Informal Contracts in an Incomplete Market: The Price of Milk in Paraguay *

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Abstract

The relative price of locally-produced and locally-sold milk and cheese in rural Paraguay is puzzling, apparently leaving opportunities for arbitrage. Despite requiring additional labor and inputs, the price of cheese per liter of milk is lower than the price of a liter of fluid milk. We propose a framework of relational contracts to explain this puzzle. Consumers who desire a steady supply of milk enter into relational contracts with producers, paying a price premium for stable access to milk. This framework is consistent with our data. Producers sell milk to the same consumers year-round; producers with more variable milk production sell milk fewer trimesters of the year and are more likely to sell cheese; and more price inelastic consumers are more loyal to their seller. There are other potential explanations for this pricing puzzle including collusion among milk sellers, milk quality differentials, and the relative ease of transporting and storing cheese compared to milk. We give suggestive evidence that consumers' desire for stable access to milk fits the data best.

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1 Introduction

We give evidence of a puzzling relationship between the prices of locally-produced milk and cheese sold directly from the producer to the consumer in rural Paraguay. Fluid milk is sold at a relatively high price while cheese, which takes extra labor and materials to produce, is sold at a relatively low price. In 2007, a producer could convert 1,000 Gs worth of fluid milk into 632 Gs worth of cheese. Why wouldn't a cheese seller take advantage of an arbitrage opportunity, offer that fluid milk for sale at a slightly lower price, for example 900 Gs, and save herself the effort of converting it into cheese?

Relational contracts ensuring consumers access to a stable supply of milk is one potential explanation for the high price of fluid milk. Many fluid milk consumers value having access to a stable supply of milk. On the other hand, milk producers must contend with a variable supply of milk. Consumers are willing to pay a higher price to get a reliable steady supply, and producers can process excess milk to produce cheese which they then sell at a relatively low price.

There are other potential alternative explanations for this price puzzle including the possibility that milk sellers collude to keep the price artificially high, the potential for differential milk quality across producers, the fact that cheese is easier to transport and can be stored longer than milk, interlinked transactions with milk sellers, altruism of cheese sellers, and imperfections in rural Paraguayan markets more generally. We provide evidence that consumers' desire for a stable supply of milk fits the data well, though we do not argue that it is the only mechanism in effect.

Relational contracts have been found to be quite important in developing countries where markets do not function well, and for perishable goods which require individuals to trade with one another more frequently. These contracts often involve charging higher prices to loyal buyers who desire a reliable supply as found for transactions involving fish (Weisbuch et al., 2000), Chinese cabbage (Song and Ma, 2023), and ice (Ghani and Reed, 2022).

Relational contracts are characterized by dynamic incentive compatibility constraints, or the requirement that both parties value the relationship enough that neither party wishes to renege (Macchiavello, 2022). That said, data does not usually measure the temptation to deviate. Macchiavello and Morjaria (2015) use variation in the Kenyan flower market caused by electoral violence and high Valentine's day demand to proxy for variation in temptation to deviate. Their insight is that one can measure the value of the relationship by seeing the difference between the prices that sellers get in the spot market and in relational contracts. If sellers can sell roses on the spot market for a higher price, but choose not to do so, this must mean the relationship is worth more to them than the price difference.

In this paper, we take a different strategy, directly asking both buyers and sellers if they could be tempted into reneging on their long-term relationships. While a disadvantage is that some of our measures are hypothetical, the measures give suggestive evidence of the value of relationships. We see that 73% of consumers would not stop buying from their usual provider if another seller temporarily offered them milk that was 200 Gs (approximately 17%) cheaper. Similarly, 70% of sellers would not stop selling to their usual customer if temporarily offered a price that was 200 Gs higher.

The relational contract hypothesis in which consumers contract for a stable milk supply fits the observational data as well as the hypothetical responses. First, milk-trading partnerships are quite stable over time - the same buyer often buys the same amount of milk from the same seller every day year round. Most milk transactions are conducted by the same partners year-round, with little switching to new partners. Second, producers who sell milk but not cheese have less variable milk production. Third, using unique measures of consumers' price elasticity of demand and of their loyalty to their trading partner we find, as predicted, that price inelastic consumers are more likely to be loyal.

There are other potential explanations for the price discrepancy between milk and cheese, and the mechanisms we describe and explore are by no means exhaustive. One potential alternative explanation is that relational contracts with high milk prices could be maintained to provide access to high quality milk rather than a stable supply of milk. We provide suggestive evidence that concerns about milk quality do not fully explain the patterns in the data. Collusion between milk sellers could also be an explanation for the price puzzle, though patterns in the prices of milk and cheese over space and time suggest that is less likely. Market frictions in all rural Paraguayan markets (not just dairy markets) may be so severe as to make prices of all goods idiosyncratic. But, we compare the prices of fresh yuca and processed yuca starch and find that the prices of those two products are in accord with one another, which is evidence that at least some markets do function properly. Another alternative is that cheese may be less expensive than fluid milk because it can be stored for longer periods of time, but the data shows that Paraguayans do not store cheese for very long. And the possibility of storage wouldn't explain why a producer would sell cheese at a loss rather than offer their milk up at slightly lower price and take advantage of arbitrage opportunities. Another possible explanation is interlinked transactions. For example, a milk buyer may be willing to pay a higher price for milk to a seller who also offers her credit. We find that loyalty is more common between partners who live within 300m of one another, but not between partners who have potentially interlinked transactions. Overall, relational contracts ensuring stable milk transactions seem to be the best-fit explanation for the price differential we find.

