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INTERNATIONAL TRADE, AGRICULTURAL PRODUCTIVITY AND POVERTY: THE ROLE OF PRODUCT TRADABILITY IN THE CHILEAN CASE

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ABSTRACT

Globalization is an issue that during the last two decades has been a major topic of discussion by different actors in society. Questions have arisen about the impacts that an open economy has on the agriculture and poverty of developing countries. Is the internationalization of agriculture improving the efficiency of farmers in poor regions through international transfers and spillovers of technology and knowledge? Are local producers better off as a result of agricultural trade liberalization? Is poverty being affected by the internationalization of agriculture? This study attempts in some degree to answer these questions through the creation and analysis of an agricultural tradability index (TI), which measures the degree to which a country or an individual farm produces commodities that are internationally traded as opposed to commodities for which international trade is small. Using data from Chile three analyses are undertaken. First, a TI at the national level is constructed for 37 traditional and non-traditional crops, and its impact on corresponding yields for these crops is analyzed for the period 1991-2005. Results show that the TI is positively correlated with growth in crop yields. Second, the role of the TI at the farm level is analyzed. Using farm-level data from the 1997 Chilean agricultural census, a cross-sectional regression is used to evaluate the role that international agricultural trade—measured by the farm-level TI—has on yields of traditional crops (grains and beans are the main crops in the census for which farm-level yields are reported). In order to consider the trade structure of agriculture in Chile, this analysis is performed on two different groups of farms: 1) farms that produce exclusively traditional crops, which are heavily influenced by import trends; and 2) farms that in addition to producing traditional staples also produce non-traditional crops (especially fruits), which are more heavily exported. An endogenous switching regression model is used to predict which farms produce only traditional crops versus those that produce both traditional and non-traditional crops. The results indicate that, in general, farms with a higher TI have higher yields. Also, comparing the two groups of farms, those producing both traditional and non-traditional crops have a larger coefficient for the TI variable than farms producing only traditional crops. Third, the role of the TI at the community level is analyzed. Using data from different sources, a cross-sectional regression is done to evaluate the role that international agricultural trade—measured by the community-level TI—has on the poverty rate reported in Chilean communities. Including variables controlling for spatial dependence on poverty presence, results indicate that in general communities with a higher TI have less poverty.

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Chapter 1

INTRODUCTION

The effect of international trade on development has been a topic widely discussed by researchers during recent decades. Within this discussion Carter *et al.* (1996) state that the scholarly positions can be summarized in two main branches: one group advocates for the great contribution of international trade to macroeconomic performance and productivity; the other group worries about impacts on equity and local development. Many researchers have employed cross-country models, which in general find a positive relationship between trade and growth (Frankel & Romer, 1999; Edwards, 1993) and between trade and productivity (Badinger, 2007; Edwards, 1998; Jonsson & Subramanian, 2001). The latter branch has been supported by the study of particular country cases, which are more emphatic when highlighting caveats regarding the particular conditions necessary to obtain gains from trade. This thesis attempts to contribute to this debate by analyzing whether, and to what extent, international trade in agricultural commodities affects the productivity of agriculture in Chile, a country on the transitional path from traditional to modern agriculture. Additionally, considering the second branch of scholarly concerns about trade, this study also evaluates if the trade/productivity relationship in agriculture has any effect on poverty.

In order to use international trade as an explanatory variable in growth models, researchers have employed different approaches and methods (Harrison, 1994). One widely used and tested trade variable is the trade dependency ratio, which is equal to the share of imports and exports in the total GDP of a region (Harrison, 1994; Jonsson &

Subramanian, 2001; Frankel & Romer, 1999). Following the method for creating this variable, one of the contributions of this study is the idea of assessing the international trade variable in a disaggregated form, considering the 'trade dependency ratio' *per agricultural commodity*. This study constructs a product-specific tradability index (TI) that measures the share of imports and exports in the total production of an agricultural commodity in a particular year. The quantitative nature of this index allows incorporating it as covariate covering international trade in economic models.

This thesis is an empirical study of the effects that international trade—measured by the product-specific TI—has on two main issues of rural development of Chile: agricultural productivity and poverty. For the productivity analyses, country- and farm-level analyses are developed, with the latter being a cross-sectional analysis of farms located in the mid part of Chile. The poverty analysis is done for communities[1], which are the minor civil division level that Chile has for an aggregated analysis of poverty. This introductory chapter will provide a background on the Chilean case, a description of the different objectives, and an outline of the thesis.

1.1 Background on Chile and its Agriculture Sector

After the military coup occurred in 1973, Chile became the first country in Latin America to shift from import-substitution to an open economy. This change meant several structural adjustments in macroeconomic policies and institutions, and one of the priorities given by authorities was to create an export-oriented strategy supported by a

[1] "Communities" is the best-found translation for *comunas*. These minor civil divisions are ruled by elected mayors positioned in municipalities that depend heavily on federal funds for their operational budget.

market-friendly regulatory system.

Before the political disruption of 1973, the Chilean agriculture sector was strategically managed under a grassroots development approach, where the famous icon was a profound agrarian land reform. This reform, started in 1962, expropriated and divided hundreds of *fundos* (large farms) land into small farms given to peasant associations throughout the country[2]. With the new militarized political regime the agrarian reform was abolished and the agriculture sector was transformed to a system based on market resource allocations. This transformation included, but was not limited to, the following: a strengthening of property rights that helped to improve access to land ownership; a reduction in government (public) services and expenditures; the privatization of input and product markets; a gradual elimination of price controls[3]; and the liberalization of trade (non-tariff barriers were eliminated and tariffs on most imports were rapidly reduced) (Foster & Valdes, 2006). However, it was not until 1984, with the reversion of the currency appreciation policy, when the agriculture sector really started receiving major private investment and generating significant profits. Agricultural commodity prices became more competitive for the export market and the import trend was adjusted by demand[4].

Geographically Chile has comparative natural advantages for producing different agricultural, forestry, and fishery commodities. Among agricultural products, certain

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[2] By 1960 the concentration of land ownership in Chile was among the highest in the world, where 73.4% of the active agricultural population controlled barely 1% of the arable land (Smith, 1974). This was one main cause that motivated the agrarian reform, which among others was supported by the American President J. F. Kennedy's Alliance of Progress Program, in the early 1960's.

[3] Except for wheat, oilseeds and milk.

[4] However, price bands remained for wheat and oilseeds, and were added for sugar.

fruits gained a considerable presence and growth in exports after trade liberalization. These commodities have been referenced in the literature as 'non-traditional exports', since they corresponded to products that were traditionally cultivated for local consumption but then started being exported (Barham *et al.*, 1992)[5]. In this thesis I include in 'non-traditional crops' all kinds of fruits and nuts, including avocados. These products, in general, have very low import flows and an important export market presence.

On the other hand, although the weather and soil conditions are propitious, the production of cereals and grains are not favored in the Chilean case. Chile does not have considerable large extensions of arable land as Argentina and Brazil do (direct competitors for cereal farms in Chile). This has meant that historically, and more consistently since trade liberalization, an important part of the supply of these goods has come from imports. In this study I refer to 'traditional crops' as mainly agricultural commodities that have in general been imported or that have not been considered as cash crops for export markets. Tables 2 and 3 present agricultural commodities divided by traditional versus non-traditional crops[6].

Based on the issues mentioned above, rural areas of Chile have seen important changes during the last decades. These changes have been characterized by a reshaping and modernization of agriculture, and a consolidation of the forest and salmon industries.

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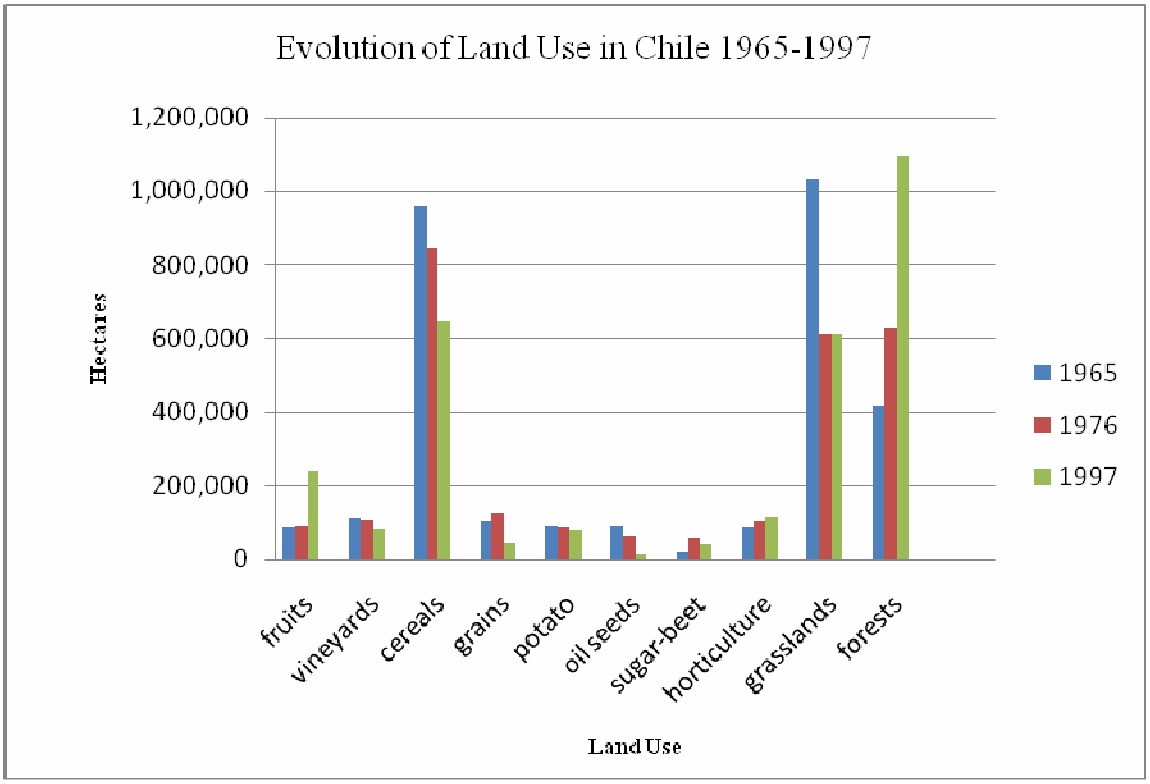
5 These authors also make reference to other two definitions of non-traditional export products: a) products that have not been produced in a particular region before, and b) products that have created new markets abroad.

6 In spite of the definitions given here, it can be noticed in table 2 that exportation does not necessarily occur for all the commodities considered as "non-traditional crops". Similarly some "traditional crops" do not have any imports at all, and some even have an export presence. These considerations do not alter my definition of "non-traditional" or "traditional" since the most important argument is that for the Chilean context, production of traditional crops is not driven by export markets.

Figure 1 shows the trends in land use during recent decades by type of product.



Source: Portilla (2000)

Figure 1. Rural land use change between 1965 and 1997 in Chile.

As can be observed in figure 1, area devoted to fruits—non-traditional products—has shown significant growth since 1976, which clearly demonstrates the effect of trade liberalization (the same phenomenon explains the boom in forest plantations). The area devoted to cereals and grains—traditional products—has fallen considerably over time, a trend explained by the growth in imports from large producer countries such as Argentina and Brazil. Summarizing, the international agricultural trade structure of the country has clearly defined an increasing participation of non-traditional crops in the export market and of traditional crops in the import market.

The trade liberalization era has also been characterized by important reductions in the levels of poverty affecting rural and urban areas in Chile. Although poverty and inequality are still high, since 1987 the reduction in poverty has been considerable: in 2003 Chile had a headcount poverty rate of 18.59%, while in 1987 it was 46.08%[7] (Anriquez & Lopez, 2007). Historically, poverty in rural areas has been higher than in urban areas, although some convergence has occurred since trade liberalization: in the period 1987-1998 the poverty rate in rural areas was halved from 53.47% to 27.57%, and in 2003 was less than 2 percentage points higher than the country average[8].

Most of the empirical analyses performed in this thesis are geographically focused on the mid part of Chile. This zone practically covers virtually all agriculture linked to non-traditional crops[9], has good soils for agricultural production, and ideal weather conditions for production of both traditional and non-traditional products[10]. The geographic location of this zone can be seen in figures 2 and 3. Figure 2 shows the zone within Chile (the shaded area), while figure 3 displays an expanded map of this zone.

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7 Inequality has not shown the same reduction: the GINI index for 2003 was 55.83 while for 1987 was 56.74 (Anriquez & Lopez, 2007).

8 Note that the definition of rural in Chile changed in 1996. For this reason part of the reduction can be attributable to urban absorption of poverty formerly considered rural.

9 Although northern regions have an important presence of grapes, most of these are oriented to the Pisco industry (a liquor only produced in these northern regions), a product that is not exported. Southern regions have also some presence of apples and berries, but practically do not have any significant presence of other fruits.

10 In particular this zone is considered to have a 'Mediterranean' climate, since climatologically it has similar conditions to those in Italy, southern France and Greece.

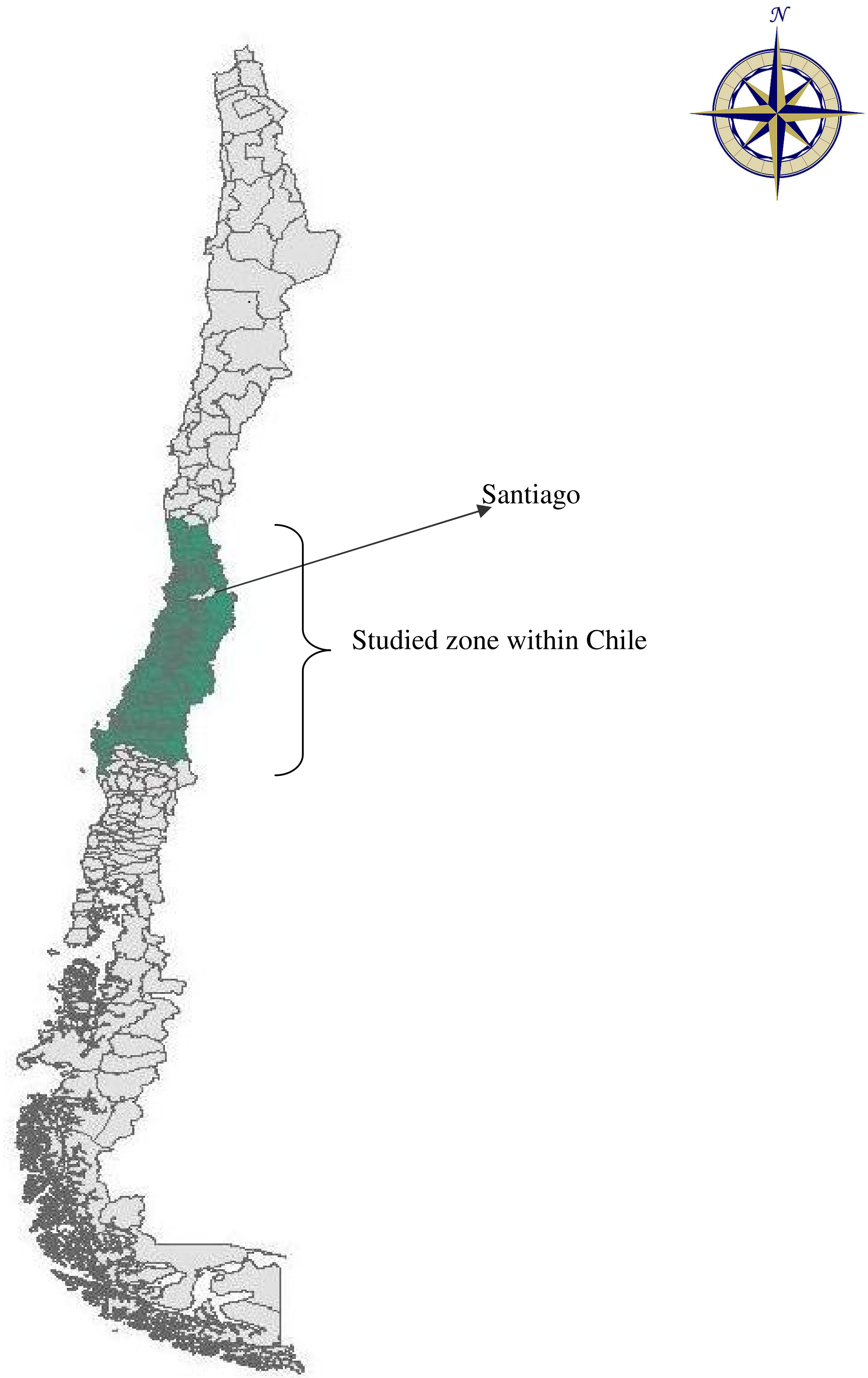

Figure 2. Map of Chile highlighting the studied zone.

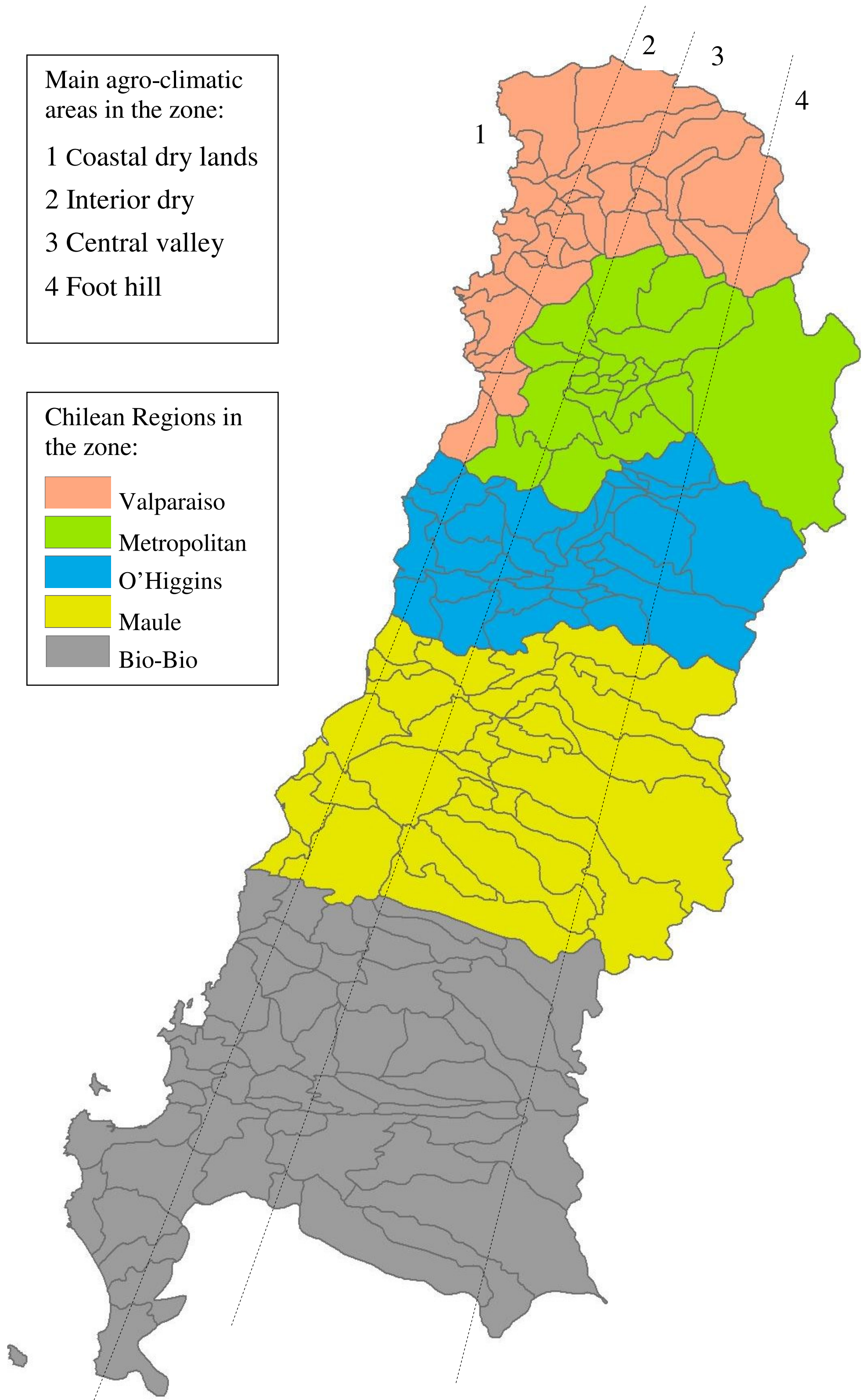

Figure 3. Communities, regions, and agro-climatic areas of the zone under study.

