Local and international determinants of coffee berry prices in Costa Rica? The role of environmental attributes

Jorge Valenciano Salazar\textsuperscript{a*}, Francisco J André\textsuperscript{b}, Rafael Díaz Porras\textsuperscript{c}

\textsuperscript{a} Economics’ School. Universidad Nacional, 86-3000, Heredia, Costa Rica.
\textsuperscript{b} Department of Economic Analysis and ICEI. Universidad Complutense de Madrid. Campus de Somosaguas, 28223, Spain
\textsuperscript{c} International Center for Economic Policy (CINPE), Universidad Nacional, 86-3000, Heredia, Costa Rica.

Abstract:
In this work, we investigate the determinants that affect coffee berry prices in Costa Rica. Using a panel data set of coffee berries purchases between 2008 to 2016 we found that the international coffee price is the main reference of domestic prices. Likewise, there are some intrinsic characteristics of berries that are positively related with their average prices: mainly, the use of an organic coffee production system, the altitude of the region where the coffee is harvested, and the yield of the berries. Our estimations also show that multinational coffee companies tend to pay lower average prices than other firms. Finally, the coffee mills certified as Fair-Trade Producers do not necessary pay higher prices to the growers. Actually, we obtain a somewhat surprising result that it is the other way around: certified mills tend to pay, on average, a lower price than non-certified ones.

JEL classifications: C23, Q02, Q11, Q13
Key words: Coffee berry prices, panel data, Fair Trade Producers, organic coffee, international coffee prices.

*Corresponding author. Tel. +91 611020748; fax: 34 913942412
E-mail address: jorge.valenciano.salazar@una.cr

\textsuperscript{1} This article is based on Valenciano’s Ph.D. thesis at the Universidad Complutense de Madrid. The authors would like to thank Elena Huergo and Guillermo Arenas for comments on an earlier version of this paper. Any remaining errors are solely the responsibility of the authors. F. J. André acknowledges support from the Spanish Ministry of Economy, Industry and Competitiveness and Development Fund, ERDF (grant ECO2015-70349-P), Complutense University of Madrid and Banco Santander (grant PR26/16-15B-4) and the European Commission (project SOE1/P1/F0173).
1. Introduction

About 20-25 million families in 51 nations depend on coffee production, so this activity is one of the most important in many rural regions of some developing countries around the world (Castro, et al., 2004; Lewin, et al., 2004; Varangis, et al., 2003). Only in Central America coffee production holds 291 thousand farmers and provides 1.7 thousand seasonal jobs (Castro, et al., 2004; Rahn, et al., 2014).

In Costa Rica, coffee production is an economic activity of great importance for many rural cantons (Pelupessy & Díaz, 2008), where the primary production is mostly carried out by families with small farms. In fact, 92 percent of coffee farmers have plots that are less than 5 hectares and 6 percent have plots that are between 5 and 20 hectares (Dragusanu & Nunn, 2018; Instituto del Café de Costa Rica, 2017).

The Costa Rican coffee value chain is made up of coffee growers, coffee milling companies, exporting firms and roasting firms. In 2017, there were 45,035 coffee growers, 246 coffee mill companies, 76 exporting firms and 65 roasting firms. In 2016-2017 harvest, the coffee exportations were 1.4 million of green coffee\(^2\) bags of 46 kg, which represented 288.3 million of US$. In 2016 coffee production accounted for almost 0.29% of Gross Domestic Product (GDP) and 8.45% of Agricultural GDP (Instituto del Café de Costa Rica, 2017, p. 31,37).

The coffee price is one of the more influential variables that affect the benefits of all the actors along the coffee value chain, especially the growers. Price drops affect both short and long-term growers’ profitability, because they discourage investment in coffee plantations and thus the plots become more vulnerable to pests and diseases (Avelino, et al., 2015). Consequently, the productivity of plantations falls, generating a double crisis for producers, as lower productivity is added to price reductions (Eakin, et al., 2013; Renard & Ortega, 2010).

\(^2\) Green coffee beans are the raw seeds of coffee berries that have been separated from the skin and pulp, i.e., beans have yet to be roasted. Green coffee is also known as “parchment coffee”.
Pelupessy & Díaz (2008), Rettberg (2017), Sick (2008) have reported that low international coffee prices are also related to higher levels of unemployment, poverty, migration, violence and corruption within the coffee production regions.