Relational contracts have been shown to put upward, downward, or stabilizing pressure on prices depending on the setting. Supply uncertainty, like the milk supply uncertainty we model in this paper, can lead buyers to form relational contracts guaranteeing stable supply and involving higher average prices (Cajal-Grossi et al., 2023; Ghani and Reed, 2022; Song and Ma, 2023; Weisbuch et al., 2000) and more stable prices (Cajal-Grossi et al., 2023; Macchiavello and Morjaria, 2015; Song and Ma, 2023). On the other hand, demand uncertainty and a supplier's desire for stable demand can lead relational contracts to have lower prices (Macchiavello and Miquel-Florensa, 2018). Supply uncertainty is not the only reason why relational contracts might lead to higher prices. Other mechanisms that can put upward pressure on relational prices are a buyer's desire for product quality (Macchiavello and Miquel-Florensa, 2019), collusion between suppliers (Bernasconi et al., 2023), and task clarity (Antić et al., 2024). We discuss milk quality and collusion as alternative explanations to supply uncertainty for the milk-pricing puzzle; task clarity is less relevant in this setting. One unique feature about milk is that it can be converted to cheese and sold in a different market, a distinguishing feature compared to the products studied in the above-mentioned papers.

Milk markets are especially important to study due to the nutritional function milk serves. Children in Ethiopia in households that own cows (even conditional on assets and income) consume more milk and are less likely to be stunted. The health effects of owning a cow are significantly smaller in areas with better access to markets (Hoddinott et al., 2015). The relationship between the price of milk and child health outcomes is large. For example, Filmer et al. (2023) shows that a cash transfer program in the Philippines raises the price of dairy and eggs, decrease purchases among households that are not eligible to receive the cash transfer, and increases stunting in their children. Headey et al. (2018) look more broadly at 49 low and middle income countries and find that the high price of animal proteins, especially fresh milk, causes children to consume them less and be more likely to be stunted. This suggests the importance of understanding within-village milk trade and how milk prices are set for their implications for child health.

Incomplete milk markets may lead to inequality between milk producers with and without relational contracts. Milk markets could potentially be integrated through adoption of milk storage technologies and transportation cost reducing infrastructure. Extension programs to stabilize the milk production of small milk producers could also allow them to more easily enter into relational contracts. These interventions would make it possible for all dairy farmers to participate in milk markets, and reduced milk prices would benefit consumers as well.

In Section 2, we describe features of rural Paraguayan dairy markets, give details about the price puzzle, and introduce relational contracts as a potential explanation. Section 3 gives the intuition behind the relational contract model and discusses testable hypotheses. Section 4 describes the data. Section 5 gives evidence that the relational contracts set-up can explain the puzzling pricing pattern well, while Section 6 discusses other explanations which may additionally be at play. Finally, Section 7 concludes.

2 Setting

Dairy markets occupy an important position in Paraguayan villages, where many rural households engage in the production, sale, and consumption of milk and cheese. We first give a broad brush overview of rural Paraguayan dairy markets in this section, with more details about the data and setting following in subsequent sections. Many households (slightly over half of the households in our sample) produce milk in any given year. The only thing a farmer needs to produce milk is to own a cow which has recently given birth and is still supplying milk.

Milk production is a family enterprise and there is no mechanization. For example, the male head of household may be in charge of leading the cattle to pasture in the morning and bringing them back to their sleeping area and drinking water in the evening, while the female head of household may be in charge of milking the cows each morning. This makes it difficult to quantify the costs of and profits from milk production.

Many milk producers produce just enough milk and cheese for their own family to consume, and do not engage in market exchange. While over half of the households in our sample produce milk, only slightly more than 10% sell it. Those who do sell milk and cheese, sell directly to consumers who live in their villages. The buyers are their neighbors, friends, and extended family. The median distance between the consumer's house and the producer from whom he purchases is 300 meters. The matching between sellers and buyers tends to be one-to-one. We find that 90% of sellers only sell to one or two individuals year-round, with the maximum number of milk clients for a seller being six. Similarly, 83% of buyers purchase from the same producer year round, with the maximum number of milk sellers for a buyer being three. These relationships are quite stable over time, with very few people switching trading relationships over the year. It is our understanding that these milk trading relationships last multiple years, though we do not have data on previous years.

There is no barrier to entry to sell milk. After a cow is milked, the milk which is to be sold is usually poured (using a funnel) into an old cleaned liter-size soda bottle. More than three quarters of the time, the buyer is in charge of transportation. The buyer (or more commonly a young child of the buyer) travels by foot or by bicycle to the seller's residence to pick up the milk. There is no middleman involved and no sale through stores. Milk is sold raw, and the buyer is responsible for boiling it before drinking to reduce the bacterial load.

Households purchase fresh milk on a daily basis. The median household does not store milk, consuming it all the day it is purchased. They tend to purchase the same amount of milk every day - for example purchasing one liter every day. Almost half (42%) of consumers who purchase milk in our survey purchase the exact same amount every day year round.

While consumers would like a stable supply, quantity produced by any given producer is much more variable. Only a bit more than half (54%) of milk producers produce milk in all three trimesters (May 2006, September 2006, and January 2007). Even for those who produce in all three trimesters, the coefficient of range (maximum monthly production minus the minimum monthly production divided by the sum of the two) is 26%. Compare this with the coefficient of range of quantities purchased by consumers who purchase in all three trimesters of 12%. This highlights a potential mismatch in the stability of milk production over time compared with the desired stability of milk purchases over time.