In figure 3 it is possible to observe the civil divisions of the zone in regions (colors) and communities (line borders). From north to south the zone includes five regions of Chile: Valparaiso, Metropolitan, O'Higgins, Maule, and Bio-Bio[11]. Within these five regions it is possible to find 207 communities[12] and more than 90,000 farms. Moreover, in figure 3, the dashed lines provide a proxy subdivision of four main agro-ecological areas that exist in Chile: coastal dry lands (1), interior dry lands (2), central valley (3), and foothills or *precordillera* (4). These areas have different conditions for agricultural production, which are important to consider when evaluating agricultural productivity. Table 1 shows some important facts of the zone under study in comparison to the entire country.

Table 1. Some comparisons between the studied zone and the entire country.

	Area Under Study	Chile
Population (2002)	11,211,528	15,116,435
Population excluding Santiago (2002)	5,782,938	9,687,845
Number of communities (1997)	207	342
Surface in Km^2 (2007)	115,524.1	755,838.7
% of GDP (2006)	74.47	100

Note: in parenthesis the year of the corresponding comparison data
Source: own elaboration using data from INE (1997) and SINIM (2007)

The main information to highlight from table 1 is that the capital of Chile—Santiago—is located in the area under study. This city concentrates most of the

[11] These regions correspond to administrative districts in Chile and are also known as 5, 13, 6, 7, and 8 regions, respectively.

[12] Note that the Santiago metropolitan area alone encompasses more than 30 communities, which are merged in one community in figures 2 and 3.

population and financial resources of the country, and has practically zero agriculture. These characteristics mean that other Chilean cities (including the ones within the zone under analysis) practically lose relevance when comparing them with Santiago. As a matter of fact, the next urban concentration in ranking has only around 10% of Santiago's population.

1.2 Research Questions and Core Objectives of the Study

The discussion of this thesis is centered on gaining a greater understanding of local agricultural productivity and poverty responsiveness to international agricultural trade. Several questions suggest themselves: Is the internationalization of agriculture improving the efficiency of farmers in poor regions through international transfers, spillovers of technology and knowledge, and competition? Is the export market tendency affecting the efficiency of farmers? Do imports affect the productivity of a farm facing this international competition? Are local producers better off as a result of agricultural trade liberalization?

This thesis is an empirical study that attempts to shed some light on these questions. Different levels of analysis are included in the study in order to address different perspectives and obtain sound conclusions about the potential effects of trade on productivity and poverty. The keystone of the empirical analyses of this work is to consider international trade through a 'product tradability index' that measures the weight of an agricultural commodity in the international market of Chile (more details about this index is provided in section 3.1). Thus it is hypothesized that a positive correlation exists between the tradability index and agricultural productivity, and a negative correlation between the tradability index and poverty rate. To determine whether this general hypothesis is supported, a series of objectives must be addressed.

Objective 1: Evaluate the role of international trade in the national long-term agricultural productivity growth.

In order to test the accuracy of the product tradability index as measure of international trade, it is important to first check whether this index has some relationship with the national average productivity growth of the particular agricultural commodity. The presence of a positive and significant correlation in this relationship will support the idea that international trade is indeed a factor that spurs agricultural productivity growth in the country.

Objective 2: Understand the influence of international trade upon local farm productivity.

Considering a farm tradability index (see section 3.4.1) in a cross-sectional analysis over farms located in the mid part of Chile, it is intended to estimate whether, and to what extent, international trade affects the productivity of a farm. Much like objective 1, the idea behind objective 2 is to empirically check whether or not international trade explains increases in productivity, but in this objective at the farm level in Chile.

Objective 3: Evaluate whether international trade affects the welfare of local communities.

This objective aims to complement the previous objectives looking now at the effect of international trade on poverty. Although trade could be increasing (or decreasing) agricultural productivity, this would not necessarily imply a reduction (or increase) in poverty. This objective will be accomplished by performing a cross-sectional regression upon Chilean communities using a community tradability index (see section 3.4.2) as an explanatory variable for poverty.

Summarizing, this thesis is an empirical exercise in testing the general hypothesis that the tradability index has a positive and statistically significant association with agricultural productivity and a negative, statistically significant association with the poverty rate.

1.3 Thesis Outline

This thesis is structured as follows. Chapter 2 provides a literature review that details the effects of international trade on the performance of agriculture and poverty. General findings, theoretical considerations and empirical limitations are summarized together with a brief summary of findings for the Chilean case. Chapter 3 provides a complete review of the methodology used to perform this study. Descriptions of the data and procedures used for incorporating international trade in the analyses are provided. The econometric models and their implications are also described. Chapter 4 details the results obtained for the different levels of analysis and empirical models. Finally, Chapter 5 concludes with the implications of the study and ideas for future investigation.

Chapter 2

LITERATURE REVIEW

An important and increasingly accepted implication of neoclassical economic theory is that trade-oriented economies experience more rapid economic growth than closed ones (Balassa, 1988). Along the same lines, it is also commonly accepted that improved productivity is necessary for sustained economic growth and development (Winters *et al.*, 2004). For these reasons, when we talk about agricultural and rural development, it is crucial to observe the effects of trade liberalization on agricultural productivity and how these affect poverty.

This chapter scrutinizes some theories and findings that have been discussed in the research literature to explain the effects of international trade on rural development. The particular effects of trade liberalization on agricultural productivity and on poverty are reviewed with more detail. This chapter is divided into four sections; the first section describes the theoretical base and empirical findings of the effects of trade liberalization on agricultural productivity. The second section reviews the poverty topic, as it relates to the influences of trade and agricultural productivity. The third section mentions some caveats to consider when using international trade as a variable in econometric models. And finally, the fourth section provides a summary of the main findings, related to the Chilean case.

2.1 International Trade and Agricultural Productivity

Several researchers have studied the impacts of trade liberalization on industrial and agricultural productivity of countries across the world. Using a sample of countries, Coe *et al.* (1997) and Edwards (1998) find that countries with greater trade barriers experienced slower productivity growth. Using individual countries for the analysis, Hay (2001), Ferreira and Rossi (2001), and Jonsson and Subramanian (2001) also find a positive link between openness and productivity. All these studies are based on the analysis of total factor productivity (TFP) at the industry level, concluding that in general firms facing import or export competition tend to increase their TFP.

However, it can be argued that despite the neoclassical theory implications—with its references to increased competition, access to new technology, better intermediate goods and so on—in general the response of productivity to trade liberalization is at most ambiguous (Krishna & Mitra, 1998; Winters *et al.*, 2004). On the import side, although firms can improve their total productivity due to international competitiveness, international prices can produce a reduction in productivity by an exodus of assets (human and financial capital) from local firms that become less financially attractive. Under these circumstances productivity gains would only emerge if the irreversibility of investment in capital does not impede the exit of less productive plants (Pavcnik, 2002). On the export side, although firms are more exposed to new markets through trade, innovation and R&D can be reduced in local economies due to the accessibility to already improved inputs from more developed countries.

For the particular case of agriculture, the same ambiguous aspects of the import and export sides may apply. Also, estimation of the trade/productivity relationship is complicated by difficulties in obtaining accurate measures of agricultural inputs or outputs (Martin & Mitra, 2001). This issue is even more critical for regions that still have traditional agriculture or ancestral forms of production, since data recollection is in many cases not adequately developed by researchers [see Rhoades (1990) for an interesting discussion about this topic].

In spite of the ambiguities and problems of assessing net outcomes produced by international trade on agricultural productivity, there are some clear effects important to highlight. These can be summarized in three concepts: accessibility, competitiveness and spillovers. Accessibility refers to the effects of trade in facilitating access to better and/or cheaper input factors from imports—see, for example, Grisselquist and Grether (2000) for a positive effect in Bangladesh—as well as new markets for exports. Competitiveness refers to the effort and resources that farmers should place in order to obtain a space in export markets or to avoid being picked off by import competition. Spillovers refer to all knowledge, technology, biological improvements, innovation and so on, that a farmer can receive by exposure to international markets—in this context, for example, Martin and Mitra (2001) state that in agriculture there exists a relatively rapid international dissemination of innovation.

It can be argued that for the accessibility and spillovers effects, improvements in agricultural productivity may indeed be easier for less-developed regions to bring about, i.e., the potential for raising agricultural productivity might be high[13]. However, in this context, it is the 'competitiveness' issue that produces more concerns in the net results, since a country not prepared for international competitiveness can see its agricultural

[13] For instance, in the case of technology, it is very lively that spillovers or transfers would go from a developed to a developing country and not vice-versa (Coe *et al.*, 1997).

sector deteriorate. Along these lines, several researchers and international institutions claim that clear and consistent policies along with infrastructure improvements are critical factors that ought to be considered by planners in order to attain net positive effects from international spillovers, accessibility to new markets, and import/export competitiveness (Irz *et al.*, 2001; Rodrick *et al.*, 2004).

The effects of trade on productivity can be encompassed in short and long term. Trefler (2004) argues that in the short term the main impact would be labor displacement and earning changes, while in the long term the net effect would be an adjustment of higher efficiency. In agriculture both effects may happen, although with different magnitudes according to the rural reality of a region. Thus, if the countryside is characterized by small farmers, short-term effects can be less important than long-term. By general equilibrium peasants will continue producing in the long run only if their profits are larger than to liquidate their land. In this context the large producer may take advantage of scale effects and advanced technology. On the other hand, if the countryside is characterized by large farms, trade liberalization would indeed impact employment in the short term, adjusting productivity in the long run by lower employment per unit of output or by better uses of technology available internationally.

2.2 International Trade, Agriculture and Poverty Alleviation

Several studies have demonstrated that agricultural growth is an important path to reducing poverty. Lipton (1977) was one of the first researchers to claim that improvements of agricultural technology are indeed an effective tool for reducing poverty in developing countries. More recently, Mellor (2001) argues that agricultural productivity reduces both rural and urban poverty, a theory supported by Datt and Ravallion (1998), who demonstrate for the Indian case that crop yield is inversely related to poverty. The positive economic growth role of agricultural expansion has been shown in different realities: it was agriculture the sector that supported the economic growth of developed countries, like the US, before its extensive industrialization (Eswaran & Kotwal, 2006); agriculture is the base of economic growth of practically all developing nations of the globe (Self & Grabowski, 2007); and even in middle income countries (where agriculture accounts for a small share of the total GDP) agriculture is one of the most relevant actors in the challenge of reducing poverty (Anriquez & Lopez, 2007).

There are three main channels—theoretic arguments—that explain the poverty reduction effect of agriculture: (*i*) labor market channel, (*ii*) food market channel, and (*iii*) direct poor farm-household effect channel (Anriquez & Lopez, 2007; Irz *et al.*, 2001; Thirtle *et al.*, 2001). The first channel is based on potential wage and/or employment increases that improvements of agriculture productivity might produce. Some authors consider that this channel is in fact the main source of poverty alleviation from agriculture (Anriquez & Lopez, 2007). However, this channel alone may not be sufficient and sometimes even detrimental for poverty reduction. For instance, if higher productivity reflected declining inputs rather than increasing outputs, its effects could be to reduce employment and hence increase poverty (Winter *et al.*, 2004). In reference to the second channel, poverty reduction would come from an increase of people's real income due to agricultural commodity price reduction. Anriquez and Lopez (2007) claim that in general this channel does not act effectively in open economies, where prices are driven by international influences and therefore local improvements in agricultural productivity would not lead to significant price reductions. However, for non-tradable crops this channel would have important effects. For instance, for the Bolivian case De Franco and Godoy (1993) show that a productivity improvement in a non-traded crop such as potatoes has a better poverty alleviating effect than in internationally traded commodities. The third channel would improve farm household income through more outputs to sell (obtained from a better productivity). This effect is important according to the reality of the agricultural sector of a region. Thus, if small farms are predominant in an economy, a potential boost of agricultural productivity (and its potential output expansion effect) may improve the income of these farmers.

Although, in general, agricultural growth appears to have the leading role as a poverty alleviating factor in developing nations, apparently this role is not that significant for the Latin American region, where high income and land inequalities prevent the poor from gaining. In this line, Thirtle *et al*. (2003) found that research-led technological change in agriculture generates high productivity growth that is largely reducing poverty in Africa and Asia, but not significantly in Latin America. This argument is supported by de Janvry and Saudolet (2000), who argue that the reduction of rural poverty produced in Latin America in the period 1980-1996 was mainly due to rural-urban migration. In a summary about the theoretical implications of agricultural productivity growth on poverty, Irz *et al*. (2001) describe how in theory the effects of agriculture on poverty, and the extent of these, will depend heavily on the circumstances of a particular case. Latin America would not necessarily present adequate channels for obtaining real gains from agricultural improvements.

On the general topic about the effects of international trade on poverty, several researchers argue that the outcomes are mostly positive. The work of Dollar and Kraay (2004) shows how trade liberalization is favorable to the economic development of poor countries. However, when talking about particular cases and realities the findings provide more ambiguities than clarifications. Winters *et al.* (2004) provide a wide survey of the literature on this topic, where the main conclusions advocate for at least an ambiguity of the real results of trade as a poverty-alleviating factor in the long run and on average. However, these same authors claim that there is strong evidence for the beneficial impact of trade liberalization on productivity, where agriculture is not an exception. Agricultural knowledge is rapidly spreading and developing countries are still on a path of productivity improvements from knowledge and spillover gains from other more developed countries (Martin & Mitra, 2001). Considering these relationships, it can be argued that, in general, trade would reduce poverty in stagnant regions through improvements in agricultural productivity.

International trade also produces different effects on rural well-being that in some degree can be attributed to long-term capital flows. In a developing country context, it is expected to find high investments in the production of commodities that face new commercialization opportunities due to trade liberalization, which in most cases for rural areas will correspond to natural resources such as mining, forest and agriculture. In this topic, Key and Runsten (1999) scrutinize one important approach related to investments in rural zones of developing countries: contract farming. These authors claim that contract farming has the potential to reduce poverty through the participation of small producers in the modern agriculture sector. Credit, insurance, and inputs are some of the arrangements proportioned by private companies in contracts with producers, factors that commonly involve dependency and inflexibility in farmers' decisions (Key & Runsten, 1999), which in the long term might affect revenues and therefore the income of local farmers.

2.3 International Trade in Empirical Models

In the academic literature it is possible to find international trade (or trade liberalization) assessed in different forms and measurements for testing its association with growth or productivity (Harrison, 1994). One typical measure used is the 'trade dependency ratio', which is calculated as the ratio of the sum of export and import values over total GDP. This ratio has been used in a wide variety of studies, proving in general to be a reliable variable as a measure of trade in models of growth or productivity (Edwards, 1998; Jonsson & Subramanian, 2001; Frankel & Romer, 1999). It is precisely based on this measure how in this thesis the tradability index is created, considering the volume of imports, exports and total production of particular agricultural commodities. Section 3.1 describes more in detail the concept behind the TI and how it is measured in this study.

However, in a survey of the literature about the role of trade in development, Edwards (1993) argues that 'researchers should be aware that all encompassing indices of trade policy that are free of measurement error will *not* be found' (Edwards, 1993, pp.1390). In this way, it is not a novel point to affirm that to use international trade as a variable might induce errors in estimations of empirical models. The most important problem with the international trade variable when predicting growth or productivity is the potential endogeneity problem that it carries. Edwards (1993) claims that most studies fail in not considering the potential causality and simultaneity problems that trade has with growth: trade can influence growth but also countries whose income are high due to reasons different than trade may in fact trade more. In order to account for this problem, an interesting empirical study by Frankel and Romer (1999) suggests the use of instrumental variables for resolving the endogeneity problem of trade. These authors use an instrument for trade based on the geography coefficient of a gravity model, considering that trade is directly affected by the size and the distance between countries. Bardinger (2007) uses a similar approach in order to resolve the endogeneity problem of trade with productivity and competitiveness (a relationship that has a causality problem similar to the one of trade with growth). However, the Frankel and Romer (1999) study, as well as the one of Bardinger (2007), empirically show that the use of the instrumental variable is not as accurate as the use of a direct variable for trade. This implies that although the endogeneity problem is an important issue to consider, its correction is not straightforwardly done with the use of instruments and that the endogeneity issue would not give major problems to the final interpretation of empirical results[14].

Another important consideration when using international trade as a variable for explaining productivity or poverty in a region is to understand the role of the political environment of a region. Rodrick *et al*. (2004) warn that cross-country models predicting the effect of trade on growth can be misspecified due to the omission of an important explanatory variable: the quality of institutions in the country. In other words, cross-

[14] They found coefficients for the instrumental variable anomaly larger than the ones of OLS using the 'trade dependency ratio'. This would imply that perhaps instead of having an upward bias from the endogeneity issue, the direct international trade variable is even under-estimating the real effect of openness on growth and/or productivity [see Rodriguez and Rodrick (1999) for a critical review of Frankel and Romer's article].

regional studies that argue that trade is a positive factor for long-term growth might be inconsistent since there is no control for unobserved institutional heterogeneity (Rodrick *et al*., 2004).

2.3 Findings for the Chilean Case

Studying the link between trade and productivity in Chile, Tybout *et al.* (1991) and Pavcnik (2002) found that after trade liberalization productivity increased in industries facing export-oriented and import-competing sectors. In particular focus to the agriculture sector, Olavarria *et al*. (2004), using a Tornqvist index for measuring the total factor productivity of Chilean agriculture, found that the annual productivity growth rate from 1961 to 1973 was 2.33%, while from 1974 to 1996—that is after trade liberalization—it was 3.78%. These numbers suggest that international trade has somehow affected productivity growth, which even acquires more significance if we consider that the 1982 and 1990 international recessions produced a fall in Chilean agricultural productivity growth[15]. Supporting this finding, Arnade (1998) and Foster and Valdes (2006) argue that Chilean agriculture has, in fact, experienced a gain in overall productivity after trade liberalization, which is measured by the latter authors as a positive productivity shift of 16%.

The main actors in the Chilean agricultural export sector have been transnational fruit corporations (TFC) such as Dole and Del Monte. These companies have spurred the expansion of international markets due to their advanced global networks (Gwynne, 2003), and the introduction of important investments in new techniques (Barrientos,

[15] Olavaria *et al*. (2004) report that year 1985 and 1987 presented the most negative rate of all the period analyzed (1961-1996).