For these reasons, in Costa Rica the coffee berry price was regulated by the law 2762, which came into force in 1961. The purpose of this law is to solve the market failure due to the information gap between coffee mill companies and growers and to establish an equitable relation system between them. This law establishes that mills must pay for the coffee berries according to the prices that they charge for green coffee in the national and international markets. Specifically, it sets a consignment mechanism in which prices paid to farmers must be a function of the seasonal average price obtained individually by the coffee mills, its production costs and processing yields (Adams & Ghaly, 2007; Costa Rican Congress, 1961; Dragusanu & Nunn, 2018; Lewin, et al., 2004).

Despite this regulation, it has been observed that coffee mills report different annual average prices paid to the growers due to their different market performance and coffee characteristics (see Figure 1). For these reasons, this research aims to answer the following general question: (i) What variables explain the fluctuations of the coffee berry price in Costa Rica? Moreover, we also address the following specific questions related to environmental and social attributes: (ii) Are the organic coffee berries better paid than non-organic coffee berries? (iii) Do Fair-Trade coffee mills pay higher average prices than non-Fair-Trade ones?
Figure 1: Costa Rica. Annual average coffee berry prices paid by mill, per type of coffee and region. In US dollars by a bushel. 2007-2008 to 2015-2016 coffee harvest. Source: Instituto del Café de Costa Rica.

Among the researches who have studied the determinants of the coffee berry price in Costa Rica, Donnet, et al. (2008) estimated a hedonic price function using data from Central and South American e-auctions and found that market clearing prices are a function of sensory characteristics and reputation variables including third-party quality ranking, country of origin, coffee variety, and quantity. They found that e-auctions coffee sales result in substantially higher prices relative to conventional commodity coffee market prices.

Pelupessy & Díaz (2008) concluded that the highest quality coffees harvested in highlands of Central America obtain better prices in the international markets than coffee berries harvested in lowlands. However, by means of market differentiation through environmental and social attributes, lowland producers can increase their sales prices and survive in the coffee sector. Samper (2010) concludes that quality and the use of an organic production system are positively related with better prices for coffee growers in Costa Rica. In the same line, Wollni & Zeller (2007) found that farmers participating in the specialty coffee segment
in three coffee regions of Costa Rica received higher prices than those participating in conventional channels.

In a recent research, Dragusanu & Nunn (2018) found that the Fair-Trade certification is associated with a higher sales price and greater sales by the coffee cooperatives. These authors used a panel data set of 18 years of coffee sales of the mills certified as Fair-Trade Producer compared with those who did not have the certification.

The studies cited above mainly focus on the influence of individual variables such as quality, environmental certifications, or regional differences. The main virtue of the present paper is to analyze the determinants of coffee berry price considering jointly environmental elements as intrinsic characteristics of both product and buyers along with global aspects such as the international price. To the best of our knowledge, there is no study for the case of Costa Rica that addresses the joint effect of this set of variables through a panel data analysis.

The remainder proceeds as follows: Section 2 discusses the conceptual framework, section 3 elaborates on the variables and the data sources, section 4 presents the econometric models and the results. Finally, section 5 concludes.

2. Theoretical framework: The main drivers of the coffee berry prices

Based on the previous literature, one sensible guess is that the domestic coffee price is determined, to a large extent, by the international price, but there are other factors that have a relevant impact on the amount of money that growers receive for one bushel of coffee. In this section we identify and discuss some of the most salient ones, such as the altitude of the production region, the technology of production, the quality of the coffee and the use of environmental and social certifications, focusing on developing countries and paying more specific attention to the case of Costa Rica.
2.1 The international nominal coffee prices

It is well established that international markets are crucial to determine the domestic prices of commodity products, especially in small open countries (Igami, 2015). Lewin, et al. (2004) argue that the green coffee has traditionally been marketed as a commodity; according to Mofya-Mukuka & Abdulai (2013); Worako, et al. (2008) this characteristic increases the probability that changes in international prices drive the domestic prices via a price transmission mechanism.

Nowadays, the main references for the coffee prices in the world are the London International Financial Futures and Options Exchange, and especially the New York Stock Exchange (Jarvis, 2012; Lewin, et al., 2004; Lukanima & Swaray, 2014). Moreover, the International Coffee Organization (ICO) established a general price indicator system conformed by the prices of the different types of green coffee that are marketed around the world; one specific price indicator calculated by ICO is the “Other mild arabicas”, under which the coffee of Costa Rica is classified (International Coffee Organization, 2011; International Trade Centre, 2011).