In many other countries, dairy cooperatives play an important role in coordinating markets, but dairy cooperatives and formal milk sales are quite rare in the Paraguayan villages we study. Echoing our setting, Ferreira et al. (2007) also study milk production in rural Paraguay and find that over 70% of the milk in their sample was sold within the producer's neighborhood. Similarly, Blackmore et al. (2020) show that most milk in Kenya, Tanzania, and India, goes through the informal sector, and that the informal sector provides higher prices to producers. Only 8% of the Indian villages studied by Anagol et al. (2017) have a milk cooperative. On the other end of the spectrum, Casaburi and Macchiavello (2019) focus on dairy markets in Kenya where farmers decide between selling to a cooperative or to itinerant traders, and informal sales appear to be rare.

Fluid milk which is not consumed or sold as milk is converted to cheese. This is the only alternative use for milk in this setting - there is no production of yogurt, butter, or ice cream. Women make cheese by manually mixing milk with rennet (either locally-produced cow stomach, or manufactured liquid rennet). This causes the milk to separate into curds and whey. The curds are then placed in cheese cloth and any remaining liquid whey is squeezed out. Finally, the cheese is left to sit in a rectangular mold.

This home-made cheese has a relatively short shelf-life, with the median household claiming that the longest amount of time they have stored cheese is one week. Cheese is most often sold by producers directly to consumers, but it can also be sold by producers to neighborhood stores which sell to consumers. While milk consumption is seen as a daily necessity, especially for young children, cheese consumption is seen more as a special treat to consume when available.

Given the differences in how milk and cheese are sold, it is not surprising that there are also differences in the variability of their prices. Each seller charges relatively constant prices for milk year round, while the prices they charge differ more for cheese. In fact, while 91% of milk producers charge the same price for milk year round, only 61% of cheese producers charge the same price for cheese. On the other hand, milk prices vary much more across producers than do cheese prices.

Average prices of milk and cheese differ in potentially surprising ways as well. It takes approximately 10 L of milk plus labor and rennet to make 1 kg of cheese. Paraguayan women are usually responsible for producing cheese, and imperfect labor markets may cause the shadow wage of women's labor to be close to zero. This might explain why fluid milk would be sold at the same price as the value of cheese it produces, but can not explain why fluid milk would be sold at a higher price than the value of cheese it produces. Yet this is precisely what we find. In 2007, the average milk price was 1,500 Gs/L while the cheese price was 9,000 Gs/kg.[1] This means that cheese makers converted 1,000 Gs worth of milk to make only 632 Gs worth of cheese.

Why is the price ratio of cheese to milk so low? One could imagine a cheese maker would like to sell milk instead of making and selling cheese. One could also imagine a middleman who takes advantage of this opportunity, buying milk from a cheese maker and selling it as fluid milk to consumers.[2] A cheese maker who makes one kilo of cheese from ten liters of milk and sells it at 9,000 Gs/kg will earn 900 Gs per liter. An arbitrager could offer to buy milk from this cheese maker at 1,000 Gs per liter and sell it to a consumer at a price lower than the market price, say, 1,050 Gs per liter. At first glance it seems surprising that nobody

[1] In 2007 the exchange rate was approximately 5,000 Gs per 1 USD.

[2] We do not look at overall profitability of owning cows, as do Anagol et al. (2017) and Attanasio and Augsburg (2018). We look at the profitability of selling milk versus cheese, conditional on producing milk.

engages in this form of arbitrage.

Most milk-consuming households demand stable daily consumption of milk. However, milk supply is unstable and affected by uncontrollable factors (Manchester et al., 1994). Some of the instability is due to seasonal variation in the quality of pasture available to the animals, while some of the instability is idiosyncratic depending on how many calves were born how long ago. We hypothesize that the instability in fluid milk supply is a key factor contributing to the price puzzle - consumers form relational contracts with higher milk prices to guarantee stable access over time.

Bernard et al. (2018) document that even dairy processing companies have problems with producers' irregular milk delivery. The dairy processor in Senegal that they work with offers producers free yogurt as a reward for regular milk delivery. Thus, the idea that dairy producers need to be offered a premium in return for regular milk supply is not new or unique to Paraguay.

It may be of interest to look at the dairy pricing system in the United States for comparison. Before the 1930s, fluid milk distributors were willing to pay more for a stable supply of fluid milk with less seasonal variation, while distributors paid less for milk used for manufactured products (Lininger, 1929). Since the 1930s, a system of federal support prices and federal milk marketing orders have developed which set minimum prices for milk. Milk for drinking (fluid-grade milk) has a higher minimum price than milk for manufacturing products (manufacturing-grade milk). The main reasons for this price discrimination are (i) to prevent the fluid milk prices that consumers face from fluctuating due to a shortfall in milk production (Manchester et al., 1994) and (ii) to increase dairy farmer revenue by taking advantage of more inelastic demand for fluid milk compared to that for manufactured milk (Bailey, 2001; Cox and Chavas, 2001). Various public and private institutions, including the U.S. Department of Agriculture and (almost monopolistic) dairy cooperatives, must work together to maintain this price differential (Blayney and Manchester, 2001). It is interesting that a similar price differential is informally maintained in rural Paraguayan dairy markets without these formal institutions.