1997). These TFC have made most of their business in Latin America through contract farming, where Chile was one of the first countries to have this kind of deal with foreign investment (Gwynne & Ortiz, 1997). Although contracts have the potential to reduce poverty and facilitate the transition from traditional to modern agriculture, some of the arrangements proportioned by TFC in contracts involve dependency and inflexibility in farmers' decisions (Key & Runsten, 1999). In this line, Gwynne and Ortiz (1997) argue that some TFC and large producers have acquired land through reduced prices from small producers, taking advantage of debts and lack of bargaining power produced by the inflexibility problem of contract farming. This land concentration consequence, as mentioned by Lopez and Valdes (2000), is very likely to be producing more rural poverty in some zones of Chile.

On the other hand, the export sector has also played a role modifying rural poverty rates through employment. In general, the agricultural export industry has been an important job source for rural women, since they have had the opportunity to work as *temporeras* (seasonal work for harvesting, pruning, packing, etc.), and therefore to generate a new source of income for their families (Barrientos, 1997).

On the other side of the coin, imports have also meant important changes for Chilean agriculture. In general, the main observable impact relates to the total land destined to traditional products, which has shown a reduction over recent decades (see figure 1). On the buyer side, there is evidence of high concentration and vertical integration. These come mainly from the role of retail food sales in huge supermarket chains, which has produced significant pressure on the competitiveness of local producers in terms of volume and quality (Foster & Valdes, 2006). Nevertheless, Foster and Valdes

(2006) state that for Chilean southern farms (farms that predominantly have traditional crops) trade liberalization and market-oriented environments have supported important gains in productivity. These authors even argue (although warning of the need for more research) that gains in productivity of traditional crops have been similarly available to small and large farms.

Some studies have found that the role of agriculture in Chile is in fact important for reducing poverty. For instance, Anriquez and Lopez (2007) found that after increasing agricultural output by 4.5%, the national poverty rate would fall between 2.7% and 4.5%. In this relationship, trade liberalization has played an important role, since most agricultural growth in Chile has been linked to international commerce. The agricultural non-traditional export industry in Chile is relatively high in labor use, which has permitted an important source of poverty reduction in the countryside. However, O'Ryan and Miller (2003) claim that it is traditional agriculture that plays a more important role for the poorer groups in terms of income.

It can be asserted that, in general, trade liberalization in Chile—jointly with the structural reforms launched during the 70's—has contributed to increases productivity in both traditional and non-traditional crops. However, the real impacts on wellbeing have been at least ambiguous: while some research states that during the last 30 years there have been improvements in employment and household income as well as reductions in poverty and rural/urban migration (Foster & Valdes, 2006), other authors argue that trade effects have not been good enough for rural economies, because smallholders have been negatively affected by the new structure of Chilean agriculture (Gwynne, 1993; Gwynne

& Ortiz, 1997; Gwynne & Kay, 1997), and because there has been an important deterioration on social capital (Shurman, 2001).

Chapter 3

FRAMEWORK AND RESEARCH METHODS

Different approaches can be considered when evaluating the effects of trade on the agricultural sector of a country. Among the different alternatives, it is possible to find analyses focusing on input and output price changes, the share of agriculture in national GDP, changes in agricultural input shares, and productivity changes. This study takes the last approach, considering crop yields as direct productivity measure.

Considering that the effect of trade upon agricultural yields can be affected by external factors, it is important to look at this relationship at macro and micro levels. Two main analyses are undertaken: a national-level analysis looking at the relationship between trade and the national average growth of crop yields in Chile, and a farm-level cross-sectional analysis of yields on Chilean farms.

The objectives of this thesis go further than just to evaluate agricultural performance. In addition to the analyses of crop yields, this thesis also analyzes whether the interaction of international trade and productivity affects the poverty rate of local economies. For this purpose I include in this study a community-level analysis, which aims to evaluate the role that the interaction of trade and productivity has on poverty in different communities of Chile.

Summarizing, in an attempt to evaluate the impacts that Chile faces from international agricultural trade, this thesis consists of two main approaches at three different levels of analysis: national-level and farm-level analyses of the influence of international trade on agricultural productivity, and a community-level analysis for estimating the impacts of trade on poverty. This chapter describes the main data, procedures, and models employed.

3.1 International Trade Variable: The Tradability Index

As was described in the previous chapter, both the theoretical and empirical literature have reviewed and debated the potential influences of trade on agricultural productivity and poverty. This study aims to complement this debate through the use of a novel approach for assessing trade in econometric models. This approach considers the weight of international trade that a particular agricultural commodity faces in local economies.

This thesis assesses international trade through a product tradability index (TI), which measures the share of exports and imports in the total local production of a particular agricultural commodity. The TI index can be expressed as

$$TI_{ij} = (Exp_{ij} + Imp_{ij}) \;/\; Total\ Production_{ij} , \tag{1}$$

where TI_{ij} is the product-level tradability index of commodity j in year i . On the right-hand side, the numerator is the product quantity associated with international trade for a particular year: the summation of exports and imports of commodity j that the country faces in year i. The denominator corresponds to the total quantity of commodity j produced in the country for the specific year i. The TI's lower bound is zero for the case of commodities that do not cross the border; there is no upper bound since this will depend on the local production of the crop, which could be zero. A crop that is not produced in the country and is only imported would have an infinite TI index. However, this latter case will not happen in this study since I am looking at the effects of trade on crop yields, and therefore at crops that have at least some presence in the country[16].

3.2 Levels of analyses

In order to evaluate the effects of international trade on the rural development of Chile, this thesis considers three main levels of aggregation: national, community and farm levels. Theoretically and empirically each level of analysis implies different approaches and limitations. For this reason it is important to describe the methodology used for each case.

3.2.1 National-Level Analysis

At the national level, crop yield is a variable that expresses important information about the performance of a country's agricultural sector. Thus, the role that the TI plays in the growth of yields to some extent demonstrates whether international trade is improving agriculture in a country. It can be argued that countries facing more competition from international markets will tend to be more efficient. Thus, the question arises of whether this statement can be applicable to the transitional agriculture of a developing country like Chile. Based on this claim, following hypothesis is presented.

Hypothesis #1: *The higher the international tradability that an agricultural commodity presents, the higher its yield growth over time will be.*

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[16] Refer to table 5 for a list of the commodities considered in this work.

The null hypothesis would be that the product-specific TI has either a negative effect or no effect on the average yield growth of a commodity. Thus, in order to evaluate hypothesis 1, this study proposes to perform an econometric evaluation of the association that exists between TI and yield growth. If the correlation is either negative or statistically not different from zero, the null hypothesis would not be rejected. Section 3.5.1 describes in detail the empirical approach and variables to be used in order to test the null hypothesis.

3.2.2 Farm-level Analysis

In order to theoretically express how the TI affects productivity, consider the following model:

$$Q = T\,\mathrm{f}(C, L), \tag{2}$$

$$T = \mathrm{g}(FTI, K, O), \tag{3}$$

where Q is output, C is a set of quasi-fixed conventional factors of production such as irrigation and land size, L is a set of variable conventional factors of production such as labor and fertilizer, T is the level of total factor productivity, K is a set of farmer-specific characteristics such as education and sex that may affect productivity, O represents other forces affecting productivity, and FTI is the farm tradability index[17]. This variable aims to capture the potential effects of international trade on productivity.

[17] The concept and measure of the farm tradability index are explained in section 3.4.1.

For estimation purposes, the functions ‘f’ and ‘g’, in (2) and (3) are approximated by a Cobb-Douglas form and *O* is approximated by an exponential time trend (Griliches, 1975), so that the production function model becomes

$$Q_t = Ae^{pt} \; L^{a}_{t} \; C^{(1\text{-}a)}_{t} \; K^{b} \, FTI^{c} \,. \tag{4}$$

On the right hand side, A is a constant and *p* is the rate of disembodied “external” technical change (Griliches, 1975). The empirical model of this Cobb-Douglas specification will be the log linearized expression given by

$$\ln Q_t = pt \ln Ae + a \ln L_t + (1 - a) \ln C_t + b \ln K + c \ln FTI, \tag{5}$$

where ln is the natural logarithm, and it is assumed that the conventional factors present constant returns to scale. However, as this study considers the analysis of an agricultural production function based on crop yields, equation (5) will retain a consistent theoretical base if this is rewritten to a form with all the conventional variables expressed per unit of land, given in this way as dependent variable the natural log of yield (Thirtle *et al.*, 2003). The full expression of this empirical model is given by equation (11) below. Based on this theoretic approach, the following hypothesis can be stated,

Hypothesis #2: *The higher the level of trade that a farm faces, expressed by its farm TI, the higher the average yield of the farm will be.*

The null hypothesis would be that the farm TI has either a negative effect or no effect on the average yield of a farm. As can be noticed, this hypothesis is similar to hypothesis #1; nevertheless, hypothesis #2 might be more difficult to test due to the necessity of different explanatory variables to control for other factors affecting the productivity of an individual farm. In order to address this problem, this thesis considers different empirical approaches based on cross-sectional analyses upon Chilean farms. Section 3.5.2 describes the empirical approaches and variables to be used, according to the available data at farm-level.

3.2.3 Determinants of Community Poverty and the TI

As discussed in the previous chapter, the effects of agricultural growth on poverty have been widely discussed in the literature. Irz *et al.* (2001) provide a sound summary of the theoretical implications of this relationship at various levels of analysis. These authors show that, in general, agricultural growth would alleviate poverty, although restricted to certain local conditions.

Following the theoretical implications of agriculture productivity on poverty, this thesis includes the TI as a variable in order to evaluate the relationship between trade/productivity and poverty. In other words, since in the first two parts of this study I expect to find a positive correlation between the TI and yield (at the national and farm levels), this index might be used as a proxy for the interaction of trade/productivity at the community-level, and thus we can expect an indirect causality: higher levels of TI would imply better productivity on farms and therefore less poverty in a community. This means that there will be a negative correlation between trade and the poverty rate. For the empirical implementation the poverty rate (PR_i) is expressed as a function of the TI and other pull and push factors that theoretically and pragmatically are related with poverty. In particular, I postulate for each community (represented by i) the relationship

$$PR_i = f(\mathrm{C}TI_i, X_i), \qquad (6)$$

where CTI_i is the tradability index calculated at community level (see section 3.4.2) and X_i is other poverty rate determinants (controls). Thus, the third hypothesis to test is that international trade (represented by the CTI_i variable) is a precondition to, and has a significant positive impact on, poverty reduction. The implication of such a hypothesis would be that communities that do not have crops that are internationally trade have a higher poverty rate than those that have these kinds of crops. This hypothesis can be formally stated as,

Hypothesis #3: *The higher the influence of international trade on a community, expressed by its community TI, the lower its poverty rate will be*.

The null hypothesis would be that the community TI has either a positive effect or no effect on the poverty rate of a community. Of course, other factors influencing the poverty rate in a community, which are represented by X_i in (6), should be considered as controls in the analysis. For instance, variables related to education should be considered since it is very likely that they will have a negative relationship with poverty, since the more human capital a community has the less poverty it would present. Other variables related to possible scale effects (size of the community), geographic isolation (distance from cities) and labor sources are also likely to influence poverty.

3.3 Data and Sources

For the national-level analysis, data from the FAO's FAOSTAT database are used; for the farm-level analysis the main data source is the 1997 Chilean agricultural census; and for the community-level, Chilean governmental and institutional sources were consulted. All the data management was done using the computational software Microsoft Excel 2007, Microsoft Access 2007, and STATA 10.

3.3.1 FAO Data Set

The FAOSTAT database provides access to agricultural data from more than 200 countries since 1961. For this study I used Chilean data from four categories: production quantity, import quantity, export quantity, and yield per hectare. Specifically, the data used considered 37 Chilean agricultural commodities. The average values of each category are provided in table 2.

Table 2. Chilean agricultural commodities and average category values for the period 1990 – 2005.

Commodity	Production quantity (tons)	Import quantity (tons)	Export quantity (tons)	Yield (kg/ha)	Yield growth over the period (%)
Traditional crops					
Artichokes	22,535.4	5	506.65	75,14.39	0.1404
Asparagus	17,825.86	41.34	3,080.01	42,43.33	5.7746
Barley	84,721.40	35,626.70	1,425.59	3,867.04	3.3888

Beans, dry	57,101.8	791.19	25,686.35	1434.45	3.6894
Beans, green	42,922.4	371.32	60.61	5799.05	0.5415
Cabbage and other brassicas	63,527.53	15.37	132.978	27937.62	-0.4401
Carrots	107,666.73	454.85	74.5	26,138.98	0.3474
Cauliflower and Broccoli	31,532.20	11.55	28.978	19,580.84	2.4735
Chilies and peppers	60,637.6	4.59	930.31	16,937.35	1.1357
Cucumbers	25,333.33	21.87	15.4321	22,761.49	0.0381
Lentils	5,391.27	10,714.06	402.574	754.71	5.7353
Lettuce and Chicory	70,155.13	25.5	1,799.91	13,312.58	0.5902
Maize	1,168,406.07	802,840.42	41,477.06	9,382.47	0.6847
Oats	290,687.67	4,053.81	12340.13	3,399.28	4.9833
Onions	296,107.93	2,138.27	45,784.66	40,120.01	3.4486
Peas, dry	29,82.93	4,952.48	339.40	921.59	4.4725
Peas, green	31,884.2	24.74	32	5,667.41	1.3233
Potatoes	1,009,745.66	4,346.34	1,835.91	16,823.34	2.4987
Rice	124,211.33	1,202.11	63.71	4,503.91	1.2954
Rye	2,874.06	11,717.33	197.01	2,604.08	4.7510
Tomatoes	1,145,736.26	12.27	2,916.98	59,357.16	3.8686
Wheat	1,571,370.4	441,861.59	256.24	38,77.01	3.1661
Non-traditional crops					
Apples	1,003,000.00	62.13	495,658.46	29,999.09	2.7527
Apricots	23,613.33	0	29,22.31	10,548.59	2.9877
Avocados	89,600.00	204.83	48,373.22	4,920.68	4.5128
Cherries	23,600.00	1.8	7,650.73	4,998.63	0.4120

Grapes	1,646,937.93	50.09	574,745.35	11,766.87	2.1912
Kiwi fruit	120,000	66	106,469.26	14,142.49	14.1354
Lemons and limes	122,933.33	213.16	14,582.2	17,628.03	3.7666
Oranges	110,400.00	184.95	4,360.46	15,767.13	1.7009
Melons and cantaloupes	65,154.8	14	349.298	15,008.67	0.5547
Papayas	6011	95.94	7.02	17,434.09	9.1268
Peaches and nectarines	263,166.66	1.5	90,833.77	14,258.50	2.2475
Plums	172,853.33	12.25	70,516.04	14,055.27	2.5098
Strawberries	19,673.33	12	94.18	23,593.89	1.2524
Walnuts	11,196	204.63	4343.80	1,444.39	2.3065
Watermelons	79,087.73	401.71	26.77	17,185.42	-1.3459

Source: own elaboration with data from FAO (2007)

Table 2 subdivides commodities into 22 traditional and 15 non-traditional crops. A mentioned in section 1.1, this subdivision is done mainly to separate fruits from cereals, beans and other agricultural crops[18]. The last column presents the average production growth of each product for the period 1990-2005, which is calculated from the 'yield per hectare' category. As can be observed, 35 out of 37 commodities present a positive yield growth, showing that Chilean agriculture improved its performance over the period 1990-2005.

[18] Fruits are more 'export oriented' than other agricultural commodities in Chile.

3.3.2 Chilean Agricultural Census

For the cross-sectional analysis of Chilean farms, data from the VI Chilean agricultural census were used. This census, conducted by the National Institute of Statistics of Chile, was performed during 1997 throughout the country. As mentioned in section 1.1, I focus the farm-level analysis on five Chilean regions in the middle part of the country, which includes more than 80,000 farms. Among these data, I consider only farms that produce at least one traditional crop; in other words, farms that do not present traditional crops in their production were excluded. I also excluded observations that correspond to companies or associations of farmers, focusing the analysis only upon individual producers. Moreover, farms that reported yields equal to zero in one of their reported crops were also eliminated from the final sample[19]. The final data consists of 73,332 farms.

One very important consideration is that the census does not report yields of non-traditional commodities. This is the main reason why this study considers only data from farms with traditional products in their crop alternatives[20]. Thus, in order to evaluate what happens with non-traditional crops, the sample of farms is divided in two groups:

- Group *(a)*: Farms producing both traditional and non-traditional products, and possibly other commodities.
- Group *(b)*: Farms producing traditional products and possibly other commodities.

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[19] As the census does not indicate if the zero yields were caused by crop failure or unwillingness to report data on the part of the farmer, the option of excluding all these observations was chosen.

[20] Traditional crops correspond to the ones reported in table 2 (in the 'traditional crops' category) plus tobacco, sunflower seeds, rapeseeds, and sugar beet.

The idea behind this subdivision is to have the opportunity to evaluate the effects of the TI on non-traditional products even though they do not have reported yields in the census. Thus, with the identification of group (*a*), it is possible to evaluate the role of the tradability index in a farm that also has potential spillover effects from the non-traditional products (or more predominantly, from fruits).

From the agricultural census it is possible to obtain farm data on total area, irrigation, ownership status, labor force employed, and use of machinery. Social data are also gathered from the census, where the sex, age, educational level and family size of the farmers are the main available variables. Table 3 summarizes the variables included for the cross-sectional analysis of Chilean farms.

The first row of table 3 provides the description of the yield variable, *YLD*, which is constructed from the yields of traditional crops reported by farms. Considering that the census data report yields from different crops and that it is not difficult to find farms producing more than one crop, it was necessary to transform these data into one comparable measure per farm. Thus, for the reported yields in the census a percentile rank transformation was performed in order to aggregate all the yield data of a farm into one variable. Specifically, the maximum yield reported in a region for a particular commodity was converted to 100, and the yields of the same commodity on other farms of the same region[21] were transformed in the percentile range with the formula:

Crop yield = (reported yield in the farm) x100 / (maximum yield reported in the region).

[21] The Valparaiso and Metropolitan regions were considered as the same region in order to include the variability coast/central valley/foothill presented in the other regions.

In the creation of this variable the presence of extreme outliers in the data, or unique farms reporting the highest yield, were adjusted to the second highest reported yield in the region. All the reported yields by farms were transformed using the formula above, giving, then, for all the commodities a yield situated in the range (0 – 100][22]. Finally, the *YLD* variable (the final yield per farm) was calculated as the average of the percentile yields of all the traditional crops reported by a farm in the census.

Table 3. Definitions and summary statistics of variables obtained from data of the VII Chilean agricultural census.

Variable	Definition	Mean	Std. Dev.
YLD	Average yield percentile rank of the farm (original data reported as quintals/ha.)	28.6791	18.0889
dNTD	Dummy for the presence of non-traditional crops in the farm (=1 if farm presents at least one non-traditional crop in production, 0 otherwise)	0.0773	0.2671
SURF	Total hectares utilized for agricultural production	11.0215	34.7641
IRRG	Proportion of total farm covered by irrigation	0.5491	0.6103
dMNG	Farm managed by a hired administrator (=1 if the farm employed a manager)	0.0597	0.2370
LABR	Number of employees that worked on the farm during the agricultural year	3.072	6.095
HHAD	Number of adults in the household	1.945	2.706
dMAC	Use of modern machinery (=1 if the farm uses this kind of technology, 0 otherwise)	0.6938	0.4608
dOWN	Ownership of formal land titling (=1 if farmer has official ownership records, 0 otherwise)	0.6829	0.4653
CAPT	Aggregated proxy value composed by the sum of the capacity of wells, warehouses, and silos (m^2)	45.7955	375.4833
INFT	Aggregated proxy value composed by the amount of constructions, roads, and other infrastructure	0.5193	1.7751
dSEX	Sex of the reported farmer (=1 if male)	0.8377	0.3686

[22] Note that farms reporting "zero yields" were not considered in the analysis, therefore the *YLD* variable actually varies from 0.6 to 100.

