Liquidity, Scale Economies, and Shocks: Theoretical and Empirical Determinants of Side-Selling in Peruvian Specialty Coffee Cooperatives

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Abstract

Organic coffee farming households in Peru can benefit from participation in specialty coffee cooperatives because cooperatives offer higher and more stable prices than private buyers, distribute end-of-season dividends, and offer extension and credit services. Despite these economic benefits, around 20% of the members of two specialty coffee cooperatives in Cajamarca, Peru sell at least some of their organic coffee to private buyers. Since cooperatives operate on scale economies, understanding such "side-selling" is imperative for cooperative managers since side-selling weakens the ability of cooperatives to provide price premiums and other benefits to their members. Most studies on side-selling in coffee cooperatives analyze situations in which private buyers offer price premiums, but the higher and more stable prices offered by specialty coffee cooperatives in Peru make side-selling in this context all the more perplexing. This paper builds upon existing economic theory of side-selling and empirically examines the determinants of side-selling in two Peruvian specialty coffee cooperatives using panel data. Our analysis shows that risk preferences, liquidity demand, scale economies, and fixed costs to private marketing are the key mechanisms driving side-selling behavior. We then examine how households respond to the coffee leaf rust epidemic that ravaged Peruvian coffee production from 2012-2013 and find that production shocks affect households' marketing decisions through the aforementioned mechanisms. Our results are in line with previous studies on side-selling, suggesting that cooperative price premiums and price stability do not alter the mechanisms driving side-selling found in studies on conventional coffee cooperatives. Our paper contributes to a growing literature surrounding the determinants of side-selling in farmer cooperatives by extending existing economic theory to include risk and outside liquidity, by using panel data to empirically examine determinants of side-selling, and by examining side-selling behavior in the presence of production shocks.

1 Introduction

Coffee is one of the world's most important agricultural commodities, consisting of 19 billion USD in global exports in 2017 (Voora et al., 2019). Coffee is almost exclusively produced in developing countries and is central to the economy of many coffee-producing countries serving as the source of income for millions of people. Despite its massive global scale, smallholder farmers produce 70% of coffee globally (Panhuysen and Pierrot, 2014). Smallholder coffee farmers' incomes and livelihoods are dependent on volatile international coffee prices, which can have detrimental household welfare effects (Mohan et al., 2014). Further, rising temperatures and increasingly volatile climatic patterns threaten coffee production and quality while also

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creating conditions the proliferation of pests and diseases that can decimate coffee harvests (DaMatta and Ramalho 2006, Jaramillo et al. 2011). On a microeconomic level, there have been numerous attempts to build smallholder resiliance to volatility in markets and climate (e.g. contract farming, improved varieties, and farmer field schools), but often such programs are not self-sustainable.

Coffee cooperatives can potentially improve smallholders' livelihoods in a financially sustainable way. Collective marketing and leveraging economies of scale to reduce transaction costs make smallholder farms more profitable (Bacon 2005, Stockbridge et al. 2003). By aggregating production, cooperatives also have more bargaining power with buyers and can sell directly to traders or exporters, fetching better prices (Thorp et al., 2005). The extra profits are typically channeled to members through price premiums and/or dividends paid to members at the end of the season (Enelow, 2014). Further, cooperatives can offer extensions services and other benefits, such as access to finance.

Membership in agricultural cooperatives has generally been shown to improve farmers' livelihoods through increased technology and input adoption (Abebaw and Haile 2013, Ma and Abdulai 2016, Zhang et al. 2020), improved productivity (Ortega et al. 2019, Verhofstadt and Maertens 2014, Ma and Abdulai 2016), and improved incomes (Wollni and Zeller 2007, Markelova et al. 2009, Ma and Abdulai 2016, Mojo et al. 2017). In a review of peer-reviewed publications, Grashuis and Ye (2019) finds that cooperative membership generally improves members' outcomes across the aforementioned factors; however, there is heterogeneity between large and small farmers and across organizational structures. Improvements to livelihoods and farm performance are also dependent on o members' commitment to and participation in the cooperative (Grashuis and Ye, 2019).

Specialty coffee cooperatives can be particularly beneficial to small farmers because they can help households gain access to certification, such as organic and/or fair-trade certification, that would have prohibitively high costs for individual farms, but not for a collective of farmers (Barrett et al., 2001). Certification can improve incomes and household assets (Ruben and Fort, 2012).

In the last decades, specialty (e.g. fair-trade, organic) coffee markets have seen drastic growth in Europe and the United States (The International Trade Centre 2004, Voora et al. 2019). With this growth, specialty coffee cooperatives (cooperatives dealing primarily in cerified organic and/or fair trade coffee) have taken hold in many producing countries, particularly in Latin America (Linton 2008, Simatovic and Remy 2007). Compared to conventional coffee, speciality coffee yields higher prices on global markets (Bissinger, 2019). Further, specialty coffee markets are less volatile than conventional coffee markets, meaning that specialty coffee producers can have more stable incomes (Simatovic and Remy, 2007). Specialty coffee cooperatives also provide technical assistance to farmers who wish to transition from conventional to organic farming, reducing farmers' reliance on input markets and increasing the long-term environmental sustainability of coffee farming (Bissinger, 2019). Across different agricultural markets, sustainability standards and certification have also been shown to improve household income across have also been shown to improve farmers' incomes over time (Meemken, 2020). This holds true in specialty coffee markets as well. In Peru for example, input adoption, household income, and household assets were shown to increase as a result of fair-trade certification (Ruben and Fort, 2012). A review of papers analyzing the impacts of sustainability standards and certification in the coffee industry reveals that certification is more likely to improve livelihood measures than not (Bray and Neilson, 2017). However, there are of course significant heterogeneities in these effects, particularly with regard to institutional and organizational strength.

The effectiveness of cooperatives (and their certification programs in the case of specialty coffee cooperatives) in improving livelihoods is dependent on the capacity of the cooperatives themselves (Grashuis and Ye, 2019). One of the key factors contributing to the success of cooperatives is member commitment (Sexton and Iskow, 1988). Despite the benefits offered by coffee cooperatives, members still engage in side-selling – the sale of coffee outside of the cooperative (Arana-Coronado et al. 2019, Wollni and Fischer 2015, Enelow 2014). Even in specialty coffee cooperatives where there are price premiums offered when selling to the cooperative, side-selling is still prevalent. For example, in Mexico farmers on averages side-sell about 20% of their coffee (Arana-Coronado et al., 2019). In our dataset of farmers in Peru, around 20% of respondents also side-sell at least some of their organic coffee.

Side-selling can be detrimental to the financial health of cooperatives, and consequently reduce their effectiveness in providing benefits to their members (Sexton and Iskow 1988, Mosheim 2008). For example, side-selling creates uncertainty in the supply of coffee the cooperative can sell, making it harder to meet contractual obligations and have healthy long-term relationships with buyers (Murray et al., 2006). Lower supplies also result in decreased revenue and margins for cooperatives, resulting in lower dividends paid to members and decreased capacity to provide access to inputs, extension, and other services. Finally, side-selling presents a free-rider problem where members may extract services from the cooperative, but not contribute to building cooperative resources (Mujawamariya et al., 2013). These issues drain cooperative resources and jeopardize the long-term viability of the organization.

Numerous studies have researched the determinants of side-selling decisions, and have found that household demographics, economic factors, member attitudes, and institutional arrangements are potentially related with members' side-selling decisions. In terms of demographics, older household heads have been found to side-sell less in Ethiopian barley cooperatives (Alemu et al., 2020), and higher education is associated with higher side-selling rates Costa Rican coffee cooperatives Wollni and Fischer (2015). Among female cooperative members, improved household bargaining is correlated with higher member commitment in Ugandan coffee cooperatives (Meier zu Selhausen, 2016).

Household economic factors can also play a role in side-selling decisions. Farm size is particularly important with concerns over cooperatives' ability to serve the smallests/poorest farmers (Bijman and Wijers, 2019). Medium-sized generally make up the bulk of cooperative membership because small farmers cannot cover the fixed costs of membership and large farmers have enough bargaining power to sell on private markets (Bernard and Spielman, 2009). While large farmers are shown to be the most likely to side-sell in some instances (Gadzikwa et al., 2007), this relationship does not always hold. Small and large farmers are the most committed members in Costa Rican coffee cooperatives, while medium-sized farmers are the most likely to side-sell (Wollni and Fischer, 2015). Other household economic factors such as labor, credit, and on-farm diversification may influence marketing decisions. In Peru, reliance on family labor and/or local community labor networks is associated with lower levels of outside marketing, while reliance on hired on-farm labor is associated with higher levels of side-selling (Enelow, 2014). The type of on-farm labor used can also be representative of households' underlying economic conditions and social capital. Wollni and Fischer (2015) also shows that having outstanding credit reduces the incidence of side-selling, perhaps because members with outstanding credit feel more attached to their cooperative. Finally, the relationship between on-farm diversification and side-selling is unclear. In (Fischer and Qaim, 2011), more diversified farmers tend to side-sell more frequently in Kenyan banana cooperatives, while in Ethiopian barley cooperatives, households with a higher percentage of land devoted to barley also tend to side-sell more frequently (Alemu et al., 2020).

Farmers' attitudes and interactions with cooperatives also influence side-selling decisions. The number of interactions with a cooperative and having a price as the primary motivation for selling reduce side-selling when the cooperative offers price premiums (when dividends are included) (Wollni and Fischer, 2015). When farmers believe that cooperatives are committed to the well-being of the relationship between the farmer and cooperative, they tend to sell more of their harvest through the cooperative (Arana-Coronado et al., 2019). Similarly, Fischer and Qaim (2011) notes that farmers' belief that the cooperative is exploiting them is associated with a greater propensity to sell outside of the cooperative. Risk aversion in decision-making leads farmers to sell through the less risky marketing channel. In some cases, cooperatives offer more stable prices, and risk aversion is associated with greater sales to the cooperative (Mujawamariya et al., 2013). In other cases, when cooperatives delay payments, farmers may be worried that the cooperative will not pay because of default. In such cases, more risk averse farmers are more likely to sell on the private market, even if the cooperative offers a price premium (Woldie, 2010). Even if there is uncertainty around payment timing, risk aversion is positively associated with side-selling (Arana-Coronado et al., 2019).

Farmers interactions with and attitudes towards cooperatives underscore the importance of institutional factors in member commitment. When cooperatives offer price premiums, members are less likely to side-sell (Woldie 2010, Arana-Coronado et al. 2019). Further, quicker payments result in less side-selling (Shumeta et al. 2018, Fischer and Qaim 2011, Saitone et al. 2018, Arana-Coronado et al. 2019, Alemu et al. 2020). This is likely due to the fact that discount rates play a smaller role in marketing decisions when cooperative payment timing is similar to that of private markets (Wollni and Fischer, 2015). Some cooperatives are virtual monopsonies (e.g. Kenyan coffee cooperatives), but others operate in more competitive environments, where the presence of other buyers increases the rate of side-selling (Macchiavello and Morjaria, 2019). Institutional factors related to social-capital can also be important in influencing marketing decisions. When cooperatives are subdivided into farmer groups, smaller groups strengthen social networks within the cooperatives, increasing the social cost of free-riding and decreasing side-selling (Fischer and Qaim 2011, Shumeta et al. 2018). The cooperative can also try to exert pressure itself to disincentivize side-selling. For example, in an experiment with Kenyan dairy cooperatives, Casaburi and Macchiavello (2015) shows that distributing letters among members describing financial penalties, sanctions, and potential expulsion if members side-sell resulted in less side-selling. Unlike Kenyan dairy cooperatives; however, many cooperatives do not have regulations and/or enforcement mechanisms to prohibit members from selling to outside buyers.

Only one previous study specifically focuses on specialty coffee cooperatives (Arana-Coronado et al., 2019), and to date, there are no studies addressing the role of production shocks and outside income in side-selling, despite climate change making production environments more volatile. Climate change is causing rising temperatures and more volatile rainfall, and this trend is expected to continue in the foreseeable future (Marengo et al., 2014). Smallholders are now operating under more volatile conditions than ever before - for example, smallholder farmers are beginning to perceive more variable weather patterns and changes in seasonality, making it difficult for them to plan their farms' growing cycles (Osbahr et al., 2011). Further, Arabica coffee is sensitive to temperature changes and even marginally higher temperatures put many coffee farms at risk of producing lower quantities and quality of coffee (DaMatta and Ramalho, 2006). Rising temperatures are also creating conditions for plant diseases to proliferate, threatening smallholder farm production on yet another front (Jaramillo et al., 2011). Organic farmers in particular are left vulnerable to these pests because they do not use chemical pesticides. As production shocks become more common, an understanding of how these shocks affect cooperative member commitment is needed, particularly when production shocks can affect a large number of members in the same season.

The literature on side-selling is heavily reliant on cross-sectional empirical studies, which have weak internal validity and questionable generalizability (external validity) since they generally focus on few co-operatives in geographically-limited areas. Cross-sectional studies have uncovered numerous correlates of side-selling, but it is unclear whether these correlates play a role when accounting for differences individual characteristics. Panel data analysis can overcome this weakness by controlling for individual fixed effects and absorbing much of the endogeneity inherent in cross-sectional analysis. Further, case studies of specific markets in specific countries are likely the only approach to empirically understanding the determinants of side-selling (as data collection across many markets, cooperatives, and countries would be prohibitively expensive), but case studies tend to have low generalizability (external validity). Placing the results within a theoretical framework can help assess the mechanisms at play and improve assessments of whether findings can be applied to other contexts (Garcia and Wantchekon, 2010). However, only Woldie (2010) and Wollni and Fischer (2015) develop economic models to show the theoretical underpinnings of side-selling decisions.