Figure 2 shows how, in the period between 1990 and 2012, the domestic coffee prices in Costa Rica have followed the same trend as the international prices. This evidence seems to confirm the hypothesis that Costa Rican coffee berry prices are strongly anchored to international markets.
2.2  Coffee berry yield

The agroindustry process of coffee consists in the separation of the husk and the pulp from the coffee berries. Afterwards, the coffee beans must be completely dry. The resulting product is called green coffee or parchment coffee.

The coffee delivered by growers to processors is measured in bushels. One bushel is equal to 4 hectoliters, and results in approximately 100 pounds of green coffee after being processed (González, 1998; Samper, 2010; Wollni & Zeller, 2007). According to the Costa Rican Coffee Institute (2014) an increase in the yield of a bushel of coffee berries implies an increase in the prices paid to coffee growers because coffee berries with larger and heavier seeds are related to higher quality of that beans and, thus, the mills obtain higher yields for their inputs.
2.3 Multinational coffee companies

Multinational companies (MCs) control value-added activities in more than one country (Dunning & Lundan, 2008). These companies are typically vertically integrated, in the sense that the production process has been divided into separate stages but all of them take place within the boundaries of a single firm, and/or horizontally integrated insofar as they establish the same or similar production processes in different locations, mainly to gain market access or because tariffs and transportation costs; see, e.g., Borga & Zeile (2004).

MCs will extract a "fee" to offset the risk of investing specialized and immobile assets dedicated to the host country. “The fee might take the form of higher prices for goods sold in the host country, and/or lower prices for commodities purchased” (Teece, 1985, p. 237). Similarly, Dunning & Lundan (2008); Markusen (1995) consider that the MCs can used their dominant position to get competitive advantages in the form or cheapest factors of production in different countries.

In the coffee sector, multinational coffee companies (MCCs) tend to use a vertical integration strategy, as they integrate most of the value-added processes along the coffee chain; but at the same time, normally they also use a horizontal integration strategy because they carry out the agroindustry process in different countries and in different production regions within the same country (Talbot, 1997; Talbot, 2002). By using these strategies, we would expect that MCCs get better prices than their competitors.

2.4 Coffee differentiation as a strategy to improve coffee berry prices

Most growers and coffee mills follow a lowest-cost strategy; however, a growing group of them are pursuing strategies other than commodity pricing and cost reduction. These alternatives include product differentiation both in the agricultural and the agroindustry processes. In the case of coffee, different channels for product differentiation include geographic indications of origin, gourmet and specialty, organic, Fair Trade Certifications (FTC), Eco-friendly or shade grown, or other certifications (Lewin, et al., 2004).
For their relevance, we focus on the FTC, the organic coffee system production and coffee quality as a differentiation strategies that can improve the price that coffee growers receive for their product.

**2.4.1 The Fair-Trade Producer certification**

Coffee mills buy the berries from growers and make the first industrial transformation to the coffee. Fair Trade Producers (FTPs) are mills, normally cooperatives, that buy coffee from growers who, in many cases, are the partners of the cooperative itself and meet production standards from FT Organizations. In theory, this certification gives more upgrading opportunities to these cooperatives, especially those that are in a lowland coffee area (Pelupessy & Díaz, 2008).

To become certified as such, FT producers must ensure compliance with several requirements, which include paying a fair price to the farmers, transparency and accountability, commitment to non-discrimination, gender equity and freedom of association (labor unions), promotion of fair trade, ensuring good working conditions, facilitating capacity building, respect for the environment, ensuring the absence of child labor and forced labor and creating opportunities for economically disadvantaged producers (The Fair-Trade Coordinator for Costa Rica and Panama, 2016; Ruben, 2009). These efforts are expected to be rewarded by higher prices for agricultural producers.

Several studies in the literature show the willingness of consumers from developed countries to pay higher prices for FT certified coffee, see Campbell, et al. (2015); Langen & Adenaeuer (2013); Schollenberg (2012). According to Varangis, et al. (2003) apart from helping small and disadvantaged producers to earn higher and more reliable incomes from commodity production, the FTC could significantly increase coffee exports from Central America.