3 Relational contracts and testable hypotheses

In this section, we provide an intuitive framework of relational contracts and explain how this framework can solve the Paraguayan dairy market pricing puzzle posed in the previous section. Here we provide the intuition behind the model whose details can be found in

Appendix A. Consumers contract with dairy producers to purchase a set quantity of milk at a set price year-round, thus allowing consumers to enjoy a stable supply of milk at a stable price. Those contracts are not enforceable and either party can renege at any time.

Milk production is seasonal. Producers differ in how stable the quantity of milk they produce is across seasons. Consumers differ in how elastic their demand for milk is. Consumers with inelastic demand prefer to consume a constant amount of milk year-round, and are willing to pay a premium for a contract that allows them to do so.

There exist two markets for milk. Producers and consumers who have long-term relational contracts make transactions at predetermined contract prices in the contract market. Producers and consumers can agree to transact a certain amount of milk in every period at a given price. If the consumer purchases the contracted amount of milk from the contracted producer, then the contract continues into the next period. If either party does not maintain their side of the contract, the contract is terminated, the buyer and seller have no contract from the next period onward, and they conduct future interactions on the spot market. Given that both parties know each other well and often live near one another, social sanctions may also be applied in case of breach of contract. We do not include this possibility in the mathematical model in Appendix A, but decreased distance would make relational contracts easier to sustain.

Milk may also be sold in the spot market at a competitive price. Milk prices in the spot market are determined by demand and supply, so when supply is higher the price will be lower. In the high season, the price of milk in the spot market faces a floor; it can not go below the equivalent milk price of cheese. There exists only one market for cheese, the spot market.

This model leads to some intuitive testable hypotheses. First and foremost, this model predicts the puzzle that was our starting point: the price of milk in relational contracts is higher than the equivalent milk-price of cheese. A second implication is that producers will sell to the same consumers repeatedly year-round, while consumers will repeatedly purchase from the same producers year-round. Inasmuch as most consumers tend to be price inelastic, this will be true for most buyers and sellers. Consumers will be unwilling to leave their usual partner if offered a lower price for a few weeks, and producers will be unwilling to stop selling to their usual partner if offered a higher price for a few weeks.

The model also gives predictions about which producers will enter into relational contracts to sell milk, and which will sell cheese. First, producers who sell milk but not cheese are predicted to have less variable production compared to those who ever sell cheese. Relational contracts for milk sales involve the same amount of milk being sold in each time period. If the producer's milk production has low variability, he would prefer to sell it as milk at a higher price. Second, because producers get a higher price for milk sold in a relational contract, any producer who sells cheese must do so because the amount he produces in his lowest production period is relatively low. Finally, the quantity of milk produced by producers who sell milk in more periods will be more stable. Producers with less stable production will not find relational contracts and will sell milk in fewer periods.

Finally, we can think about the purchasing behavior of consumers with different price elasticities of demand through the lens of the model. Consumers who are more price inelastic will be less willing to break their relational contract for a temporarily lower price. In other words, less elastic consumers are more likely to be loyal.

4 Data

We conducted agricultural household surveys with 449 households in 15 Paraguayan villages in 2007. For more details about the sample, see Ligon and Schechter (2012). The survey asked detailed retrospective information about production, sales, purchases, and gifts of milk and cheese for three months (which we consider to be three trimesters) in the previous year: May 2006, September 2006, and January 2007. For every transaction we ask the quantity, price, identity of the trading partner, the relationship, the geographic distance between the two sides of the trade, and which actor (buyer or seller) traveled to make the transaction. We also have less detailed survey data on milk production from a smaller sample of 223 households collected in 2002. Summary statistics are shown in Table 1 and Appendix Table B-1.[3] Our sample contains 168 milk buyers and 50 milk sellers spread across 15 villages. Some analyses, especially of sellers, may thus have relatively low power.[4]

In terms of seasonality, while 80 and 82% of milk producers produce a non-zero amount of

[3]We drop the four milk producers who produce more than 2000 liters per month. All four of those sellers reside in the same village which has many immigrants from Brazil (many of whom are of German descent), all of them speak Portuguese or German as their first language at home, and they sell to a larger milk-buying factory rather than to individual consumers living nearby. Results are similar if we do not drop these producers. None of these four producers purchase milk, so their omission does not affect the results focusing on milk purchases.

[4]The literature on relational contracts has tended to consider the relational contract to be the relevant level of observation, and the number of locations is often quite small. For example, Macchiavello and Morjaria (2015) studies relational contracts of 74 rose exporters clustered in 14 locations across Kenya, while Ghani and Reed (2022) studies relational contracts in three wharves of Sierra Leone, in which five independent ice retailers sell ice to 150 fishing firms.