This paper helps to address the shortcomings in the side-selling literature by extending existing theory and using panel data to understand the determinants of side-selling in two specialty coffee cooperatives in Peru. From a theoretical standpoint, Wollni and Fischer (2015) proposes that liquidity demand and scale economies are key drivers of cooperative side-selling, and Woldie (2010) argues that risk and risk preferences are important to side-selling decisions. We build upon the existing side-selling theories in two key ways. First, we include a cash endowment and fixed costs to marketing to explore how liquidity from non-coffee sources (i.e. an external endowment) can affect side-selling decisions through liquidity, scale economies, and fixed costs to marketing. Second, we analyze the model outcomes in the context of production shocks and show how the risk, scale economy, and liquidity demand mechanisms affect households' responses to shocks.

From an empirical standpoint, this study is the first to analyze side-selling determinants using panel data. Our data comes from a survey of 200 farmers belonging to two specialty coffee cooperatives in Cajamarca Peru.[1] The first wave of data collection took place in early 2014, followed by a second wave in early 2016. We

[1] Due to attrition and missing data, the final sample used in econometric analysis is smaller.

apply a within-between panel data estimator (Allison 2009, Bell and Jones 2015), which is able to provide estimations of correlations of side-selling and time-varying characteristics within households, as well as time-varying and time-invariant characteristics between (or across) households. While our methods are still not able to make causal claims, we are able to reduce the endogeneity inherent in cross-sectional studies. Further, we are able to test the predictions of Wollni and Fischer (2015) in the Peruvian specialty coffee cooperative context, analyze the role of risk and outside income in side-selling, and show how production shocks can influence side-selling decisions. We further explore heterogeneity in marketing responses to production shocks based on households' outside income and risk preferences. Beyond exploring new determinants of side-selling (e.g. production shocks), the panel analysis makes improvements over cross-sectional analysis in the internal validity of the study, while linking the empirical findings with economic theory is an attempt at improving the generalizability of the findings.

Our findings are consistent with (Wollni and Fischer, 2015), which finds a U-Shape relationship between farm size and member commitment. Our findings show that small farmers and larger farmers are more likely to sell through the cooperative than medium-sized farmers. Our results are also consistent with Arana-Coronado et al. (2019), Mujawamariya et al. (2013), Saitone et al. (2018), and Woldie (2010) who find that risk aversion is associated with increased sales through the less risky marketing channel (the cooperative in the context of this paper). However, we do not find significant associations between side-selling and attitudes or demographics in contrast to many papers in the literature. This non-finding could be a result of the panel data models being able to control for time-invariant household-level heterogeneity. We also find that non-coffee income is correlated with higher side-selling rates, likely because outside liquidity can help households pay for fixed costs (e.g. search costs) to marketing through private channels.

On average, production shocks do not have a statistically significant correlation with side-selling within households across time, but for households with high risk-taking tolerance and high levels of outside income, production shocks are correlated with increased side-selling. These findings confirm the theoretical predictions of heterogeneous marketing responses to production shocks.

The rest of the paper is organized as follows. Section 2 describes the study context in terms of Peruvian specialty coffee cooperatives and the coffee leaf rust epidemic. Section 3 describes the theoretical framework that builds upon Wollni and Fischer (2015). Then, 4 presents the data used in the empirical analysis, and Section 5 discusses the empirical methodology used to measure the determinants of side-selling. Section 6 presents the main empirical results, and Section 7 concludes.

2 Study Context: Peruvian Cooperatives and Coffee Leaf Rust

2.1 Peruvian Coffee Cooperatives

Our study uses data from members of two specialty coffee cooperatives – Cooperativa Agraria Cafetalera La Frontera (Frontera) and the Cooperativa Agraria Cafetalera La Prosperidad de Chirinos (Chirinos) – in the Cajamarca region of Peru. Both cooperatives in our study were founded in the 1980s and experienced dips in membership in the 1990s (like most cooperatives) as a result of a national changes in policies that reduced subsidies to farmers. Since the 2000s, they have been recovering membership with the help of certification projects and collaboration with international actors to help them access specialty coffee markets. This history largely reflects that of Peruvian coffee cooperatives in the past three decades (Simatovic and Remy, 2007). . Further, according to qualitative interviews with cooperative managers, improved cooperative access to external capital has helped the cooperatives to offer more services, such as micro-loans, farmer training, and technical assistance (especially related to organic farming).

Selling to these cooperatives is characterized by three key features – price premiums, more stable prices, and delays in payment. The specialty coffee cooperatives focus on organic, fair-trade coffee, which yields higher prices than conventional coffee (Bissinger, 2019). While individual farmers can sell certified organic coffee on the private market, fair trade certification is given at the cooperative level, allowing cooperatives to offer a price premium over private buyers. According to the surveys in 2014 and 2016, these prices premiums are estimated to be 4.8% and 5.6% respectively.[2]. Table 1 shows the price premiums reported by farmers in the survey and Section 4 discusses this data in more detail. Further, specialty coffee prices are less volatile on the international market than conventional coffee, and because of this, cooperatives can offer not only higher, but also more stable prices than private buyers. While farmers can benefit from these incentives offered by cooperatives, it comes at a cost – cooperatives payments to members are delayed. Qualitative interviews with cooperative managers suggest that cooperative payment delays in recent years have been reduced from months to cooperatives offering 80% of the sale price upon delivery and the remaining 20% months later. This has largely been the result of cooperatives gaining access to external capital. In another study of side-selling in Peruvian cooperatives, the delay in the delivery payment is generally 1-2 weeks (Enelow, 2014). Finally, the cooperative dividend is distributed at the end of the season, so members must wait a full season to receive dividend payments.

Table 1: Cooperative Price Premiums

	2013	2015
Cooperative Price/Kg	1.04	1.43
	(42)	(28)
Outside Buyer Price/Kg	1.09	1.51
	(172)	(141)
Cooperative Premium	4.8%	5.6%

Observations in parentheses

According to cooperative managers, the improved payment times have helped increase 'fidelity' to the cooperative (i.e. reduced side-selling). Despite these advancements in cooperative capacity, side-selling still exists. From the survey data, 23% of farmers side-sold at least some of their organic coffee[3]. The cooperatives do not have any regulations prohibiting members from selling on the private market.

2.2 Coffee Leaf Rust

Coffee leaf rust develops from a fungus called Hemileia vastatrix, which develops in settings of decreased moisture and temperatures between 10 and 35 degrees Celsius. The disease inhibits the ability for leaves to photosynthesize and produce fruits, drastically reducing yields (Arneson, 2000). The disease's impact can be mitigated by planting improved varieties or using fungicides (often copper-based). Organic farmers have greater difficulties in fighting coffee rust because fungicides are often non-organic (Torres Castillo et al., 2020). Further, switching to new varieties takes time. Once planted or grafted, coffee trees take 2 to 3 years to produce cherries, making changes in varieties a long-term, rather than short-term, solution to to mitigating the effects of coffee leaf rust (Abate et al., 2021).

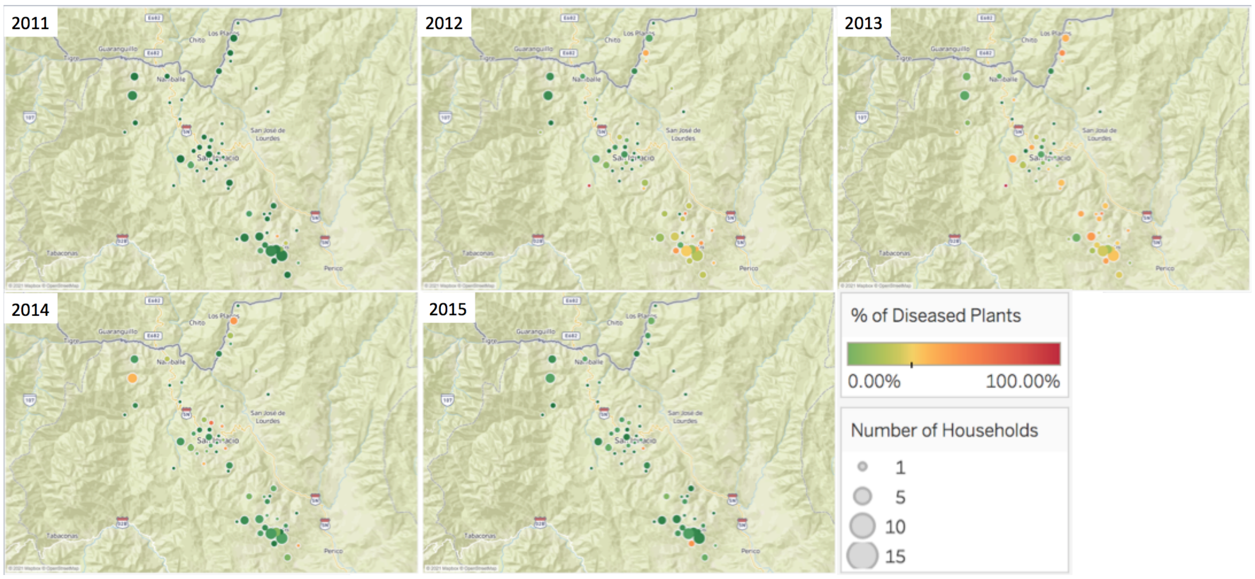
In the last decade, coffee leaf rust has devastated yields in numerous Latin American countries, including Peru where it peaked in 2013 (Avelino et al., 2015). Despite other Latin American countries experiencing outbreaks of coffee leaf rust before Peru, the epidemic was unexpected and few precautions were taken to prevent the disease from spreading in Peru (Avelino et al., 2015). As a result, coffee leaf rust affected about 60% of the value of coffee harvests in 2013, amounting to 290 million USD in lost value (Julca Otiniano

[2]These are rough calculations based on farmers' responses to selling prices in the survey. The sample sizes are low for prices of organic coffee on private markets, but still show evidence of a price premium. The presence of price premiums is consistent with other studies on fair trade coffee (Bacon, 2013)

[3]We focus on organic coffee because the cooperatives' is on organic coffee. Only 17 of 200 farmers do not grow organic coffee at all, and these farmers are excluded from the sample

et al., 2019). About 76% of farmers in our 2014 survey reported having at least one tree with plant diseases in 2013 (up from 10% in 2009). 25% of the median farm was infected in 2013, but the leaf rusted subsided in 2015 with the median farm having only 8% of trees infected. The geographic and temporal distribution of coffee leaf rust in the study area is shown in Figure 1.

Figure 1: Geographic Distribution of Plant Diseases (2011-2015)



While the effects of the outbreak were widespread, they were not homogeneous. Farmers were unable to stop the spread of coffee leaf rust, but several farm characteristics and farm management practices could help mitigate the impacts of the disease. For example, using best practices builds up the health of trees and this can reduce the impacts of coffee leaf rust. Farms with older trees are more susceptible to coffee leaf rust, so farmers who continuously rejuvenate their farms are less susceptible (Ehrenbergerová et al., 2018). Finally, certain varieties are resistant to coffee leaf rust (although they can still get the disease) (Borjas-ventura et al., 2020). In the study area, the *Catimor* variety is resistant to coffee leaf rust, while other common varieties – *Pache*, *Typica*, *Caturra*, and *Bourbon* – are not resistant to coffee leaf rust (World Coffee Research, 2019). The median farm in our study is comprised of 50% *Catimor* trees.

3 Theoretical Framework

The theoretical framework explains how farmers make marketing decisions between private and cooperative buyers given an exogenous coffee production quantity. The model uses the theoretical framework of Woldie (2010) and Wollni and Fischer (2015) as a starting point, but certain assumptions and minor features are adjusted to to reflect the Peruvian specialty coffee cooperative context. Wollni and Fischer (2015) proposes that there are two key mechanisms that determine side-selling: liquidity demand and scale economies. Small farmers have a lower discount rate (Hazell, 2000) and a higher demand for liquidity. since the cooperative dividend is paid at a later date, demand for liquidity leads to side-selling. Meanwhile, larger farmers can leverage scale economies to more profitably operate in the private market. We extend the existing models by including price risk in an isoelastic utility function (as opposed to a simple coefficient, as in Woldie 2010 and its exclusion altogether in Wollni and Fischer 2015). This introduces decreasing absolute risk aversion (DARA) to the model, but also facilitates the inclusion of an exogenous cash endowment, which is introduced along with fixed costs to marketing. The cash endowment can affect marketing decisions through DARA, liquidity demand, or fixed costs. The theoretical analysis is then extended to explore how the households choose their marketing outlets after experiencing a production shock.

This section first presents the main hypotheses of the theoretical framework. We then introduce the utility function, followed by a presentation of the the private and cooperative marketing channels for farmers' coffee. The optimal shares to private and cooperative buyers are shown with the derivation in Appendix A. Finally, we show the comparative statics of the model with respect to risk, farm size, and cash endowments to show the main results of model.