Despite what one could expect, the empirical results regarding the effect of FT on price is mixed. In a study for Costa Rica, Dragusanu & Nunn (2018) found that cooperatives and
growers associations who have FT certification receive higher prices and higher revenues when the minimum sales price that is guaranteed by FT is higher than the international price. The same work shows that FT is associated with higher incomes and better social indicators for coffee farmer families.

On the other hand, some papers show that FT certifications do not necessarily involve better prices for the coffee growers. In this respect, see Haight (2007); Jena, et al. (2015); Omidvar & Giannakas (2015); Sick (2008). In short, these papers suggest that the effect of FT certification over coffee growers depends on the margin that the cooperatives can earn on the FT market, as well as on the initial social and economic conditions of the growers. Haight, (2007) and Sick (2008) show that, in the case of Costa Rica, most of the FTPs sold nearly half of the harvest in conventional markets, and some coffee growers do not observe better prices due to FT certifications. On the other hand, FT price is not necessarily the best one available in the international market for quality coffees.

2.4.2 Altitude of coffee production areas

Altitude is an important determinant of the sensorial qualities of coffee (body, acidity, and aroma); the optimal growing conditions in Central America appear to be between 1,200 and 2,100 meters above sea level. The coffee harvested in such areas is classified as hard bean (HB) and strictly hard bean (SHB), which often command significant premiums in the market (Boot, 2002; Pelupessy & Díaz, 2008; Varangis, et al., 2003).

In the specific case of Costa Rica, it has been reported that coffee quality differs considerably across regions. While growers on the highlands tend to produce higher quality coffee and earn significant price premiums, those in lower areas offer lower quality and emphasize cost reduction and volume (Samper, 2010).

Strategically, the agricultural policy in Central America tries to promote the cultivation of coffee in highest altitude areas, since the HB and SHB coffee types have greater prestige and better price in the international markets (Castro, et al., 2004; Pelupessy & Díaz, 2008). For
example, with funding from the Inter-American Development Bank, many growers in Costa Rica have ripped out coffee at lower altitude areas and planted new coffee plants at higher elevations, looking for quality-coffee niche markets (Sick, 2008).

2.4.3 Organic certified coffee

Coffee producers certified as organic must comply with a strict package of technological and environmental standards, which entails the following practices in their farms (Blackman & Naranjo, 2012; Van der Vossen, 2005):

(i) using composted organic matter rather than chemical fertilizer inputs,
(ii) implementing soil conservation practices such as planting shade trees, planting cover crops and mulching,
(iii) using natural substances for controlling diseases, pests, and weeds instead of synthetic pesticides and herbicides
(iv) minimizing the use of fossil fuels in the production process and
(v) minimizing the pollution during postharvest handling.

Summing up, organic coffee growers have to reduce chemical inputs and adopt environmentally friendly management practices such as agroforest techniques. These actions increase the level of biodiversity in the farms (Blackman & Naranjo, 2012; Inter-American Development Bank, et al., 2002). At the same time, organic coffee growers obtain economic benefits, mainly because they can participate in a differentiated market and get better prices while safeguarding their natural resources (Lewin, et al., 2004).

Varangis, et al. (2003) argue that roaster companies pay a premium for organic coffee because final coffee consumers, in turn, are willing to pay higher prices. Alike, Barham & Callenes (2011) found that Mexican organic-coffee growers received, on average, 34 cents more per kilogram than conventional growers in the period from 1995 to 2004. Jena, et al., (2015) found positive effects of organic coffee over the coffee prices in Nicaragua. They show that the farm price obtained by organically certified farmers is 27% higher than the FT-certified and non-certified farmers.
It is important to note that although organic coffee usually obtain higher prices, it also tends to give lower yields than the conventional one. In an experimental study, Lyngbæk, et al. (2001) found that the coffee production of organic farms was 22% lower than that of the conventional farms; however, net income were similar for both groups.

3. Data and model specification

3.1 Panel data set

We built an unbalanced panel data set with the average annual coffee prices paid by mills to growers in Costa Rica. The data correspond to the harvests from 2007-2008 to 2015-2016. Our units of analysis are the purchases of one bushel of coffee berries, denoted as $P_{i(brc)t}$, where: $P_i$ is the group of coffee purchases “$i$”. A group is defined by a given mill or buyer ($b$), a production region ($r$) and a coffee type ($c$). The subscript $t$ refers to the years between 2008 and 2016. So, a same coffee mill could appear in several groups of the panel if it bought more than one type of coffee or from more than one region in the sample period.