Table 1: Selected summary statistics

	Mean	SD	Count
Panel A: All households			
Milk producer	0.58	0.49	445
Monthly milk production (L)	210.30	245.73	258
Milk seller	0.11	0.32	445
Monthly milk sales (L)	198.25	337.38	50
Milk buyer	0.38	0.49	445
Monthly milk purchases (L)	19.37	17.79	168
Cheese producer	0.40	0.49	445
Monthly cheese production (kg)	15.17	20.18	179
Cheese seller	0.22	0.41	445
Monthly cheese sales (kg)	17.31	23.34	98
Cheese buyer	0.52	0.50	445
Monthly cheese purchases (kg)	2.35	2.10	232
Panel B: Milk buyers			
Loyal buyer	0.73	0.45	168
Extra milk (L) for 200Gs cheaper	9.04	13.66	168
No 1-5 year-old children in HH	0.55	0.50	168
Buyer within 300m	0.58	0.50	168
Interlinked transaction	0.41	0.49	168
# of risky choices made	1.63	1.64	136

Notes: In panel A, milk producers, sellers, and buyers are households that produced, sold, or bought milk in at least one of May 2006, September 2006, and January 2007. The same is true for cheese producers, cheese sellers, and cheese buyers. Monthly quantities are in liters for milk and kilos for cheese. Quantities are averaged over all trimesters (including trimesters with zero quantity) for all households who have a strictly positive quantity in at least one trimester. Panel B includes the 168 households which purchase milk in at least one trimester. 'Loyal buyer' is an indicator for whether the buyer says she would continue to purchase the same amount from her usual seller if a new seller temporarily offered her milk at a lower price. 'Extra milk (L) for 200Gs cheaper' measures how many extra liters of milk a buyer would buy if her usual seller lowered the price by 200 Gs per liter. 'No 1-5 year-old children in HH' is an indicator for no children who are at least one year old and not older than five living in the household. 'Buyer within 300m' is an indicator for whether the buyer lives within 300 meters of the producer from whom she purchased. 'Interlinked transaction' is an indicator for whether the buyer and seller are linked in the social network. '# of risky choices made' is the number of risky choices made out of four in a hypothetical risk experiment, and excludes individuals who did not pass the test for understanding.

milk in May and January, only 73% of them produce strictly positive amounts in September which is the end of winter in Paraguay. While more than half of the households produce milk in at least one trimester, only 11% of the households (or 19% of milk-producing households) engage in milk sales in at least one trimester. Thus in our sample, 11% of households sell milk, while 58% of households produce milk and so presumably could choose to sell milk under the right circumstances. Conversely, 38% of households purchase milk.

Given what we know about the identities of the two parties, we can characterize the relationship between the producer and consumer. The median distance between the consumer's house and the producer from whom he purchases is 300 meters. This close distance has benefits both in terms of decreasing transportation costs and in terms of ease in sustaining a relational contract (for example due to increased possibilities for sanctioning close neighbors). We consider a consumer to have an interlinked relationship with the producer from which he purchases if they are linked in some other way in the social network.[5] This is true for 41% of milk buyers.

In addition to measures of dairy production and transactions at three points in time in the past year, the survey was designed to measure other important variables. These include the loyalty of milk buyers, the price elasticity of demand of milk buyers, and the risk preferences of all respondents.

To measure the loyalty of milk buyers, we asked: "If a new milk seller came to your house and offered to sell you milk temporarily, just for one week, at a price 200 Gs lower than what you usually pay, would you buy from him?" If the respondent answered yes to this question, the enumerator followed up by asking: "What would you do during that week? i) continue to buy your usual amount of milk at the previous price from your usual seller, ii) buy a lower than usual amount of milk at the previous price from your usual seller, or iii) buy nothing from your usual seller." We consider a consumer to be loyal to his relational contract either if he answers that he would not purchase from the temporary seller, or if he answers that he would purchase from the temporary seller while also continuing to buy the usual amount at the usual price from his usual seller. We see that 73% of milk buyers in our data are loyal. This measure is similar to that in Ghani and Reed (2022) who define loyal buyers as those who would wait to purchase from their usual retailer even if they had another way of getting the product (ice) earlier from a different retailer.

To measure the price elasticity of milk demand, we asked: "If the person from whom you usually buy milk lowered the price by 200 Gs per liter, how many extra liters of milk would you buy in a month?" This entails an approximately 17% decrease in price. More than half (54%) of milk buyers would not increase their milk purchases given this discount.

[5]The two are considered to have a link if the producer: lent to or borrowed money from the buyer, is someone the buyer would go to if he needed money, is someone who would come to the buyer if he needed money, chose the buyer as a godfather, was chosen as a godfather by the buyer, gave to or received money from the buyer for health-related expenses, gave to or received agricultural gifts from the buyer, and lent land to or borrowed land from the buyer.

Conditional on wanting to buy more milk, the average respondent claims they would like to purchase 20 extra liters in a month. This can be compared to milk buyers' current average monthly purchases of 19 liters in all months (or 26 liters conditional on non-zero purchases). This measure of price elasticity of demand conditions on the price the respondent currently pays (and indirectly on the quantity they currently purchase), rather than measuring the quantity demanded at multiple prices. It is an unfortunate oversight that we did not ask the opposite question - how much less they would buy if the price were increased.

We asked all respondents hypothetical questions measuring their risk preferences. The first risk preference question asks the respondents to choose between a sure 50,000 Gs or a 50/50 chance between 40,000 and 100,000 Gs. The questions progress, decreasing the lower number from 40 to 30, to 20, to 10 thousand Gs until the respondent chooses the sure thing.