3.1 Hypotheses

The theoretical model highlights the mechanisms behind coffee farmers' marketing decisions. It first shows that even in the context of cooperative price premiums, the predictions of Wollni and Fischer (2015) hold – Side-selling is increased by scale economies and demand for liquidity. Medium-sized farmers side-sell more frequently because small farmers do not have the scale economies to side-sell and large farmers do not have the demand for liquidity to side-sell. We extend the model to show three propositions:

Proposition 1 *Risk aversion leads to increased sales to the relatively safer marketing outlet (the cooperative in the Peruvian specialty coffee setting) and decreased sales to the relatively risky outlet (private buyers). Price risk on the private channel has the same effect.*

Proposition 2 *Liquidity from non-coffee sources crowds in side-selling when the scale economy channel channel gives higher utility than the liquidity demand channel.*

Proposition 3 *Production shocks increase side-selling through an increase in the discount rate and a decrease in cooperative dividends, but this effect is mediated by risk preferences and scale-economy parameters.*

3.2 The Utility Function

The marketing decision of smallholder coffee farmers can be thought of as a portfolio problem whereby farmers maximize utility by choosing between a risk-free and risky marketing channel in an isoelastic utility function. The general utility function is given as:

$$U = \frac{(I + E)^{1-\gamma} - 1}{1 - \gamma} \text{ for } \gamma \neq 1 \tag{1}$$

where I is total income, E is a cash endowment, and γ is the coefficient of relative risk aversion. The cash endowment is assumed to be exogenous. We assume that farmers are risk averse,a claim that has been shown by (Vieider et al., 2013). Further, households have decreasing absolute risk aversion (DARA), resulting in the assumption that $0 < \gamma < 1$. This implies that as households have higher incomes (either from coffee or non-coffee sources), then they will be willing to take more risks in marketing.

In the context of the isoelastic utility function, income is derived from a risky income source and a risk-free income source. The proportion of the portfolio allocation going to the risky source is δ and the portion allocated to the risk-free source is $1 - \delta$. Let the expected payoff of the risky asset be μ and the payoff of the risk-less asset be r. We assume that the risky source has a higher payoff than the risk-free source (i.e. $\mu > r$), otherwise there would be no incentive to allocated sales to the risky source.

Income from the risky source is stochastic and follows a lognormal distribution such that $\log(I) \sim \mathcal{N}(\mu, \sigma^2)$, where μ is the expected income and σ^2 is the variance of income. The log distribution of income is given by:

$$\ln I + E \sim \mathcal{N}(E + r + \delta(\mu - r) - \frac{\delta^2\sigma^2}{2}, \delta^2\sigma^2) \tag{2}$$

Because e is the inverse of ln, and the expected log-normal income is $r + \delta(\mu - r) - \frac{\delta^2\sigma^2}{2}$, the expected income and the cash endowment can be inserted into the utility and the maximization problem Equation 20. Appendix A shows how this maximization problem becomes:

$$\max E + r + \delta(\mu - r) - \frac{1}{2}\delta^2\sigma^2\gamma \;\forall\; \gamma \neq 1 \tag{3}$$

In Appendix A, we see that taking the derivative and solving for δ, we get:

$$\delta^* = \frac{(\mu - r)}{\sigma^2\gamma} \tag{4}$$

Equation 4 gives the general solution to the portfolio decision problem.

3.3 Marketing Channels

The quantity of organic coffee produced is given by Q and assumed to be exogenous. Farmers can choose to sell a proportion, δ, of their quantity produced on the private market and a proportion, $1-\delta$ to cooperatives. They receive price, p_p for each unit sold to private buyers and price, p_c, for each unit sold to the cooperative. In Peru, cooperatives offer higher sales prices and cooperative dividends. For this reason, we assume that there is a premium, such that $p_c = p_p + x_c$, where x_c the price premium cooperatives gain from selling specialty coffee. However, the cooperative offers delayed prices, while private prices are paid on the spot. In the model, private payments are not discounted while cooperative payments have a discount rate, $\beta(Q, E)^{t_p}$. Following Wollni and Fischer (2015), the discount rate is a decreasing function of quantity because smaller farmers tend to have higher discount rates than larger farmers (Hazell, 2000). The discount rate is also a function of the cash endowment. t_p represents the time delay in payment. Revenues from private and cooperative sales are respectively given by:

$$\begin{aligned} R_p &= p_p\delta Q \\ R_c &= (p_p + x_c)(1-\delta)Q\beta(Q,E)^{t_p} \end{aligned} \tag{5}$$

At the end of the season, cooperative offer dividend payments, d_c [4,5]. Following Wollni and Fischer (2015), the cooperative dividend is based on international prices and the total quantity sold to the cooperative. Since the cooperative leverages economies of scale, the cooperative dividend rate is a an increasing function of total quantity sold:

$$R_d = (1-\delta)Q(p_x - p_c)^{\alpha}(\sum_{j=1}^{N}(1-\delta_j)Q_j)^{(\alpha-1)}\beta(Q,E)^{t_d} \tag{6}$$

[4] The model can be mirrored by letting the private market have the premium, as is the case in other settings (e.g. Costa Rica, source). However, we have chosen to express the model in terms of the Peruvian context, instead of a more flexible or general framework.

[5] Peruvian cooperatives typically set a delivery price at the beginning of the season, (i.e. p_c), and determine the dividend at the end of season, taking into account international prices

where p_x is the export price received by the cooperative, the α imposes decreasing marginal returns to both profit margins and quantity sold by the cooperative on dividends and implies differential returns for each factor (prices and quantity). Total quantity sold to the cooperative is given by $\sum_{j=1}^{N}(1-\delta_j)Q_j$, following Wollni and Fischer (2015).[6] Each farmer is paid a dividend proportional to their sales to the cooperative with a delay of t_d. Intuitively, this shows that the cooperative dividend an individual farmer receives is a function of international price margins, the quantity sold by all members to the cooperative (economies of scale), and an individual's discount rate. Total revenue is the sum of R_p, R_c, and R_d. These assumptions reflect the context described in Section 2.

Private sales also assumed to be more volatile than Cooperatives' networks of fair trade sales also make their prices less volatile (Bacon, 2013). To simplify the model, we assume that cooperative payments are risk-free, while private payments are log-normally distributed with mean p_p and variance σ^2 (i.e there is a risk premium). However, private buyers pay faster than cooperatives. The marketing risk premium is given by:

$$\text{private risk premium} = \delta^2\sigma^2 \tag{7}$$

In terms of revenue, the advantage of selling to private buyers versus specialty coffee cooperatives is quicker payment times. The extent to which households prefer quicker, but lower and riskier, payments is determined by their discount rates, which are a decreasing function of quantity.

Selling on each marketing channel carries variable and fixed costs as well. Variable costs are accounted for by reducing the unit sale price in a given marketing channel. Fixed costs are only encountered for a marketing channel if a household sells a positive quantity of coffee on that channel. If the household does not sell on a particular channel, fixed costs are not incurred.

Farmers can exploit economies of scale in delivering coffee to both cooperatives and private buyers. However, economies of scale should be more important in private markets where buyers can facilitate transport or other cost-reducing measures with large farmers. In cooperatives, all farmers are treated equally, so no such measures exist for large farmers. Therefore, the economies of scale parameter assumed to be zero for cooperative sales and only exist for private sales. The costs of selling to private and cooperative buyers are respectively given by:

$$\begin{cases} C_p = c_1^p\delta_i Q - \frac{c_2^p}{2}(\delta_i Q)^2 + f_p & \text{if } \delta > 0 \\ C_p = 0 & \text{if } \delta_i = 0 \\ C_c = c_1^c(1-\delta)Q + f_c & \text{if } \delta < 1 \\ C_c = 0 & \text{if } \delta_i = 1 \end{cases} \tag{8}$$

where c_1^p and c_1^c are the linear costs for private and cooperative sales, respectively. c_2^p is the economy of scale term for private buyers (and can be thought of as the private scale economies premium over the cooperative economy scale parameter). f_p and f_c are the fixed costs associated with selling to private buyers and the cooperative, respectively. f_p and f_c are only incurred if the household respectively sells to private buyers and/or the cooperative. Fixed costs can be paid for out of a cash endowment, which is introduced in the next section.

[6]For ease of presentation, we have not included i subscripts to denote the representative household of interest, but use the j subscript to represent quantity of another household

3.4 Optimal Shares

In terms of the utility framework, the private profits are μ (the risky payoff) and the cooperative profits are r (the safe payoff). This means that the maximization problem with the cash endowment becomes:

$$\begin{aligned} &\max\,[E + p_p\delta Q + (p_p + x_c)(1-\delta)Q\beta(Q,E)^{t_p} + R_d] \\ &- [c_1^p\delta Q - \frac{c_2^p}{2}(\delta Q)^2 + c_1^c(1-\delta_i)Q] \\ &- \frac{1}{2}\delta^2\sigma^2\gamma \\ &\forall\ \gamma \neq 1 \end{aligned} \tag{9}$$

The optimization follows a two-stage process. In the first stage utility is maximized by setting the marginal utility of private (and by default cooperative) sales to zero. Appendix A shows the derivation of the optimal share from stage one sold to private markets, which is given by:

$$\begin{aligned} &\delta^* = \frac{p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^p Q - c_1^c Q}{c_2^p Q^2 + \sigma^2\gamma} \\ &\text{where} \\ &\frac{\partial R_d}{\partial \delta} = -Q(p_x - p_c)^{\alpha}(\sum_{j=1}^{N}(1-\delta_j)Q_j)^{(\alpha-1)}\beta(Q,E)^{t_d} \end{aligned} \tag{10}$$

In the second stage of optimization, the household decides on its use of the cash endowment – to incur fixed costs in an additional market, or to contribute the endowment linearly to utility. The makes this choice by evaluating the value function at each of the three possible cost regimes from Equation 8. Households choose to use their endowment following whichever regime maximizes utility from following:

$$\begin{cases} U(I(\delta^*) + E - f_p) & \text{if} \quad \delta == 1 \\ U(I(\delta^*) + E - f_c) & \text{if} \quad \delta == 0 \\ U(I(\delta^*) + E - f_p - f_c) & \text{if} \quad < \delta < 1 \end{cases} \tag{11}$$

Intuitively, the household chooses a δ^* between 0 and 1 if utility is higher from selling on both the private market and to the cooperative (and incurring the fixed costs of both) than selling (and incurring the fixed costs) on only one channel. The household will sell through only one channel if the utility after incurring fixed costs is higher than selling on two channels.

Selling to the private market becomes profitable when the optimal solution yields a utility higher than that of the solution when only selling to the cooperative. Similarly, selling the cooperative is only profitable when the optimal solution yields a utility that is higher than the utility from only selling to the private market. These threshold values change based on the parameters, and we explore three key parameters: the quantity of coffee produced, risk preferences, and the level of endowment.

3.5 Comparative Statics

This section displays the comparative statics of the optimal side-selling share solution, δ^*, in the context of the propositions put forth above. We show that risk aversion and cooperative price premiums reduce side-selling, and in spite of offering price premiums and lower risk, side-selling can still occur because of liquidity demand, scale economies, and fixed costs of marketing. When inflicted with a shock, side-selling increases through these mechanisms – liquidity demand increases, scale economies decreases, and ability to pay fixed costs decreases. Further, widespread shocks (such as the coffee leaf rust epidemic) reduce the cooperative dividend through decreased deliveries to the cooperative (so scale economies are reduced at the cooperative level). Outside liquidity and risk preferences can mitigate the shock's increase in side-selling.

Inverse U-Shape: Liquidity demands and scale economies drive side-selling, creating an inverse U-shape side-selling curve with respect to size – small and large farmers are more likely to sell to the cooperative, while midsize farmers are more likely to side-sell. Liquidity demands and scale economies incentivize side-selling in spite of the price premiums and reduced price risk offered by cooperatives, but work in opposite directions. Appendix B shows the derivation of the comparative static of δ^* with respect to quantity, Q. Equation 12 shows the rearranged comparative static such that the left-hand side is the percent change in side-selling from changes in liquidity demand mechanism and the right-hand side is the percent change in side-selling from the scale economies mechanisms. If the liquidity effect outweighs the scale economies effect, then an increase in quantity will increase side-selling, while if the scale economies effect outweighs the liquidity effect, then an increase in quantity will decrease side-selling.