In the sample there are 426 coffee purchases groups and 2415 observations. We do not take into account those groups in which the buyer only reports one year during the period. In this way, we seek to reduce the bias that could be introduced by companies that bought coffee in a speculative and non-systematic manner during the period.

3.2 Data sources

We used data from different sources: the data about the average annual coffee berry prices paid by each mill to each type of coffee and production region, as well as the coffee berry yield were taken from the Costa Rican Coffee Institute Web Site. We converted the prices, which were originally in colons, the domestic currency, to dollars using the annual average exchange rate of the Central Bank of Costa Rica.
We identified the FTPs from the Web Site of The Fair-Trade Coordinator for Costa Rica and Panama. This information has been complemented using the Fair-Trade Certification Mark Web Site (FLOCERT, 2017) and the Web Site of The Consortium of Coffee Cooperatives of Guanacaste and Montes de Oro, R.L. (COCAFE).

We identified 20 buyers as FTP, 9 of which are grouped in the cooperative COCAFE, and 11 are independent cooperatives or grower’s associations. Then we sent an email to the cooperatives managers to confirm the period in which they have kept the FT certification and to know the average sales in the FT market in the last 5 years. We got complete answers from COCAFE and 4 more cooperatives.

MCCs have been identified by Faure & Le Coq (2009); García & Valenciano (2016) and Talbot (2002). We have also corroborated the MCCs that operate in Costa Rica through their web pages.

Finally, the international green coffee prices, “other mild arabicas coffee”, are available from ICO.
3.3 Variables:

The dependent variable is the logarithm of the average annual prices paid by a mill according to the coffee type and production region (logACBPdol_{ibrc|t}). On the other hand, the independent variables are both qualitative and quantitative. The former refers to buyers and coffee characteristics, while the second ones are the yield of coffee berries and the international price. Table 1 shows the definition and statistical behavior of each variable.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>n= 2415</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LogACBPdol_{ibrc</td>
<td>t}</td>
<td>Dependent variable. It is the log of average coffee berry prices paid by a mill, (in dollars per bushel)</td>
<td>4.9429</td>
</tr>
<tr>
<td>Quantitative explanatory variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logpoic_{t}</td>
<td>Log of other mild arabicas reference price of ICO (In US Cents per pound)</td>
<td>5.1676</td>
<td>0.2035</td>
</tr>
<tr>
<td>logyb_{ibrc</td>
<td>t}</td>
<td>Log of yield of a bushel of coffee berries. Amount of green coffee that is obtained from a bushel of coffee berries</td>
<td>3.7834</td>
</tr>
<tr>
<td>Qualitative variables (take the value 1 if the relevant characteristic is true, 0 otherwise)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bpa_{ibrc</td>
<td>t}</td>
<td>Brunca.</td>
<td>0.2472</td>
</tr>
<tr>
<td>wvpd_{ibrc</td>
<td>t}</td>
<td>Western Valley</td>
<td>0.1975</td>
</tr>
<tr>
<td>guapa_{ibrc</td>
<td>t}</td>
<td>Guanacaste Coffee</td>
<td>0.0605</td>
</tr>
<tr>
<td>tuaapa_{ibrc</td>
<td>t}</td>
<td>Turrialba and Orosí</td>
<td>0.0683</td>
</tr>
<tr>
<td>lpa_{ibrc</td>
<td>t}</td>
<td>Tarrazú</td>
<td>0.2265</td>
</tr>
<tr>
<td>cvtrpa_{ibrc</td>
<td>t}</td>
<td>Central Valley and Tres Ríos</td>
<td>0.2000</td>
</tr>
<tr>
<td>Characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mcc_{ibc</td>
<td>t}</td>
<td>Multinational coffee company</td>
<td>0.0675</td>
</tr>
<tr>
<td>ftp_{ibc</td>
<td>t}</td>
<td>Fair-Trade Producer</td>
<td>0.1569</td>
</tr>
<tr>
<td>ocof_{ibc</td>
<td>t}</td>
<td>Organic coffee</td>
<td>0.0675</td>
</tr>
<tr>
<td>Cross effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ftpocof_{ibc</td>
<td>t}</td>
<td>Fair Trade Producer that bought an organic coffee</td>
<td>0.0141</td>
</tr>
<tr>
<td>ftpNocof_{ibc</td>
<td>t}</td>
<td>Fair Trade Producer that bought a non-organic coffee</td>
<td>0.1416</td>
</tr>
<tr>
<td>Nftpocof_{ibc</td>
<td>t}</td>
<td>Non-Fair-Trade Producer that bought an organic coffee</td>
<td>0.0534</td>
</tr>
<tr>
<td>NftpNocof_{ibc</td>
<td>t}</td>
<td>Non-Fair-Trade Producer that bought a non-organic coffee</td>
<td>0.7909</td>
</tr>
</tbody>
</table>