AGE	Age of the reported farmer	55.6155	14.0453
AGE2	Squared value of the *AGE* variable	3290.35	1572.20
dOXEN	Dummy for the presence of oxen on the farm (=1 if farm has at least one ox, 0 otherwise)	0.1954	0.3965
dFOREST	Dummy for the presence of forest on the farm (=1 if farm presents forest, 0 otherwise)	0.3355	0.4721
dRESID	Dummy for residence status of the farmer's family (=1 if family lives in farm land, 0 otherwise)	0.7142	0.4517
dMIRR[(a)]	Dummy for presence of modern irrigation (=1 if farm has modern irrigation, 0 otherwise)	0.0102	0.1006
$dEDU_1$	Dummy for farmer in educational level 1: basic education attained (maximum of 8 years)	0.6649	0.4720
$dEDU_2$	Dummy for farmer in educational level 2: high school education attained (maximum of 12 years)	0.1279	0.3339
$dEDU_3$	Dummy for farmer in educational level 3: technical education attained (maximum of 14 years)	0.0264	0.1605
$dEDU_4$	Dummy for farmer in educational level 4: superior education attained (maximum of 17 years)	0.0515	0.2211
$dEDU_5$	Dummy for farmer in educational level 5: no education attained	0.1291	0.3478
$dREG_5$	Dummy for farm location: region of Valparaiso	0.0300	0.1707
$dREG_6$	Dummy for farm location: region of O'Higgins	0.1945	0.3958
$dREG_7$	Dummy for farm location: region of Maule	0.3068	0.4611
$dREG_8$	Dummy for farm location: region of Bio-Bio	0.4225	0.4939
$dREG_{13}$	Dummy for farm location: metropolitan region	0.0460	0.2095
$dAEC_1$	Dummy for farm agro-climate zone: coastal dry lands	0.0907	0.2872
$dAEC_3$	Dummy for farm agro-climate zone: coast erosion	0.0737	0.2613
$dAEC_6$	Dummy for farm agro-climate zone: interior dry lands	0.0729	0.2600
$dAEC_7$	Dummy for farm agro-climate zone: interior erosion	0.0423	0.2014
$dAEC_8$	Dummy for farm agro-climate zone: dry lands valley	0.0161	0.1260
$dAEC_{14}$	Dummy for farm agro-climate zone: central valley	0.6108	0.5742
$dAEC_{15}$	Dummy for farm agro-climate zone: foot hills	0.0881	0.2835
$dAEC_{21}$	Dummy for farm agro-climate zone: mountains	0.0043	0.0658
$dAEC_{24}$	Dummy for farm agro-climate zone: urban	0.0011	0.0334

Source: own elaboration with data from INE (1997)
(a) Modern irrigation corresponds to all systems involving mechanical irrigation.

The last eight variables presented in table 3 correspond to agro-climatic locations of farms ($dAEC_{.}$). As was shown in figure 3, it is possible to easily identify four main zones: coastal dry lands ($dAEC_1$), interior dry lands ($dAEC_6$), central valley ($dAEC_{14}$), and foot hills or *precordillera* ($dAEC_{15}$)[23]. However, the census data also specify farm location on other agro-climatic zones that are in the studied area as well. These other agro-climatic zones are coast erosion ($dAEC_3$), interior erosion ($dAEC_7$), dry lands valley ($dAEC_8$), mountains ($dAEC_{21}$), and the special case when farms are located within—or very near to—cities ($dAEC_{24}$).

3.3.3 Community-Level Data

The community-level data originate mainly from the web site of the National System of Municipality Indicators (SINIM, 2007), which is provided by the Chilean government. On this web page it is possible to find a compilation of available Chilean community data from different institutions and ministries since the year 2000[24]. Among these data, the first variable described in table 4 is the community poverty rate (*PR*) reported by the *Encuesta de Caracterizacion Socioeconomica Nacional* (CASEN)[25], a survey that the Chilean government performs at the national level every three years. The poverty rate is defined as the proportion of households that in per capita terms do not have enough

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[23] The sub-index of each variable corresponds to the ID number given to each zone by the Agricultural Census (1997).

[24] In 2000 there were 207 communities in the studied zone, 209 in 2007.

[25] National socioeconomic survey managed by the Ministry of Planning and Cooperation, more known as MIDEPLAN in Chile.

money to cover the cost of two times a basket of basic food (CASEN, 2007)[26]. Unfortunately, the CASEN does not cover every community in the country; therefore the poverty rate, as a reliable variable, is not available for all the communities within the studied zone of this thesis. These communities are not included in the poverty analysis performed below. Additionally, I also excluded from the sample two communities that are islands and the communities that belong to the Santiago metropolitan area. The latter are excluded because there is practically no presence of agriculture in Santiago. In total the sample of communities considered for the community level analysis of this study is composed by 150 observations[27].

The other data gathered for the community-level analysis came from the 1997 Chilean agricultural census and from the Human Development Index (HDI) report for Chile of the United Nations Development Programme and the Ministry of Planning and Cooperation (UNDP & MIDEPLAN, 2006). Column 2 in Table 4 specifies the primary sources of each variable data and their corresponding year of collection.

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26 The urban poverty line assumes an Engel coefficient of 0.5 (the equivalent to 2 food baskets); however, the poverty line for rural areas considers an Engel coefficient of 0.75 (the equivalent to 1.75 food basket). This difference is already accounted in the statistics reported by the CASEN.

27 Appendix B shows a list of the communities and explains more the sample reduction. This appendix also provides regression results using an expanded pool of the sample.

Table 4. Definitions and summary statistics of the 150 communities of the sample.

Variable	Definition	Primary Source / year	Mean	Std. Dev.
PR	Poverty rate reported in the community	CASEN / 2000	26.5268	8.3835
HDIE	Average of the community Human Development Index value for education of 1994 and 2003	UNDP & MIDEPLAN (2006) / 1994 and 2003	0.6544	0.0536
POP	Total population of the community	INE / 2000	40022.67	65219.59
POPAD	Total population age 18 years and over	INE / 2000	26272.54	42409.77
DIST	Distance of the community to the regional capital (Km.)	SINIM (2007) / 2000	81.3370	50.4546
IRPW[(a)]	Hectares of modern irrigation system in the community	INE (1997) / 1997	.0033	.0098
AREA	Total surface of the community (Ha.)	SINIM (2007), 2000	72265.33	75256.95
DENST	Population density = *POP / AREA*	INE / 2000	1.6637	5.1065
AVAG	Average age of the population	INE / 2000	57.0215	3.6451
M2PW[(a)]	Total amount of m^2 constructed in the community the last 2 years	SINIM (2007) / 1999 and 2000	1.0842	1.4595
WKED	Interaction of variables = HDIE x POPAD		18487.46	31974.41
ALPW[(a)]	Hectares of agricultural land	INE (1997) / 1997	1.6573	2.0193
$dREG_5$	Dummy for community location: Valparaiso region		0.22	
$dREG_6$	Dummy for community location: O'Higgins region		0.14	
$dREG_7$	Dummy for community location: Maule region		0.1933	
$dREG_8$	Dummy for community location: Bio-Bio region		0.3266	
$dREG_{13}$	Dummy for community location: Metropolitan region		0.12	

Source: own elaboration using data from INE (1997) SINIM (2000) and UNDP & MIDEPLAN (2006)
(a): Indicates that the corresponding variable is considered at a per worker, instead of per capita, measure. This means that the data was divided by the variable *POPAD*, which is the number of people in the community of 18 or more years old

The second variable (*HDIE*) reported in table 4 corresponds to the human development index value for education, which in one variable aggregates information about the literacy rate, average educational level and educational coverage in a community (UNDP & MIDEPLAN, 2006)[28]. In this particular data source the only available indices correspond to the years 1994 and 2003; therefore, in order to incorporate this relevant variable to the analysis, the average value of *HDIE* 1994 and *HDIE* 2003 was used. The other variables in table 4 come from different governmental sources.

A lag of three years between the poverty rate and some independent variables is used, specifically *ALPW*, *IRPW*, *HDIE* and the *CTI*. This lag is used in order to better explain the effects of these variables on poverty. It is important to recall that the poverty rate data are not available for all the communities within the geographical framework of this study, and that I also excluded from the analysis all the main communities that are part of the Santiago metropolitan area; hence, for this section of the empirical study only 150 communities (85% of the total communities with agricultural production in the area) are used in the analysis[29].

3.4 The Tradability Index at Different Levels of Analysis

Based on equation (1) and on the data from FAO (2007), the first empirical procedure of this work is to calculate the TI of traditional and non-traditional Chilean agricultural commodities for different years. Table 5 shows the TI values calculated with the FAOSTAT data by commodity and year.

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[28] The HDI is an index that was created by the UNDP to evaluate the development level of countries of the whole world. Nonetheless, in Chile the UNDP, with the support of MIDEPLAN, has extended this index for all the 345 communities of the country. Thus, it is possible to obtain indexes, at a community level, for the years 1994 and 2003.

[29] See appendix B for more references and alternative regressions using an expanded pool of the sample.

Table 5. Product-level TI, values for selected years [(a)].

Commodity	TI 1985	TI 1991	TI 1997	Commodity	TI 1985	TI 1991	TI 1997
Traditional crops				Non-traditional crops			
Artichokes	0	0.0407	0.0278	Almonds[(b)]		0	0.3095
Asparagus	0.5367	0.2227	0.2412	Apples	0.5460	0.4849	0.5143
Barley	0.2238	0.0410	0.4850	Apricots	0.0649	0.1510	0.1100
Beans	0.5205	0.6987	0.4189	Avocados	0.0560	0.3525	0.3566
Beans green[(b)]			0.0026	Blueberry[(b)]			0.7
Cabbages	0	0.0002	0.0010	Cherries	0.1270	0.3089	0.2563
Carrots	0	0.0019	0.0011	Grapes	0.2289	0.3771	0.3255
Cauliflowers and broccoli	0	0.0036	0.0015	Kiwi	0.225	0.7302	0.9075
Chilies and peppers	0	0.0218	0.0220	Lemons and limes	0.0741	0.0303	0.0840
Cucumbers	0	0.0011	0.0005	Olives[(b)]			0.3130
Lentils	0.4198	0.300	2.1890	Oranges	0.0114	0.0057	0.004
Lettuce	0	0.0076	0.0168	Melons and cantaloupes	0.1222	0.0086	0.0023
Maize	0	0.2479	0.6614	Papayas	0	0.0003	0.00006
Oats	0.0587	0.0343	0.0431	Peaches and nectarines	0.2208	0.3550	0.3377
Onions	0.0742	0.1904	0.1241	Pears	0	0	0
Peas	0.0956	0.1993	2.1157	Plums	0.3442	0.4142	0.4140
Potatoes	0.0009	0.0010	0.0073	Raspberry[(b)]			0.1
Rapeseed[(b)]			0	Strawberries	0.0271	0.0034	0.0027
Rice	0	0.0001	0.0004	Walnuts	0.7138	0.7446	0.3111
Rye	0.0091	0.0009	0.0367	Watermelons	0.0010	0.0015	0.0046
Sugar-beet[(b)]	0	0	0				
Sunflower seed[(b)]			1.132				

Tobacco[b]			0.4656				
Tomatoes	0.0017	0.0026	0.0029				
Wheat	0.4907	0.1606	0.3462				
Average	0.1157	0.1036	0.3337		0.1726	0.2334	0.2526
Average2[c]	0.1008	0.0882	0.1755		0.1365	0.2014	0.2495

Source: own elaboration with data from FAO (2007).
(a): In order to avoid biases from shocks (from the demand or supply side) or rare weather conditions of particular seasons, all the TI values calculated and used in this work correspond to the average TI of the previous, following and corresponding years. Thus, for instance, the TI 1991 is in fact the average TI of the years 1990, 1991 and 1992.
(b): Products not used in the empirical procedure given by model (2) and (3) below since these commodities do not present all the necessary data in 1991. The TI values of raspberry and blueberry are assumed by the authors according to the Chilean reality.
(c): Average2 corresponds to the average value excluding lentils and peas in traditional crops, and walnuts in non-traditional crops.

From table 5 one can observe that after excluding peas, lentils and walnuts (products that suffered particularly extreme changes in their TI value for 1997), the values of the TI for non-traditional crops on average are higher than those for traditional crops. Complementing the data of table 5 with that reported in table 2, it may be noted that the TI difference between non-traditional and traditional crops points out the export-oriented nature of Chilean agriculture. While most of the TI value of non-traditional crops is explained by outward flows, the TI of traditional products is mainly explained by imports. However, up to 1997 exports were not significant in some non-traditional crops such as oranges and strawberries, and imports were not part of the TI of some traditional crops such as carrots.

3.4.1 The Tradability Index at the Farm Level

In order to evaluate the role of the TI on the yields of Chilean farms, a TI is also estimated at the farm level. The TI per farm is calculated according to the equation

$$FTI_i = [\, \Sigma \, (Cland_{ij} \text{ x } TI_{ij}) \,] \, / \, Tland_i \, , \qquad (7)$$

where FTI_i is the farm-level TI in year *i*. The variable $Cland_{ij}$ is the amount of farm-land cultivated with crop *j* in year *i*, $Tland_i$ is the farm's total agricultural land in year *i*, and TI_{ij} is the product-level tradability index for the commodity *j* in the year *i*. In this case, since the farm data come from the VI Chilean agricultural census, the subscript *i* corresponds to the year 1997.

The idea behind the *FTI* is to aggregate the international trade weight that a farm faces according to what it produces. For instance, in 1997 farms only producing wheat on their entire farm-land would have a farm-level TI of 0.34, while a farm producing only lentils and peas in equal land proportion would have a *FTI* of 2.15.

The estimation of the TI at this level of analysis uses data from the agricultural census, which allows calculating a farm-level TI for the 73,332 farms in the sample. Table 6 reports the descriptive statistics of the farm-level TI for the entire sample, for each group farm, and for the five Chilean regions under study.

Table 6 Farm-level TI, main statistics.

	Average	Standard Deviation	Minimum value	Maximum value
Entire sample				
Farm-level TI (n = 73,332)	0.2335768	0.2062312	0	2.189008
Farms per group				
Farms group (*a*) (n = 5656)	0.2204654	0.1594477	0	1.613352
Farms group (*b*) (n = 67677)	0.2346725	0.2096328	0	2.189008

Farms-TI per region				
Valparaiso region (n = 2,203)	0.1584476	0.2197213	0.0000165	2.189002
Metropolitan region (n = 3,377)	0.1840359	0.1899443	0.0000639	2.016851
O'Higgins region (n= 14,266)	0.3636318	0.2315338	0	2.189001
Maule region (n = 22,502)	0.2195659	0.1900627	0	2.189008
Bio-Bio region (n = 30,985)	0.1946133	0.1796318	0	2.189001

Source: own elaboration with data from INE (1997) and FAO (2007)
Note: 'n' makes reference to the number of observations.

As can be observed in table 6, the minimum farm TI is equal to zero, which says that those particular farms have only crops with a TI very near or equal to zero (as strawberries or rice) for the year 1997, implying that there was virtually no international trade effect on its production.

3.4.2 The Tradability Index at the Community Level

In order to evaluate the role of international trade on the poverty rate of particular Chilean communities, a procedure for calculating a community-level TI is employed. Using the last column of table 5 (but now considering the total agricultural land of a community), similarly to equation (7), the TI for a particular community is calculated as

$$CTI_i = [\, \Sigma\, (\, TLTC_{ij} \text{ x } TI_{ij}\,)\,] \,/\, ACL_i\,, \qquad (8)$$

where CTI_i is the community-level TI in year i . The variable $TLTC_{ij}$ is the total land surface of the community used for the production of the particular crop j in year i, and

ACL is the total land of the community suitable for agricultural production in year *i*. Again the subscript *i* corresponds to the year 1997.

Similar to the farm-level TI case, the idea behind the *CTI* is to aggregate the agricultural international trade weight that a community faces according to what crops its farmers are producing. With the use of equation (8), a community-level TI is estimated for the communities within the regions under analysis. Table 7 shows the main statistics of the *CTI* in the 150 communities of the sample considered for the study of poverty.

Table 7 Community-level TI, main statistics.

	Average	Standard Deviation	Minimum value	Maximum value
Community-level TI	0.0890	0.0663	0.0020	0.3322
CTIF	0.0327	0.0456	0	0.1976
CTIT	0.0562	0.0476	0.0009	0.2775

Source: own elaboration with data from SINIM (2000) and INE (1997)

Table 7 shows a breakdown of the CTI index, i.e., the *CTI* is separated according to its sources: the index from traditional crops (*CTIT*) and the index from non-traditional crops (*CTIF*)[30]. This disaggregation is shown because, unlike traditional crops, non-traditional products are not cultivated in all the communities under study, which might produce a differentiated effect of trade on poverty.

3.5 Empirical Models

Based on the theoretical framework and considering the data availability described in previous tables, different econometric models were chosen for the analysis of the TI at

[30] In this way *CTIF* + *CTIT* = *CTI*

the three levels. The main econometric procedure employed is ordinary least squares (OLS). However, at each level of analysis alternative econometric procedures were considered, according to the specifics of each case.

3.5.1 The National-level Models

In order to begin the empirical analysis of the TI, a procedure is implemented for checking whether or not a correlation between trade and productivity at national level exists. Using FAOSTAT data, the 37 agricultural commodities reported in table 2 are used as observations for the correlation analysis. A standard linear model (Model I) is constructed, given by,

$$YavG = \beta_0 + \beta_1 (TI91) + e , \qquad (9)$$

where *YavG* is the average growth of yield of the particular agricultural commodity during the period 1991-2005, *TI91* is the tradability index of the corresponding commodity for the year 1991, and *e* is an error term.

I also consider an alternative model to control for other variables that may also affect productivity growth. This new model (Model II) also includes the natural log of yield in 1991 (ln*Y1991)*, the Italian yield growth per commodity (*YavIT*)[31], and an interaction term between *YavIT* and the *TI91* variable (*ITTI91*). Theoretically, ln*Y1991* is designed to capture convergence effects in productivities growth, *YavIT* is designed to

[31] This variable is also estimated from data of FAO (2007).

capture the state of the world level of technology in agriculture[32], and I*TTI91* is designed to capture interactions between Chilean trade and international improvements in agricultural productivity. Model II is specified as

$$YavG = \beta_0 + \beta_1 (TI91) + \beta_2 \ln(Y1991) + \beta_3 (YavIT) + \beta_4 (ITTI91) + e . \quad (10)$$

Model II captures the potential impacts that trade might have on agricultural commodity yields during the period 1991-2005, after controlling for the influences of the yield level at the beginning of the period and international spillovers.

3.5.1.1 The Potential Endogeneity Problem

In models I and II, given by equations (9) and (10), there is a potential endogeneity problem. This problem is related with the reverse causality problem, which occurs when two (or more) variables might be causing each other simultaneously. The dependent variable (*YavG*) and the independent variable (*TI91*) could be influenced by bi-directional causality, that is the TI affects yield growth while yield growth influences the tradability of a product. Even though TI is measured at the beginning of the 1991-2005 time period, this does not necessarily resolve the potential endogeneity problem (Self and Grabowski, 2007). The ideal solution would be to use instrumental variables such as the ones considered by Frankel and Romer (1999) and Badinger (2007), but appropriate instruments for a product-specific tradability index of the year 1991 variable does not

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[32] In this case I used the productivity growth of Italy, a developed country with similar agro-climatic characteristics to the study zone in Chile.

arise so obviously. For this reason the empirical approaches given by (10) and (11) are maintained as core analyses in order to avoid the use of poor instruments that could produce unreliable results.