For small farmers, the scale economies effect is likely to be smaller than the liquidity demand effect (as Q^2 is in the denominator of the right-hand side of Equation 12). Increases in quantity will incentive side-selling. Conversely, the scale economies mechanism is likely to play a larger role for large farmers, and an increase in the quantity of organic coffee produced will decrease side-selling. As a result, there is an inverse U-shape pattern with respect to side-selling, as in (Wollni and Fischer, 2015).

$$\begin{aligned}
&\frac{[-(p_p+x_c)t_p\beta(Q,E)^{t_p-1}\frac{\partial\beta'(Q,E)}{\partial Q}+\frac{\partial R_d}{\partial\delta\ \partial Q}-c_1^p-c_1^c]}{[p_p-(p_p+x_c)Q\beta(Q,E)^{t_p}+\frac{\partial R_d}{\partial\delta}-c_1^pQ-c_1^cQ]}\lesseqgtr\frac{[2c_2^pQ]}{[c_2^pQ^2+\sigma^2\gamma]}\\
&\text{where } \frac{\partial R_d}{\partial\delta\ \partial Q}=[-(p_x-p_c)^\alpha(\sum_{j=1}^{N}(1-\delta_j)Q_j)^{\alpha-1}][\beta(Q,E)^{t_d}-Qt_d\beta(Q,E)^{t_d-1}\frac{\partial\beta(Q,E)}{\partial E}]
\end{aligned} \tag{12}$$

Proposition 1: Risk aversion and risk decrease side selling. Equation 13 shows that the comparative static of δ^* with respect to γ is negative. When risk aversion increases, side-selling to the risky channel decreases. Since all farmers are assumed to be risk averse, households have a risk-based disincentive to sell on the private market. The results can be analogously interpreted in terms of risk, σ^2, as well – an increase in price risk on the private market results in in a decrease in sales to the private market. An analogous comparative static and interpretation holds for price risk, σ^2.

$$\frac{\partial\delta^*}{\partial\gamma}=-\frac{(p_p-(p_p+x_c)Q\beta(Q,E)^{t_p}+\frac{\partial R_d}{\partial\delta}-c_1^pQ-c_1^cQ)(\sigma^2\gamma)}{(c_2^pQ^2+\sigma^2\gamma)^2}<0 \tag{13}$$

Proposition 2: Outside liquidity can reduce side-selling through a liquidity effect or increase side-selling through a fixed costs effect. In terms of liquidity, Equation 14 shows that the comparative static of side-selling is negative with respect to the cash endowment. Since the discount rate, $\beta(Q,E)$ is a decreasing function of both quantity, Q, and the cash endowment, E, then higher values of the cash endowment result in lower discount rates and higher discounted returns on cooperative sales. As a result, side-selling decreases.

$$\begin{aligned}
\frac{\partial\delta^*}{\partial E}=&-(p_p+x_c)t_pQ\beta(Q,E)^{t_p-1}\frac{\partial\beta(Q,E)}{\partial E}\\
&-Qt_d(p_x-p_c)^\alpha(\sum_{j=1}^{N}(1-\delta_j)Q_j)^{(\alpha-1)}\beta(Q,E)^{t_d-1}\frac{\partial\beta(Q,E)}{\partial E}
\end{aligned} \tag{14}$$

In the second stage of optimization (Equation 11), the endowment plays a role in increasing utility and (potentially) covering fixed costs. At minimum, coffee-producing households must participate in either the private market (Case 1 in Equation 8) or the cooperative market (Case 2 in Equation 8). To demonstrate how the endowment can increase side-selling, let $f_c <= f_p < E < f_c + f_p$. This means that the endowment can cover either the fixed cost to the cooperative or the fixed costs to private markets, but not both. If the endowment increases, such that $E \geq f_c + f_p$, then the household can participate in both markets, and potentially increase utility (depending on the solution to the first stage, δ^*[7] Generally, we assume that households are more likely to sell to the cooperative by default and only sell to the private market if costs permit[8]. Intuitively, the cash endowment can give households the ability to cover fixed marketing costs to private sellers and increase side-selling.

Proposition 3: Production shocks can increase side-selling by increasing the liquidity effect, decreasing the fixed cost effect, and decreasing cooperative dividends. Only the increase in the scale economies effect can reduce side-selling in the event of a shock. These Effects are mediated by risk aversion and outside liquidity.

Equation 13 shows the comparative static with respect to quantity. When discussing the inverse U-Shape of side-selling with respect to quantity, these results were discussed in terms of an increase in quantity, but a production shocks is just the opposite. When quantity decreases, the liquidity demand effect increases (the left-hand side of Equation 13 increases) and the scale economy effect decreases (the right hand side of Equation 13 becomes smaller), causing respective decreases and increases in side-selling.

Shocks affect two other mechanisms – the fixed cost effect and the cooperative dividend. Following the logic of Proposition 3, the household has less cash to pay for fixed costs, and is therefore more likely to sell to the cooperative. Further, if the shock is widespread (as is the case with coffee leaf rust), then overall sales to the cooperative decrease (a decrease in $Q_j \ \forall \ j$), resulting in lower returns to scale for the cooperative. In this event, the cooperative dividend decreases, along with the returns from selling to the cooperative. By assuming that δ_j is exogenously determined (for simplicity), this mechanism can be seen by the comaprative static of $\frac{\partial R_d}{\partial \delta}$ with respect to Q_j:

$$\frac{\partial R_d}{\partial \delta \, \partial Q_j} = -Q(1-\delta_j)(\alpha-1)(p_x - p_c)^\alpha (\sum_{j=1}^{n}(1-\delta_j)Q_j)^{\alpha-2}\beta(Q,E)^{t_d} < 0 \tag{15}$$

In other words, when total quantity sold to the cooperative increases (decreases), then side-selling with respect to the cooperative dividend will decrease (increase). During a shock, the dividend decreases and side-selling increases. The overall effect of a shock will depend on the relative size of each of these effects. If sum of the liquidity, fixed costs, and cooperative dividend effects is larger than the scale economies effect, then side-selling will increase, and vice versa. The scale economies effect will only outweigh the other effect in the case of large farmers, so we expect that shocks will generally increase side-selling.

These probable increases in side-selling as a result of shocks can be mitigated by risk preferences and the cash endowment. It is trivial to note that the right-hand side of Equation 12 decreases when the risk parameters increase. This is tantamount to an increase (decrease) in the relative effects of liquidity when quantity increases (decreases). For all farmers, a decrease in quantity produced increases the liquidity effect and side-selling, but risk aversion mitigates this increase because households become more risk averse when quantity decreases (DARA).

Similarly, Equation 15 shows that the cash endowment decreases (increases) the liquidity effect of increases (decreases) in Q in Equation 15 (because the discount rate is also a function of E). This means that when there is a shock to quantity (i.e. Q decreases), the outside cash endowment reduces the resulting increase

[7] This process can also occur through changes in income (and therefore, quantity), as income can be used to cover fixed costs.

[8] This assumption is based on the relatively low rates of selling to private markets compared to cooperative sales.

in liquidity demand and reduces side-selling on the market. On the other hand, the fixed costs effect can also be in play and E could increase the ability of households to sell on private markets during a production shock.

4 Data

The empirical analysis uses a original panel dataset of Peruvian coffee farmers, who are members of one of two specialty coffee cooperatives in the northern part of the Cajamarca region – Cooperativa Agraria Cafetalera La Frontera (Frontera) and the Cooperativa Agraria Cafetalera La Prosperidad de Chirinos (Chirinos). In 2013, 200 households were randomly selected from lists of 316 and 573 eligible farmers in Frontera and Chirinos, respectively. A household questionnaire was administered to each of the selected households to understand household demographics, farm characteristics, cooperative involvement, marketing decisions, and other respondent characteristics such as risk aversion. The survey was administered in January 2014 and January 2016. The attrition rate from the first to second wave was 13.5%, as 29 farmers were not interviewed in the second round. Appendix C shows the differences characteristics of those participating in two rounds and those who dropped out of the study and confirms that there is no attrition bias – only one variable in 23 variables tested shows a statistically significant difference.

4.1 Data Measurement

The primary outcome variable is the percent of organic coffee sold to outside buyers. We focus on organic coffee because cooperatives do not purchase conventional coffee. This data is derived from survey questions concerning the amount of organic coffee sold to the cooperative and to private buyers.

The main explanatory variables are farm size, risk aversion the percent of the farm affected by plant diseases, and the log of outside (non-coffee) annual income. Farm size is measured by asking farmers to recall the size in acres of their organic coffee farms. As a robustness check we also use farmer recall of the number of productive organic coffee trees on their farm. Risk attitudes were measured by asking respondents how much they would be willing to pay to participate in a standard raffle with potential winnings of 50, 100, and 1000 soles[9]. A higher willingness to pay indicates less risk aversion. For the exposure to coffee leaf rust, farmers were asked how many organic trees were affected by plant diseases in the past year[10]. The measure of exposure to coffee plant diseases is the percentage of organic trees affected by diseases in a given year. Log outside income is measured as the log of self-reported total (in Soles) annual income from non-coffee sources.

The literature indicates that demographic factors, economic factors, and attitudes may be driving side-selling. The demographic variables measured are the sex, age, and number of years of education of the household head (SOURCES). Economic variables include log expenditures on coffee installations and hired labor (in soles). Log loan amount, an indicator for whether a household's plots are organically certified or not, and an indicator for whether respondents are aware of fair-trade are also used. The percentage of resistant coffee varieties is included since this is a source of heterogeneity in the propensity to be affected by leaf rust. Finally, a measure for distance in kilometers from the household to the cooperative is also used.

A series of questions were asked concerning farmers' perception of and identification with the cooperative based on a Likert scale. Concerning the perception of the cooperative, respondents were asked five questions asking about the capacity of the cooperative to provide commercialization, technical assistance, inputs, credit, and improvements in coffee quality. For the identification with the cooperative, respondents were asked about whether they felt the cooperative was theirs, if other members felt the cooperative belonged to

[9] 1 sol $\approx$ 0.35 USD in January, 2014

[10] While plant diseases encompasses all potential plant diseases, the context suggests that coffee leaf rust was dominant plant disease during the study period

them, if they felt proud to be a part of the cooperative, if they felt committed to the cooperative, and if they shared the same values as the cooperative. A simple average of the five questions about perceptions and identification were calculated to create a perception and identification index, respectively.

Finally, respondents were asked about side-selling, plant diseases, and payment times in from 2009 to 2012 (in addition to the primary year in question, 2013). In each year, variables for the percent of total coffee side-sold, percent of trees infected with plant diseases, and the number of days to receive payment are created so that we can use these variables in robustness checks and to get a greater sense of the context.

4.2 Summary Statistics

Figure 2 plots the average values for the percent of total coffee side-sold and the percent of trees diseased. The percent of total coffee side-sold increased over the period, going from around 15% in 2009 to 20% in 2013. A possible explanation for this trend is the rise in plant diseases (due to the coffee leaf rust epidemic). In 2012, over 20% of coffee trees were infected with plant diseases on the average farm. This figure rose to nearly 30% by 2013 and dropped off in the following two years. The rise in side-selling appears to be correlated with plant diseases. Only the period from 2014 to 2015 shows a divergence in trends between the two figures. While our empirical analysis is unable to explore these longer-term trends, they provide motivation for the influence of production shocks on side-selling.

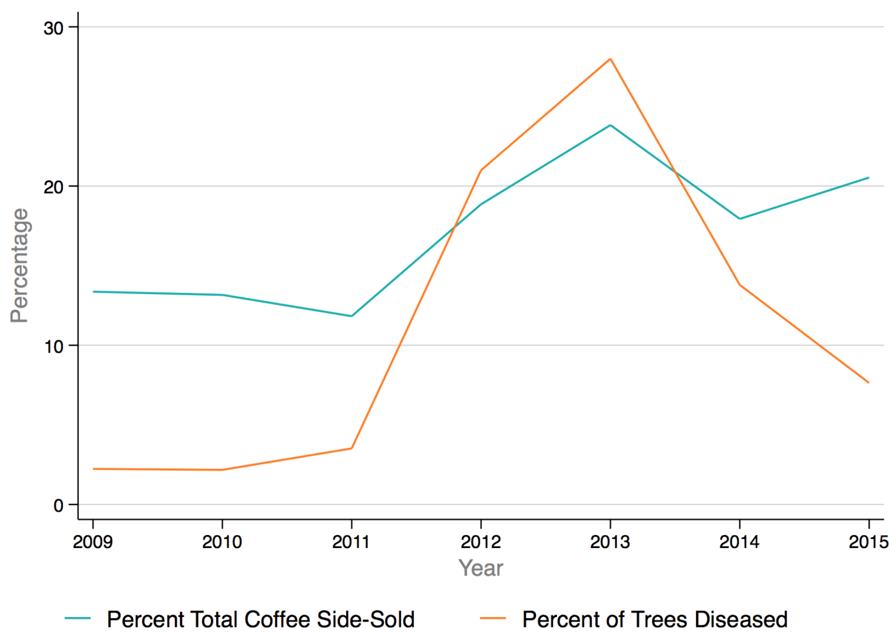


Figure 2: Side-Selling, Plant Diseases, and Number of Days for Coop. Payment 2009-2013)

Figure 1 in Section 2 shows there is some correlation with location and plant diseases – households in the south are slightly more likely to have plant diseases in 2013, but appear less likely to have them in 2015. Controlling for individual fixed effects in the within estimations and cooperative and district fixed effects in between estimations helps alleviate concerns arising from the somewhat uneven geographic distribution of plant diseases (Section 5).

The descriptive statistics of the variables used in the empirical analysis are shown in Table 2 for each year. In both years, around twenty percent of households in the sample side-sold any coffee all. Conditional on side-selling, households side-sold about 51% of there organic coffee in 2013 and 34% of their organic coffee in 2015. This difference is statistically significant. Households in 2013 also experienced more coffee leaf rust with the average farm having about 28% of coffee trees infected in 2013, compared to only 8% in 2015. Further, area devoted to organic coffee production and expenditure on coffee installations are lower in 2015 than in 2013, but all farmers in the sample had become organically certified by 2015. In both years, expenditure on labor was extremely low on average reflecting the low reliance on outside labor. On average, the center-points of households' *centro poblados* (the lowest administrative district in Peru) are about 10km away from cooperatives. Despite, the focus of cooperatives on specialty coffee, only about 60% of respondents are aware of fair trade coffee.

In terms of demographics and socio-economics, the average household head has nearly seven years of education and is in their late forties/early fifties. Very few households are headed by women, and the typical households has about four members. Non-coffee income is fairly common and is larger than expenditures on coffee installations and labor. Further, non-coffee income appears to be the main source of non-coffee income, as it is more than three times the size of outstanding loan values in 2013 and two times the size of outstanding loan values in 2015.