Table 1: Summary statistics

4. The econometric models
We specify two equations. The difference between them is that the first one seeks to identify the individual effects of coffee type \((\text{ocof}_{i(bc)t})\) and the Fair-Trade certification \((\text{ftp}_{i(bc)t})\) separately, while the second model considers cross effects of both variables.

\[
\begin{align*}
\text{LogACBPdoli}(brct) &= a_i + \beta 1 \log poi ct + \beta 2 \log yb i(brct) + \beta 3 bpa i(r)t + \\
& \beta 4 wvpa i(r)t + \beta 5 guapa i(r)t + \beta 6 tuapa i(r)t + \beta 7 tpa i(r)t + \\
& \beta 8 mcci(bc)t + \beta 9 ftpi(bc)t + \beta 10 ocofi(bc)t + uit \quad \text{[Eq.1]}
\end{align*}
\]

\[
\begin{align*}
\text{LogACBPi}(brct) &= a_i + \beta 1 \log poi ct + \beta 2 \log ybi(brct)t + \beta 3 bpa i(r)t + \\
& \beta 4 wvpa i(r)t + \beta 5 guapai(r)t + \beta 6 tuapai(r)t + \beta 7 tpa i(r)t + \beta 8 mcci(bc)t + \\
& \beta 11 ftpocofi(bc)t + \beta 12 ftpnocofi(bc)t + \beta 13 Nftpocofi(bc)t + uit \quad \text{[Eq.2]}
\end{align*}
\]

where \(u_{it}\) is a random term.

### 4.1.1 Fixed or random-effects

According to Heij \textit{et al.} (2004), RE is more suitable when the regressors include variables that are constant over the observed time interval but vary between units. In our coffee purchases panel some variables like the coffee type and the production regions are constant in the same group of purchases. According to Torres-Reyna (2007) RE must be used when the following two conditions hold at the same time: (i) there are reasons to believe that differences across entities (in our case, types of purchases) have some influence on the dependent variable and (ii) the model includes time-invariant variables.

To find out what is the best approach, we estimated the Pooled, FE and RE version of our two equations (see equation 1 and 2). For both equations, the Hausman Test confirms that there is no evidence to reject the null hypothesis that the preferred model is RE, so estimated this version of our equations (see appendix A). On the other hand, the Breusch-Pagan Lagrange Multiplier Test (LM) confirms that variances across groups of purchases are different from zero (see appendix B). This is evidence of significant differences among each
group of purchases, so a General Least Square Estimator (GLS) with a Random Effects Regression (RE) is appropriated to estimate our models.

4.1.2 Some problems and the approach of an alternative estimator

We used the Wooldridge test (see appendix C) for autocorrelation and the Wald test for heteroskedasticity (appendix D), which detected the presence of both problems in our models. We also estimated RE models using Generalized Least Squares (GLS) assuming AR(1) disturbances. However, the Durbin–Watson test still suggests the presence of a first order serial correlation (see appendix E). These tests suggest the need to correct the standard errors for serial correlation.

In the literature there are at least two proposals to address these problems in a panel data set: Panel Corrected Standard Errors (PCSE) or Feasible Generalized Least Squares (FGLS) (Moundigbaye, et al., 2018). We chose PCSE estimator insomuch Beck & Katz (1995) showed that the standard errors of PCSE are more accurate than those of FGLS in these circumstances. Specifically, we follow Freybote (2016) Gutiérrez (2017), Onder & Karal (2013) and Thomas et al. (2014) by using the Panel Corrected Standard Errors (PCSE) with the Prais–Winsten Estimation (PWE). This approach allows to correct the problems of heteroskedasticity and autocorrelation following an autoregressive process of order 1, AR (1) even when the data panel is not balanced (Gutiérrez, 2017; Freybote, 2016), as in these panel data set.

