the Chilean water management system, is that as trust in the community is low in terms on believing that neighbours or farmers could do something to harm them, a need to have higher control over the access of water increases. Although the explanations diverge, they are feasible considering the sector and can act together. This result opens the question on how the communities are organized and how the collective and trust in the collective influences the decisions of individual farmers regarding the adoption of technologies.

Our findings on the influence of networks (H2) on farmers' adoption decisions align with many results offered in the literature. The important role of networks within social capital and their impact on technology adoption are often emphasized. Because we divided networks into three single components, different impacts are recognizable. While the size of networks and formal networks are significant, informal networks, in contrast to what the literature suggests, do not have a significant effect (Solano et al., 2003; Pannell et al., 2006). These results indicate that farmers make their productive decisions independently of their informal relations, using instead the benefits offered by formal networks. According to the statements used in the questionnaire formal networks refers to access of information via technical advisors and trainers, being then a catalyst for promoting adoption. Adding to the discussion the negative impact of general trust on the adoption decision, we can configure a more complete explanation regarding the influence of the surrounding community in the decision to adopt. We have seen in our results that informal networks are strongly and positively related to general trust, but both components behave differently in their impact on adoption. We can argue that informal networks have only an indirect impact on adoption through trust, an argument in line with the literature that suggest that networks allows for the flow of information, whereas trust is the catalyst to make the information into usable knowledge, acting together.

One of the main questions raised in the introduction was how the components of social capital relate to each other and, accordingly, how social capital is constructed. More specifically, we found that general trust, being related to formal and informal networks, has a strong role in building networks (H3). Additionally, trust forms the foundation for building networks, because it is seen as the key to social capital. Furthermore, a network with a high level of trust is able to accomplish more (Coleman, 1988) because networks that are built on trust and reliability represent kind of safety net for people to reduce risk (Narayan and Pritchett, 1999). It follows, then, that general and specific levels of trust should be valued. The success or failure of adoption is likely to be highly context-dependent, and trust may play a key role herein – in concert with social network dynamics.

As already described in the literature and also substantiated here, in both models the influence of human capital, measured as educational level, has to be accepted because it has a significant and positive influence on all three types of networks found in the study. These results are in line with the assertion of many authors that human capital and social capital are related to each other (Narayan and Pritchett, 1999; Chou, 2006; Kaasa, 2009; Spielman et al., 2008).

Finally, it is apparent that social capital predicts farmers' decisions to adopt irrigation technology and scheduling in vineyards in central Chile. Within the concept of social capital, the main influencing components are networks, more precisely formal networks and the size of networks. At the same time, network seems to be the core component of social capital, which is built, as the present results indicate, on a foundation of trust and human capital. A community's construction of an environment conducive to improving performance by incorporating technologies should take as its basis social capital, in this case trust and human capital that, in turn, will enhance networks.

The implications of this study in the context of the area under study and productive sector are several. The central – south region in Chile is experiencing water scarcity as a product of climate change effects (reduction of water supply) and increasing population (increment in water demand) leading to a more complex scenario regarding availability of water for agricultural activities. Under this scenario experts have identified irrigation technology as one of the most effective tools to cope with it. Strengthening social capital could act as a means to encourage cooperation and a self-governance system at the local level taking advantage of its smaller scale and use of local knowledge to produce a resilient system of trial and error. Going in this direction, extension efforts to promote efficient use of resources and agricultural innovations should be built on programs that not just consider technical capabilities, but also strengthen social abilities – more specifically trust within networks. Self-evidently, building trust is a lengthy process of repeated positive interactions, but avenues for achieving this are for example acts that show a lack of bias in information provision (objectivity), the acknowledgement and adequate representation of relevant viewpoints (fairness), and honest and open communication (sincerity; see Renn and Levine, 1991).

In summary, our study set out to understand and estimate the interactions among social capital components and their influence on technology adoption. Motivated by the literature on technology adoption, we analysed vineyard farmers' behaviour imbedded in a complex system in which their social and human skills become relevant factors. The interconnectedness between human capital and the components of social capital allow for a better understanding of how social capital possessed by the famers is constructed. But there are still open questions. The directionality of the relationships needs more analysis. Furthermore, it is also important to study the construction of social capital in different contexts and for different technologies before extrapolating from these results. What we conclude here is only a first step in quantifying interrelations, if only because the personality and conduct of the farmer are likely much more complex than the framework used in this study. Extending that framework to include innovative behaviour, empathy, teamwork and other individual characteristics could result in a broader and deeper understanding of farmers' decisions about adoption.