Behaviorally, the average respondent in both years expressed a favorable opinion on four out of five questions related to the capacity of the cooperative to provide adequate services. Additionally, most respondents have identify with their cooperative on nearly four out of five measures. In terms of risk-taking, respondents are generally risk averse, and are willing to pay only small amounts to play in standard lotteries.

Table 2: Descriptive Statistics

Variable	2013	2015	Diff
Side-Selling Indicator	0.23	0.19	-0.042
	(0.00)	(0.00)	(0.359)
% Organic Coffee Side-Sold	51.16	34.03	-17.127**
	(0.00)	(0.00)	(0.049)
% Trees with Leaf Rust	28.33	8.05	-20.281***
	(0.00)	(0.00)	(0.000)
Has. Organic	2.76	2.40	-0.359*
	(0.00)	(0.00)	(0.073)
Total Organic Trees	10131.36	9036.33	-1095.035
	(0.00)	(0.00)	(0.181)
% Resistant Variety	53.57	59.01	5.438
	(0.00)	(0.00)	(0.131)
Exp. on Coffee Installations (soles)	1434.20	594.62	-839.587***
	(0.00)	(0.00)	(0.000)
Exp. on Labour (soles)	18.99	12.17	-6.822
	(0.00)	(0.13)	(0.501)
Outstanding Loan Value (soles)	2155.50	1545.67	-609.829
	(0.01)	(0.00)	(0.522)
Distance to Coop. (km)	10.24	10.04	-0.197
	(0.00)	(0.00)	(0.834)
Organic Certification	0.84	1.00	0.160***
	(0.00)	(.)	(0.000)
Knowledge of Fair Trade	0.57	0.58	0.008
	(0.00)	(0.00)	(0.876)
HH Head Years of Edu.	6.92	6.67	-0.244
	(0.00)	(0.00)	(0.587)
HH Head Age	47.14	50.56	3.418**
	(0.00)	(0.00)	(0.015)
Female HH Head	0.15	0.12	-0.039
	(0.00)	(0.00)	(0.271)
Household Size	4.20	4.47	0.273
	(0.00)	(0.00)	(0.173)
Non-Coffee Incomes (soles)	4644.78	2709.62	-1935.151
	(0.00)	(0.00)	(0.241)
Perception of Coop. Services	0.78	0.81	0.029
	(0.00)	(0.00)	(0.821)
Identification with Coop.	3.82	3.82	-0.004
	(0.00)	(0.00)	(0.965)
50 Sol Lottery	5.61	5.66	0.052
	(0.00)	(0.00)	(0.891)
100 Sol Lottery	10.07	10.40	0.326
	(0.00)	(0.00)	(0.715)
1000 Sol Lottery	26.50	28.07	1.569
	(0.00)	(0.00)	(0.714)
N	200	173	373

[1] Significance levels: * < 10% ** < 5% *** < 1%
[2] P-Values in parentheses
[3] % of Organic Coffee Side-Sold is conditional on side-selling any organic coffee.

5 Empirical Predictions and Methodology

5.1 Empirical Predictions

The econometric approach is designed to uncover the mechanisms at play in Section 3. Table 3 summarizes the linkages between the propositions in Section 3 and the econometric approach. Only risk aversion and the interaction of risk aversion and production shocks are theoretically predicted to have a uniform direction across all households, while changes in the other variables could theoretically increase or decrease sales to the private market. Proposition 4 is listed three times because there are three components of Proposition 4: the overall change in side-selling because of production shocks and the heterogeneity of this change with respect to risk preferences and the cash endowment (proxied by outside income).

Table 3: Empirical Hypotheses

Proposition	**Variable**	**Theoretical Relationship**	**Hypotheses**	**Primary Empirical "Effect" Tested**
Proposition 1	Risk Aversion	-	-	Between
Proposition 2	Hectares and Hectares Squared	+/-	Inverse U-Shape	Within
Proposition 3	Non-Coffee Income	+/-	+/-	Within
Proposition 4	% Plant Diseases	+/-	+	Within
Proposition 4	% Plant Diseases × Risk Aversion	-	-	Interaction of Within and Between
Proposition 4	% Plant Diseases × Non-Coffee Income	+/-	-	Interaction of Within

While the theoretical relationships are ambiguous in terms of the effect on side-selling, we propose separate empirical hypotheses each of the theoretically ambiguous propositions. First, we expect an inverse U-shape pattern of side-selling with respect to farm size. This is the main hyptothesis of Wollni and Fischer (2015), which proposed that side-selling follows an inverse U-shape pattern when the private market offers price premiums. Even though cooperatives in our study offer a price premium (rather than lower prices, as in the Costa Rican cooperatives of Wollni and Fischer (2015)), we expect the the curve to be an inverse U-Shape (as discussed in Section 3). This is because discount rates and scale economies can still make selling on the private market profitable.

Second, the predominance of the fixed costs effect or the liquidity effect will determine whether outside income increases or decreases side-selling in Proposition 3. Since most farmers have two hectares or fewer (considered smallholders by Lowder et al. 2016), the liquidity effect may predominate. Further, 74% of farmers sell second-quality coffee outside of cooperatives, indicating that they are able to pay for fixed costs of selling second quality coffee on the private market. Likely, they would also be able to pay for similar fixed costs of selling organic coffee on the private market, which weakens the fixed costs effect. Therefore, we expect the liquidity effect to predominate and outside income to be negatively associated with side-selling.

Third, production shocks (plant diseases) will increase side-selling if the liquidity effect predominates, while they will decrease side-selling if the fixed costs effect is larger. Following the same logic as Proposition 3, we expect that the liquidity effect is larger than the fixed cost effect and side-selling will increase because of a production shocks.

Finally, the same logic is extended to the interaction of plant diseases and non-coffee income. Since the liquidity effect is expected to be smaller than the fixed costs effect, then the interaction of plant diseases and non-coffee income will have a negative correlation with side-selling.

5.2 Econometric Model

The empirical estimation strategy takes advantage of the available panel data and uses the within-between estimator (Bell and Jones, 2015), also known as a hybrid model (Allison, 2009). This estimator builds on the decomposed panel models first proposed by Yair Mundlak (1978), who introduced the correlated random effects model.

Since panel data is used in the analysis, there exists heterogeneity in data points across time within individual respondents and across (or between) respondents. The standard approach in economic analyses is to employ a fixed effects model, which controls for the heterogeneity between respondents and gives estimates of "within effects" (i.e. the differences across time within individual respondents). Less commonly applied, but still a textbook approach, is the random effects model, which assumes that errors are uncorrelated with covariates. The RE model estimates "between effects" (i.e. heterogeneity across individual respondents). To choose between which model is most appropriate, the standard approach is to estimate the coefficients of both models and apply a Huasman test to test whether the coefficients are different. If the coefficients are not significantly different, then a RE model is chosen because it is more efficient than FE. If the coefficients are significantly different, then a FE model is chosen because the RE will give biased estimates (Hausman, 1978).

RE and FE models have several weaknesses that make them unsuitable for our study. First, RE models assume that between and within effects are equivalent. This assumption does not hold theoretically. For example, the effects on side-selling of a being exposed to a production shock in one period is likely different than the effect of being exposed to production shocks at an above average rate over time. Further, the RE model assumes that errors are uncorrelated with covariates. As with most economic studies, this assumption is unlikely to hold, making RE an inappropriate specification (Wooldridge, 2013). FE models can solve this latter issue by controlling for individual-level heterogeneity – time invariant characteristics are controlled for and consistent estimators of within effects are found. However, the FE solution brings forth another problem. Propositions 1 and 4 concern a time-invariant measure, risk aversion (which is only measured in the first wave of data collection). Applying an FE estimation would come at the cost of not being able to answer our research questions, and a methodology that cannot answer the research question surely cannot be the correct methodology (Bell and Jones, 2015).

Following the standard approach, we estimated RE and FE models and ran Hausman tests to determine which model is more appropriate (Appendix D). The Huasman tests were run using models with only main explanatory variables and models with both main explanatory variables and controls. Out of the seven tests run, the Hausman test suggests RE to be used in two of the specifications and FE in five of the specifications. These variable results are concerning because it suggests that the propositions cannot be tested in a single coherent framework. Further, the assumptions underlying both models are either methodologically problematic (as in RE) or cannot answer the research questions (as in FE).

The solution to these issues lies in the hybrid estimator, which can provide the within effects estimates equivalent to those estimated by FE and between effects estimates that do not rest on the assumption made in RE that within and between effects are equivalent (Allison, 2009). Let X_{it} be a k-length vector of time-varying variables for individual i and $\bar{X}_i$ be a k-length vector of the means (over time) of each element of X_{it}. X_{it} and $\bar{X}_i$ can include interaction terms as well as standard covariates. Each element, k, of $\bar{X}_i$ can be given by $\bar{x}_{i,k} = \frac{(\sum_{t=1}^{T} x_{it,k})}{T}$, where k is the variable for indivudal i in time t, and T is the total number of panels (2 in this study). Let C_i be an h-length vector of time invariant variables. Following (Schunck, 2013), The estimator is then given by:

$$y_{it} = \beta_0 + \beta_1(X_{it} - \bar{X}_i) + \beta_2 C_i + \beta_3 \bar{X}_i + \mu_i + \epsilon_{it} \tag{16}$$

where y_{it} is the outcome for individual i at time t, μ_i is the time-invariant error term and ϵ_{it} is the time variant error term. β_1 is a k-length vector of coefficients of the within effects, and these terms are equivalent to the coefficients for time-varying variables estimated by FE (Schunck, 2013). β_2 is an h-length vector coefficients for variables, C_i, that only vary between individuals (but not across time). β_3 is a k-length vector of coefficients of the between effects for time-varying variables. The within-effects coefficients, β_1, do not rely on the assumption that $E(\mu_i|X_{it}, C_i) = 0$ to be unbiased (as with the FE approach). However, the estimates of the between effects, β_2 an β_3, are only unbiased if $E(\mu_i|X_{it}, C_i) = 0$ (as in the RE approach), and this assumption is unlikely to hold.

One of the key advantages of the hybrid approach is the ability to include interaction terms between time-variant and time-invariant variables (Bell and Jones, 2015). The model can be easily extended to include these interaction terms, as in (Bell and Jones, 2015). The interaction terms follow the same interpretation as they would in a standard FE or RE model.

The hybrid formulation combines the advantages of FE and RE, but it does not imply causal interpretations. Bias in the within effects estimation can arise if $E(\epsilon_{it}|x_{it} \neq 0)$. This is likely to occur if there are omitted time-varying variables. While we attempt to control for all relevant time-varying characteristics possible, this condition is still unlikely to hold, and therefore we abstain from making causal interpretations in the analysis. The absence of causal interpretations is standard in the literature on the determinants of side-selling, which largely relies on cross-section analysis (SOURCES of examples). While causality is not claimed, this panel approach removes some of the endogeneity in the estimation and is an improvement over cross-section approaches.

Only the coefficient for within effect of the % of plants infected in a given year could be reasonably be assumed to be a causal effect. Plant diseases are commonly thought of as a 'production shock' (Jezeer et al., 2019). A recent study on the resilience of smallholder farmers used coffee plant diseases as an exogenous shock (Serfilippi et al., 2020). Coffee Leaf Rust was certainly a shock to Peruvian farmers. National authorities were under-prepared to fight the coffee leaf rust epidemic, despite its outbreak in other Latin American countries (Avelino et al., 2015). Further, organic coffee farmers were unable to change their practices to effectively fight the disease because copper-based fungicides that eliminate coffee leaf rust are inorganic and cultivating new resistant varieties takes two to three years to generate yields. However, out of an abundance of caution we do infer causality even in this coefficient because the number of plants infected (as opposed to only exposed) to the disease is dependent on time-varying farm practices (Ehrenbergerová et al., 2018).

6 Results

The empirical results provide suggestive evidence for the mechanisms at play in Section 3. This section first addresses whether the inverse U-shape relationship between side-selling and farm size holds in the context of cooperative price premiums. Then, we address Propositions 1 and 2, which address the risk and outside liquidity, respectively. Finally, empirical evidence is shown for each component of Proposition 4, which relates to side-selling and production shocks.

Inverse U-Shape: Side-selling follows an inverse U-Shape pattern with respect to farm size, reflecting the liquidity demand mechanism for small farmers and the scale economies mechanism for large farmers (Wollni and Fischer, 2015). These results hold for both the within and between estimations. The within estimations in Column 2 of Table 4, show that farmers are more likely to side-sell when they they have either have moderate amounts of land producing organic coffee.[11] Figure 3 shows the within-estimation of the inverse U-shape side-selling curve graphically. The smallest farmers – households with 1 hectare or fewer of organic coffee production – are not predicted to side-sell any coffee. When households have 2 to 7 hectares of organic coffee production, they tend to side-selling small amounts of their organic coffee (less than 20% on average). These estimates confirm the idea that the smallest farmers do not have the scale economies and/or the cash to pay fixed costs of side-selling, while larger farmers sell to the cooperative because they have lower discount rates and do not need liquidity from private markets.

The between estimation corroborates these results, but has a slightly different interpretation. The between estimator shows that members with small and larger organic farms, on average across time, are more likely to side-sell. Only the within estimates are robust to the inclusion of control variables (Column 5). Table XX in Appendix XX shows the results using the number of organic coffee trees as a measure of farm size, and the results are similar.

Proposition 1: Equation 13 shows that risk-taking (risk aversion) increases (decreases) side-selling.