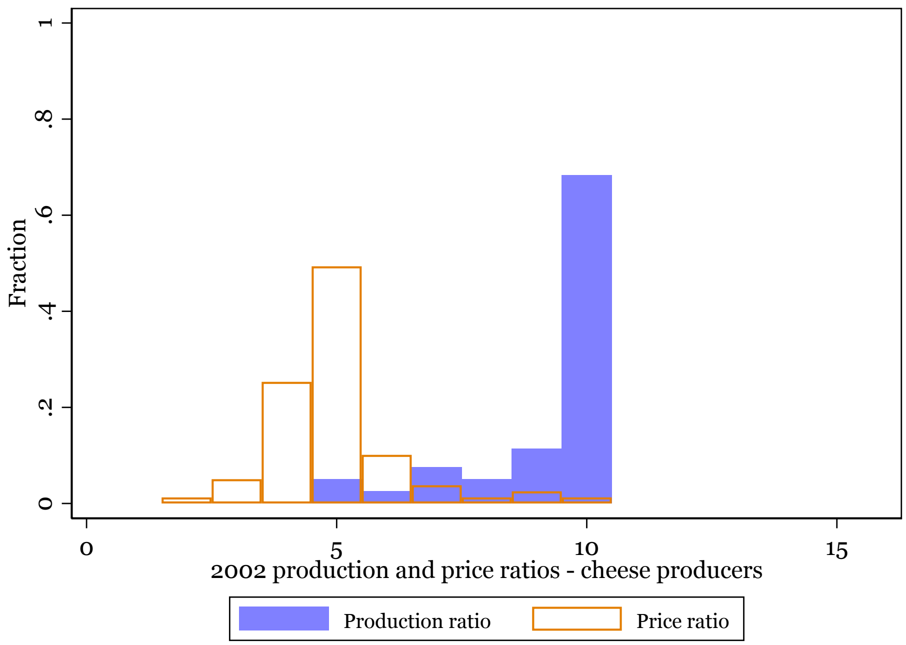
5 Empirical results

In this section, we first show evidence of the milk and cheese pricing puzzle in rural Paraguayan villages - with the price of milk being higher than the equivalent milk price of cheese. Then, we show that the other empirical implications of the model of relational contracts with uncertain supply are supported in the data. On the producer side, we predict that the more stable a producer's milk production is, the more likely he is to engage in a relational contract. On the consumer side, we predict that more inelastic consumers are more likely to engage in relational contracts.

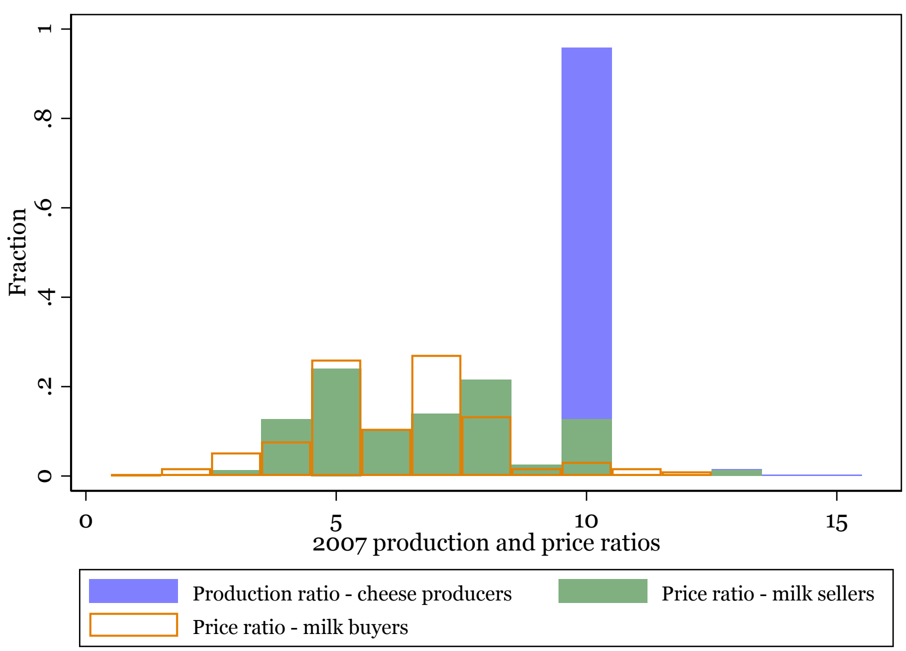
When one of the co-authors of this paper lived in a rural Paraguayan village in the 1990s, she noticed that cheese was surprisingly inexpensive given how much work it was for the producers to make. In a data collection exercise in 2002 surveying farmers in rural villages across the country, it became obvious that this pricing puzzle was a more general phenomenon. Becoming more interested in exploring this puzzle, a section of 2007 data collection was dedicated to milk and cheese markets. Figure 1 shows histograms of the production and price ratios in 2002 and 2007. In 2002, we only have price data from producers, while in 2007 we have price data from both producers and consumers. We see that in 2002 it takes on average 9.1 liters of milk (plus rennet and labor) to make a kilo of cheese, while a kilo of cheese only costs, on average, 5 times the price of a liter of milk. On average, cheese producers convert 1000 Gs worth of milk to 567 Gs worth of cheese. The results in 2007 are quite similar with an average production ratio of 10 liters of milk to make a kilo of cheese, the average price of cheese being 6.2 times the price of milk, and cheese producers converting

Figure 1: Production and price ratios for milk and cheese

(a)



(b)



Notes: Panel a shows how many liters of milk it took to make a kilogram of cheese (the production ratio) and how much a kilogram of cheese costs compared to a liter of milk (the price ratio) in 2002 for all cheese producers. Panel b shows the production ratio for cheese producers in 2007 and the price ratio for milk sellers and milk buyers in 2007.

