Production efficiency and commercialization channels among small-scale farmers: Evidence for raspberry production in Central Chile

Roberto Jara-Rojas
Department of Agricultural Economics,
Universidad de Talca, Chile
rjara@utalca.cl

Boris E. Bravo-Ureta
Department of Agricultural and Resource Economics
University of Connecticut
boris.bravoureta@uconn.edu

Daniel Solís
Agribusiness Program, College of Agriculture and Food Sciences,
Florida A&M University
daniel.solis@famu.edu

Daniela Martínez
Department of Agricultural Economics,
Universidad de Talca, Chile
dmartinez@utalca.cl

Selected Paper prepared for presentation at the Southern Agricultural Economics Association's 2016 Annual Meeting, San Antonio, Texas, February, 6-9 2016

Production efficiency and commercialization channels among small-scale farmers: Evidence for raspberry production in Central Chile

Abstract

Raspberry production has become a significant cash crop that supports the livelihood of many small-scale growers in Central Chile. Almost 100% of raspberry production is exported, and the cultivation of this crop has put pressure on smallholder farmers to integrate into the modern agri-food chain system. The goal of this article is to analyze technical efficiency (TE) levels for a sample of 139 small-scale raspberry farmers in the Maule region of Chile, the main production area for this crop in the country. One focus of this study is to evaluate the association between TE -understood as an indicator of managerial performance- and farmers' decisions to sell their production directly to the agri-industry or indirectly through an informal middleman. Using a stochastic production frontier model we find that the commercialization decision plays an important role in the productivity and revenue of small-scale raspberry producers. The analysis also reveals a positive relationship between TE levels and income among experienced and trained farmers. The role of implementing food quality and safety standards on farm income is also discussed.

Key words: commercialization, stochastic production frontiers, technical efficiency, small-scale farmers.

Production efficiency and commercialization channels among small-scale farmers: Evidence for raspberry production in Central Chile

1. Introduction

Since the 1960s, Chile has promoted non-traditional exports as part of a general outward-looking economic strategy (Barham et al., 1992; Melo et al, 2014). A number of economic reforms implemented in the 1990s and early 2000s have led to a deep transformation of the agricultural sector. Among the strategies implemented during this period are: 1) an undervalued currency; 2) government incentives to boost exports; and 3) increasing investments in export-oriented sectors, such as agriculture, agribusinesses, wood products and fish (fresh, frozen and processed). In the past 10 years, the monetary value of fruit exports (fresh and processed) has increased at annual averages close to 13%. During the 2011 season, more than 50% of the national fruit production was exported, representing over US $5 billion in sales (Domínguez, 2012).

Raspberry production represents approximately 3% of total fruit exports. However, it is an important economic enterprise for a significant number of small-scale producers and thus has substantial implications for the well being of many rural families and localities (Domínguez, 2012). Over time, this cash-crop has shown high volatility in real prices, which can fluctuate by as much as 300% from one season to the next, making raspberry cultivation a very risky endeavor with the potential for high profits, but also for high losses (Challies and Murray, 2011). Prior to the conflict in the Balkans during the 1990s, Yugoslavia was the world's most important producer of raspberries. The war disrupted production and resulted in a sharp increase in international prices for the fruit. As a result of this market opportunity, raspberry production increased dramatically in Chile, from close to zero in 1980 to 30,000 tons in the late 1990s. With the end of the conflict in the Balkans and the resumption of raspberry production in Serbia, international raspberry prices declined drastically. The reduction in revenues combined with high labor costs forced medium-to-large producers in Chile to exit the market due to low profitability. These changes in market conditions allowed small-scale farmers, mostly family operations, to expand their participation in raspberry production. Currently, the average farm has less than one hectare devoted to raspberries and these units rely largely on family labor (Domínguez, 2012).

Raspberries are highly susceptible to physical damage and bruising; thus, harvest and post-harvest grading and packing require intensive use of well-trained workers to handle these activities. Mechanical harvesting saves a significant amount of labor, an increasingly scarce resource in Chilean agriculture; however, the initial capital outlay and maintenance costs of mechanized systems are substantial, making them financially feasible only for large-scale operations. Moreover, the overall farm architecture (i.e. spacing and layout of hedgerows, trellises and irrigation systems) must be redesigned to accommodate mechanical harvesting and, again, the initial capital required for such farm transformation is considerable (Strik, 2007). Cultivars suitable for mechanical harvesting are also required. Small-scale production can offset some of these financial restrictions, especially if the fruit can be harvested using family labor (Challies and Murray, 2011).

In Chile, the National Institute for Agricultural Development (INDAP, its official acronym in Spanish) is the main agency providing support to small-scale agriculture, with the aim of improving the competitiveness and market orientation of family farm agriculture (FFA). INDAP also finances technical assistance and management programs for smallholders, and implements general assistance for poor farmers (OECD, 2008). FFA includes a total of 280,000 small-scale farmers who cultivate 4,010,096 hectares, almost 25% of the agricultural land in Chile. FFA produces roughly 45% of the annual crops, vegetables, wine grapes and livestock in the country, and 29% of the major fruit crops (apples, avocados, and table grapes). More importantly, in the context of this study, FFA accounts for 96% of all raspberries grown in the country (SAG, 2012).