5. Results and discussion

The estimated models are showed in Table 2. According to the statistical evidence presented in section 4.1.2, PCSE regression whith Prais–Winsten Model is the preferred approach. Nevertheless, for the sake of robustness, we also show other versions.
According to our results, both of our quantitative variables are positively related with the coffee berry prices. Indeed, all the estimations confirm, first, that the international green coffee price is an important reference for the domestic prices or, in other words, domestic coffee prices react directly to the international market. Our estimation (β1) shows that an 1% increase in the international price generates an increase of about 0.6% in the average prices paid to the coffee growers in Costa Rica, ceteris paribus.

Second, the yield of coffee fruits is also positively correlated with the price as expected (coefficient β2). The interpretation is that coffee mills are willing to pay more when the yield is higher because they can save inputs and production costs.

In the case of the qualitative variables, all of them turn out to be relevant to determine the price. The region dummy variables confirm that each production region receives a differentiated average price for coffee.

We highlight the fact that the coffee harvested in Tarrazu Production Region (coefficient β7) has been sold at an average higher price than that from other coffee production regions of the country. As this is the production region with the highest altitude in Costa Rica (between 1,200 and 1,900 meters above sea level), to some extent we can interpret the variable related to the Tarrazú production region as a proxy variable for altitude. This is in line with Wollni & Zeller (2007), who used the altitude at which the coffee is grown in Costa Rica as a proxy for quality and they proved that altitude is positively related to participation in specialty markets.

Our results also show that MCCs (coefficient β8) have paid on average lower prices than the rest of coffee mills during the sample period. This is consistent with their vertical integration strategy (integrating producing, processesing and exporting links of the coffee value chain), and especially with their strategy of horizontal integration through coffee berry purchases and transformation throughout several producing countries. In the specific case of Costa Rica, MCCs are present processing coffee in most of the producing areas.
As for environmental attributes, we are interested in organic coffee (coefficient $\beta_{10}$) and the FT certification. Regarding the former, it turns out to have a positive influence on the coffee berry price: coefficient $\beta_9$ shows that organic coffee has been paid 30% more expensive than non-organic coffee berries. This finding is almost equal to the one by Jena, et al. (2015) about the organic coffee berry prices in Nicaragua.

On the other hand, Fair-Trade Producers did not appear to have paid a higher price than non-certified companies in our sample. Actually, it was the other way around: on average, they paid around 10% less, ceteris paribus (coefficient $\beta_9$). This apparently surprising result merits some discussion. First, against what is commonly believed by many consumers, the price is not the only channel by which Fair Trade cooperatives can reward growers. On the contrary, apart from the price premium, they tend to generate indirect benefits to the producers, such as technical assistance, credit facilities, or social projects in the communities; these actions are not reflected in the final price of the coffee berries; see Dragusanu and Nunn (2008) and Sick (2008).

Second, Haight (2007) and Sick (2008) claim that most FTPs in Costa Rica sell much of their coffee to roasters or brokers in conventional markets. They present three cases; two cooperatives sold only 40% of its coffee at FT prices in Costa Rica, while another cooperative sold only 23% of its coffee in the FT market in Guatemala. In the same way, the survey that we applied to the managers of the certified cooperatives shows that the proportion of coffee sold in the FT market since 2012 to 2016 is very uneven according to the cooperative, going from certified cooperatives that have not been able to sell nothing in the FT market, to others that place 67% of its production in that market. Theoretically, Omidvar & Giannakas (2015) and Weber (2007) showed that the saturation of the FT coffee market leads to a reduction in growers’ welfare.
Notes: Unbalanced Panel: years=9, n=2415, Groups of purchases=426. Our control variable is a non-fair producer that buys non-organic coffee. Observations per group: average=5.7, minimum=2, maximum=9. Legend: * p<0.05; ** p<0.01; *** p<0.001

Table 2: Regression results of some determinants over coffee berry price in Costa Rica. Dependent variable: logarithm of average of coffee berry price paid by buyer companies

---

1 We have not carried out the control of temporary effects (i.t) because the variation of local prices in each year is correlated with the variable of international prices, what generates approximate collinearity.