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Annex A

Table 1
Factor analysis results for irrigation technology adoption.
Source: Authors' calculations.

Item	Mean	Standard deviation	Factor loading >0.6	Composite reliability >0.7	Average variance extracted >0.5	Variance inflation factor
Size of network				0.784	0.644	1.281
How many commercial contacts do you have?	6.59	5.049	0.809			
How many wine producers do you know who have irrigation technology?	6.96	12.190	0.796			
Formal network				0.864	0.760	1.414
When I attend to agricultural events, I am usually more active than others.	3.14	1.218	0.872			
I know and meet regularly professionals or experts in agriculture.	4.03	1.163	0.871			
Informal network				0.777	0.538	1.423
In the area of work, I often communicate with neighbouring farmers.	4.27	1.008	0.748			
I spend time with my friends, because I think it is important to share time with them.	4.03	1.096	0.761			
I always support my farming neighbours when they have a problem.	4.44	0.755	0.691			
Norms				1.000	1.000	1.140
Whenever my friends or family are having a hard time, I support them.	4.65	0.555	1.000			
General trust				0.823	0.541	1.378
I can trust in the people around me without the need to be very cautious.	3.59	1.156	0.797			
Farmers are reliable people.	3.88	1.039	0.817			
I consider that other farmers would not harm me for their own benefit.	3.15	1.284	0.702			
The people in the community work together to solve problems of the availability of water.	3.53	1.320	0.604			
Trust in institutions				0.881	0.651	1.317
The agricultural associations work for the welfare of the farmers and the sector.	3.69	1.115	0.689			
I trust the local government.	3.19	1.201	0.766			
I trust the public institutions.	3.26	1.200	0.863			
I trust the government of Chile.	3.15	1.233	0.893			
Trust in water communities				0.865	0.617	1.087
In the last 5 years the confidence among the producers in the water community has increased.	3.49	1.143	0.675			
I trust the Comunidad de Aguas.	3.72	1.015	0.722			
I trust the Asociación de Canalistas.	3.83	0.980	0.877			

Table 1 (*continued*)

Item	Mean	Standard deviation	Factor loading >0.6	Composite reliability >0.7	Average variance extracted >0.5	Variance inflation factor
I trust the Junta de Vigilancia.	3.53	1.320	0.851			
Human capital				1.000	1.000	1.333
Education	11.63	4.145	1.000			
Physical capital				1.000	1.000	1.120
Farm size	81.62	167.184	1.000			

Table 2
Fornell-Larcker criterion for irrigation technology model.
Source: Authors' calculations.

	Formal network	General trust	Human capital	Informal network	Irrigation technology	Norms	Physical capital	Size of network	Trust in institutions	Trust in water communities
Formal networks	0.872									
General trust	0.147	0.735								
Human capital	0.260	−0.038	1.000							
Informal NETWORK	0.424	0.335	0.106	0.734						
Irrigation technology	0.228	−0.667	0.409	0.094	1.000					
Norms	0.103	0.269	−0.082	0.262	−0.077	1.000				
Physical capital	0.143	−0.004	0.263	0.055	0.507	−0.080	1.000			
Size of network	0.238	−0.008	0.411	0.063	0.352	−0.067	0.250	0.803		
Trust in institutions	0.114	0.436	−0.186	0.198	−0.068	0.184	−0.030	−0.129	0.807	
Trust in water communities	0.201	−0.024	0.040	−0.060	0.132	−0.047	0.040	0.119	0.064	0.786

Note: The values under the diagonal correspond to the square root of AVE.

Annex B

Table 3
Factor analysis results for adoption of scheduling.
Source: Authors' calculations.