Considering that small-scale farmers dominate raspberry production, Domínguez (2012) describes several challenges that must be addressed in order to increase the competitiveness and productivity of this sector, especially in seasons when low output prices prevail. Appropriate responses to these challenges include: 1) establishment of plant breeding programs to develop higher yielding varieties; 2) streamlining marketing channels; 3) greater focus on IQF (Individually Quick Frozen) products rather than block pack products to generate higher farm revenues; and 4) adaptation to climate fluctuations, particularly through the adoption of improved irrigation technologies. As important as these responses are, the work required to develop and promote the adoption of innovations is a lengthy process; thus, in the short run, it is critical that farmers make the best use of their current technologies in order to enhance their competitiveness. Therefore, understanding the efficiency gaps that might exist in the utilization of the available technology is an important endeavor.

The main goal of this article is to describe the production technology of small-scale raspberry producers and analyze prevailing technical efficiency (TE) levels using a sample of 139 farmers from the Maule region of Chile. This area was selected because it has roughly 67% of the total land and 77% of farmers devoted to raspberries (Table 1). Studying the sources of efficiency in agriculture is important because it allows farmers and policy makers to identify and target private and public resources in the most appropriate manner to improve agricultural production, productivity and agricultural incomes (Ogundari 2014; Bravo-Ureta et al. 2007).

Numerous empirical studies that estimate productivity and TE at the farm level have focused on annual crops, dairy or livestock. Recent reviews of these studies can be found in Bravo-Ureta et al. (2007), Moreira and Bravo-Ureta (2009), and Ogundari (2014). However, empirical studies focusing on the productivity of the fruit sector, especially among small-scale producers, are scarce. The few exceptions are Plénet et al. (2009), who measured efficiency in peach and nectarine production in France, and Townsend et al. (1998), Henriques et al. (2009) and Moreira et al. (2011) who studied the TE of vineyards for wine production. There is also some work on table grapes (Ma et al., 2012), olives (Lachaal et al., 2005), and citrus (Lambarraa et al., 2007); but, to our knowledge, the present article is the first to study farm level TE for raspberry production. Our study also adds to the literature by explicitly analyzing the relationship between production efficiency and the commercialization channel used. Two alternative channels are available for these farmers: direct sale to the agri-industry; and the use of an informal trader. Informal traders play a crucial role in fruit transportation especially for the marginal farmers; however, they usually pay lower prices.

The rest of the article is organized as follows. Section 2 contains a description of the raspberry agri-chain sector with special emphasis on the role of informal traders. Section 3 presents the methodological framework, describes the data, and the empirical model. Section 4 discusses the results and Section 5 concludes.

2. Overview of the raspberry agri-chain sector.

The international market for fresh fruit is regulated by different standards and norms, some of which are obligatory and enforced by public entities. Others are voluntary, developed by global food distribution chains, such as GlobalGap (Neven and Reardon, 2004). In developed countries, mandatory private food safety and quality standards govern the importation of fresh fruits. These norms are also becoming increasingly important in the domestic markets of many non-OECD countries in Africa, Latin America and East Asia due to the expansion of supermarket chains (Henson and Humphrey, 2009). The consequences of food safety standards for smallholder agriculture in developing countries have led to a debate over the complexity and costs of quality and safety norms (Miewald et al., 2013).

The market exclusion of small-scale farmers due to lack of funds and managerial capacity is a concern, and strategies that encourage the implementation of stringent requirements pose major challenges for policymakers in providing opportunities for smallholder farmers to upgrade their operations (Asfaw et al., 2009). In Chile, since 2000, there have been several initiatives to support the certification of private Good Agricultural Practices (GAP), which are standards to facilitate access to the most competitive and demanding markets (Cofré et al., 2012). Also, INDAP has promoted GAP practices among small-scale famers since 2005 with mixed results. Handschuch et al. (2013) show that the main barriers to implementing GAP certification among raspberry farmers are low educational levels, limited volumes and poor quality of the fruit sold. However, once farmers adopt GAP certification, a positive effect has been observed on the quality of their fruit as well as on their net raspberry income. Challies and Murray (2011) argue that medium and large-scale producers comply easily with the certification process, but, for many small-scale farmers, the implementation of even basic technical norms is a significant challenge.

Currently, in Chile, more than 21,000 farmers are growing raspberries on 16,000 hectares, a national average of 0.76 hectares per farm. Table 1 shows the geographical and size distribution of these farmers. In the Maule Region, our study area, average farm size is below the national average at 0.66 hectares. Small-scale production and low levels of formal education are major challenges to meet any type of certification process (Handschuch et al., 2013). Therefore, small-scale producers are highly dependent on the technical support provided by extension agents contracted by INDAP, such as PRODESAL (Local Development Program) and SAT (Technical Assistance Service), to guide farm management and fruit marketing, and to help comply with standards.