1000 Gs worth of milk to 632 Gs worth of cheese. Figure 1b does not show any noticeable difference in price ratios for milk sellers compared to milk buyers.[6]

The relational contracts model could explain this price differential between milk sold as milk and milk used for cheese. There are three additional families of testable implications from this model as described in Section 3. First are the more obvious trappings of relational contracts. Consumers should tend to purchase from the same producer year-round, and producers should tend to sell to the same consumers year-round. Consumers and producers should not be willing to leave their usual partner for a temporarily better price. Second are a series of predictions about how the variability of a producer's milk production will affect their sales choices. Finally, consumers with more inelastic milk demand should be more loyal to the partner with whom they have a contract. In this section, we show that these additional implications of the relational contracts model are supported by the data.

5.1 Empirical characteristics of relational contracts

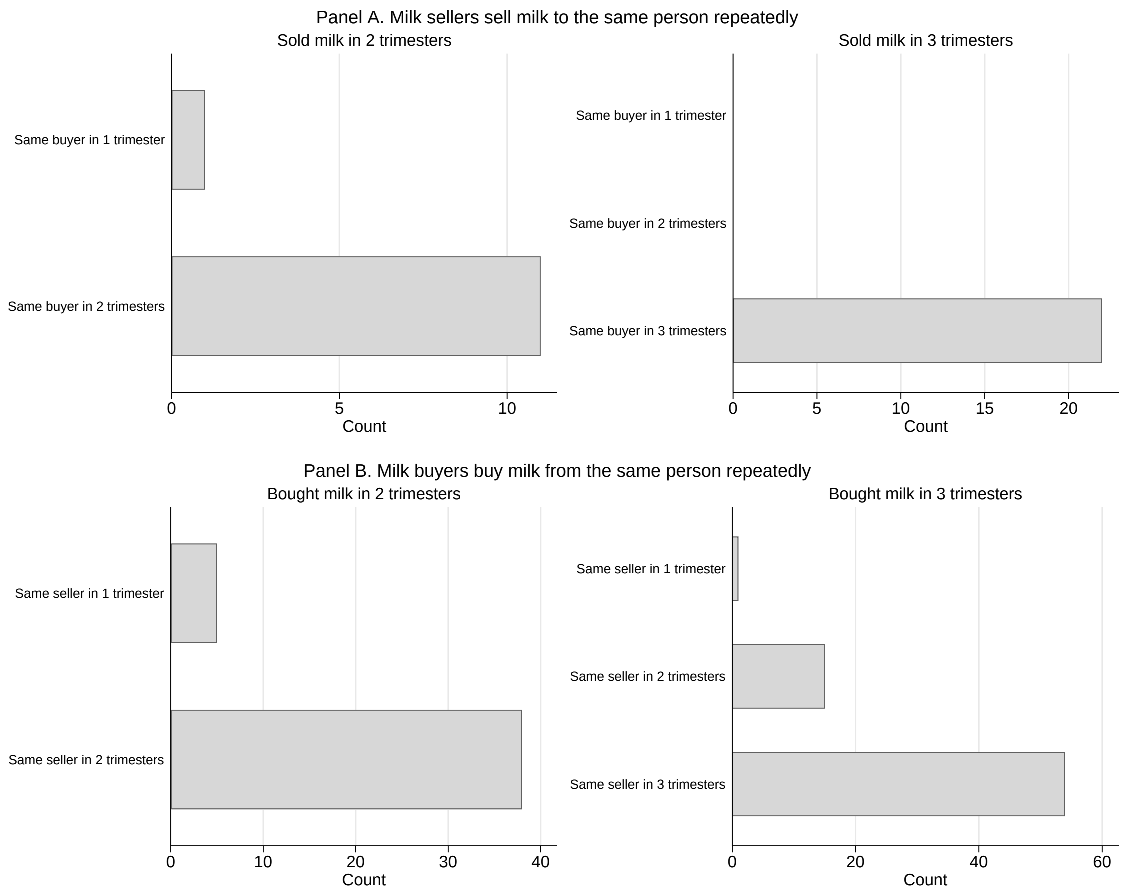
We start by giving direct evidence that milk markets are characterized by relational contracts. Figure 2 shows that all producers who sold milk in all three trimesters sold to the same consumer in all three of those trimesters. Most producers who sold milk in two trimesters sold to the same person in both trimesters. The same patterns hold for those who purchase milk. Trading partners are very stable over time. In conversations prior to the surveying, it became clear that both milk buyers and milk sellers had informal contracts with their partners that they were loathe to break even for a better price, and hypothetical questions in the survey confirm this.

5.2 Relation between who sells dairy products and production variability

Table 2 shows the size and variability of milk production by seller types. There are 258 milk producers (defined as households that produced some milk in any of the three trimesters), and they are classified into the following four mutually exclusive categories: (i) those who never sold milk or cheese in any of the trimesters (Non-seller), (ii) those who sold milk in at least one trimester but never sold cheese (Milk seller), (iii) those who sold both milk and

[6] The price ratio in 2002 shows a large mass at 5, because the modal price of cheese was 5,000 and the modal price of milk was 1,000. Due to inflation, by 2007 the cheese price had a main mode at 10,000 with a secondary mode at 8,000 and the milk price had a main mode at 1,500 with secondary modes at 1,000 and 2,000.

Figure 2: Repeated milk transactions



Notes: This figure shows milk sellers and milk buyers who sell or buy milk in at least two of May 2006, September 2006, and January 2007. Panel A shows the number of sellers who sell to a different buyer each trimester ('same buyer in 1 trimester') or to the same buyer in two or all three of the trimesters. Panel B shows the same but for milk buyers.

cheese in at least one trimester (Milk and cheese seller),[7] and (iv) those who sold cheese in at least one trimester but never sold milk (Cheese seller).