[11] Land devoted to coffee production does vary between years. Table 2 shows that area of organic coffee production is 0.359 hectares less on average in 2015 than 2013. This difference is not driven by attrition (Appendix C). Further, the inclusion of a year indicator does not explain the statistically significant inverse U-Shape (Table 9 in Appendix D).

Column 1 in Table 4 provides the between estimations of Equation 16 for risk. Members with a higher preference to take risks side-sell more than their more risk averse counterparts, providing evidence of the risk mechanism. A one percentage point increase in the willingness to take risks is correlated with a 0.4 percentage point increase in the quantity of coffee sold on the private market. This positive and significant relationship is robust to the inclusion of controls (Column 5) and the inclusion of cooperative and district fixed effects (Column 6). Appendix XX shows that the results are robust to using risk-taking measures from a 50 soles and 1000 soles lottery and to using alternate covariates (Table XX). These results are consistent with Woldie (2010) in that risk-averse households sell to the less risky channel; however, the less risky channel in this case is the cooperative as opposed to the private market.

Proposition 2: Log outside income is positively correlated with side-selling when looking at the within estimation in Column 3 of Table 4. A one percent increase in outside income is associated with a one percentage point increase in side-selling. This suggests that the fixed cost mechanism is playing a larger role on average than the demand for liquidity mechanism (which would imply a negative coefficient of log outside income). When households have outside income, they may be using it to cover their fixed costs of marketing on private markets, as suggested in Section 3. The results are robust to the inclusion of controls (Column 5), but the between estimation does not show the same pattern. The between estimation suggests that households with higher average outside incomes do not have different side-selling behaviors than those with lower average outside incomes. This indicates that it is likely the liquidity from outside income that is important in households' decision-making rather than features inherent to households with outside income (e.g. larger social networks or more entrepreneurial tendencies).

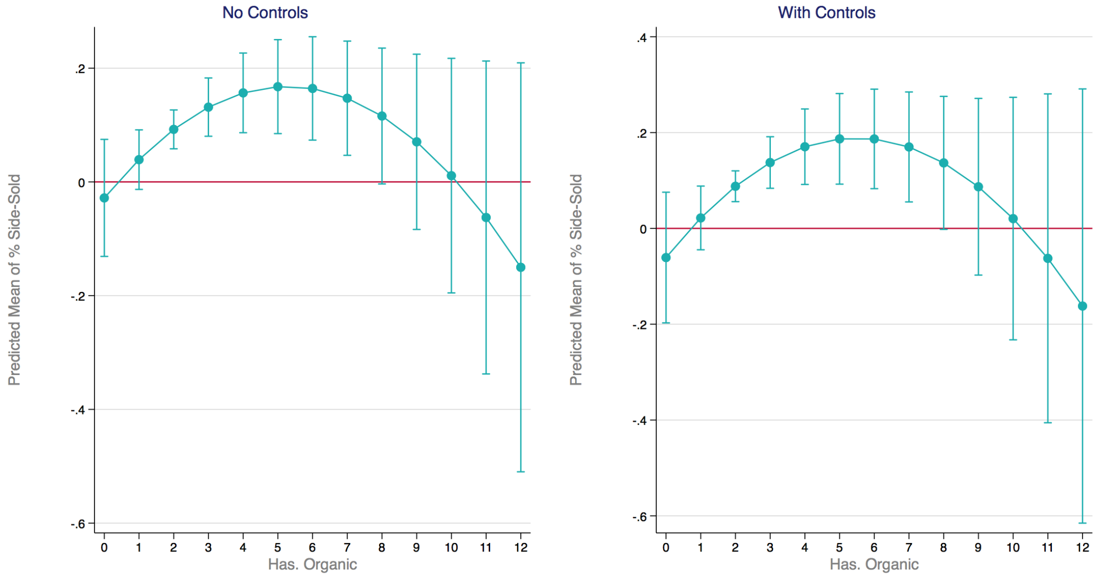
Proposition 3a: The within estimates in Table 4 show that increases in the percent of coffee trees infected with plant diseases is correlated with increases in side-selling, but this relationship is not statistically significant either with (Column 4) or without controls (Column 5). This lack of a significant relationship may reflect the competing mechanisms at play. Shocks increase liquidity demand and encourage side-selling while also reducing scale economies and the profitability of covering fixed costs to side-selling. The between estimates show that households experiencing more intense production shocks on average are more likely to side-sell, conditional on controlling for other covariates (Column 5) and cooperatives and district indicators (Column 6). This suggests that there is household-level heterogeneity in marketing responses to shocks.

Table 4: Hybrid Model: Base Results

	(1) % Organic Coffee Side-Sold	(2) % Organic Coffee Side-Sold	(3) % Organic Coffee Side-Sold	(4) % Organic Coffee Side-Sold	(5) % Organic Coffee Side-Sold	(6) % Organic Coffee Side-Sold
Within Estimation						
Has. Organic	0.0743**				0.0910**	0.0910**
	(0.0329)				(0.0425)	(0.0428)
Has. Org. ×Has. Org.	-0.00704**				-0.00828*	-0.00828*
	(0.00335)				(0.00435)	(0.00438)
Log Outside Income			0.0125**		0.0138*	0.0138*
			(0.00580)		(0.00715)	(0.00720)
% Trees with Leaf Rust				0.0432	0.0973	0.0973
				(0.0840)	(0.107)	(0.108)
HH Head Years of Edu.					0.00233	0.00233
					(0.0176)	(0.0177)
HH Head Age					0.00346	0.00346
					(0.00910)	(0.00916)
Female HH Head					-0.0215	-0.0215
					(0.112)	(0.113)
Household Size					-0.0135	-0.0135
					(0.0104)	(0.0105)
Log Expenditure on Coffee Installments					-0.00318	-0.00318
					(0.00472)	(0.00475)
Log Loan Amount					0.00922	0.00922
					(0.00723)	(0.00728)
% Resistant Variety					-0.0000577	-0.0000577
					(0.000760)	(0.000765)
Organic Certification					-0.0888	-0.0888
					(0.159)	(0.160)
Between Estimation						
Has. Organic	0.0444**				0.0309	0.00902
	(0.0216)				(0.0215)	(0.0205)
Has. Org. ×Has. Org.	-0.00355*				-0.00268	-0.00107
	(0.00199)				(0.00176)	(0.00158)
Risk: 100 Sol Lottery		0.00448**			0.00617***	0.00582***
		(0.00202)			(0.00215)	(0.00207)
Log Outside Income			-0.00184		-0.00348	-0.00294
			(0.00481)		(0.00514)	(0.00521)
% Trees with Leaf Rust				0.0709	0.139*	0.215**
				(0.0862)	(0.0842)	(0.0902)
HH Head Years of Edu.					0.00725*	0.00512
					(0.00437)	(0.00434)
HH Head Age					0.000613	0.00000875
					(0.00134)	(0.00129)
Female HH Head					0.0575	0.0664
					(0.0642)	(0.0626)
Household Size					-0.00484	-0.00407
					(0.00895)	(0.00857)
Log Expenditure on Coffee Installments					0.00247	-0.000186
					(0.00631)	(0.00659)
Log Loan Amount					0.00870	0.00895
					(0.00531)	(0.00570)
% Resistant Variety					0.000259	0.000618
					(0.000514)	(0.000488)
Organic Certification					-0.107	-0.0781
					(0.0722)	(0.0682)
Distance to Coop. (km)					0.00332**	0.00190
					(0.00169)	(0.00129)
Perception of Coop. Services					-0.0116	-0.00172
					(0.0126)	(0.0140)
Identification with Coop.					-0.0277	-0.0223
					(0.0170)	(0.0175)
Constant	0.0152	0.0526***	0.105***	0.0838***	0.0402	0.0747
	(0.0384)	(0.0204)	(0.0266)	(0.0228)	(0.116)	(0.108)
District Indicators	No	No	No	No	No	Yes
Cooperative Indicators	No	No	No	No	No	Yes
Observations	330	330	330	323	315	315

[1] Within and between correlations are estimated using the hybrid model in Equation XX. The within estimation is identical to the fixed effects estimation in Equation XX and presented in Table XX in Appendix XX.
[2] Heteroskedastic robust standard errors are clustered at the *Centro Poblado* (lowest administrative unit) level and reported in parentheses.
[3] * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$

Figure 3: Within Correlations: Inverse U-Shape Side-Selling Curve



The left panel corresponds to the results in Column 1 of Table XX, and the right panel corresponds to the results in Column 5 of Table 4. The graphs were generated using the correlated random effects model, which gives the same results as the hybrid model, but can be used within Stata's margins framework (while the hybrid model cannot) (Schunck, 2013).

Proposition 3b: When households experience a production shock, risk-taking is correlated with an increase in side-selling. Column 1 of Table 5 shows that households do not significantly change their side-selling behavior when affected by a shock, but households that are willing to take more risks side-sell more often when affected by a shock. A one percentage point increase in the number of trees infected with leaf rust and a one percentage point increase in the willingness to take risks are correlated with a 2.5 percentage point increase in side-selling. This relationship is only significant at the 90% confidence level, but when controls are included, the relationship becomes significant at the 95% confidence level (Column 2). The results are robust to the inclusion of district and cooperative indicators (Column 3). Figure 4 shows the marginal effects of this relationship graphically. For households that are extremely risk averse (i.e. not willing to pay high amounts to participate in the lottery), production shocks are not significantly correlated with side-selling. However, for households that are willing to pay 15 soles or more to participate in the lottery, side-selling increases as the intensity of production shocks increases. These relationships are only significant at the 90% confidence level when no controls are included (Panel 1 of Figure 4), but at the 95% confidence level when controls are included (Panel 2 of Figure 4). These results corroborate the theoretical model's prediction that risk aversion mitigates any increases in side-selling that may occur from production shocks. The between estimates do not show a significant relationship.

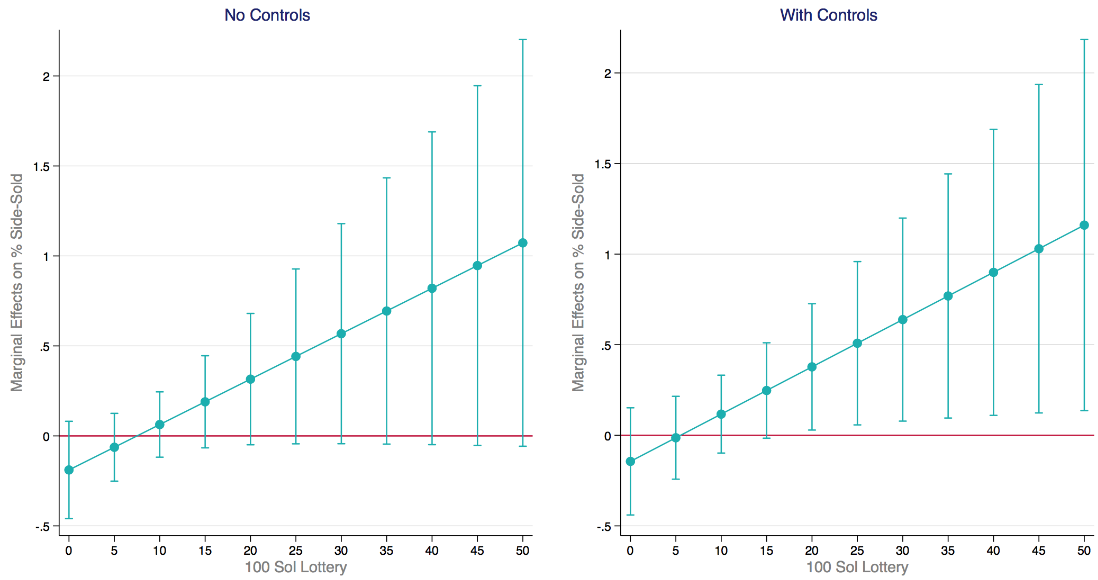
Proposition 3c: Log outside income is correlated with increases in side-selling when households are affected by production shocks. Table 4 above shows that outside income likely plays a larger role in facilitating sales to the private market through the fixed cost mechanism. When households experience a production shock, they demand liquidity more (since their production is lower), but they are also less able to sell on the private market because they are less able to pay for fixed costs to marketing (Section 3). Outside income reduces these increased liquidity demands from shocks, but can also ensure that households are still able to pay the fixed costs of private marketing. The latter appears to play a larger role during the coffee leaf rust crisis. Columns 4-6 show that log outside income is not significantly correlated with side-selling for households not experiencing shocks, but is correlated with increased side-selling in households affected by shocks. A one percentage point increase in coffee leaf rust on a farm combined with a 1% increase in outside income, is correlated with a 5 percentage point increase in side-selling, conditional on other covariates. In other words, households with higher outside income are more likely to side-sell during shocks. These results are shown graphically in Figure 5. In the left panel, the relationships is not statistically significant, but shows a clear upward trend. In the right panel, shocks are positively and significantly correlated with side-selling for households with the highest outside income, but are not significantly correlated with side-selling in households with low outside incomes. As above in Proposition 2, these correlations are driven by within estimates, not between estimates, suggesting that liquidity is playing a large role, not individual household characteristics that are linked with having outside income.