The Chilean raspberry agri-chain is export-oriented, and around 80% of the berries are processed as frozen and the rest are exported as pulp or juice (Challies and Murray, 2011). Exports of fresh raspberries were interrupted when Serbia and Mexico started to provide fresh fruit to Europe and USA at lower prices than Chile (Domínguez, 2012) and, as a result, production is currently marketed almost exclusively as processed fruit. In rural Chile, farmers have the option to sell their production using formal or informal channels (Challies, 2010). Formal channels include sending the fruit to "raspberry collection centers" located near the raspberry fields, from where the fruit is transported to agri-industry firms. Formal channels also include the possibility to send the fruit directly to agri-industry firms. Under both modalities, the payment conditions are 30 to 60 days from the date of the invoice. The agri-industry firms export the raspberries directly or sell them to domestic wholesalers.

An alternative trading system includes transient intermediary traders, known colloquially (and slightly derogatorily) as *conchenchos*, which are common players in the informal trade business (Challies and Murray, 2011). *Conchenchos* generally buy raspberries by the tray for as low a cash price as possible, and then transport the fruit and sell it to agri-industry firms. Despite the low prices they pay, these informal traders solve several problems especially for disadvantaged farmers: 1) they provide transportation for those producers who have no private means and cannot deliver their produce directly to an agri-industrial market; 2) provide immediate cash for farmers' operational and living expenses; and 3) make it possible to have transactions without formal invoicing thus avoiding tax payments. However, these informal traders usually do not fulfill the traceability demands imposed by international markets (Challies, 2010).

3. Material and methods

3.1. Methodological approach

In this study, we employ Stochastic Production Frontier (SPF) methodology to measure farm level TE. Following Battese and Coelli (1995), the general model can be depicted as:

$$Y_i = \exp(x_i\beta + v_i - \mu_i) \tag{1}$$

where Y_i is the value of the raspberries produced by the *i*th farmer, x are inputs, *ß* is a vector of unknown parameters, and $v - \mu = \varepsilon$ is the composed error term. The term v represents a two-sided random error with a normal distribution (v ~ N [0, σ_v^2]) that captures stochastic factors beyond the farmer's control (e.g., climate, luck, etc.) and statistical noise. The term μ is a one-sided non-negative component that captures the TE of the producer. In other words, μ measures the gap between observed and maximum output that could be produced if the farm operated on the frontier, given the technology, inputs and the production environment. TE for the *i*th farm can be measured as:

$$TE_i = \exp(-\mu_i) \tag{2}$$

where μ is the efficiency term as defined above. TE for each farm is calculated using the conditional mean of *exp*(-µ), given the composed error term for the stochastic frontier model (Jondrow et al., 1982; Battese and Coelli, 1988). TE ranges between 0 and 100%, where a value of 100% denotes full efficiency.

The maximum-likelihood method developed by Battese and Coelli (1995) makes it possible to estimate the determinants of farm technical inefficiency (TI) in a one-step procedure. Thus, TI can be estimated by incorporating the following expression in the frontier model shown in equation (1):

$$\mu_j = \delta_0 + \sum_{n=1}^{k} \delta_n z_{nj} + \omega_j \tag{3}$$

where μ_j is technical inefficiency, z_{nj} are variables that affect efficiency, δ_n are unknown parameters to be estimated, and ω_j is an error term.

3.2. Data and study area

This research was undertaken in the North Maule Basin, Province of Curicó, in Central Chile. The data used in this study were obtained from a farm-level survey of 139 small-scale farmers, carried out between July and September of 2011. The questionnaire was divided into the following six sections: (1) human capital; (2) crops and land use; (3) inputs and infrastructure; (4) credit and incentives; (5) social capital; and (6) perceptions.

Most of the farmers in the survey are enrolled in the two INDAP programs mentioned earlier, SAT and PRODESAL. SAT includes extension support, as well as the design, financing, monitoring and evaluation of technical assistance projects that are implemented in the field by external contractors (Apey and Barril, 2006). The aim of SAT is to increase the competitiveness of peasant enterprises in national and international markets. In contrast, PRODESAL aims to build technical and productive capacity among low-income, small-scale producers and their families, with the goal of increasing their share of value added along the production process. PRODESAL is implemented at the local level through agreements between INDAP and municipal governments (Challies and Murray, 2011).

3.3. Empirical model

The empirical model estimated is the following Cobb–Douglas (CD) stochastic production frontier:

$$\ln Raspberry_i = \alpha_i + \beta_1 \ln Land_i + \beta_2 \ln Pinputs_i + \beta_3 Labor_i + \beta_4 Channel_i + \beta_5 Plants_i + \nu_i - \mu_i[\delta_{0i} + \delta_1 Age_i + \delta_2 Education_i + \delta_3 Experience_i + \delta_4 Extension_i + \delta_5 Training_i + \omega_i] \quad (4)$$

where *Raspberry* represents the value of the raspberry production of the *i*th farm; *Land* is the number of hectares devoted to raspberry production; *Pinputs* represents expenses on purchased inputs used for raspberries (new vegetative material, fertilizers, pesticides); *Labor* is the value of both unpaid (family) and hired labor used for raspberry production.

The value of unpaid labor was computed as kilograms harvested by family members by the price paid to hired workers per kilogram; *Channel* is a dummy variable equal to 1 if the fruit is marketed directly and zero if a trader is used[1]; and *Plants* is a continuous variable that specifies the age of the canes in years and this variable is a proxy for the productive potential of the raspberry plants. Plants come into production in the same season they are planted; thus, younger plants are expected to produce more than older ones, holding all else constant.