3.5.2 The Farm-level TI Models

The econometric procedure for the cross-sectional analysis of Chilean farms considers two alternative approaches: a standard linear model using OLS estimates for the analysis of the entire sample, and an endogenous switching regression model for the analysis of each farm group *(a)* and *(b)*. The former approach uses a simple regression model based on the logarithmic Cobb-Douglas production function specification given by equation (5). This can be expressed as

$$\ln(YLD) = \beta_0 + \beta_1 (FTI) + \beta_2 \ln(IRRG/SURF) + \beta_3 (dMNG) + \beta_4 \ln(LABR/SURF) + \beta_5 (dOWN) + \beta_6 (dMAC) + \beta_7 \ln(CAPT/SURF) + \beta_8 \ln(INFT/SURF) + \beta_9 (dSEX) + \beta_{10} \ln(AGE) + \beta_{11} \ln(AGE2) + \beta_{12\text{-}15} (dEDU_n) + \beta_{16\text{-}23} (dAEC_m) + \beta_{24\text{-}27} (dREG_p) + e \,,$$

n = educational levels,

m = agro-ecological areas,

p = regions (see table 3), (11)

where ln denotes the natural logarithm. The dependent variable in the production function is the natural logarithm of yield (*YLD*) of a particular farm. The conventional factors include the proportion of farm area covered by irrigation (*IRRG*), a dummy variable for the presence of a hired person as manager of the farm (*dMNG*), total farm labor (*LABR*), a dummy variable for the use of modern agricultural machinery (*dMAC*), a dummy variable for farmers with possession of formal land titles (*dOWN*), a variable for the amount of fixed capital in the farm (*CAPT*), and a variable for the amount of infrastructure on the farm (*INFT*). The non-conventional factors include a dummy variable for the sex of the reported producer (*dSEX*), the age and age squared of the farm head, the farm-level tradability index (*FTI*) variable and dummy variables for the educational level of the producer (*dEDUn*). In addition to these conventional and non-conventional factors, this model also includes dummy variables for agro-ecological zones ($dAEC_m$) and regional ($dREG_p$) location of the farm, as control for yield differences across different areas of Chile[33].

As mentioned in section 3.1.2, model (11) has a solid theoretical base, as it is an agricultural production function, with the conventional variables expressed per unit of agricultural land (Thirtle *et al.*, 2003). All the conventional and non-conventional production factors are expected to have a yield-increasing effect, including *FTI*.

The log transformations are performed to keep the Cobb-Douglas production function form and thus to obtain results straightforwardly interpretable as elasticities. In order to permit estimation in the presence of zero inputs, a constant equal to one is added to all the variables converted to ln (with the exceptions of land and age), since a farm will not always have all the inputs considered in the model. The *FTI* variable is not converted

[33] Both site dummies are different since the agro-ecological dummy looks for controlling soil quality and micro-climate specific conditions, while regional dummy seeks to control for governmental administrative influences and in somehow rain conditions (from north to south Chile presents an increasing rain average).

to logarithms in order to better evaluate its impact on yields (considering that the *FTI* values range from 0 to only 2.189). Alternatives were tried incorporating the natural logarithm of *FTI*[34] to the model, as well as one alternative considering a complete linear version of the model. These alternative estimations gave, in general, qualitatively similar results to those shown below.

3.5.2.1 Analysis per Farm Group: An Endogenous Switching Regression Model

As mentioned previously, the farm sample is subdivided into two groups in order to evaluate the role of the TI effect from both (*a*) farms with both traditional and non-traditional crops, and (*b*) farms having only traditional crops. On that account, an econometric analysis can be performed for each farm group and in this manner evaluates if the *FTI* affects them with similar or different degree.

The question arises whether farms that have non-traditional crops also have a greater average productivity over the entire sample. If concerns that the *FTI* and conventional and non-conventional factors of production indeed have differential effects on yields of farms (*a*) and (*b*), separate production functions for each farm group ought to be specified. Hence, if model (11) is considered for each farm group without taking into account the potential differential effects, the resulting OLS estimates could be biased due to a sample selection problem (Heckman, 1979)[35].

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[34] The transformations was done adding 1 (and alternatively also a 0.1) as constant, since many farms present a TI of zero.

[35] Concern of an endogeneity problem due to self-selection is important to consider. Specifically, the adoption of non-traditional crops by farms (*a*) could be either voluntary or as consequence of external characteristics not presented in farms (*b*).

As a way of dealing with these problems I use an endogenous switching regression model, which accounts for both sample selection and endogeneity problems (Alene & Manyong, 2007). This model allows interactions between both farms groups and covariates in the production function: one production function for group (*a*) and one production function for group (*b*) (Goetz, 1992; Fuglie & Bosch, 1995).

The endogenous switching regression approach is a two-stage model that uses first a probit model to determine the criterion of a farm in having or not having non-traditional products, and then second step equations to estimate the production function of each group separately [farms of group (*a*) with non-traditional crops and farms of group (*b*) without non-traditional crops], conditional on the criterion established in the first step. This thesis first uses a probit maximum likelihood specification to model the farmer decision of having or not having 'non-traditional crops' in production (the criterion). Let the adoption of non-traditional crops be a dichotomous choice, where farmers decide to plant these crops if they perceive a net positive benefit (B*). While this value is not directly observable with the data available, what indeed can be appreciated is whether the farm has non-traditional crops (dichotomous choice defined by the dummy *dNTD* in table 3). This criterion can be represented in a probit model given by

$$\begin{aligned} B^* &= Z'\alpha + \varepsilon_c , \\ dNTD &= 1, \text{ if } B^* > 0 \\ dNTD &= 0, \text{ if } B^* \leq 0. \end{aligned} \qquad (12)$$

where α is a vector of unknown parameters to be estimated and ε is an error term.

The elements of Z are the same explanatory variables presented in the RHS part of model (11) excluding FTI (which would not explain the presence of non-traditional crops) and including *dOXEN*, *dRESID*, *dFOREST, dMIRR* and ln*SURF* (where ln stands for natural logarithm). These variables are added in order to identify the switching regression model (Maddala, 1988; Alene & Manyong, 2007). The probit model for the presence of non-traditional crops can be expressed empirically as

$$dNTD = f\,(FTI,\ \ln IRRG,\ dMNG,\ \ln LABR,\ dMAC,\ dOWN,\ \ln CAPT,\ \ln INFT,\ dEDU_n,\ dSEX,\ \ln AGE,\ \ln AGE2,\ dOXEN,\ dRESID,\ dFOREST,\ dMIRR,\ \ln SURF,\ dAEC_m,\ dREG_p). \quad (13)$$

All the variables, with the exception of *dOXEN* and the location dummies, are expected to have a positive influence on the likelihood of observing non-traditional crops in the farm. Farmers living on the farm (*dVIVEN*) are more likely to have non-traditional crops since these are generally located near houses and require treatment during winter season (more easily provided if the farmer lives in situ). The presence of forest (*dFOREST*) suggests that the farmer has a more diverse pool of products and is therefore more likely to have non-traditional crops. Higher levels of education can be related to innovation and therefore the adoption of non-traditional crops. *dOXEN* is the only variable expected to have a negative sign, since this variable implies that the farm is under traditional agriculture and I expect to find a stronger link between modern agriculture and non-traditional crops.

In the second switching step, separate equations are used to model the agricultural production of each farm group [group (*a*) and group (*b*)] conditional on the criterion established in (12). In other words, it is the modeled probit regression that identifies the farm group and from which the criterion function is estimated (the criterion of having or not having non-traditional crops). The second step equations are

$$\ln(YLD)_{k} = \beta_{0k} + \beta_{1k}(FTI) + \beta_{2k}\ln(IRRG/SURF) + \beta_{3k}(dMNG) + \beta_{4k}\ln(LABR/SURF) + \beta_{5k}(dOWN) + \beta_{6k}(dMAC) + \beta_{7k}\ln(CAPT/SURF) + \beta_{8k}\ln(INFT/SURF) + \beta_{9k}(dSEX) + \beta_{10k}\ln(AGE) + \beta_{11k}\ln(AGE2) + \beta_{12\text{-}15k}(dEDUn) + \beta_{16\text{-}23k}(dAEC_{m}) + \beta_{24\text{-}27k}(dREG_{p}) + \beta_{28k}(MILLS) + e,$$

$$k = \text{farm group } (a), \text{ farm group } (b), \qquad (14)$$

where the *MILLS* variable is the inverse Mills ratio, which is the ratio of the probability density function to the cumulative distribution function of the standard normal distribution derived from the probit regression (evaluated at $Z'\alpha$) [see Maddala, (1988); Fuglie and Bosch, (1995); and Alene and Manyong, (2007) for further details]. The inverse Mills ratio is the variable that incorporates the criterion function in the second step of the switching regression. As can be seen, model (14) is similar to model (11), but with the major exception that now it includes the inverse Mills ratio as a variable. Thus, *MILLS* can be treated as an important missing covariate in (11) (Lee, 1978).

3.5.3 The Community-level TI Models

In this level I consider a quantitative analysis of poverty using a simple OLS linear model. This model is constructed using community level variables, which based on the theoretical framework includes explanatory variables related to social and capital factors. The econometric model is expressed as

$$PR = \beta_0 + \beta_1 (CTI) + \beta_2 \ln(POP) + \beta_3 \ln(POP2) + \beta_4 \ln(DIST) + \beta_{5\text{-}8} (dREG_p) + \beta_9 (HDIE) + \beta_{10} (IRPW) + \beta_{11} (M2PW) + \beta_{12} (DNST) + \beta_{13} (WKED) + \beta_{14} (AVAG) + \beta_{15} (ALPW) + e, \tag{15}$$

where the dependent variable *PR* is the poverty rate that the community reports in the CASEN 2000 and *e* is an error term. The explanatory variables, besides the inclusion of the community tradability index (*CTI*), include the natural log of the population (*POP*) and its square value (*POP2*), the natural log of 1 plus the distance of the community to the regional capital (*DIST*), regional dummies ($dREG_p$), the human development index for education (*HDIE*), the modern irrigation area per worker (*IRPW*), the total area of construction per worker (in m^2) in the community during the last two years (*M2PW*), population density per hectare(*DNST*), an interaction variable between *HDIE* and the total number of adults in a community (*WKED*), the average age of the population (*AVAG*), and total agricultural land per worker (*ALPW*).

The *POP, HDIE, WKED, IRPW, M2PW,* and *ALPW* variables are expected to have a negative influence on poverty, since they are respectively related to scale, educational, and labor opportunity effects that reduce poverty. In the same fashion, the *CTI* is hypothesized to have a negative influence on poverty for reasons discussed earlier (see hypothesis 3 on section 3.1.3). The only variable expected to have a positive correlation with *PR* is *DIST*, since households located further from cities have fewer alternatives for income diversification than households closer to the regional capital (the largest city in the region). The density variable (*DNST*) and *POP2* in some degree may also be positively associated with poverty, since at larger agglomerations welfare can be negatively affected. One caveat to consider in this section of the study is related to the exclusive reliance on cross-sectional estimations, which limits the ability to ascertain causality from many of the relationships obtained by the econometric analysis.

3.5.3.1 Spatial Influence

Several studies have empirically shown that poverty is a phenomenon that can be heavily influenced by geographical spatial dependence (Rupasingha & Goetz, 2003; Crandall & Weber, 2004; Benson *et al.*, 2005; Goetz & Swaminathan, 2006). For this reason, a more detailed analysis is done to consider the influences that spatial dependence can produce in the estimates of model (15). I consider three alternative specifications. One specification, that is relevant when the spatial dependence works through a spatial lag, is the so-called spatial autoregressive model (SAR), which in our case can be expressed as,

$$PR = \beta(X) + \rho\, W(PR) + e \;,$$
$$e \sim N(0, \sigma^2 I_n)\;, \qquad (16)$$

where X represents a matrix containing the determinants of poverty (including the CTI), the scalar ρ is a spatial autoregressive parameter, and W is a spatial weight matrix that captures the fact that spatial units (communities in this case) that are near each other would be expected to have a greater degree of spatial dependence than those units more distant from each other (LeSage, 1999)[36]. The elements of the spatial contiguity matrix W are:

$$W_{ij} = d_{ij} \Big/ \sum_{i=1, i \neq j}^{n} d_{ij} ,$$

$$\text{where } d_{ij} = \begin{cases} d_{ij} = 1, \text{ if a community } j \text{ is connected to community } i, \\ d_{ij} = 0, \text{ otherwise.} \end{cases} \tag{17}$$

Another specification postulated in this section is the spatial error model (SEM), which is important to consider when there are concerns that the spatial dependence works through the disturbance term (Rupasingha & Goetz, 2004). In our case this model can be expressed as,

$$\begin{aligned} PR &= \beta(X) + u \\ u &= \lambda \, Wu + e \\ e &\sim N(0, \sigma^2 I_n) , \end{aligned} \tag{18}$$

[36] I use a queen contiguity mode based on polygons (Chilean communities' borders). Thus a nonzero entry in the symmetric weights matrix indicates that communities share border at least in one point [see LeSage (1999) for more details].

where u is a disturbance term and λ is a scalar spatial error coefficient.

Finally a third model, known as the general spatial model (SAC), incorporates both spatial lag and error terms. This model incorporates both terms when concerns exist that the spatial dependence is coming from lag and error interactions (LeSage, 1999). This model can be expressed as,

$$PR = \beta(X) + \rho\, W(PR) + u$$

$$u = \lambda\, Wu + e$$

$$e \sim N(0, \sigma^2 I_n)\,, \qquad (19)$$

All the procedures for calculating the spatial weights matrix and the spatial econometric regressions were conducted in the software GEODA 0.9.5-i (Beta), based on Chilean communities shape files. Finally, because I am relying on data from 150 communities, the exclusion of some communities from the sample might produce some bias in the final spatial dependence results. These communities can be either large or small recipients of poverty that could be influencing the poverty rate of surrounding communities; however, this is very unlikely to happen since in general the communities with no data do not have major socio/economic differences from the rest. Exceptions, though, are the communities belonging to the Santiago urban metropolis, which are different from the rest of the country. Nonetheless, these should not affect the results of interest since they were excluded because they have little or no agriculture.

Chapter 4

RESULTS AND DISCUSSION

This chapter provides the results obtained after running the different econometric models with STATA, version 10. The first section deals with the role of the TI at the national level. The second section discusses the results at the farm level and the importance of the switching regression model. Finally, the third section is devoted to evaluate the potential role of the TI in poverty rates and the potential spatial dependence affecting the analysis.

4.1 The Product Tradability Index and National-level Response

Results of the OLS estimations for models I and II (equations 10 and 11, respectively) are presented in table 8. The results indicate that in both models the tradability index of an agricultural commodity has a positive effect on yield growth of the corresponding commodity. This would mean that, in fact, the weight that a commodity obtains from international commerce indirectly explains the long term gains in yield. Thus, even considering both models, we can reject the null hypothesis that the TI has no statistically significant effect.

Table 8. Results of national-level analyses, models I and II (dependent variable = average growth of yield per commodity between 1990 and 2005).

	OLS Model I		OLS Model II	
Variable	Coefficient	Std. error	Coefficient	Std. error
Constant	1.9057***	0.5401	7.6626***	2.9080
TI91	5.2844**	1.9622	12.6752***	2.3365
ln*Y1991*			-0.8123**	0.3122
YavIT			0.9359***	0.1973
ITTI91			-3.3835***	0.6146
R^2	0.1716		0.6208	

***, **, * describe significance at 1%, 5% and 10% level, respectively.

Table 8 shows that when controlling for initial agricultural yield in model II, conditional convergence is occurring among the crops in the sample, given the negative and statistically significant coefficient for the natural log of the 1991 year yield. In other words, commodities with a lower initial productivity have more ‘catching up’ to do and therefore will grow faster. Furthermore, model II also presents significant values for Italian agricultural productivity. The coefficient of the variable *YavIT* indicates that international advances (spillovers) contribute to the national yield growth of Chile. However, interestingly the negative coefficient on the interaction between the tradability index of 1991 and the yield growth rate of Italy (reported by the variable *ITTI91*) suggests that this particular control of ‘state of the world level of productivity’ has less effect on the productivity of Chilean commodities when these were more internationally traded initially. These results can perhaps be explained because international spillovers are already mostly controlled in the *TI91* variable.

4.2 The Farm Tradability Index and the Responsiveness of Farms

The first pair of columns of table 9 reports OLS estimates based on the cross-sectional analysis over 73,332 Chilean farms of model (11). The second pair of columns (OLS estimates [2]) reports estimates considering the same sample and model given by equation (12), but now replacing the location dummies given by $dREG_p$ and $dAEC_m$ with geographical location dummies according to the community where the farm is settled (170 communities for the farm sample considered in this study).

Table 9. Production function results of the farm-level analyses (dependent variable = average percentile yield rank of farm).

	OLS estimates [1][(a)]		OLS estimates [2][(a)(b)]	
Variable	Coefficient	Std. error	Coefficient	Std. error
Constant	1.1953**	0.3594	1.2774***	0.3536
FTI	0.2048***	0.0124	0.1516 **	0.0615
ln(*IRRG/SURF*)	0.4651***	0. 0117	0.4892***	0.0520
dMNG	0.0699***	0.0105	0.0736***	0.0112
ln(*LABR/SURF*)	-0.1216***	0.0037	-0.1129***	0.0096
dMAC	0.2901***	0.0058	0.2504***	0.0197
dOWN	0.0410***	0.0055	0.0412***	0.0099
ln(*CAPT/SURF*)	0.0168***	0.0019	0.0184***	0.0038
ln(*INFT/SURF*)	-0.1257***	0.0170	-0.1476***	0.0339
dSEX	0.0719***	0.0065	0.0724***	0.0085
ln*AGE*	0.9344***	0.1853	0.7859***	0.1842
ln*AGE2*	-0.1331***	0.0238	-0.1112***	0.0239
$dEDU_1$	0.03160***	0.0074	0.0433***	0.0099
$dEDU_2$	0.1002***	0.0100	0.1299***	0.0127
$dEDU_3$	0.1068***	0.0165	0.1470***	0.0185
$dEDU_4$	0.1528***	0.0133	0.1946***	0.0190
R^2	0.2932		0.3611	
Adjusted R^2	0.2935		0.3595	

(a): Geographic dummy coefficients not reported. (b): Results obtained using the 'areg' and 'absorb' commands in STATA.
***, **, * describe significance at 1%, 5% and 10% level, respectively.

The second row of results of table 9 shows that the farm tradability index has a positive and statistically significant effect on yield. This supports hypothesis #2 that farms facing more pressure from international markets tend to be more productive than farms without this pressure. The magnitudes of the results are important to analyze since the implied yield elasticity with respect to the *FTI* is in the range around 1.5 to 2, meaning that a 10% of increase in the TI of a farm would increase productivity around 15% to 20%.