4 Central Valley Region is outside the model and remains as a point of comparison, besides, NftpNocof is the point of comparison.
Our result differs from the one by Dragusanu & Nunn, (2018), who found a clearly positive relationship between the FT certification and the prices that cooperatives get by green coffee. However, there is an important different between their approach and ours. While we used the average prices that coffee growers received by mills, Dragusanu and Nunn used the prices got by the cooperatives. By combining both results, one can conclude that, although cooperatives can sell Fair Trade coffee with a price premium in the market, this is not necessarily reflected in average higher prices paid by cooperatives to the growers because cooperative can be sell coffee to other markets where coffee prices are lower.

Finally, in equation 2, coefficients $\beta_{10}, \beta_{11}$ and $\beta_{12}$ reveal that FTP mills have paid lower average prices for both organic and non-organic coffee berries, so non-FTP mills have paid during the sample higher average prices, both for organic and non-organic coffee.

### 6. Conclusions

According to our results, the domestic coffee price in Costa Rica appears to be affected mainly by international green coffee prices. This is an expected result given that, as a commodity, coffee berry prices are strongly affected by international coffee market. We have also concluded that coffee mills have paid higher average prices linked to the coffee berries quality and the attribute of being organic coffee.

Moreover, our estimations suggest that there is a direct relation between the coffee berry prices and the altitude at which the coffee is harvested. This result is explained because the altitude is correlated whit the quality of coffee berries. Moreover, most of the coffee harvested in the high altitude regions is classified as HB or SHB, some of the most appreciated in the international market. So, highland coffee growers have a comparative advantage because the quality of their coffee is more valued in the market.
We have also shown that multinationals take advantage of their scale of production and its domestic and international disaggregation to obtain lower average prices than the rest of the coffee mills.

Regarding the environmental characteristics, we have concluded that the organic coffee has generated a significant price differential at the domestic level. However, a fully-fledged profitability analysis should also account for the fact that the organic productions imply some reductions in productivity per hectare.

On the other hand, FTPs have not paid higher but lower average prices of coffee berries than non-certified coffee mills. This price difference may be due to the fact that the certified mills do not manage to place all their production at the Fair Trade market, so they must access also conventional markets. It must be born in mind, anyway, that this result does not mean that FT does not bring any benefit to coffee growers, since the FT premium is not only delivered via prices, but also through other channels such as community projects or technical assistance for the farmers.

Appendix: Econometric tests

A. Hausman test
Test: $H_0$: difference in coefficients not systemat

$\text{Eq 1}: \chi^2 (3) = 3.82, \text{ Prob} > \chi^2 = 0.2816$

$\text{Eq 2}: \chi^2 (4) = 8.94, \text{ Prob} > \chi^2 = 0.0626$

B. Breusch and Pagan Lagrangian multiplier test for random effects.

$\text{Eq 1}: \chi^2 (01) = 422.62, \text{ Prob} > \chi^2 = 0.0000$

$\text{Eq 2}: \chi^2 (01) = 423.16, \text{ Prob} > \chi^2 = 0.0000$

C. Wooldridge test for autocorrelation in panel data

$H_0$: no first-order autocorrelation
Eq 1: \( F(1, 337) = 52.553, \) Prob > \( F = 0.0000 \)
Eq 1: \( F(1, 337) = 52.820, \) Prob > \( F = 0.0000 \)

D. Modified Wald test for groupwise heteroskedasticity in fixed effect regression model

Eq 1: \( \chi^2 (426) = 6.7e+30, \) Prob > \( \chi^2 = 0.0000 \)
Eq 2: \( \chi^2 (426) = 3.0e+31, \) Prob > \( \chi^2 = 0.0000 \)

E. First order serial correlation test

Eq1: Modified Bhargava et al. Durbin Watson = 1.673719
Baltagi-Wu-LBI = 2.0232302

E12: Modified Bhargava et al. Durbin Watson = 1.675195
Baltagi-Wu-LBI = 2.0246648

References


Jarvis, L. S., 2012. The welfare implications of Brazil’s coffee export price subsidies during the ICA. Agricultural Economics, 43(S1), p. 19–32.


Rahn, E. et al., 2014. Climate change adaptation, mitigation and livelihood benefits in coffee production: where are the synergies?. Mitigation and Adaptation Strategies for Global Change, 19(8), pp. 1119 - 1137.