The inefficiency term is explained by the following variables: *Age* and *Education* of the household head, both in years; *Experience* or knowledge of raspberry production of the household head; *Extension* (if the household head received extension); and *Training*; (if the household head participated in training courses). The βs and δs are the parameters to be estimated; and v and μ are as previously defined. Table 2 shows a definition of variables used included in equation (4).

Table 3 presents descriptive statistics for the sample. On average, the annual value of raspberry production is CL$2.48 million[2] per farm, with a standard deviation of CL$2.16 million. On average, the amount of *Land* devoted to raspberry production in our sample is one hectare, and the average *Pinputs* (mainly fertilizers and pesticides) is CL$100 thousand. The amount spent on new plants is nearly zero, despite the fact that young plants and improved varieties are crucial to increasing the productivity and competitiveness of the sector. *Labor* represents the major expense in raspberry production and has an average value, including unpaid family labor, of CL$1.48 million. The fact that raspberries are harvested without machinery makes this crop an attractive alternative for small-scale farmers (Toledo and Engler, 2008). According to Challies (2010), during the harvest season (December to March), all household members, including children and the elderly, may be engaged in picking the fruit.

The average age of the head of household is 52 years, which is consistent with other studies focusing on the FFA in Chile (Jara-Rojas et al., 2012; 2013). The level of education of the household head in the sample is low with only 7.8 years of schooling. On average,

[1] It is important to indicate that the decision to sell the production using a formal or an informal trader is made *post hoc*, i.e., at harvest time. Therefore, the type of trade system selected does not affect the production decisions implemented by the farmer. This issue is important because it avoids any potential endogeneity problems in our estimations. None of those raspberry producers have pre-production contracts.

[2] 1 US$ = 710 CL$ (Chilean pesos), November 2015.

household heads have 13.4 years of experience in raspberry production. Many (42.5%) of the farmers have contacts with extension from SAT or PRODESAL, and 40.3% have received training in topics related to raspberry production and Good Agricultural Practices (GAP).

4. Results and discussion

Table 4 presents the parameter estimates for the SPF model. The null hypothesis that $\gamma = 0$ is rejected at the 1% significance level in all cases (Table 5), which lends support to the SPF model, i.e., the SPF model is superior to an average production function resulting from estimation using ordinary least squares (OLS). Moreover, the value for γ is statistically significant, with a value of 0.78, which indicates that inefficiency is an important contributor to observed output variability (Battese and Coelli, 1995). The function coefficient is 0.922, revealing decreasing returns to scale.

The parameters for the three inputs in the Cobb–Douglas (CD) production frontier, which can be interpreted as partial production elasticities, are statistically significant at the 5% level or better. Typically, *Land* exhibits the largest elasticity in studies analyzing small-scale agriculture (Jaime and Salazar, 2011). However, our study suggests that *Labor* is the most significant input, with a partial elasticity equal to 0.62. This value indicates that a 10% increase in *Labor* results in a 6.2% increase in the value of production revealing the importance of labor in raspberry farming. According to our survey data, harvest labor accounts for roughly 95% of labor costs and 93% of total operating costs.

The parameter of the variable *Plants* is negative and significant, which means that the raspberry plants produce less as they age. Raspberry plants produce their best yields in the first six years, but many farmers keep their plants for more than 10 years (REF). Although the *Plants* parameter does not capture the possible effect of different raspberry varieties, this is a matter that should be considered by farmers, consultants, and policy makers. In our study, 99% of the farmers grow the 'Heritage' variety, but it is likely that using improved varieties could increase yields and fruit quality.

Of particular importance in this study is the parameter for the dichotomous variable *Channel*, which is negative and significant. This outcome indicates that farmers who sell their production using an informal trader (or *conchencho*) have a value of output that is

25% lower (CL$ 2,285,320 *vs*. CL$ 3,044,461), *ceteris paribus*, than those who sell directly to the market. As mentioned, *Channel* is related to the quality of the fruit. Farmers who can meet high quality standards can sell to the markets for fresh or frozen IQF raspberries; thus, getting a higher price compared to those with lower quality fruit who must sell the berries to juice and marmalade factories or to an informal trader.

Our results show a strong relationship between the level of GAP practices employed in the farm and the use of formal trade. Farmers in our sample use 12 different GAP practices. Specifically, most of the farmers (82.6%) with lower level of GAP (1 to 3 practices) sell their production to informal trader. This percentage decreases to less than 50% for those farmers with 6 GAP practices. On average, farmers in our sample have implemented 5 of the 12 recommended practices and the most adopted one is "Fruit storage", which is a place where farmers select, classify and pack the fruit prior to transportation to the agri-industry. Table 5 also shows a positive trend between the number of GAPs implemented and income. Ten farmers had implemented 10-12 GAP practices and their average income was CL$4.98 million, while the income for those farmers with 1-3 was CL $0.84 million. Handschuch et al. (2013) show that Chilean small-scale raspberry farmers benefit from the implementation of food quality and safety standards through better farming and higher management skills.