Among the parameter coefficients, it is interesting to observe how at higher levels of education the elasticity also increases, i.e., the impact of education on farm output increases the higher the level of education that the farmer has. Farm management offers opportunities for applying education through the use of new technologies and management techniques. This result is consistent with the findings of Lopez and Valdes (2000) for the Chilean case, who argue that education is a factor spurring farm outcomes. However, these same authors argue that this statement cannot be generalized to other Latin American countries, where the impact of education on farm outcome is small and not statistically significant. Another important result to highlight is that the age of the farmer has an inverse U relationship with yields, which implies that experience is an important factor of production. The coefficients of the other independent variables are consistent with expectations with the exception of two cases: *INFT* and *LABR*. The negative sign of the former variable, which measures the presence of roads (and other similar infrastructure) within or immediately adjacent to the farm, may appear contradictory. However, as most rural roads in Chile are dirt roads that during the dry spring/summer season produce high levels of dust, the negative sign is not necessarily counterintuitive. Dust can reduce agricultural yields because it reduces plant respiration and facilitates the presence of pests and plant diseases[37].

The variable *LABR* reported in table 9 corresponds to the number of adults in the farm household, i.e., I use instead of *LABR* the variable *HHAD* in the model. This is done in order to avoid bias problems with the labor variable; however, the results are still unsatisfactory. I performed regressions using the *LABR* variable, also obtaining the same negative results. This negative relationship with yields does not seem to have a logical explanation, but if we consider that the farm yields only include traditional products, the negative sign could be explained by the fact that farm labor may also be used on other products and activities of the farm. Another explanation might be problems with the census data collection. Regressions without this variable were run for all the specifications presented in this thesis (including the ones in Appendix A) with no major differences in results from the ones reported in table 9.

As an attempt to control for different effects and circumstances that different farms face (e.g., farm size, location, etc.), appendix A provides several tables with regressions of model (11) constrained to different alternatives. In this way appendix A provides more support and information about the general applicability of the TI as variable for international trade in agricultural production function analyses.

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[37] This is an interesting result that showed up in this study. Further research about this topic would be a novel contribution to the 'air pollution/agricultural productivity' discussion.

4.2.1 Subdivision of Farms and Results of the Switching Regression Model

The first-step results of the endogenous switching regression model are presented in table 10. Marginal effects are in the second pair of columns, whose values indicate the effect of a one unit change in an exogenous variable on the probability that the farm will have non-traditional crops.

Table 10. Probit results and marginal effects [dependent variable = dummy variable for the presence of non-traditional crops (fruits) in the farm].

	Probit estimates		Marginal Effects [2]	
Variable	Coefficient	Std. error	Coefficient	Std. error
Constant	-7.6790***	1.2701		
ln*IRRG*	0.7526***	0.0395	0.0812***	.0041
dMNG	0.1813***	0.0276	0.0222***(a)	.0038
ln*LABR*	0.0497**	.0230	0.0053**	.0024
dOWN	0.2062***	0.0191	0.0209***(a)	.0018
ln*CAPT*	0.0406***	0.0038	0.0043***	.0004
ln*INFT*	0.0530**	0.0187	0.0057***	.0020
dSEX	0.0421*	0.0219	0.0044**(a)	.0022
ln*AGE*	2.3624***	0.6502	0.2548***	.0700
ln*AGE2*	-0.2897***	0.0829	-0.0312***	.0089
$dEDU_1$	0.0784**	0.0251	0.0082***(a)	.0026
$dEDU_2$	0.2851***	0.0317	0.0364***(a)	.0047
$dEDU_3$	0.4122***	0.0458	0.0602***(a)	.0086
$dEDU_4$	0.5180***	0.0377	0.0800***(a)	.0077
lnSURF	0.1555***	0.0067	0.0167***	.0007
dMIRR	1.2572***	0.0492	0.3031***(a)	.0028
dOXEN	0.0326***	0.0258	0.0035(a)	.0182
dRESID	0.1237***	0.0375	0.0128***(a)	.0037
dFOREST	0.0571**	0.0181	0.0062***(a)	.0020
Pseudo R^2	0.1553			
Correctly predicted	92.46%			

Note: Geographic dummies not reported. (a) The marginal effect ‘dy/dx’ is for discrete change of dummy variable from 0 to 1. ***, **, * describe significance at 1%, 5% and 10% level, respectively.

Table 10 shows that the coefficients of most of the variables have the expected sign. However, the variable *dOXEN* is positive (I expected negative), which implies that modern farms are not necessarily the only ones with non-traditional crops. Another result that some might find counterintuitive is the effect of age: the relationship is an inverse U, with a maximum at around 60 years old[38]. This may be explained by the property rights issue: older farmers are perhaps more likely to have regularized property rights than young farmers, and therefore more likely to have fruit trees (a long-term investment) on their land. Most estimates are statistically significant at the 10% or lower levels, and the model correctly predicts the presence of non-traditional products for 92.46% of the sample.

The second step results of the endogenous switching regression model, that is the separate production functions for groups (*a*) and (*b*), are presented in column pair [5] and [6] of table 11. The last row shows that the inverse Mills ratio variable (*MILLS*) variable is statistically significant, implying that self-selection occurs (Fuglie & Bosch, 1995). This means that prior to adoption of non-traditional crops there were differences in the average productivity of the two groups due to unobserved factors (probably soil quality or managerial expertise). For comparison purposes, table 11 also includes column pairs [3] and [4] that provide the production function of groups (*a*) and (*b*) using a simple OLS estimation with no control for self-selection.

In general, all the coefficients of the switching model are—in absolute terms—less than the OLS estimates, implying that the self-selection was overstating the true impact of most factors in the model—an upward bias effect in the parameters. Thus, for example, the coefficient for irrigation is reduced by 20% from the OLS to the switching

[38] Note that the variable age is transformed to natural logs in the analysis that give results of table 10.

model for farms of the group (*a*). It is also important to consider that some coefficients lost their significance after including the *MILLS* variable, and even in a couple of cases the parameters become negative, as the case of *AGE* for farms (*a*). This last case would imply that after controlling for self-selection young farmers are the relevant actors in highly productive farms, perhaps because they are more likely to innovate and invest in new forms of production.

There are two exceptions to the results showing a reduction in the parameters from the OLS to the switching model: the constant term and the tradability index. The increase in the constant term shows that self-selection of non-traditional crops has an effect on productivity by way of an upward shift in the production function of farms. The tradability indices also show an increase for each farm group.

Table 11. Regression coefficients of production functions for farms separated by presence of non-traditional crops (dependent variable = average percentile yield rank of farm).

	Farms group (*a*)[(a)] OLS estimates [3]		Farms group (*b*)[(b)] OLS estimates [4]		Farms group (*a*) [(a)] Second-step switching [5]		Farms group (*b*) [(b)] Second-step switching [6]	
Variable	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Constant	2.7249*	1.5143	1.1570***	0.3702	4.3043***	1.5256	3.3851	0.3815
FTI	0.4100***	0.0596	0.1935***	0.0126	0.4384***	0.0595	0.2387***	0.0127
ln(*IRRG/SURF*)	0.5148***	0.0540	0.4552***	0.0120	0.4193 ***	0.0556	0.2826***	0 .0142
dMNG	0.0737***	0.0267	0.0605***	0.0115	0.0283	0.0274	-0.0025	0.0118
ln(*LABR/SURF*)	-0.1726	0.0194	-0.1178***	0.0038	-0.1404***	0.0199	-0.0871***	0.0040
dOWN	0.0717***	0.0240	0.0363***	0.0056	0.0232	0.0249	-0.0348***	0.0064
dMAC	0.2438***	0.0241	0.2910***	0.0060	0.2273***	0.0242	0.2652***	0.0061
ln(*CAPT/SURF*)	0.0170**	0.0069	0.0158***	0.0020	0.0047	0.0071	0.0002	0.0021
ln(*INFT/SURF*)	-0.1049	0.0684	-0.1289***	0.0175	-0.0781	0.0683	-0.0917***	0.0175
dSEX	0.0531**	0.0264	0.0719***	0.0067	0.0308	0.0264	0.0445**	0.0068
ln*AGE*	0.1729	0.7751	0.9510***	0.1910	-0.3884	0.7763	0.2548	0.0700
ln*AGE2*	-0.0352	0.0988	-0.1354***	0.0245	0.0333	0.0989	-0.0312*	0.0089
$dEDU_1$	0.0157	0.0319	0.0318***	0.0076	0.0071	0.0318	0.0138*	0.0077
$dEDU_2$	0.0723*	0.0373	0.0984***	0.0104	0.0173	0.0380	0.0217**	0.0109
$dEDU_3$	0.0795	0.0496	0.1017***	0.0178	-0.0001	0.0507	-0.0115	0.0184
$dEDU_4$	0.1059**	0.0402	0.1472***	0.0146	0.0022	0.0428	0.0025	0.0158
MILLS					-0.2034***	0.0296	-0.2851***	0.0125
R^2	0.3056		0.2910		0.3113		0.2964	
Adjusted R^2	0.3023		0.2907		0.3079		0.2961	

Note: Geographic dummies not reported. (a) Farms producing both non-traditional and traditional crops and other commodities. (b) Farms without non-traditional crops.
***, **, * describe significance at 1%, 5% and 10% level, respectively.

When analyzing the switching regression model results of table 11, the sign of the MILLS variable has economic interpretations. The fact that for both farm groups the MILLS coefficient sign is the same (negative), would indicate hierarchical sorting (Maddala, 1988; Fuglie & Bosch, 1995); i.e., farms producing non-traditional crops have above-average yields whether or not they adopt these crops, but they are better off producing them. Those farms without non-traditional crops have below-average yields in either case, but are better off not adopting non-traditional crops. In the field this phenomenon may in part be explained by the soil quality of a farm, a crucial variable that unfortunately is not available in the census data.

As can be observed in figure B4 of appendix B, the average level of the TI for non-traditional crops is heavily influenced by the northern communities (where fruits are more predominant). For this reason, in order to check whether this geographical concentration affects the general results reported in tables 9 and 11, appendix A reports results of switching regression using data solely from the northern regions of the studied zone. There are no major differences in the results.

Although, in general, the results are consistent and inside the boundaries of what is expected in an agricultural production function, the role of a trade variable could be influenced by external factors: international prices and exchange rates. Since this thesis does not include these issues in the empirical analyses, appendix C provides a brief discussion on how these external factors could influence international trade and therefore the necessity for further research in order to incorporate them when assessing impacts of trade on local agriculture (and poverty).

4.3 The Community Tradability Index Relationship with Poverty Rate

The results of the standard linear regression model given by equation (15) are shown in table 12. The second column pair of this table reports OLS estimates with the same explanatory variables of model (15), but disaggregating the community tradability index according to its source: traditional (*CTIT*) or non-traditional crops (*CTIF*) (see table 7).

Table 12. Results of the community-level analyses (dependent variable = Poverty rate).

	OLS estimates [1]		OLS estimates [2]	
Variable	Coefficient	Std. error	Coefficient	Std. error
Constant	313.0665***	143.3833	318.378***	143.5134
HDIE	--63.3721***	18.4392	-62.8024***	18.4746
ln*POP*	-50.05883**	20.8402	-51.5808**	20.9061
ln*POP2*	2.7160**	1.1071	2.7991**	1.1108
AVAG	-0.7641	2.5008	-0.7037	2.5027
AVAG2	0.0094	0.0208	0.0089	0.0208
ln*DIST*	-0.33149	0.7087	-0.3746	0.7104
ALPW	-1.2357***	0.4173	-1.2693***	0.4189
IRPW	-18.4984	54.3385	-23.1175	54.5981
WKED	-0.0003***	0.0001	-0.0003***	0.0001
M2PW	-1.0643**	0.4495	-1.1149**	0.4531
DESNT	0.58254**	0.2386	0.5912**	0.2389
dREG5	4.21012**	2.0671	4.4334**	2.0826
dREG6	4.2674*	2.1930	3.7066	2.2863
dREG7	4.9224**	2.0523	4.4541**	2.1158
dREG8	11.1662***	2.0272	10.6871***	2.0913
CTI	-22.0258**	10.3523		
CTIF			-31.0620**	14.2652
CTIT			-14.0801	13.8588
R^2	0.5547		0.5578	

***, **, * describe significance at 1%, 5% and 10% level, respectively.

OLS estimates [1] and [2] of table 12 show interesting results worth discussing before focusing on the analysis of the community TI variable(s). The results call attention the magnitude of the coefficients of the variable *HDIE* (by far the largest in both columns). These parameters confirm the importance of education in poverty alleviation as has been reported by several researchers (Krueger & Lindhal, 2001). However, to my knowledge this is the first study that directly includes the human development index for education as an explanatory variable in poverty analysis in Chile[39]. Another variable with an important magnitude is *POP* (in logarithms), which suggests that at low population levels an increase in community population is likely to lead to less poverty. However, according to the sign of the *POP2* variable, the data demonstrate that the relationship between poverty and population can be described as a U-shaped function. This last argument is confirmed by the *DENST* coefficient results, which show that at large agglomerations poverty increases[40]. Finally, it is important to highlight the effect of agriculture: the more agricultural land per adult a community has, the lower is the presence of poverty. This last result is in the line of the work of several researchers that claim that agriculture is an important path to reducing poverty (Self & Grabowski, 2007; Thirtle *et al.*, 2001), especially for developing rural regions.

The *CTI* variable in the OLS estimates [1] of table 12 shows a coefficient that is consistent with hypothesis #3 of this work: negative and significant. This result implies

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[39] I also tried with the component of health of the HDI in the regression analyses, which gave no statistically significant results.

[40] The variable *DENST* can be affected by endogeneity problems, since poor places will tend to have more agglomeration or density. In order to control for this problem I ran regressions excluding this variable without significant changes in magnitude or sign of the general results. The same endogeneity potential is considered for the variable *M2PW*, where alternative regressions were also performed without including it, proving no relevant changes.

that international agricultural trade is indeed associated with poverty alleviation in Chilean communities. The second column of OLS estimates disaggregates the community tradability index in *CTIT* and *CTIF*. This separation allow us to observe the differences between the tradability index sources: while the tradability index from non-traditional crops is negative and significant, the tradability index from traditional products is negative but fails to be statistically different from zero. Unambiguously the effect is more considerable for non-traditional products, which implies that the export market of a commodity (the main source of the *CTIF*) has a negative effect on poverty.

4.3.1 Poverty under Spatial Analysis

Table 13 shows the results of the general spatial model (SAC) given by equation (19). This specification considers spatial dependence coming from both spatial lags and the error term. The results of table 13 report that rho (spatial autocorrelation coefficient) and lambda (spatial error coefficient) are statistically significant, indicating the presence of both types of spatial effects. Therefore, this model would be the most accurate among the alternatives considered in section 3.5.3.1 (LeSage, 1999). Two specifications were tested, one with a first-order and another with a second-order spatial weight matrix. Because the former specification was found to better fit the data, it is the one chosen and reported in table 13.

Table 13. Results of the community-level spatial analyses (dependent variable = Poverty Rate).

	SAC estimates [1]		SAC estimates [2]	
Variable	Coefficient	Std. error	Coefficient	Std. error
Constant	125.7147	115.3182	188.7743	124.5505
HDIE	-14.0205	13.3428	-18.9217	13.3119
ln*POP*	-6.6573	16.8710	-17.2411	18.2189
ln*POP2*	0.4835	0.9087	1.0401	0.9718
AVGAG	-3.2365	2.1844	-3.5258*	2.1979
AVAG2	0.0315*	0.0185	0.0337**	0.0186
ln*DIST*	-0.4019	0.5036	-0.1498	0.4634
ALPW	0.0000	0.0000	-0.2989	0.29044
IRPW	-69.6806***	41.6371	-62.4689	42.7182
WKED	-0.0002***	0.0000	-0.0002***	0.0000
M2PW	-1.5884***	0.3634	-1.6561***	0.3594
DESNT	0.8113***	0.2106	0.8117***	1.3153
dREG5	2.2016*	1.3403	2.1424*	1.3082
dREG6	1.8683	1.2225	1.6267	1.3165
dREG7	1.75000	1.2317	1.5510	1.2246
dREG8	4.0993***	1.3909	3.6753***	1.3919
CTI	-17.5586***	5.6295		
CTIF			-28.0124***	7.8519
CTIT			-12.2810	7.8880
Rho (ρ)	0.5952***	0.0628	0.5942***	0.0618
Lambda (λ)	-1.2696***	0.0484	-1.2951***	0.0532
R^2	0.6439		0.6510	

***, **, * describe significance at 1%, 5% and 10% level, respectively.

Interestingly, when comparing the OLS results from table 12 to the SAC model estimate results of table 13, it can be observed that most of the coefficients are reduced in magnitude and significance. This phenomenon means that the explanatory variables have less influence after controlling for spatial effects. However, some coefficients see an increase in their values such as *IRPW* (which also becomes more significant) and *M2PW*, which are related perhaps to investments in infrastructure that cross the border of communities and therefore become more important in spatial terms. Also it is important to observe how the role of age becomes statistically significant and the U-shaped relationship that age has with poverty (although in table 12 the parameters were not statistically different from zero). This relationship between age and poverty can be explained by the effect of child poverty: in a developing country context, as the Chilean one, households with more children are more likely to be poor. The turning point for this relationship (when age starts having a positive relation with poverty) is approximately 52 years old, which could be explained by older households having fewer economically active members and therefore less income.

For the case of the *CTI* variable, it is interesting to observe that the parameter is smaller than the OLS estimates of table 12, but with a higher statistical significance. Thus, it can be deduced that after controlling the spatial effects that affect poverty, the international trade effects are somewhat lower in magnitude. For the case of the *CTIF* and *CTIT* the results show the same phenomenon, although in these parameters the statistical significance remains the same. The results imply that international trade in non-traditional crops supports poverty reduction while traditional crops fail to contribute to poverty alleviation. This phenomenon can be explained in the Chilean context by employment opportunities created by export-oriented commodities in Chile (fruits in particular are a labor-intensive industry). These results are in line with the findings of some authors that demonstrate how non-traditional commodities have boosted some

Chilean rural areas through the generation of employment (Shurman, 2001; Foster & Valdes, 2006).

The value of 0.59 that the rho (ρ) term has in the SAC estimates [1] of table 13 implies that a 10% increase in the poverty rate of a community results in a 5.7% increase in the poverty rate in a neighboring community. On the other hand, the significant lambda (λ) coefficient in the spatial model suggests that a random shock which affects poverty in a particular community may trigger a change in the poverty not only in that community but also in its neighboring communities. Because the significant spatial parameters values indicate that spatial dependence exists in the community data, it looks like a model incorporating spatial effects is more appropriate when modeling poverty in Chilean communities.

Chapter 5

SUMMARY AND CONCLUSIONS

This chapter provides a summation of the work detailed in the previous chapters and also discusses the main policy implications of the results. It also provides a brief discussion about the relevance of this study for future academic research on the topics of international trade and rural development.

5.1 Summation of Research

During recent decades researchers have studied the impacts that international trade produces on the growth and development of developing nations around the world. Although most studies suggest a positive role for trade liberalization, when focusing on particular realities the results become more ambiguous. In order to contribute to this discussion, this study analyzed the influence of trade on agricultural productivity and poverty in a Latin American middle income country, Chile. The main hypothesis in this thesis is that international trade has a positive impact on agricultural productivity and helps to reduce poverty in Chile. In order to test this hypothesis I incorporated trade as covariate in different empirical models using an agricultural product-specific tradability index (TI), which was given by the sum of export and import volumes of a particular agricultural crop divided by its total production in the country for a specific year.