Table 5: Hybrid Model: Interaction Results

	(1) % Organic Coffee Side-Sold	(2) % Organic Coffee Side-Sold	(3) % Organic Coffee Side-Sold	(4) % Organic Coffee Side-Sold	(5) % Organic Coffee Side-Sold	(6) % Organic Coffee Side-Sold
Within Estimation						
Log Outside Income		0.0143**	0.0143**	0.00764	0.00552	0.00552
		(0.00725)	(0.00731)	(0.00520)	(0.00637)	(0.00641)
% Trees with Leaf Rust	-0.191	-0.150	-0.152	-0.0838	-0.108	-0.108
	(0.138)	(0.152)	(0.154)	(0.143)	(0.125)	(0.126)
Risk ×% Trees Leaf Rust	0.0254*	0.0267**	0.0269**			
	(0.0136)	(0.0126)	(0.0128)			
Log Outside Income ×% Trees Leaf Rust				0.0351	0.0518**	0.0518**
				(0.0250)	(0.0234)	(0.0236)
Has. Organic		0.0813*	0.0812*		0.106**	0.106**
		(0.0421)	(0.0424)		(0.0449)	(0.0452)
Has. Org. × Has. Org.		-0.00762*	-0.00761*		-0.00961**	-0.00961**
		(0.00424)	(0.00428)		(0.00450)	(0.00453)
HH Head Years of Edu.		0.00580	0.00583		0.00524	0.00524
		(0.0168)	(0.0170)		(0.0154)	(0.0155)
HH Head Age		0.00447	0.00448		0.00248	0.00248
		(0.00867)	(0.00872)		(0.00873)	(0.00879)
Female HH Head		-0.00865	-0.00855		-0.0235	-0.0235
		(0.108)	(0.109)		(0.106)	(0.107)
Household Size		-0.0183	-0.0183		-0.0151	-0.0151
		(0.0113)	(0.0114)		(0.0100)	(0.0101)
Log Expenditure on Coffee Installments		-0.00344	-0.00344		-0.00295	-0.00295
		(0.00467)	(0.00471)		(0.00488)	(0.00492)
Log Loan Amount		0.0128*	0.0128*		0.00916	0.00916
		(0.00742)	(0.00747)		(0.00676)	(0.00680)
% Resistant Variety		0.0000299	0.0000306		-0.000309	-0.000309
		(0.000742)	(0.000748)		(0.000769)	(0.000775)
Organic Certification		-0.0950	-0.0950		-0.0721	-0.0721
		(0.157)	(0.158)		(0.161)	(0.162)
Between Estimation						
100 Sol Lottery	0.00347	0.00533*	0.00549*			
	(0.00295)	(0.00320)	(0.00312)			
Log Outside Income		-0.00309	-0.00243	-0.00381	-0.00607	-0.00255
		(0.00516)	(0.00533)	(0.00667)	(0.00716)	(0.00643)
% Trees with Leaf Rust	0.0289	0.0922	0.190	0.0366	0.0707	0.206*
	(0.146)	(0.147)	(0.156)	(0.119)	(0.126)	(0.114)
Risk ×% Trees Leaf Rust	0.00261	0.00230	0.0000343			
	(0.0125)	(0.0130)	(0.0124)			
Log Outside Income ×% Trees Leaf Rust				0.0130	0.0203	0.00548
				(0.0240)	(0.0279)	(0.0245)
Has. Organic		0.0336	0.0115		0.0330	0.0105
		(0.0217)	(0.0208)		(0.0210)	(0.0194)
Has. Org. × Has. Org.		-0.00300*	-0.00137		-0.00256	-0.000970
		(0.00175)	(0.00158)		(0.00188)	(0.00169)
HH Head Years of Edu.		0.00674	0.00466		0.00720	0.00458
		(0.00433)	(0.00432)		(0.00488)	(0.00474)
HH Head Age		0.000481	-0.000119		0.00142	0.000628
		(0.00133)	(0.00127)		(0.00150)	(0.00140)
Female HH Head		0.0562	0.0655		0.0515	0.0606
		(0.0612)	(0.0597)		(0.0676)	(0.0659)
Household Size		-0.00402	-0.00277		-0.00467	-0.00481
		(0.00866)	(0.00853)		(0.00918)	(0.00869)
Log Expenditure on Coffee Installments		0.00162	-0.00110		0.000946	-0.00168
		(0.00600)	(0.00632)		(0.00646)	(0.00671)
Log Loan Amount		0.00853*	0.00900*		0.00852	0.00865
		(0.00494)	(0.00527)		(0.00549)	(0.00572)
% Resistant Variety		0.000219	0.000600		0.000259	0.000681
		(0.000515)	(0.000487)		(0.000555)	(0.000495)
Organic Certification		-0.104	-0.0738		-0.122	-0.0965
		(0.0745)	(0.0710)		(0.0744)	(0.0695)
Distance to Coop. (km)		0.00328*	0.00198		0.00278	0.00107
		(0.00175)	(0.00127)		(0.00194)	(0.00152)
Perception of Coop. Services		-0.0102	-0.000582		-0.00766	0.00184
		(0.0123)	(0.0137)		(0.0127)	(0.0139)
Identification with Coop.		-0.0290*	-0.0236		-0.0103	-0.00808
		(0.0174)	(0.0179)		(0.0182)	(0.0179)
Constant	0.0502	0.0600	0.0815	0.0964***	0.0216	0.0687
	(0.0367)	(0.126)	(0.117)	(0.0357)	(0.129)	(0.115)
Observations	315	315	315	315	315	315

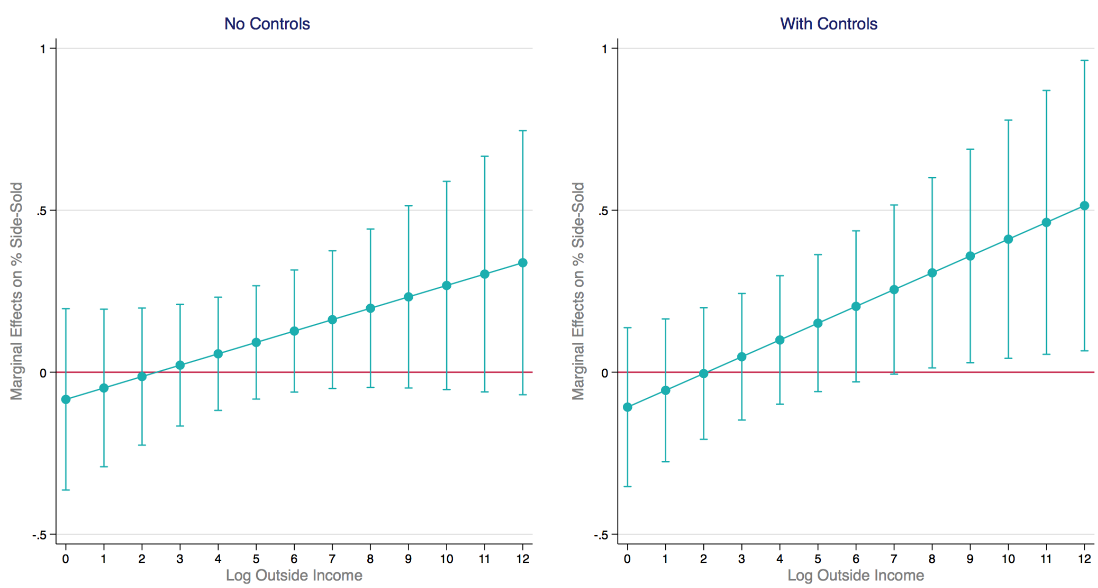
Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 4: Within Correlations: Interaction of Risk and Plant Disease



The left panel corresponds to the results in Column 1 of Table 5, and the right panel corresponds to the results in Column 2 of Table 5. The graphs were generated using the correlated random effects model, which gives the same results as the hybrid model, but can be used within Stata's margins framework (while the hybrid model cannot) (Schunck, 2013).

Figure 5: Within Correlations: Interaction of Outside Income and Plant Disease



The left panel corresponds to the results in Column 4 of Table 5, and the right panel corresponds to the results in Column 5 of Table 5. The graphs were generated using the correlated random effects model, which gives the same results as the hybrid model, but can be used within Stata's margins framework (while the hybrid model cannot) (Schunck, 2013)

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7 Discussion and Conclusion

Side-selling potentially threatens the financial viability of cooperative, and there have been many efforts to understand the determinants of side-selling in a diverse set of contexts. However, these empirical studies use cross-sectional analysis and typically do not place their results within a broader theoretical framework. Further, the role of production shocks, which climate change is making increasingly prevalent, has not been explored in the existing literature. In this paper, we use panel data and extend existing theoretical model to understand the determinants of side-selling in two Peruvian specialty coffee cooperatives.

Our results show that farm size, non-coffee income, risk preferences, and production shocks play a role in side-selling decisions of organic coffee farmers. However, there is significant heterogeneity among farmers. As in Wollni and Fischer (2015), medium-sized are most likely to side-sell, while small and large farmers are more likely to sell to the cooperative. More risk averse households are more likely to sell to cooperatives, and the correlation between production shocks and side-selling depends on non-coffee income and risk preferences. When affected by production shocks, households with higher non-coffee income are more likely to side-sell, while households with lower non-coffee income are not affected. This can be because non-coffee income helps cover fixed costs to marketing on private market or because households have DARA with respect to total income (not just income related to coffee). Finally, households that are willing to take more risks are more likely to side-sell when affected by production shock.

We place the results in the context of a theoretical framework that heavily relies on Woldie (2010) and Wollni and Fischer (2015). This theoretical framework is crucial to understanding why the correlations shown in the empirical results hold, particularly during production shocks. For example, an intuitive response from cooperative managers may be to provide farmers affected by shocks with liquidity so that their demand for liquidity decreases and they sell more to the cooperative. However, this intuitive response ignores the decreasing absolute risk aversion of farmers and increased difficulty in covering fixed costs to private marketing induced by shocks. Emergency liquidity may increase, rather than decrease side-selling during production shocks. We see that higher non-coffee income has just this relationship with side-selling when households are affected by shocks.

This paper presents a methodological improvement over previous studies, extends existing side-selling theories, and explores new mechanisms which can influence side-selling. However, the results still rely on a dataset with low sample size in a geographically confined area. While the theory should help with generalizability of the findings, further research must be conducted to understand side-selling behavior in other contexts. We encourage future research on this topic to use panel data and follow side-selling behavior over longer periods of time to get a truer understanding of side-selling behavior.

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Appendices

A Solving the Utility Maximization Problem

A.1 General Utility Function

Utility is given by:

$$U = \frac{(I+E)^{1-\gamma} - 1}{1-\gamma} \text{ for } \gamma \neq 1 \tag{17}$$

Let the total income be given by:

$$I = (1-\delta)r + \delta\mu = r - \delta(\mu - r) \tag{18}$$

The variance of income is given by:

$$V = \delta^2\sigma^2 \tag{19}$$

Income follows a log-normal distribution. The expected return of a log-normal variable is given by $\rceil^{r-\delta(\mu-r)+\frac{\sigma^2\delta^2}{2}}$. Therefore we can maximize the expected return. The log distribution of income and the cash endowment is then:

$$\ln I + E \sim \mathcal{N}(r + E\delta(\mu - r) - \frac{\delta^2\sigma^2}{2}, \delta^2\sigma^2) \tag{20}$$

We plug this expected return, its variance, and the cash endowment into the utility function:

$$E[U(\delta)] = \frac{e^{(1-\gamma)(E+r+\delta(\mu-r)-\frac{\delta^2\sigma^2}{2})+\frac{1}{2}\delta^2\sigma^2(1-\gamma)^2} - 1}{1-\gamma} \ \forall \ \gamma \neq 1 \tag{21}$$

Since e is a constant, we can simply maximize the expression in the exponent. This is equivalent to maximizing:

$$\max E + r + \delta(\mu - r) - \frac{\delta^2\sigma^2}{2} + \frac{1}{2}\delta^2\sigma^2(1-\gamma) \ \forall \ \gamma \neq 1 \tag{22}$$

Simplifying:

$$\max E + r + \delta(\mu - r) - \frac{1}{2}\delta^2\sigma^2\gamma \ \forall \ \gamma \neq 1 \tag{23}$$

The FOC becomes:

$$\frac{\partial E[U(\delta)]}{\partial \delta} = (\mu - r) - \delta\sigma^2\gamma = 0 \tag{24}$$

We now solve for δ:

$$\boxed{\delta^* = \frac{(\mu - r)}{\sigma^2\gamma}} \tag{25}$$

We have now solved for the optimal share in the risky channel.