Figure 1 shows the values of TE derived from our model, which averages 81%. This result indicates that several farms could increase their level of output significantly using the same level of inputs, thus increasing productivity. Figure 1 also shows that more than 50% of the producers attain TE in the 70-79% range; and 22% of farmers reach a TE of 90% or higher. The average TE value is consistent with other studies focused on Latin America. Jara-Rojas et al. (2012a) reported an average level of TE of 80%, Solís et al. (2009) 78%, and Bravo-Ureta et al. (2007) found an average TE of 78% in their meta-analysis.

4.1. Determinants of inefficiency

Table 4 also presents the parameters of the variables that explain inefficiency. Following the usual practice, the interpretation is in terms of TE (instead of inefficiency). Frequently, the variable *Age* is used as a proxy for household experience in agriculture. However, the literature shows mixed results with respect to the relationship between *Age* and TE. For example, young farmers tend to be efficient because they are more educated (Adeoti, 2006; Mariano et al., 2010); yet, older farmers are likely to become more efficient through experience (Munroe, 2001; Jaime and Salazar, 2011). Following Bozoğlu and Ceyhan (2007), and Mahadevan (2009) we include the variables *Age* and *Experience* separately. The results indicate that younger farmers are more efficient, but the parameter is not significant, while the *Experience* associated with raspberry production is positively and significantly associated with TE.

The parameter for *Education* shows a positive but non-significant relationship with TE. Abdulai and Huffman (2000) found that education has a positive and significant effect on TE, and suggested that an appropriate response to changes in market prices requires management skills acquired through education and access to information. Also, Asfaw et al. (2009) identify the lack of human capital (e.g. level of education of household members) and physical capital as major determining factors that limit the adoption of safety standards by smallholders. The same authors add that public investment designed to promote farmers' productivity and connectivity to markets, and the promotion of collaborative action among producers are crucial policies to build the technical capacity of farmers.

Consistent with Feder et al. (2004), the variable *Extension* shows a positive but non-significant relationship with TE. The *Extension* services provided by the PRODESAL and SAT programs focus on various aspects of production, such as fertilization and crop protection, but do not address issues related to financial management and marketing. Extension services showed a positive association with TE in Lindara et al. (2006) and in Sauer and Balint (2008). The parameter for the variable *Training* is significant and reveals a positive effect on TE. Training is defined as short courses taken by farmers, usually related with raspberry production and GAP topics. This result suggests that training courses that help farmers develop GAP help boost TE and this finding is consistent with those of Li and Sicular (2013).

Table 6 shows mean values for TE, Raspberry Income (RI) and Gross Margin (GM) among farmers in the sample for several variables. For example, TE, RI and GM for farmers who sold their produce to an informal trader (captured by the variable *Channel*) are significantly lower than for those farmers who sold to the agri-industry. Similar significant differences are exhibited when comparing farmers with training who had an average TE of

84% and an average RI of $3.05 million, while those without training had an average TE of 80% and an average RI of $2.09 million. Challies (2010) also found that off-farm work and training courses are highly beneficial in helping small-scale farmers become successful raspberry producers. In addition, we include the variable *Project*, which captures the effect of participating in an "Investment Development Program (PDI)". PDI is an INDAP initiative that co-finances investment projects that enable the modernization of production processes, and provides support for project design and implementation. The results show that famers with PDI projects reach significantly higher levels of TE (84%), RI ($3,627,885) and GM $3,033,4494) than farmers without such projects (TE=81.2%, RI=$2,218,261, and GM=$2,960,160, respectively). By contrast, credit provided by INDAP exhibits no significant effects on TE, RI and GM.

5. Summary and conclusions

This study analyzed the determinants of production efficiency for a sample of small-scale raspberry producers in central Chile, with special focus on the effect of the type of commercialization channel used. To do so, we estimated a stochastic production frontier, which explicitly accounted for farmers' decisions to sell their production directly or indirectly in the market. The empirical results suggest that the commercialization channel used plays an important role in the productivity and competitiveness of raspberry farmers in Chile. The empirical results also showed that human capital, in terms of *Age*, *Experience* and *Training*, is a crucial factor associated with higher levels of technical efficiency (TE), where the latter is a proxy for managerial performance.

The Chilean Government is directly involved in supporting raspberry production and the overall agri-chain through SAG and INDAP, two leading governmental agencies within the Ministry of Agriculture (Challies and Murray, 2011). While SAG has a regulatory function, INDAP is the main agency that provides support to small-scale farmers and its mission is to increase the competitiveness of such farmers. INDAP has several support programs and the most far reaching one is technical assistance, which has been provided since the Institute's foundation in 1962. In the 1980s, the government went from the direct public provision of technical assistance to the provision of these services using private organizations but still with public funding. At the end of the 1980s roughly 23,000 small-scale farmers participated in the technology transfer program, which amounted to just over 16% of the estimated total small-scale farms in Chile at that time. Currently, technical assistance programs include more than 100,000 farmers, where around 13,000 are beneficiaries of the SAT program (Technical Assistance Services). In 2014 the budget for the SAT program was CL$ 9,833,307,000 (about US$ 1,200 per farmer) and the services continued to be offered by different private-external consultant services. SAT beneficiaries are concentrated in three regions of Chile, O'Higgins, Maule and Bio-Bio, that together account for more than 50% of the total number of beneficiaries. The three major farming systems covered by the program are raspberries, cereals and vegetables. The agricultural extension assistance for raspberry farmers is mainly focused on various aspects of production and on helping farmers to comply with GAP regulations.