Item	Mean	Standard deviation	Factor loading >0.6	Composite reliability >0.7	Average variance extracted >0.5	Variance inflation factor
Size of network				0.783	0.644	1.286
How many commercial contacts do you have?	6.59	5.049	0.829			
How many wine producers do you know who have irrigation technology?	6.96	12.190	0.775			
Formal network				0.864	0.760	1.406
When I attend to agricultural events, I am usually more active than others.	3.14	1.218	0.861			
I know and meet regularly with professionals or experts in agriculture.	4.03	1.163	0.882			
Informal network				0.774	0.534	1.386
Concerning farming, I often communicate with neighbouring farmers.	4.27	1.008	0.742			
I spend time with my friends, because I think it is important to share time with them.	4.03	1.096	0.786			
I always support my farming neighbours when they have a problem.	4.44	0.755	0.658			
Norms				0.693	0.538	1.065
Whenever my friends or family are having a hard time, I support them.	4.65	0.555	0.846			
I disapprove when farmers receive benefits for which they are not qualified.	3.74	1.297	0.601			
General trust				0.823	0.541	1.343
I can trust in the people around me without the need to be very cautious.	3.59	1.156	0.793			
Farmers are reliable people.	3.88	1.039	0.818			
I consider that other farmers would not harm me for their own benefit.	3.15	1.284	0.708			
The people in the community work together to solve problems of the availability of water.	3.53	1.320	0.603			
Trust in institutions				0.909	0.834	1.278
I trust the public institutions.	3.26	1.200	0.920			
I trust the government of Chile.	3.15	1.233	0.906			
Trust in water communities				0.861	0.611	1.074
In the last 5 years the confidence among the producers in the water community has increased.	3.49	1.143	0.842			
I trust the Comunidad de Aguas.	3.72	1.015	0.896			
I trust the Asociación de Canalistas.	3.83	0.980	0.688			
I trust the Junta de Vigilancia	3.53	1.320	0.678			
Human capital				1.000	1.000	1.337
Education	11.63	4.145	1.000			
Physical capital				1.000	1.000	1.115
Farm size	81.62	167.184	1.000			

Table 4
Fornell-Larcker criterion of the scheduling adoption model.
Source: Authors' calculations.

	Formal network	General trust	Human capital	Informal network	Norms	physical capital	Irrigation scheduling	Size of network	Trust in institutions	Trust in water communities
Formal network	0.872									
General trust	0.147	0.735								
Human capital	0.260	−0.039	1.000							
Informal network	0.422	0.335	0.111	0.731						
Norms	0.089	0.209	−0.013	0.158	0.733					
Physical capital	0.144	−0.004	0.263	0.059	−0.078	1.000				
Irrigation scheduling	0.264	−0.028	0.391	0.175	−0.078	0.620	1.000			
Size of network	0.240	−0.060	0.413	0.062	−0.022	0.250	0.352	0.802		
Trust in institutions	0.085	0.401	−0.214	0.159	0.087	−0.040	−0.029	−0.162	0.913	
Trust in water communities	0.184	−0.024	0.023	−0.068	−0.015	0.027	0.070	0.093	0.058	0.782

Note: The values under the diagonal correspond to the square root of AVE.

Annex C

Table 5
Estimation results of probit models for irrigation technology adoption and adoption scheduling.

	Irrigation technology		Scheduling	
Variables	Coefficient	Std. error	Coefficient	Std. error
Experience (years)	−0.017***	0.004	−0.016***	0.005
Use of Internet for meteorological information	0.721	0.174	0.675**	0.273
Chachapoal – Colchagua Valley	–	–	–	–
Curico Valley	0.374*	0.201	−0.245	0.224
Maule Valley	0.5839**	0.2663	−0.176	0.186
Hectares of vineyards	0.003***	<0.001	0.002***	<0.001
Percentage of producers that have IRR related total number acquaintances	1.951***	0.302	1.023***	0.295
Number of acquaintances	−0.009*	0.005	0.012*	0.005
Use of adviser	0.607***	0.149	0.651	0.162
Constant	−1.171	0.274	−1.973	0.365
Log pseudolikelihood	−215.821		−164.803	
Correctly classified values	78.10%		81.19%	
Correlation predicted values and irrigation technology adoption	0.601		0.57	
N	452		452	