A.2 Explicit Utility Function

This section solves for the explicit solution to the utility maximization problem.

$$\begin{aligned} \max U = & [E + p_p\delta Q + (p_p + x_c)(1-\delta)Q\beta(Q,E)^{t_p} + R_d] \\ & - [c_1^p\delta Q - \frac{c_2^p}{2}(\delta Q)^2 + c_1^c(1-\delta_i)Q] \\ & - \frac{1}{2}\delta^2\sigma^2\gamma \\ & \forall \ \gamma \neq 1 \\ & \text{where } R_d = (1-\delta)Q(p_x - p_c)^\alpha(\sum_{j=1}^{N}(1-\delta_j)Q_j)^{(\alpha-1)}\beta(Q,E)^{t_d} \end{aligned} \tag{26}$$

Taking the first order condition with respect to δ, we get:

$$\frac{\partial U}{delta} = p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^pQ - c_2^p\delta Q^2 - c_1^cQ - \delta\sigma^2\gamma = 0 \tag{27}$$

Rearranging:

$$p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^p Q - c_1^c Q = \delta(c_2^p Q^2 + \sigma^2\gamma) \tag{28}$$

The optimal solution is given by:

$$\delta^* = \frac{p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^p Q - c_1^c Q}{c_2^p Q^2 + \sigma^2\gamma}$$
$$\text{where} \tag{29}$$
$$\frac{\partial R_d}{\partial \delta} = -Q(p_x - p_c)^{\alpha}(\sum_{j=1}^{N}(1-\delta_j)Q_j)^{(\alpha-1)}\beta(Q,E)^{t_d}$$

B Selected Comparative Statics

$\frac{\partial \delta^*}{\partial \mathbf{Q}}$: Take partial derivative of δ^*:

$$\frac{\partial \delta^*}{\partial Q} = \frac{[-(p_p + x_c)t_p\beta(Q,E)^{t_p-1}\frac{\partial \beta'(Q,E)}{\partial Q} - c_1^p - c_1^c][c_2^p Q^2 + \sigma^2\gamma] - [p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^p Q - c_1^c Q][c_2^p]}{(c_2^p Q^2 + \sigma^2\gamma)^2} \tag{30}$$

Only the numerator will determine whether the comparative static is positive or negative:

$$[-(p_p + x_c)t_p\beta(Q,E)^{t_p-1}\frac{\partial \beta'(Q,E)}{\partial Q} - c_1^p - c_1^c][c_2^p Q^2 + \sigma^2\gamma] - [p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^p Q - c_1^c Q][2c_2^p Q] \lesseqgtr 0 \tag{31}$$

Rearranging:

$$[-(p_p + x_c)t_p\beta(Q,E)^{t_p-1}\frac{\partial \beta'(Q,E)}{\partial Q} - c_1^p - c_1^c][c_2^p Q^2 + \sigma^2\gamma] \lesseqgtr [p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^p Q - c_1^c Q][2c_2^p Q] \tag{32}$$

Rearranging:

$$\frac{[-(p_p + x_c)t_p\beta(Q,E)^{t_p-1}\frac{\partial \beta'(Q,E)}{\partial Q} - c_1^p - c_1^c]}{[p_p - (p_p + x_c)Q\beta(Q,E)^{t_p} + \frac{\partial R_d}{\partial \delta} - c_1^p Q - c_1^c Q]} \lesseqgtr \frac{[2c_2^p Q]}{[c_2^p Q^2 + \sigma^2\gamma]} \tag{33}$$

Equation XX shows that the comparative static of δ^* with respect to p_x is negative. Intuitively, this means that if the cooperative premium increases, then side-selling decreases because farmers get higher profits from the cooperative. In Equation, the first term in the numerator represents the change in quantity sold to the private market based on cooperative premiums in delivery price – if delivery price premiums increase, then side-selling decreases. The second term shows the change in side-selling with respect to the cooperative dividend. Holding international prices constant, delivery price premium increases decrease the dividend (because the cooperative's margins decrease). However, this effect is less than the delivery price premium effect because cooperative dividends are more delayed (i.e. $t_d > t_p$), and therefore more steeply discounted. Therefore, the overall effect of a price premium in delivery prices on side-selling is negative.

$$\frac{\partial \delta^*}{\partial x_c} = \frac{-Q\beta(Q,E)^{t_p} - [\alpha Q(p_x - (p_p + x_c)^{\alpha-1}][(\sum_{j=1}^{N}(1-\delta_j)Q_j)^{(\alpha-1)}\beta(Q,E)^{t_d}]}{c_2^p Q^2 + \sigma^2\gamma} < 0 \tag{34}$$

C Attrition Tests

Table 6: Test for Attrition Bias

Variable	Incomplete Cases	Complete Cases	Difference
Side-Selling Indicator	0.27	0.23	-0.038
	(0.01)	(0.00)	(0.671)
% Organic Coffee Side-Sold	0.09	0.13	0.039
	(0.01)	(0.00)	(0.498)
% Trees with Leaf Rust	0.29	0.28	-0.011
	(0.00)	(0.00)	(0.840)
Has. Organic	3.33	2.97	-0.362
	(0.00)	(0.00)	(0.407)
Total Organic Trees	13125.00	10732.62	-2392.376
	(0.00)	(0.00)	(0.198)
% Resistant Variety	47.38	54.22	6.842
	(0.00)	(0.00)	(0.337)
Exp. on Coffee Installations (soles)	1330.58	1514.69	184.111
	(0.00)	(0.00)	(0.709)
Exp. on Labour (soles)	61.15	13.04	-48.109**
	(0.12)	(0.01)	(0.013)
Outstanding Loan Value (soles)	903.85	2465.61	1561.759
	(0.06)	(0.02)	(0.534)
Distance to Coop. (km)	11.68	9.89	-1.793
	(0.00)	(0.00)	(0.364)
Organic Certification	0.81	0.90	0.090
	(0.00)	(0.00)	(0.182)
Knowledge of Fair Trade	0.50	0.57	0.073
	(0.00)	(0.00)	(0.488)
HH Head Years of Edu.	5.69	6.93	1.238
	(0.00)	(0.00)	(0.171)
HH Head Age	43.50	47.70	4.201
	(0.00)	(0.00)	(0.137)
Female HH Head	0.08	0.17	0.095
	(0.16)	(0.00)	(0.221)
Household Size	3.92	4.24	0.319
	(0.00)	(0.00)	(0.476)
Non-Coffee Incomes (soles)	1371.92	5247.71	3875.784
	(0.03)	(0.01)	(0.400)
Perception of Coop. Services	0.54	0.82	0.277
	(0.01)	(0.00)	(0.284)
Identification with Coop.	3.85	3.85	0.006
	(0.00)	(0.00)	(0.973)
Risk: 50 Sol Lottery	5.25	5.56	0.307
	(0.00)	(0.00)	(0.683)
Risk: 100 Sol Lottery	8.06	10.39	2.334
	(0.00)	(0.00)	(0.188)
Risk: 1000 Sol Lottery	16.85	28.28	11.437
	(0.00)	(0.00)	(0.188)
N	26	157	183

[1] Significance levels: * < 10% ** < 5% *** < 1%
[2] P-Values in parentheses

D Tests for Panel Model Specification

Table 7: Random Effects

	(1) % Organic Coffee Side-Sold	(2) % Organic Coffee Side-Sold	(3) % Organic Coffee Side-Sold	(4) % Organic Coffee Side-Sold	(5) % Organic Coffee Side-Sold	(6) % Organic Coffee Side-Sold
Has. Organic	0.0550***				0.0522***	0.0393**
	(0.0169)				(0.0187)	(0.0180)
Has. Org. ×Has. Org.	-0.00463***				-0.00446***	-0.00345**
	(0.00163)				(0.00169)	(0.00158)
Log Outside Income		0.00447			0.00491	0.00526
		(0.00402)			(0.00417)	(0.00421)
% Trees with Leaf Rust			0.0565		0.0917	0.120*
			(0.0564)		(0.0613)	(0.0659)
Risk: 100 Sol Lottery				0.00448**	0.00575***	0.00543***
				(0.00202)	(0.00216)	(0.00205)
HH Head Years of Edu.					0.00560	0.00407
					(0.00463)	(0.00439)
HH Head Age					0.000887	0.000310
					(0.00149)	(0.00142)
Female HH Head					0.0223	0.0310
					(0.0547)	(0.0543)
Household Size					-0.00635	-0.00578
					(0.00724)	(0.00709)
Log Expenditure on Coffee Installments					-0.00124	-0.00202
					(0.00372)	(0.00386)
Log Loan Amount					0.00794*	0.00764*
					(0.00437)	(0.00450)
% Resistant Variety					0.000157	0.000334
					(0.000521)	(0.000524)
Organic Certification					-0.111	-0.0986
					(0.0873)	(0.0801)
Distance to Coop. (km)					0.00244	0.00149
					(0.00173)	(0.00148)
Perception of Coop. Services					-0.0131	-0.00509
					(0.0114)	(0.0125)
Identification with Coop.					-0.0253	-0.0193
					(0.0166)	(0.0174)
Constant	-0.00175	0.0808***	0.0868***	0.0526***	0.0184	0.0517
	(0.0264)	(0.0202)	(0.0196)	(0.0204)	(0.122)	(0.116)
District Indicators	No	No	No	No	No	Yes
Cooperative Indicators	No	No	No	No	No	Yes
Observations	330	330	323	330	315	315

[1] Between correlations are estimated using the random effects model in Equation XX. Within correlations cannot be estimated using the traditional random effects model.
[2] Heteroskedastic robust standard errors are clustered at the *Centro Poblado* (lowest administrative unit) level and reported in parentheses.
[3] * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$

Table 8: Fixed Effects

	(1) % Organic Coffee Side-Sold	(2) % Organic Coffee Side-Sold	(3) % Organic Coffee Side-Sold	(4) % Organic Coffee Side-Sold	(5) % Organic Coffee Side-Sold	(6) % Organic Coffee Side-Sold	(7) % Organic Coffee Side-Sold	(8) % Organic Coffee Side-Sold
Has. Organic	0.0743**			0.0910**	0.0700**			0.0882**
	(0.0328)			(0.0414)	(0.0312)			(0.0432)
Has. Org. × Has. Org.	-0.00704**			-0.00828*	-0.00677**			-0.00809*
	(0.00334)			(0.00423)	(0.00331)			(0.00433)
Log Outside Income		0.0125**		0.0138*		0.0120**		0.0134*
		(0.00579)		(0.00696)		(0.00586)		(0.00724)
% Trees with Leaf Rust			0.0432	0.0973			-0.0433	0.0761
			(0.0839)	(0.104)			(0.0908)	(0.123)
HH Head Years of Edu.				0.00233				0.00252
				(0.0171)				(0.0173)
HH Head Age				0.00346				0.00418
				(0.00885)				(0.00987)
Female HH Head				-0.0215				-0.0220
				(0.109)				(0.110)
Household Size				-0.0135				-0.0132
				(0.0101)				(0.00987)
Log Expenditure on Coffee Installments				-0.00318				-0.00384
				(0.00459)				(0.00448)
Log Loan Amount				0.00922				0.00919
				(0.00704)				(0.00702)
% Resistant Variety				-0.0000577				-0.0000544
				(0.000739)				(0.000741)
Organic Certification				-0.0888				-0.0809
				(0.155)				(0.149)
Year = 1					-0.0235	-0.0287	-0.0491	-0.0153
					(0.0278)	(0.0311)	(0.0340)	(0.0429)
Constant	-0.0303	0.0474**	0.0874***	-0.176	-0.0112	0.0623**	0.126***	-0.201
	(0.0562)	(0.0222)	(0.0162)	(0.510)	(0.0519)	(0.0276)	(0.0279)	(0.532)
Time Indicator	No	No	No	No	Yes	Yes	Yes	Yes
Observations	330	330	323	315	330	330	323	315

[1] Within correlations are estimated using the fixed effects model in Equation XX. Columns 1 - 4 respectively correspond with Columns 1, 2, 3, and 5 in Table XX. Between correlations cannot be estimated using the traditional fixed effects model. Columns 5-8 include the year indicator and these models are used in the time fixed effect test in Table XX below.
[2] Heteroskedastic robust standard errors are clustered at the *Centro Poblado* (lowest administrative unit) level and reported in parentheses.
[3] * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$

Add tables for Random Effects Estimations and Fixed Effects Estimations

Table 9: Hausman Tests and Breusch and Pagan Lagrange Multiplier Tests

Explanatory Variables	Year Indicators	Control Variables	Hausman Chi-Squared	Hausman P-Value	LM Test Statistic	LM P-Value	Time Fixed Effect F-Test	Time Fixed Effects P-Value
Hectares and Hectares-Squared	No	No	0.69	0.71	1.70	0.10		
Hectares and Hectares-Squared	Yes	No	7.34	0.06			0.68	0.41
Non-Coffee Income	No	No	5.26	0.02				
Non-Coffee Income	Yes	No	11.32	0.00			0.63	0.43
Coffee Leaf Rust	No	No	1.08	0.30	1.50	0.11		
Coffee Leaf Rust	Yes	No	9.35	0.01			1.21	0.27
All Explanatory Variables	Yes	Yes	17.74	0.09			0.58	0.45

[1] The models are run with the percentage of organic coffee sold as the dependent variable, following Equation XX in Section XX. Year indicators are indicator variables for the wave to which each observation belongs, and the control variables follow from Section XX.

[2] The Hausman test is run after estimating both fixed and random effects models. The null hypothesis of the Hausman test is that there is no systematic difference between coefficients in the Fixed Effects and Random Effects models. Rejection of the null hypothesis suggests that only Fixed Effects models are consistent, while Random Effects provides inconsistent results. Failure to reject the null hypothesis suggests that random effects is both consistent and efficient, while fixed effects is efficient, but inconsistent.

[3] The Breusch and Pagan Lagrange Multiplier Test (LM Test) is run after random effects models. We only run these tests on models in which we fail to reject the null hypothesis in the Hausman test. The null hypothesis in the LM Test is that there is no panel effect (i.e. variances across units is zero) while the alternative hypothesis is that there is a presence of a panel effect. Rejection of the null hypothesis suggests that random effects should be used, while failure to reject the null hypothesis indicates that OLS should be used.

[3] The time fixed-effects F-Test tests jointly whether the year indicators are equal to zero. Since there are only two panels, this test is equivalent to the test of whether the year indicator is equal to zero in Tables XX and XX.

[5] For all tests, P-Values ≤ 0.10 are considered as statistically signicant.