Given that raspberry production is an important source of income for small-scale family farms in Chile, this article has policy implications that can be of significance to this vulnerable sector of producers. First, to increase the profitability and competitiveness of the raspberry sector, it is imperative to improve the managerial ability of small-scale producers. The ability to produce and market high-quality fruit has a major impact on farm profitability particularly when output prices are low as was the case in the 2011–2012 seasons (50% lower than the 2008-2010 period). Thus, training programs provided by INDAP should be designed to promote technical capabilities and compliance with required quality standards. Second, INDAP should improve the targeting of incentive programs that encourage new and better varieties of raspberries so as to enhance the competitiveness of the sector. Finally, now that small-scale farmers have been working on raspberry production for more than 15 years, it is important to strengthen technical assistance focusing on economic and managerial topics in order to improve performance and enhance the profitability of poor rural households.

6. References

Abdulai, A. and Huffman, W. 2000. Structural adjustment and economic efficiency of rice farmers in Northern Ghana. Economic Development and Cultural Change 48(3): 503–520.

Adeoti, A.I. 2006. Farmer´s efficiency under irrigated and rainfed production systems in the derived savannah zone of Nigeria. Journal of Food, Agriculture and Environment 4(3 & 4): 90–94.

Apey, A. and Barril, A. 2006. Pequeña agricultura en Chile: Rasgos socio productivos, institucionalidad y clasificación territorial para la innovación. Santiago: INDAP; ODEPA; MUCECH; IICA.

Asfaw, S., Mithöfer, D. and Waibel, H. 2009. EU Food Safety Standards, Pesticide Use and Farm-level Productivity: The Case of High-value Crops in Kenya. Journal of Agricultural Economics 60(3): 645–667.

Barham, B., Clark, M., Katz, E. and Schurman, R. 1992. Nontraditional agricultural exports in Latin America. Latin American Research Review 27: 43-82.

Battese, G. E. and Coelli, T. J. 1988. Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. Journal of Econometrics 38: 387–399.

Battese, G.E. and Coelli, T.J. 1995. A model for technical inefficiency effects in stochastic frontier production function for panel data. Empirical Economics 20: 325–332.

Bozoğlu, M. and Ceyhan, V. 2007. Measuring the technical efficiency and exploring the inefficiency determinants of vegetable farms in Samsun province, Turkey. Agricultural Systems 94: 649–656.

Bravo-Ureta, B., Solís, D., Moreira, V., Maripani, J., Thiam, A. and Rivas, T. 2007. Technical efficiency in farming: A meta-regression analysis. Journal of Productivity Analysis 27(1): 57-72.

Challies, E. 2010. Agri-Food Globalisation and rural transformation in Chile: Smallholder livelihoods in the global value chain for raspberries. PhD dissertation,Victoria University of Wellington.

Challies, E. and Murray W.E. 2011. The Interaction of Global Value Chains and Rural Livelihoods: The Case of Smallholder Raspberry Growers in Chile. Journal of Agrarian Change 11: 29–59.

Cofré, G., Riquelme, I., Engler, A., Jara-Rojas, R. 2012. Adopción de Buenas Prácticas Agrícolas (BPA): Costo de cumplimiento y beneficios percibidos entre productores de fruta fresca. IDESIA 30(3): 37–45.

Dominguez, A. 2012. Chilean raspberry industry. Chilealimentos. Presentation in Canada, June 4th.

Feder, G., Murgai, R. and Quizon, J.B. 2004. Sending farmers back to school: The impact of farmer field schools in Indonesia. Review of Agricultural Economics 26(1): 45–62.

Handschuch, C., Wollni, M. and Villalobos, P. 2013. Adoption of food safety and quality standards among Chilean raspberry producers – Do smallholders benefit? Food Policy 40: 64–73.

Henriques, P., Carvalho, M., and Fragoso, R. 2009. Technical Efficiency of Portuguese Wine Farms. New Medit 1: 4–9.

Henson, S., and Humphrey, J. 2009. The Impacts of Private Food Safety Standards on the Food Chain and on Public Standard-Setting Processes. Paper Prepared for FAO/WHO.

Jaime, M., and Salazar, C. 2011. Participation in organizations, technical efficiency and territorial differences: A study of small wheat farmers in Chile. Chilean Journal of Agricultural Research 71: 104–113.

Jara-Rojas, R. Bravo-Ureta, B.E., Engler, A. and Díaz, J. 2013. An analysis of the joint adoption of soil and water conservation practices in Central Chile. Land Use Policy 32: 292–301.

Jara-Rojas, R., Bravo-Ureta, B.E. and Díaz, J. 2012. Adoption of water conservation techniques: A socioeconomic analysis for small-scale farmers in Central Chile. Agricultural Systems 110: 54–62.

Jara-Rojas, R., Bravo-Ureta, B.E., Moreira, V. and Díaz, J. 2012a. Technical Efficiency and Natural Resource Conservation: Empirical Evidence from Small-Scale Farmers in Central Chile. International Conference of Agricultural Economists. IAAE Confex.