References

Abdulai, A., Huffman, W., 2014. The adoption and impact of soil and water conservation technology: an endogenous switching regression application. Land Econ. 90, 26–43.
Abdulai, A., Owusu, V., Bakang, J.E.A., 2011. Adoption of safer irrigation technologies and cropping patterns: evidence from Southern Ghana. Ecol. Econ. 20, 1415–1423.
Abebaw, D., Haile, M.G., 2013. The impact of cooperatives on agricultural technology adoption: empirical evidence from Ethiopia. Food Policy 38, 82–91.
Adler, P.S., Kwon, S.W., 2002. Social capital: prospect for a new concept. Acad. Manag. Rev. 27, 17–40.
Adrianzen, M., 2009. The Role of Social Capital in the Adoption of Firewood Efficient Stoves in the Northern Peruvian Andes. MPRA Paper (no. No 15918).
Aguilar-Gallegos, N., Munoz-Rodriguez, M., Santoyo-Cortes, H., Aguilar-Avila, J., Klerkx, L., 2015. Information networks that generate economic value: a study on clusters of adopters of new or improved technologies and practices among oil palm growers in Mexico. Agric. Syst. 135, 122–132.
Arellanes, P., Lee, D.R., 2003. "The Determinants of Adoption of Sustainable Agriculture Technologies: Evidence from the Hillsides of Honduras." Paper presented at the Annual Meeting of the International Association of Agricultural Economists, Durban, South Africa.
Armstrong, M., 2006. Handbook of Human Resources Management Practice (London).
Backeberg, G.R., 2014. Innovation through research and development for irrigation water management. Irrig. Drain. 63, 176–185.
Baerenklau, K.A., Knapp, K.C., 2007. Dynamics of agricultural technology adoption: age structure, reversibility, and uncertainty. Am. J. Agric. Econ. 89, 190–201.
Bandiera, O., Rasul, I., 2006. Social networks and technology adoption in Norhern Mozambique. Econ. J. 116, 869–902.
Baumüller, H., 2012. Facilitating Agricultural Technology Adoption among the Poor: The Role of Service Delivery through Mobile Phones. ZEF Working Paper Series (No. 93).
Becker, G.S., 1993. Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education. 3. ed. (Chicago).
Beugelsdijk, S., Smulders, S., 2003. Bridging and Bonding Social Capital: Which Type Is Good for Economic Growth? 8. ERSA Paper. 43rd Congress of the European Regional Science Association, Jyväskylä, Finland, pp. 27–30
Bolino, M.C., Turnley, W.H., Bloodgood, J.M., 2002. Citizenship behavior and the creation of social capital in organizations. Acad. Manag. Rev. 27, 505–522.
Bourdieu, P., 1980. Le Capital Social. Actes de la recherche en sciences sociale. vol. 31 : pp. 2–3. http://letunifor.xpg.uol.com.br/arquivos/capsoc2.pdf (janvier 1980, Accessed July 2015).
Bouma, J., van Soest, D., Bulte, E., 2008. Trust and cooperation: social capital and community resource management. J. Environ. Econ. Manag. 56, 155–166.
Burt, R.S., 1997. The contingent value of social capital. Adm. Sci. Q. 42, 339–365.
Census, 2007. VII Censo Nacional Agropecuario Y Forestal. http://www.censoagropecuario.cl (Accessed June 2014).
Chalupnicek, P., 2010. The capital in social capital: an Austrian perspective. Am. J. Econ. Sociol. 69, 1230–1250.
Chartzoulakis, K., Bertaki, M., 2015. Sustainable water management in agriculture under climate change. Agric. Agric. Sci. Procedia 4, 88–98.
Chou, Y.K., 2006. Three simple models of soical capital and economic growth. J. Socio-Econ. 35, 889–912.
Coleman, J.S., 1988. Social capital in the creation of human capital. Am. J. Sociol. 94, 95–120 (Supplement: Organizations and Institutions: Sociological and Economic Approaches to the Analysis of Social Structure).
Cramb, R.A., 2004. The role of social capital in the promotion of conservation farming: the case of landcare in the Southern Philippines. 13th International Soil Conservation Organisation Conference. Australia, Brisbane.
Donoso, G., 2006. Water markets: case study of Chile's 1981 water code. Cienc. Invest. Agrar. 33, 157–171.
Doss, C.R., 2006. Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement. Agric. Econ. 34, 207–219.
Eastwood, C.R., Chapman, D.F., Paine, M.S., 2012. Network of practice for co-construction of agricultural decision support systems: case studies of precision dairy farms in Australia. Agric. Syst. 108, 10–18.
Ezzhaouani, A., Valancoge, C., Pieri, P., Amalak, T., Gaudilere, J., 2007. Water economy by Italia grapevines under different treatments in a Mediterranean climate. J. Int. Des Sci. de La Vigne et Du Vin 41, 131–139.
Feder, G., Slade, R., 1984. The acquisiton of information and the adoption of new technology. Am. J. Agric. Econ. 66, 312–320.
Fisher, R., 2013. A gentleman's handshake: the role of social capital and trust in transforming information into usable knowledge. J. Rural. Stud. 31, 13–22.
Foster, A.D., Rosenzweig, M.R., 2010. Microeconomics of technology adoption. Annu. Rev. Econ. 2, 395–424.