This thesis had three main objectives. The first objective was to investigate whether the product-specific TI has any relationship with the average productivity growth (conceptualized by yields in this study) of the particular agricultural commodity. This was accomplished by a standard linear model that incorporated the TI as an explanatory variable for the growth of crop yield over the period 1991-2005. In a broader model the influence of world productivity levels and a term for capturing productivity growth convergence across commodities were included as covariates. The econometric results suggest that the product-specific TI helps to explain yield gains. This implies that the more international trade a product has, the higher is its long-term productivity growth.

The second objective was to test whether international trade has any effects on the productivity of individual farms. Different models were regressed in order to examine how a farm-specific tradability index (FTI)—calculated using the TI weighted by the proportion of land used for that commodity in a farm—influences the productivity of farms. Results reported in table 9 (as well as results of Appendix A) show that the farm TI has a positive and statistically significant impact on yields of traditional crops (yields of non-traditional crops were not available in the data used in this work).

In the Chilean case, in general, traditional crops (which in this work are cereals, grains and certain vegetables) are importables, while non-traditional crops (primarily fruits) are exportables. In order to analyze the difference between export and import market influences on agricultural productivity, it would have been optimal to make a direct comparison between farms with traditional crops (farms facing more pressure from imports) and farms with non-traditional crops (farms facing more opportunities for exports); however, this was not possible to perform because the lack of data on non-traditional crop yields. As a way to solve this problem I analyzed the impact of trade on yields of two different farm groups: farms producing both traditional and non-traditional crops (therefore farms with an import and export influence) and farms without non-traditional crops (farms facing only pressure from the import market). For this analysis I employed an endogenous switching regression model in order to correct the potential selectivity bias that could happen among farms that have or do not have non-traditional crops. Interestingly, the results show that for the case of farms with both traditional and non-traditional crops the effect of the farm TI explaining yields of traditional crops was higher than in the production function of farms without non-traditional crops (elasticities of 0.43 v/s 0.23), which implies that the influence of international trade is more important when the source is the export market. This could be explained by the private investment that non-traditional crops have attracted due to the profitability of the export market, and by knowledge focused on developing better agricultural technologies and practices on farms producing non-traditional crops.

Interestingly, results show that even though a farm may just be producing for local markets, the fact that it is growing crops that are more internationally traded produces an upward effect on its yields. This estimated parameter values for the TI are situated in the range of 0.15 to 0.43. However, the results obtained in this study do not clarify the reasons why the tradability index is having an effect. With the empirical framework of this thesis it is not possible to determine if yield improvements come from spillovers, accessibility or competition effects produced by international trade. Nevertheless, since international trade in this study is assessed by specific products, it is possible to argue that the results obtained are not related to the accessibility effect, because the fact of having more or less TI on a farm does not restrain farmers' access to new technologies or inputs from foreign markets. It makes more sense that the TI results explain the effects of international spillovers and competition in farm efficiency, where is very likely that a combination of both is improving the performance of farmers with more internationally traded crops.

The third objective of this thesis was to analyze the effects of international agricultural trade on poverty. This was performed using a model that incorporates the TI at the community level (CTI)—calculated using the product-specific TI weighted according to the presence of crops in the agricultural land of a community—as an explanatory variable for the poverty rate in the community. Spatial econometric analyses were employed in order to control for potential spatial dependence in the poverty rate of a community. One interesting result concerns the Human Development Index for education (HDIE), which is negatively related to poverty. Spatial regressions show that poverty is indeed influenced by spatial dependence, since the spatial autocorrelation (ρ) and spatial error (λ) terms are statistically significant in the analyses.

The results show that the community level TI is negatively related to the poverty rate in a community. This clearly implies that communities with more agricultural production of commodities internationally traded are likely to have less poverty than a community with agriculture based on commodities that are not internationally traded. When disaggregating the source of the TI, it is observed that international trade in non-traditional products has a greater effect on poverty reduction than traditional crops. These results are in line with other studies that show how the labor-intensive nature of non-traditional crops in Chile has led to the creation of new jobs in rural areas (Foster & Valdes, 2007; Shurman, 2001), contributing in this way to the reduction of poverty.

One important point to consider when attempting to generalize the results obtained in this study is the particular conditions of the Chilean case. Although it can be considered a good case study because of its solid and longstanding trade openness policy (Pavcnik, 2002), the labor-intensive and land concentration characteristics of non-traditional crops in Chile are not common in other countries (Bradford *et al.*, 1992; Carter *et al.*, 1996), which can imply different results for the trade/poverty relationship. Another issue important to consider in the results, especially for the productivity analyses, is that the empirical results may be biased due to missing variables (like soil quality) or problems with data reliability (labor in this case). However, even allowing for the margins of uncertainty that are inherent in any empirical work, and the particular realities of Chile, it seems clear that farms and communities derive important and substantial benefits from international agricultural trade. This is an important point to keep in mind when planning strategies for rural development.

5.2 Future Research

The main research consideration to highlight from this study is the potential for using a product-specific tradability index as a covariate in productivity and poverty models. Spillovers and competition are factors coming from international trade that can spur development, and that to some extent might be empirically captured by the TI variable used in this study.

Also important issues to consider for future research are some of the other findings of this study. One is the empirical potential that the human development index for education has as a variable in poverty models, especially in Chile where this variable is available at the community level. Another issue is the spatial dependence found in the poverty analyses. Important issues not considered in this study, and that are in need of further research, are the role that international prices and exchange rates may have on the productivity of farms (and on poverty). Appendix C of this thesis gives a general overview of these issues and explains why it is necessary to research these points when analyzing the influences of international trade on local economies.

Finally, intuitive as the results presented in this study are, they leave several questions without definitive answers. Is international trade improving productivity through positive spillovers or by driving less competitive farms out of business? What is the real extent of international trade in poverty reduction; does it come from better productivity or from employment generation that pays just above the minimum wage? Although this study shed some light on these questions, more has to be done in order to thoroughly evaluate the globalization phenomenon and its effects on local economies of developing countries like Chile.

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Appendix A

PRODUCTION FUNCTION ANALYSES CONSIDERING ESPECIAL CASES

This appendix presents two tables providing different estimations of model (11) constrained to particular specifications of the data. Tables A.1 and A.2 show the following OLS estimates[41]:

- OLS estimates [A.1] are calculated for the sample of farms with agricultural land equal to or greater than 1 ha. The results do not differ importantly from the ones shown in table 9.
- OLS Estimates [A.2] are calculated for the sample of farms with agricultural land equal to or greater than 5 ha. The results do not differ importantly from the ones shown in table 9.
- OLS Estimates [A.3] are calculated for the sample of farms with an agricultural land equal to or greater than 10 ha. In this column it is important to notice how the *FTI* variable increases in magnitude, implying that the influence of trade is more important the larger the farm is (it is more likely that large farms are directly involved in international marketing). Also worth highlighting is that primary education loses its significance.
- OLS Estimates [A.4] are calculated for the sample of farms with an agricultural land equal to or less than 1 ha. For this case practically all the education variables lose significance and interestingly the *FTI* variable acquires a coefficient even higher than the three previous estimates. This higher influence of trade would mean that small

[41] All regressions presented in this appendix included the location dummy variables given by $dREG_p$ and $dAEC_m$, but are not reported here.

farms have a greater marginal effect when incorporating international spillovers than farms of larger size.

- OLS Estimates [A.5] are calculated for the sample of farms reporting oxen as part of their assets. The presence of oxen is controlled here in order to make a distinction between modern agriculture and traditional agriculture, where farms with oxen are more likely linked to traditional agriculture. Again the *FTI* variable is interestingly high in magnitude. This higher influence of trade means that traditional farms have a greater marginal effect when incorporating international spillovers than farms already in a modern form of production.
- OLS Estimates [A.6] are calculated for the sample of farms with sugar beets in their portfolio of crops. This sample is analyzed because sugar-beet production has particular characteristics in Chile: the commodity has a TI of zero (since it is practically neither exported nor imported), its production is protected by tariffs (price band to sugar products), and farms producing this crop are heavily controlled by IANSA[42]. These characteristics are very likely to be producing an upward effect on the productivity of farms with this crop. Results in table A.2 show indeed how the TI becomes negative, which was expected due to the effect of the sugar-beet market in Chile (farms with high productivity, but influenced by a commodity of TI equal zero). The other parameters remain quite similar.
- OLS Estimates [A.7] are calculated for the sample of farms located in the Maule region, which is the region concentrating most of the sugar-beet production.

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[42] IANSA is a large private company that historically has had the monopoly of the sugar business in Chile. In part due to the extension program performed by this company during the years 2005 and 2006 the sugar-beet yields were among the highest in the world. For more references see www.iansagro.cl

Considering this characteristic, the negative sign reported by the FTI variable is (as in OLS Estimates [A.6]) logical to expect. But since this regression is at a regional level, it can be argued that the sugar-beet market might have a negative spillover effect on the yields of farms not producing this commodity: better soils, agricultural resources and efforts are destined to sugar-beet production, which would negatively affect production of other more tradable products.

- OLS Estimates [A.8] are calculated for the sample of farms of farms located in the Bio-Bio region, which is the most southern of the studied zone. The results do not differ importantly from the ones shown in table 9.

Table A.3 shows the second step switching model results (after the first step, not reported here, for each respective case) for a sample restricted by location in the northern regions of the studied zone. Estimates [A.10] and [A.11] are from farms within the geographical boundaries of regions 5, 13 and 6 (Valparaiso, Metropolitan and O'Higgins, respectively); while estimates [A.12] and [A.13] correspond to farms only located in the Valparaiso and Metropolitan regions. These specifications are calculated in order to control the spatial concentration of non-traditional crops in these regions (see figures B3 and B4). Although the results differ to some extent from the results presented in table 11, the findings for the *FTI* variable still indicate the importance of international trade when explaining traditional crop yields. The *MILLS* variables maintain also their negative sign and significance for all four cases, which demonstrates selectivity bias issues.

Table A.1. Farm production function results subject to agricultural land surface constraints (Dep. Var. = *YLD*).

	Farms with SURF ≥ 1 ha. OLS estimates [A.1]		Farms with SURF ≥ 5 ha. OLS estimates [A.2]		Farms with SURF ≥ 10 ha. OLS estimates [A.3]		Farms with SURF ≤ 1 ha. OLS estimates [A.4]	
Variable	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
FTI	0.1863***	0.0139	0.2822***	0.0199	0.2981***	0.0274	0.3169***	0.0251
ln(*IRRG/SURF*)	0.5389***	0.0127	0.6268***	0.0169	0.5874***	0.0209	0.2648***	0.0259
dMNG	0.0495***	0.0106	0.0344***	0.0115	0.0328**	0.0128	0.0882**	0.0369
ln(*LABR/SURF*)	-0.1781***	0.0063	-0.2534***	0.0175	-0.2695***	0.0337	-0.0281	0.0066
dOWN	0.0408***	0.0059	0.0356***	0.0082	0.0424***	0.0110	0.0158	0.0123
dMAC	0.2883***	0.0065	0.2346***	0.0101	0.2277***	0.0146	0.2702***	0.0121
ln(*CAPT/SURF*)	0.0247***	0.0022	0.0269***	0.0032	0.0291***	0.0042	0.0073**	0.0036
ln(*INFT/SURF*)	-0.2771***	0.0245	-0.2870***	0.0464	-0.1922**	0.0737	-0.0442*	0.0250
dSEX	0.0667***	0.0071	0.0568***	0.0100	0.0271**	0.0129	0.0549	0.0143
AGE	0.8214***	0.1983	0.3889	0.2757	0.1442	0.3549	0.6640	0.4184
AGE2	-0.1196***	0.0254	-0.0658*	0.0352	-0.0353	0.0452	-0.0981*	0.0539
$dEDU_1$	0.0348***	0.0080	0.0222**	0.0108	0.0081	0.0148	0.0150	0.0168
$dEDU_2$	0.0964***	0.0105	0.0835***	0.0134	0.0695***	0.0174	0.0493*	0.0261
$dEDU_3$	0.0974***	0.0169	0.0764***	0.0195	0.0768***	0.0236	0.0620	0.0516
$dEDU_4$	0.1416***	0.0135	0.1253***	0.0159	0.1098***	0.0194	-0.0585	0.0515
N	59,896		31,817		18,552		16,329	
R^2	0.3266		0.3359		0.3184		0.2006	
Adjusted R^2	0.3263		0.3354		0.3174		0.1993	

***, **, * describe significance at 1%, 5% and 10% level, respectively.

Table A.2. Farm production function results constrained to different farm characteristics and location (Dep. Var. = *YLD*).

	Farms with oxen OLS estimates [A.5]		Farms with sugar beets OLS estimates [A.6]		Farms located in Region 7 OLS estimates [A.7]		Farms located in Region 8 OLS estimates [A.8]	
Variable	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
FTI	0.3858***	0.0299	-0.6748***	0.0444	-0.1494	.1321	0.2039**	0.0914
ln(*IRRG/SURF*)	0.4518***	0.0322	0.2014***	0.0308	0.6653***	.1050	0.4724***	0.0639
dMNG	0.0013	0.0252	0.0588***	0.0166	0.0635***	.0180	0.0391**	0.0179
ln(*LABR/SURF*)	-0.0502***	0.0096	-0.0436***	0.0123	-0.1196***	.0184	-0.0964***	0.0107
dOWN	0.0526***	0.0119	-0.0458***	0.0107	0.0095	.0148	0.0358**	0.0142
dMAC	0.3172***	0.0113	0.0068	0.0209	0.3587***	.0201	0.2349***	0.0340
ln(*CAPT/SURF*)	0.0233***	0.0040	0.0179***	0.0042	0.0164*	.0085	0.0155***	0.0052
ln(*INFT/SURF*)	-0.0274	0.0290	-0.2126***	0.0554				
dSEX	0.0692***	0.0145	0.0115	0.0134	0.0943***	.0187	0.0605***	0.0103
AGE	0.3306	0.4231	0.0198	0.3231	0.5652	.3393	0.7518***	0.2677
AGE2	-0.0476	0.0539	-0.0124	0.0417	-0.0882*	.0445	-0.1044	0.0347
$dEDU_1$	0.0454***	0.0145	0.0807***	0.0141	0.0503***	.0160	0.0571***	0.0162
$dEDU_2$	0.1135***	0.0232	0.1565***	0.0176	0.1399***	.0179	0.1394***	0.0205
$dEDU_3$	0.1467***	0.0443	0.2028***	0.0253	0.1270***	.0299	0.1665***	0.0281
$dEDU_4$	0.1537***	0.0325	0.2457***	0.0225	0.2065***	.0381	0.1939***	0.0272
N	14,333		6,641		22,502		30,984	
R^2	0.2653		0.3056		0.3658		0.3690	
Pseudo R^2	0.2639		0.3023		0.3646		0.3677	

***, **, * describe significance at 1%, 5% and 10% level, respectively.

Table A.3. Switching regression models results for farms located in northern regions (Dep. Var. = *YLD*).

	Farms group (*a*) Second-step switching [1]		Farms group (*b*) Second-step switching [2]		Farms group (*a*) Second-step switching [3]		Farms group (*b*) Second-step switching [4]	
Variable	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
FTI	0.7348***	0.0884***	0.5367***	0.0226***	1.1360***	0.1670	0.8491***	0.0570
ln(*IRRG/SURF*)	0.1937**	0.0969	-0.0399	0.0327	0.2010	0.1535	-0.2202***	0.0669
dMNG	0.0543	0.0410	-0.0320	0.0221	0.1419**	0.0742	-0.0054	0.0530
ln(*LABR/SURF*)	-0.1510***	0.0300	-0.0858***	0.0072	-0.1809***	0.0499	-0.1590***	0.0175
dOWN	0.0919**	0.0428	-0.0354***	0.0130	0.1383*	0.0793	-0.1554***	0.0362
dMAC	0.0976**	0.0418	0.1188***	0.0124	-0.0103	0.0714	0.0602**	0.031
ln(*CAPT/SURF*)	0.0103	0.0109	-0.0168***	0.0039	0.0377*	0.0193	-0.0457***	0.0094
ln(*INFT/SURF*)	-0.3040***	0.1160	-0.0341	0.0339	-0.8547***	0.1979	-0.0539	0.0766
dSEX	0.0096	0.0438	0.0511***	0.0147	-0.0810	0.0766	0.1110***	0.0408
AGE	-0.1362	1.4364	-1.3007***	0.4245	-1.1656	2.3514	-1.3332	1.0461
AGE2	0.0040	0.1816	0.1376**	0.0541	0.1356	0.2983	0.1507	0.1333
$dEDU_1$	-0.0009	0.0524	-0.0102	0.0152	0.0340	0.0892	0.1180***	0.0389
$dEDU_2$	0.0357	0.0609	-0.0658***	0.0220	0.0344	0.1012	0.0235	0.0518
$dEDU_3$	0.0245	0.0816	-0.0701**	0.0358	-0.0166	0.1440	0.0758	0.0762
$dEDU_4$	0.0063	0.0661	-0.0598**	0.0300	-0.0203	0.1075	0.0613	0.0608
MILLS	-0.1697***	0.0419	-0.4291***	0.0212	-0.0643	0.0661	-.6112***	0.0537
N	2,412		17,434		1,129		4,451	
R^2	0.2217		0.2319		0.1495		0.1747	
Adjusted R^2	0.2139		0.2308		0.1318		0.1704	

***, **, * describe significance at 1%, 5% and 10% level, respectively.

Appendix B
COMMUNITY-LEVEL DATA CONSIDERATIONS

The communities located in the studied zone of this thesis are reported in table B.1. Most of the communities that are located in the Santiago urban area are not included on this list since agriculture is unimportant in these communities. However, the communities of Quilicura, Puente Alto and San Bernardo (that can be considered part of Santiago) are on this list because they reported some agricultural production in the census.

Table B1. List of Chilean communities presented in the studied zone.