Jondrow, J., Lovell, C.A.K., Materov, I.S. and Schmidt, P. 1982. On the estimation of technical inefficiency in the stochastic frontier production function model. Journal of Econometrics 19: 233–238.

Lachaal, L., Karray, B., Dhehibi, B., and Chebil, A. 2005. Technical Efficiency Measures and Its Determinants for Olive Producing Farms in Tunisia: A Stochastic Frontier Analysis. African Development Review 17(3): 580–591.

Lambarraa, F., T. Serra, and J.M. Gil. 2007. Technical efficiency analysis and decomposition of productivity growth of Spanish olive farms. Spanish Journal of Agricultural Research 5(3): 259–270.

Li, M., and T. Sicular. 2013. Aging of the labor force and technical efficiency in crop production: Evidence from Liaoning province, China. China Agricultural Economic Review 5(3): 342–359.

Lindara, L., F.H. Johnsen, and H.M. Gunatilake. 2006. Technical efficiency in the spice based agroforestry sector in Matale district, Sri Lanka. Agroforestry Systems 68(3): 221–230.

Ma, C., Mu, W., Feng, J., and Jiao, W. 2012. Assessing the technical efficiency of grape production in open field cultivation in China. Journal of Food, Agriculture & Environment, 10: 345–349.

Mahadevan, R. 2009. The viability of Fiji's sugar industry. Journal of Economic Studies 36(4): 309–325.

Mariano, M.J., R. Villano, and E. Fleming. 2010. Are irrigated farming ecosystems more productive than rainfed farming systems in rice production in the Philippines? Agriculture, Ecosystems & Environment 139(4): 603–610.

Melo, O., Engler, A., Nahuelhual, L., Cofre, G., and Barrena, J. 2014. Do sanitary, phytosanitary, and quality-related standards affect international trade? Evidence from chilean fruit exports. World Development 54: 350–359.

Miewald, C., Ostry, A., and Hodson, S. 2013. Food safety at the small scale: The case of meat inspection regulations in British Columbia's rural and remote communities: Journal of Rural Studies 32: 93–102.

Moreira, V. H. and Bravo-Ureta B. E. 2009. A Study of Dairy Farm Technical Efficiency Using Meta-Regression: An International Perspective. Chilean Journal of Agricultural Research 69(2): 214–223.

Moreira, V. H., Troncoso, J. L., and Bravo-Ureta, B. E. 2011. Technical efficiency for a sample of Chilean wine grape producers : A stochastic production frontier analysis. Ciencia e Investigación Agraria 38: 321–329.

Munroe, D. 2001. Economic efficiency in Polish peasant farming: An international perspective. Regional Studies 35(5): 461-471.

Neven, D., and Reardon, T. 2004. The rise of Kenyan supermarkets and the evolution of their horticulture product procurement systems. Development Policy Review 22 (6): 669–699.

OECD, 2008. OECD Review of Agricultural Policies: Chile. ISBN 978–92–64–04223–0.

Ogundari, K. 2014. The Paradigm of Agricultural Efficiency and its Implication on Food Security in Africa: What does Meta-analysis reveal? World Development 64: 690–702.

Plénet, D., P. Giauque, E. Navarro, M. Millan, C. Hilaire, E. Hostalnou, A. Lyoussoufi, and J.-F. Samie. 2009. “Using on-field data to develop the EFI© information system to characterise agronomic productivity and labour efficiency in peach (Prunus persica L. Batsch) orchards in France.” Agricultural Systems 100(1-3): 1–10.

Sauer, J., and B. Balint. 2008. Distorted prices and producer efficiency: the case of Romania. Journal of Productivity Analysis 29(2):131–142.

Servicio Agrícola y Ganadero (SAG). 2012. Estadística de superficie nacional de frambuesas.

Solís, D., Bravo-Ureta, B. and Quiroga, R. 2009. Determinants of household efficiency among small-scale hillside farmers in El Salvador and Honduras. Journal of Agricultural Economics 60(1): 202–219.

Strik, B. C. 2007. Berry Crops: Worldwide area and production systems. In Y. Zhao (Ed.), Berry Fruit: Value-added products for health promotion (pp. 3-50). Boca Raton: CRC Press, Taylor and Francis.

Toledo, R. and Engler, A. 2008. Risk preferences estimation for small raspberry producers in the Bío-Bío region, Chile. Chilean Journal of Agricultural Research 68: 175–182.

Townsend, R., Kirstena, J., and Vinkb, N. 1998. Farm size, productivity and returns to scale in agriculture revisited: a case study of wine producers in South Africa. Agricultural Economics, 19(1-2): 175–180.

Table 1. Geographical distribution of raspberry production in Chile

Region	**Total area (ha)**	**N° farmers**	**Average size (ha)**
Coquimbo	6.45	4	1.61
Valparaíso	48.8	46	1.06
Metropolitana	15.4	26	0.59
O´Higgins	147.1	494	0.35
Maule	10,850.4	16,325	0.66
Bío-Bío	3,203.2	3,420	0.94
Araucanía	621.7	468	1.33
Los Lagos and Los Ríos	1,208.0	238	5.08
Total Country	**16,128**	**21,143**	**0.76**

Source: Adapted from Domínguez and SAG, 2012.