Fukuyama, F., 2001. Social capital, civil society and development. Third World Q. 22, 7–20.
Genius, M., Koundouri, P., Nauges, C., Tzouvelekas, V., 2013. Information transmission in irrigation technology adoption and diffusion: social learning, extension services, and spatial effects. Am. J. Agric. Econ. 96, 328–344.
Haenlein, M., Kaplan, A., 2004. A beginner's guide to Partial Least Squares analysis. Underst. Stat. 3, 283–297.
Handschuch, C., Wollni, M., Villalobos, P., 2013. Adoption of food safety and quality standards among Chilean raspberry producers - do smallholders benefit? Food Policy 40, 64–73.
Hermans, F., Stuiver, M., Beers, P.J., Kok, K., 2013. The distribution of roles and functions for upscaling and outscaling innovations in agricultural innovation systems. Agric. Syst. 115, 117–128.
Huber, F., 2012. Leitfaden SmartPLS (Mainz).
Huber, F., Herrmann, A.M., Vogel, J., Vollhardt, K., 2007. Kausalmodellierung Mit Partial Least Squares: Eine Anwendungsorientierte Einführung (Wiesbaden).
Isham, J., 2002. The effect of social capital on fertiliser adoption: evidence from rural Tanzania. J. Afr. Econ. 11, 39–60.
Jara-Rojas, R., Bravo-Ureta, B.E., Diaz, J., 2012. Adoption of water conservation practices: a socioeconomic analysis of small-scale farmers in Central Chile. Agric. Syst. 110, 54–62.
Kaasa, A., 2009. Effects of different dimensions of social capital on innovative activity: evidence from Europe at the regional level. Technovation 29, 218–233.
Knack, S., Keefer, P., 1997. Does social capital have an economic payoff? A cross-country investigation. Q. J. Econ. 112, 1251–1288.
Krishna, A., 2004. Understanding, measuring and utilizing social capital: clarifying concepts and presenting a field application from India. Agric. Syst. 84, 291–305.
Kupek, E., 2006. Beyond logistic regression: structural equation modeling for binary variables and its applications to investigation unobserved cofounders. BMC Med. Res. Methodol. 6:13 Available from:. http://www.biomedcentral.com/1471-2288/6/13.
Läpple, D., Van Rensburg, T., 2011. Adoption of organic farming: are there differences between early and late adoption? Ecol. Econ. 70, 1406–1414.
Lobb, A.E., Mazzocchi, M., Traill, W.B., 2007. Modelling risk perception and trust in food safety information within the theory of planned behaviour. Food Qual. Prefer. 18, 384–395.
Lollo, E., 2012. Toward a theory of social capital definition: its dimensions and resulting social capital types. 14th World Congress of Social Economics. United Kingdom, Glasgow.
Maertens, A., Barrett, C.B., 2013. Measuring social networks' effects on agricultural technology adoption. Am. J. Agric. Econ. 95, 353–359.
von Meyer-Höfer, M., Olea Jaik, E., Padilla, C., Spiller, A., 2013. Mature and emerging organic markets: Modelling consumer attitude and behaviour with Partial Least Squares Approach. Global Food Discussion Paper No. 26. University of Goettingen https://www.uni-goettingen.de/de/globalfood-discussion-paper-series/213486.html.
Micheels, E.T., Nolan, J.F., 2016. Examing the effects of absorptive capacity and social capital on the adoption of agricultural innovations: a Canadian Prairie case study. Agric. Syst. 145, 127–138.
Narayan, D., Cassidy, M.F., 2001. A dimensional approach to measuring social capital: development and validation of a social capital inventory. Curr. Sociol. 49 (2), 59–102.
Narayan, D., Pritchett, L., 1999. Cents and sociability: household income and social capital in rural Tanzania. Econ. Dev. Cult. Chang. 47, 871–897.
Newman, L., Dale, A., 2007. Homophily and agency: creating effective sustainable development networks. Environ. Dev. Sustain. 9, 79–90.
Ng'ang'a, S.K., Bulte, E.H., Giller, K.E., Ndiwa, N.N., Kifugo, S.C., NcIntire, J.M., Herrero, M., Rufino, M.C., 2016. Livestock wealth and social capital as insurance against climate risk: a case study of Samburu County in Kenya. Agric. Syst. 146, 44–54.