Communities (in alphabetical order)					
Algarrobo[5]	Constitución[7]	Longaví[7]	Pelluhue[7]	Rengo[7]	Talca[7]
Alhué[13]	Contulmo[8]	Los Alamos[8]	Pemuco[8]	Requínoa[6]	Talcahuano[8]
Antuco[8]	Coronel[8]	Los Andes[5]	Peñaflor[13]	Retiro[7]	Teno[7]
Arauco[8]	Curacaví[13]	Los Angeles[8]	Pencahue[7]	Rinconada[5]	Tiltil[13]
Buin[13]	Curanilahue[8]	Lota[8]	Penco[8]	Río Claro[7]	Tirúa[8]
Bulnes[8]	Curepto[7]	Machalí[6]	Peralillo***[6]	Romeral[7]	Tomé[8]
Cabildo[5]	Curicó[7]	Malloa[6]	Petorca[5]	S. Familia[5]	Trehuaco[8]
Cabrero[8]	Doñihue***[6]	Marchihue[6]	Peumo***[6]	San Antonio[5]	Tucapel[8]
C. de Tango[13]	El Carmen[8]	María Pinto[13]	Pichidegua***[6]	S. Bernardo[13]	Valparaíso[5]
Calle Larga[5]	El Monte[13]	Maule[7]	Pichilemu[6]	San Carlos[7]	Vichuquén[7]
Cañete[8]	El Quisco[5]	Melipilla[13]	Pinto[8]	San Clemente[7]	Villa Alegre[7]
Cartagena[5]	El Tabo[5]	Molina[13]	Pirque[13]	San Esteban[5]	V. Alemana[5]
Casablanca[5]	Empedrado[7]	Mulchén[8]	Placilla[6]	San Fabián[8]	V. del Mar[5]

Catemu[5]	Florida[8]	Nacimiento[8]	Portezuelo[8]	San Fco. M. [6]	Yerbas Buenas[7]
Cauquenes[7]	Graneros[6]	Nancagua[6]	Puchuncaví[5]	San Felipe[5]	Yumbel[8]
Chanco[7]	Hijuelas[5]	Navidad[6]	Puente Alto[13]	San Fernando[6]	Yungay[8]
Chépica[6]	Hualañé[7]	Negrete[8]	Pumanque***[6]	San Ignacio[8]	Zapallar[5]
Chillán[8]	Hualqui[8]	Ninhue[8]	Putaendo[5]	San Javier[6]	Lampa***[13]
Chillán Viejo[8]	Isla de Maipo[13]	Ñiquén[8]	Quilaco[8]	S. José M. [13]	Las cabras***[6]
Chimbarongo[6]	La Calera[13]	Nogales[5]	Quilicura***[13]	San Nicolás[8]	
Cobquecura[8]	La Estrella[6]	Olivar***[6]	Quilleco[8]	San Pedro[13]	
Codegua[6]	La Ligua[5]	Olmué[5]	Quillón[8]	San Rafael[7]	
Coelemu[8]	Laja[8]	Padre Hurtado[13]	Quillota[5]	San Rosendo[8]	
Coihueco[8]	Lebu[8]	Paine[5]	Quilpué[5]	San Vicente[6]	
Coinco***[6]	Licantén[7]	Palmilla***[6]	Q. de Tilcolco***[6]	Santa Bárbara[8]	
Colbún[7]	Limache[5]	Panquehue[5]	Quintero[5]	Santa Cruz[6]	
Colina[5]	Linares[7]	Papudo[5]	Quirihue[8]	Santa Juana[8]	
Coltauco***[6]	Litueche[6]	Paredones[6]	Rancagua[6]	Santa María[5]	
Concepción[8]	Llay-Llay[5]	Parral[7]	Ranquil[8]	Santo Domingo[5]	
Concón[5]	Lolol***[6]	Pelarco[6]	Rauco[7]	Talagante[13]	

Note: The superscript numbers correspond to the region where the community is located. 5 = Valparaiso Region; 6 = O'Higgins Region; 7 = Maule Region; 8 = Bio-Bio Region; and 13 = Metropolitan Region.
*** describe that the community was not included in the analysis of poverty developed above.

The geographic borders of these communities can be seen in figures B1 to B4. These figures show the values of the tradability indices (*CTI*, *CTIF* and *CTIT*) and the poverty rate (*PR*). As can be seen in figure B2, several communities do not report poverty rates in the CASEN 2000. In figure B2 the Santiago metropolitan area is also categorized with no data, because it is not considered in the study. The communities not included in the analysis (communities with 'no data' in figure B2) are indicated by '***' in table B.1.

Finally, it is worth noting the spatial distribution of the TI from non-traditional crops. Figure B3 clearly shows that the fruit production is mostly concentrated in the northern non-coastal part of the area analyzed. For this reason table A.3, of appendix A, provides empirical results of the switching regression model described in section 4.2.1 focused exclusively on these particular regions.

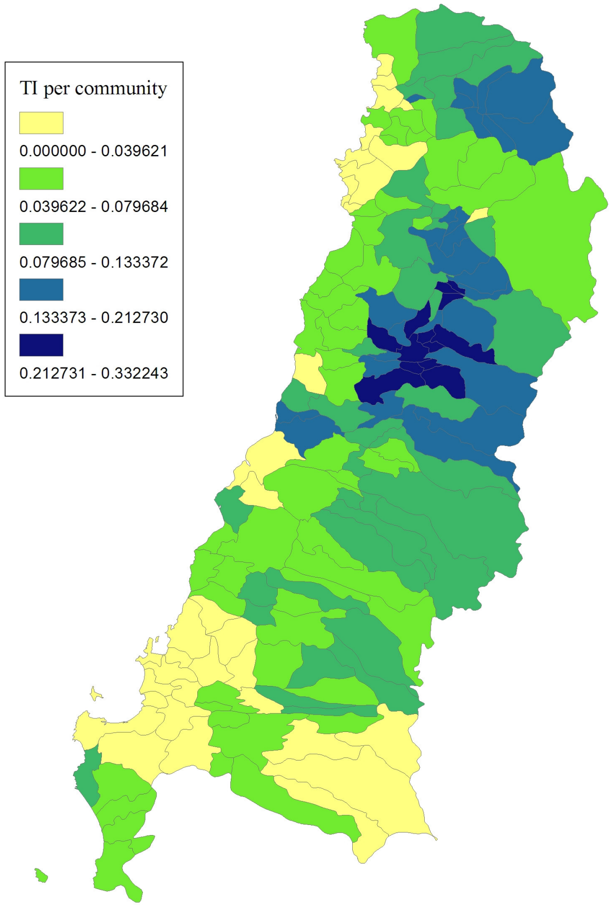


Figure B.1 TI per community

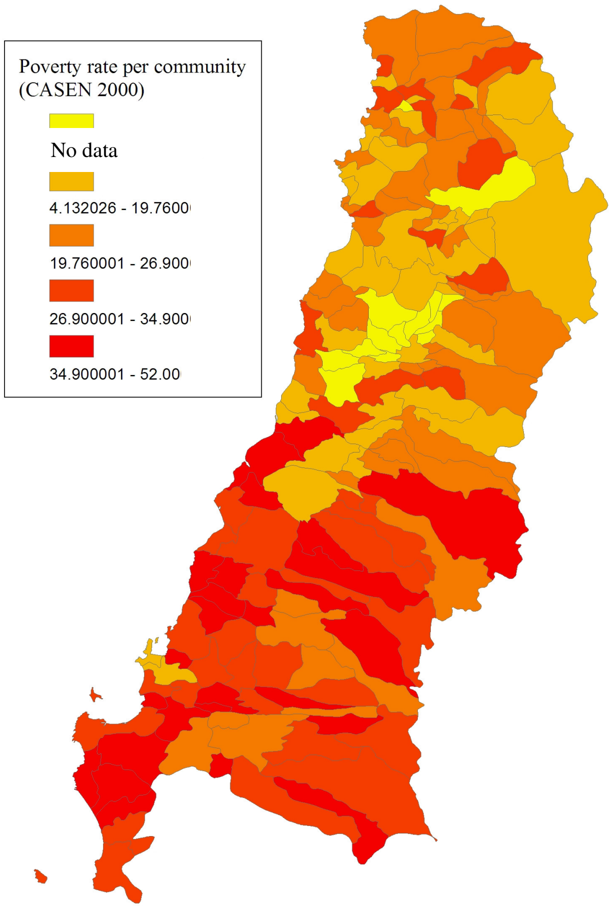


Figure B.2 Poverty rate per community

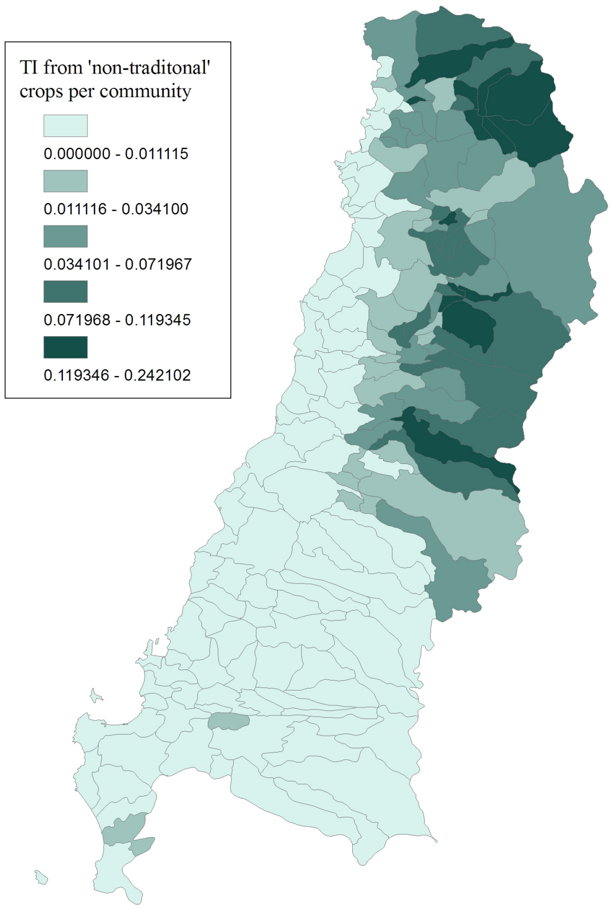


Figure B.3 TI from non-traditional products, per community

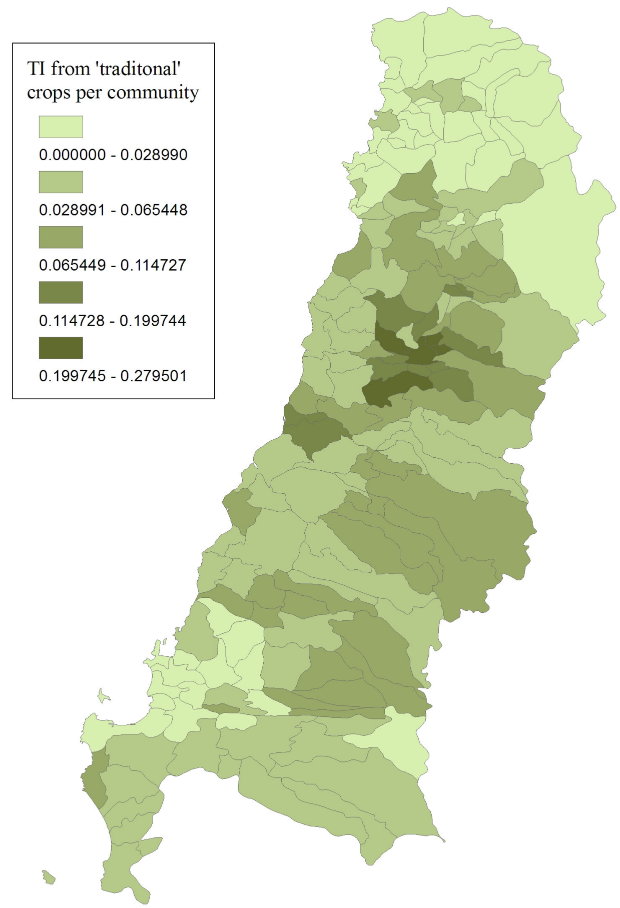


Figure B.4 TI from traditional products, per community

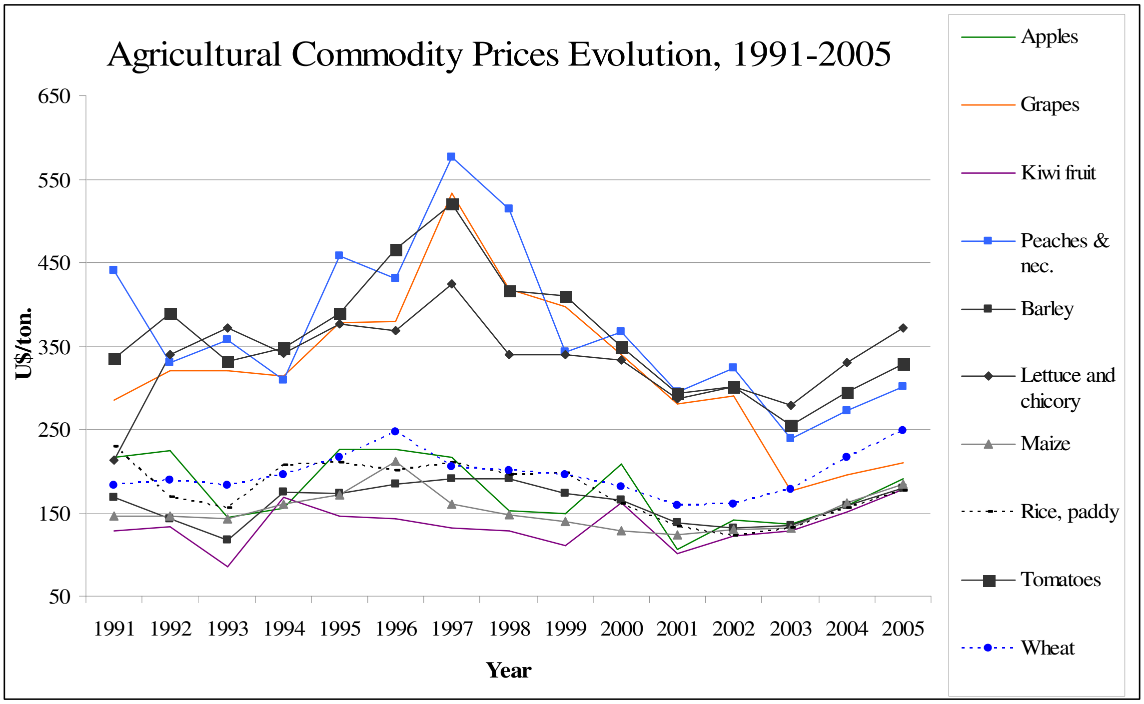
Appendix C

AGRICULTURAL COMMODITY PRICES AND EXCHANGE RATES

One important issue not considered in this study is the influence that prices and exchange rates can have on the agricultural productivity of a region. Economic theory postulates that open economies are more driven by international prices than closes ones. At the same time the exchange rate affects the profitability of international commerce: products with a higher TI from exports will be more profitable for local producers at higher exchange rates.

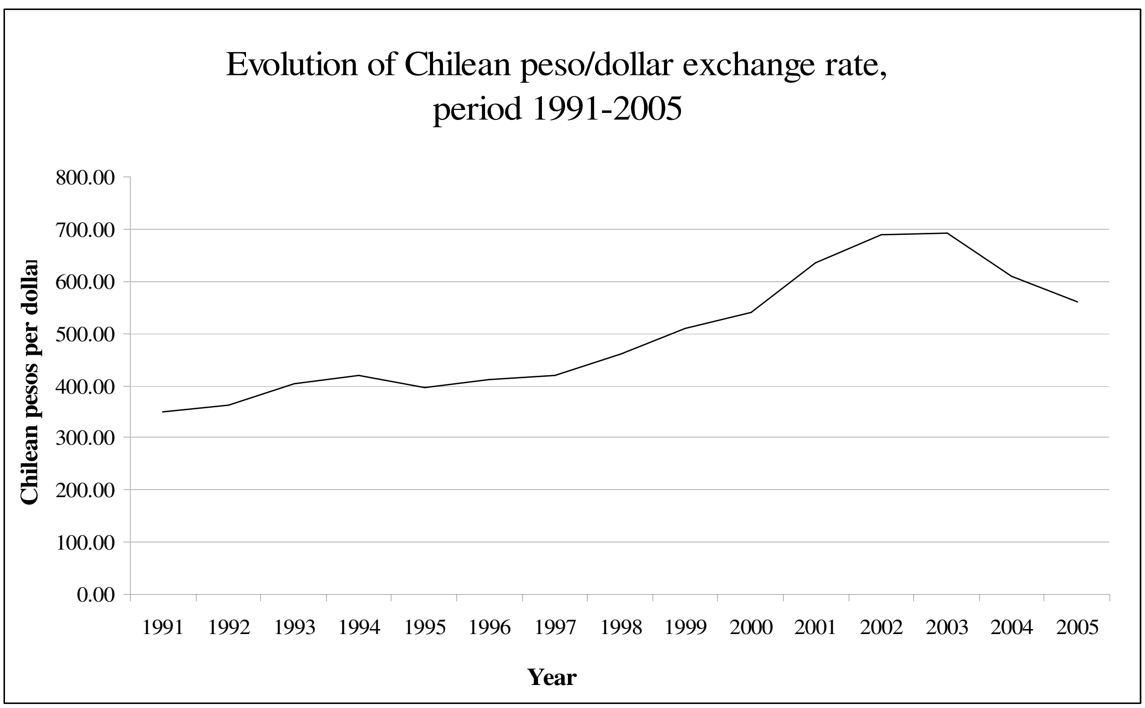
Figures C1, C2 and C3 plot trends over time in agricultural prices, the Chilean peso/US dollar exchange rate, and the TI for selected commodities. The figures show that prices vary over time, the exchange rate has shown an increase, and the tradability index—with the exception of a couple of products—shows no real time trend.

Since most of the analyses performed in this thesis are based on cross-sectional regression, it looks like the evolution of prices and the exchange rate would not alter the main results obtained from the empirical models. However, international prices and the exchange rate do become important factors to consider if a time-series model is employed. Incorporation of these issues into the analysis of international trade effects on rural development over time is left as an important open gate for further research.



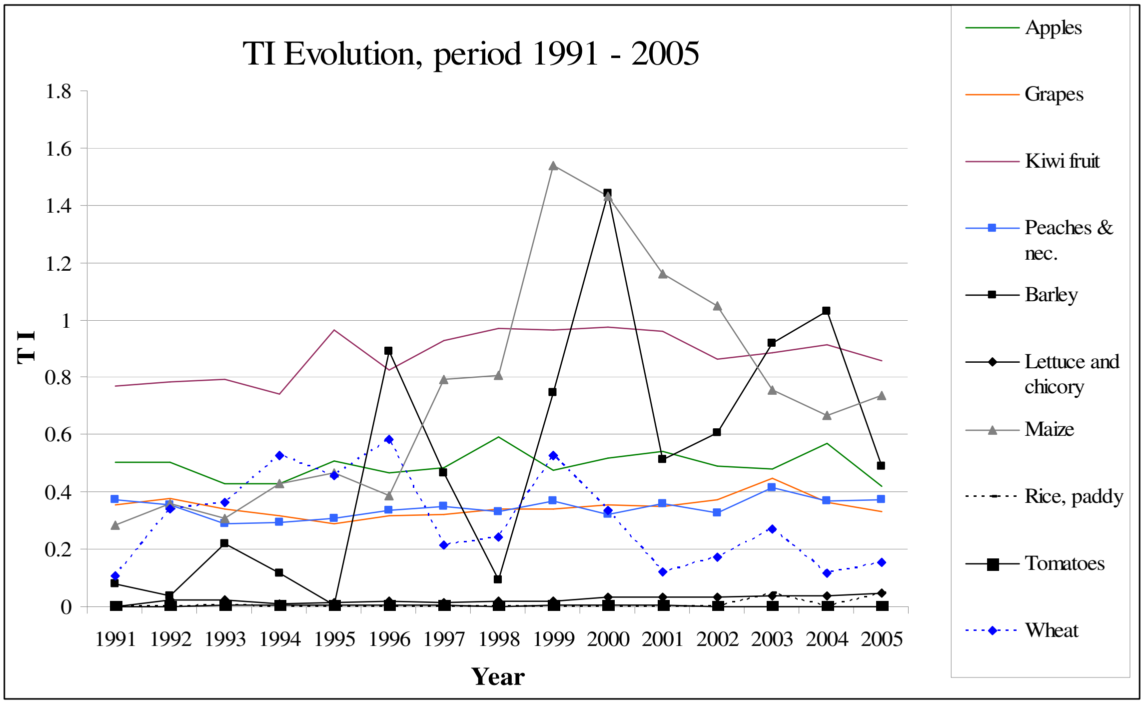
Source: FAO (2007)

Figure C1. Evolution of selected agricultural commodity prices received by producers, 1991-2005.



Source: Central bank of Chile (www.bcentral.cl)

Figure C2. Evolution of the Chilean peso/American dollar exchange rate, 1991-2005.



Source: FAO (2007)

Figure C3. Evolution of selected product-specific tradability index (TI), 1991-2005.