Table 2. Definition of variables used in the econometric model

Variable	**Type**	**Definition**
Raspberry	Continuous	Raspberry production value in Chilean pesos ($)
Land	Continuous	Hectares worked
Inputs	Continuous	Expense in plants, fertilizers, and pesticidesin Chilean pesos ($)
Labor	Continuous	Value of total labor in Chilean pesos ($)
Channel	Dummy	1 if the farmer sold his produce to an informal trader,0 if the produce is sold in the agri-industry
Plants	Continuous	Age of the raspberry plants, in years
Age	Continuous	Age of the farmer, in years
Education	Continuous	Education of the farmer, in years
Experience	Continuous	Farmer's experience in raspberry production, in years
Extension	Dummy	1 if the producer has received technical assistance by INDAP, 0 otherwise
Training	Dummy	1 if the producer has participated in training courses in raspberry production, 0 otherwise

Table 3. Descriptive statistics of the variables included in the econometric model

Variable	Mean	Std. Dev.	Max.	Min.
Raspberry	2,481,932	2,168,888	11,400,000	90,000
Land	1.0	0.7	5.0	0.1
Inputs	97,601	120,000	1,000,000	3,500
Labor	1,482,441	1,280,735	7,161,000	39,600
Channel (%)	74.1	-	-	-
Plants	5.7	2.6	11.0	2.0
Age	51.5	8.7	76.0	24.0
Education	7.8	3.2	14.0	2.0
Experience	13.4	5.6	22.0	2.0
Extension (%)	42.5	-	-	-
Training (%)	40.3	-	-	-

Table 4. Stochastic production frontier results (*Standard Error in italics*)

Variable	**Coefficients**	***S.E.***
Constant	5.715***	*0.905*
Land	0.214***	*0.069*
Purchased Inputs	0.086**	*0.047*
Labor	0.622***	*0.061*
Channel	-0.156*	*0.100*
Plants	-0.099***	*0.020*
Inefficiency model		
Constant	4.925***	*1.690*
Age	-0.050***	*0.022*
Education	-0.057	*0.066*
Experience	-0.287***	*0.068*
Extension	-0.559	*0.696*
Training	-1.569***	*0.783*
Returns to scale	0.922	
Log likelihood function	-80.47	
$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.690***	*0.105*
$\gamma = \sigma_u^2 / \sigma^2$	0.780***	*0.079*
average TE	81.0	

Table 5. GAP practices and raspberry income

Type of GAP practices			**Number of GAP**		
	N° of farmers	% of total	Frequency	N° of farmers	% of total
Input warehouse	78	56,1	1	4	2.88
Harvest tools warehouse	84	60,4	2	5	3.60
Packing	7	5,0	3	14	10.07
Fruit storage	114	82,0	4	20	14.39
Latrines	94	67,6	5	37	26.62
Fence	42	30,2	6	29	20.86
Signs	38	27,3	7	9	6.47
Workers dining	18	12,9	8	7	5.04
SAG[1] records	57	41,0	9	4	2.88
Input applications records	124	89,2	10	4	2.88
Harvest records	50	36,0	11	1	0.72
Formal business	48	34,5	12	5	3.60

Number of GAP practices	Informal Channel Sales?		Raspberry Income[2]
	Yes	No	
1 – 3	n = 19 (82.6%)	n = 4 (17.4%)	$ 849.782 a
4 – 6	n = 73 (76.8%)	n = 22 (23.2%)	$ 2.189.545 b
7 – 9	n = 6 (54.5%)	n = 5 (45.5%)	$ 2.647.364 b
10 – 12	n = 5 (50.0%)	n = 5 (50.0%)	$ 4.985.900 c

1. The Chilean Agriculture and Livestock Service (SAG) is the institution in charge of record of raspberry farmers and other value chain participants (e.g. traders, packing). Also SAG is in charge of monitoring GAP norms for farmers (food safety norm 341).
2. Different letters indicate significant differences (Tukey´s test, $p<0.05$) in raspberry income among different groups of GAP practices.

Table 6. Differences in TE, Income and Gross Margin

Variable	n	TE (%)	Raspberry Income[1]	Gross Margin[2]
Channel:				
Informal Trade	74%	81.6	2,285,320	698,841
Formal Trade	26%	83.1	3,044,461*	1,482,836*
Projects:				
Without PDI	81%	81.2	2,218,261	2,960,160
With PDI	19%	85.3*	3,627,885*	3,033,494
Training:				
No	60%	80.7	2,096,072	2,235,170
Yes	40%	84.0*	3,053,832*	3,589,819*
Credit by INDAP:				
No	57%	81.5	2,635,800	2,930,939
Yes	43%	82.6	2,358,038	3,130,108

1. Total Raspberry Income in Chilean pesos ($)
2. The Gross Margin (*GM*) is computed as Raspberry Income (*RI*) less expenditures on Purchased Inputs (*PI*) and Labor Cost (*LC*): $GM = RI – (PI + LC)$
* Indicates significant differences at 5% confidence level (T-test)

Figure 1. Distribution of the TE