Noltze, M., 2012. Adoption and impacts of system technologies in Smallholder Agriculture - the system of rice intensification in Timor Leste. Agric. Syst. 108, 64–73.
Oficina de Estudios y Políticas Agrarias, (ODEPA), 2014. Perspectiva Mundial Y Nacional Del Mercado Del Vino Y La Uva Vinífera, Octubre de 2014. www.odepa.gob.cl (Accessed June 2015).
Ojeda-Bustamente, W., Sifuentes-Ibarra, E., Slack, D., Carrillo, M., 2004. Generalization of irrigation scheduling parameters using the growing degree-days concept: application to a potato crop. Irrig. Drain. 53, 251–261.
OIV (Organización Internacional de la Viña y el Viñedo), 2015. OIV Statistical Report on World Vitiviniculture. :p. 2014. www.oiv.int/oiv/info/espublicationsstatistiques (Accessed June 2015).
Oreszczyn, S., Lane, A., Carr, S., 2010. The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations. Agric. Syst. 26, 404–417.
Ostrom, E., 1993. Design principles of long-enduring irrigation institutions. Water Resour. Res. 29, 1907–1912.
Otter, V., Engler, A., Theuvsen, L., 2014. The influence of the interplay of supply chain network relationships on farmers' performance in the Chilean NTAE sector. J. Chain Netw. Sci. 14, 149–169.
Pannell, D.J., Marshall, G.R., Barr, N., Curtis, A., Vanclay, F., Wilkinson, R., 2006. Understanding and promoting adoption of conservation practices by rural landholders. Aust. J. Exp. Agric. 46, 1407–1424.
Pavlou, P.A., 2003. Consumer acceptance of electronic commerce: integrating trust and risk with the technology acceptance model. Int. J. Electron. Commer. 7, 101–134.
Pellegrino, A., Lebon, E., Simonneau, T., Wery, J., 2005. Towards a simple indicator of water stress in grapevine (*Vitis Vinifera* L.) based on the differential sensitivities of vegatative growth components. Aust. J. Grape Wine Res. 11, 306–315.
Putnam, R.D., 1993. The prosperous community. Social capital and public life. Am. Prospect. 13, 35–42.
Ramirez, A., 2013. The influence of social networks on agricultural technology adoption. Procedia. Soc. Behav. Sci. 79, 101–116.
Renn, O., Levine, D., 1991. Credibility and trust in risk communication. In: Kasperson, R., Stallen, P.J. (Eds.), Communicating Risk to the Public. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 175–218.
Ringle, Christian M., Wende, Sven, Becker, Jan-Michael, 2015. SmartPLS 3. SmartPLS, Bönningstedt Retrieved from. http://www.smartpls.com.
Sabatini, Fabio, 2006. The Empirics of Social Capital and Economic Development: A Critical Perspective. FEEM Working Paper No. 15.2006 (accessed:). http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm.
Schultz, T.W., 1981. Investing in People. The Economics of Population Quality (Berkeley).
Solano, C., Leon, H., Perez, E., Herrero, M., 2003. The role of personal information sources on the decision-making process of costa Rican dairy farmers. Agric. Syst. 76, 3–18.
Spielman, D.J., Ekboir, J., Davis, K., Ochieng, C.M.O., 2008. An innovation systems perspective on strengthening agricultural education and training in Sub-Saharan Africa. Agric. Syst. 98, 1–9.
Teilmann, K., 2012. Measuring social capital accumulation in rural development. J. Rural. Stud. 28, 458–465.
Van Rijn, F., Bulte, E., Adekunale, A., 2012. Social capital and agricultural innovation in Sub-Saharan Africa. Agric. Syst. 108, 112–122.
Venkatesh, V., Thong, J.Y., Xu, X., 2012. Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS Q. 36, 157–178.
Weiber, R., Mühlhaus, D., 2014. Strukturgleichungsmodellierung (Berlin).
Woolcock, M., 1998. Social capital and economic development: toward a theoretical synthesis and policy framework. Theory Soc. 27, 151–208.
Woolcock, M., Narayan, D., 2000. Social capital: implications for development theory, research, and policy. World Bank Res. Obs. 15 (2), 225–249.
Wossen, T., Bergen, T., Di Falco, S., 2015. Social capital, risk preference and adoption of improved farm land management practices in Ethiopia. Agric. Econ. 46, 81–97.
Wozniak, G.D., 1984. The adoption of interrelated innovations: a human capital approach. Rev. Econ. Stat. 66, 70–79.