We see that, compared to individuals who produce milk but do not sell it (in column (1)), milk sellers (in columns (2) and (3)) own significantly more cows, produce significantly more milk, and produce that milk with a lower coefficient of variation. Producers with more cows may have smoother production because if different cows are at different stages, then when one cow's production starts to wane, another cow's production may increase.

Table 2: Milk production and sales decisions

	(1) Non-seller mean/sd	(2) Milk seller mean/sd	(3) Milk and cheese seller mean/sd	(4) Cheese seller mean/sd
Mean milk prod.	96.75	384.60	343.17	307.04
	(64.03)	(410.24)	(330.82)	(244.04)
SD milk prod.	62.65	111.04	183.88	125.29
	(49.91)	(102.49)	(129.30)	(101.32)
CV milk prod.	0.90	0.42	0.75	0.56
	(0.64)	(0.38)	(0.56)	(0.44)
Minimum milk prod.	43.05	284.48	191.43	189.53
	(68.00)	(370.44)	(278.45)	(224.51)
Trimesters with any milk prod	2.08	2.79	2.43	2.65
	(0.81)	(0.49)	(0.81)	(0.60)
Number of cattle owned	8.06	15.24	14.43	17.20
	(11.40)	(19.41)	(17.53)	(22.10)
Number of cows owned	3.26	6.07	6.57	7.32
	(5.15)	(9.55)	(8.40)	(10.99)
Observations	133	29	21	75

Notes: All producers in this table produce milk. They may additionally produce cheese. They are divided into columns based on their sales behavior. Observations in column (1) produce but never sell dairy products, in column (2) only ever sell milk, in column (3) sell both milk and cheese, and in column (4) only ever sell cheese. Retrospective data was collected about May 2006, September 2006, and January 2007. The mean, standard deviation (SD), and coefficient of variation (CV) of monthly milk production is taken over the three trimesters. Minimum monthly milk production is production in the trimester they produced the least. All include zeros for trimesters in which no milk was produced. Trimesters (out of 3) with any milk production is the number of trimesters in which they have strictly positive production. Cattle includes bulls, oxen, cows, heifers, and calves. Cows are female cattle which can be used for dairy production because they have had at least one calf.

Next, we compare those who sell only milk in column (2) with those who sell cheese in at least one trimester (in columns (3) and (4)). We predicted that producers who sell milk but not cheese have less variable production compared to those who ever sell cheese. Milk sales quantities are relatively constant over time in the relational contract. Only variable production can make it worth spending the time and effort to make cheese to then sell at a relatively lower price. This is supported by the data. For example, mean milk production is only 35% higher ((385-285)/285) than minimum milk production (production in the trimester with the lowest production) for those who sell only milk as seen in column (2). In contrast,

[7] They can sell milk and cheese in different trimesters: for example, they might sell milk only in May and cheese only in September.

the mean is 80% higher than the minimum for those who sell both milk and cheese in column (3), and 62% higher for those who only sell cheese in column (4). The coefficient of variation (CV, or the standard deviation divided by the mean) of milk production for those who sell only milk shown in column (2) is significantly lower than the CV for those who ever sell cheese in columns (3) and (4) with a p-value of 0.059.[8]

Third, milk production of producers who sell year-round is predicted to be more stable than the production of those who sell in fewer months of the year because producers with less stable production will not find relational contracts. This is borne out by the results in Table 3. In column (1), we regress the number of trimesters in which a milk producer sells milk on the CV of their milk production. The CV of milk production is significantly negatively correlated with the number of trimesters selling milk. This effect might mechanically be due to the fact that producers who do not produce milk in a specific trimester can thus not sell any milk in that trimester. So, in column (2) we add an additional control for the number of trimesters in which the producer produces milk. The number of trimesters producing milk is not a significant predictor of the number of trimesters selling milk after controlling for the CV of milk production. As the relational contract model suggests, the variability in milk production is the important determinant of selling milk. In column (2), a one standard deviation (0.42) increase in the CV of milk production among the producers in the regression leads to a 0.56 decrease in the number of trimesters selling milk. Columns (3) and (4) instead use an indicator for selling milk in all three trimester as the outcome variable. As predicted, more stable milk producers are more likely to always sell milk.

[8] Comparing milk sellers to milk and cheese sellers in column (3) the p-value is 0.016, and comparing the milk sellers to those who only sell cheese in column (4) the p-value is 0.133.

Table 3: Relationship between milk production CV and # trimesters milk sold

	# trimesters selling milk		Sold milk in all months	
	(1)	(2)	(3)	(4)
CV of milk production	-1.480***	-1.346**	-1.013***	-0.904**
	(0.336)	(0.548)	(0.225)	(0.377)
Trimesters with any milk prod		0.117		0.0944
		(0.425)		(0.272)
Observations	42	42	42	42
Outcome mean	2.26	2.26	0.52	0.52
Controls	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes

Notes: Sample includes households that produced milk in at least two out of three trimesters and sold milk in at least one out of three trimesters. The coefficient of variation (CV) of milk production is taken over the three trimesters including trimesters when no milk was produced. # of trimesters producing milk is the number of trimesters out of three in which the household produced milk. Additional control variables include log of wealth, age and schooling years of the household head, maximum schooling years of the household members, and household size. Heteroskedasticity-robust standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.3 Loyalty, elasticity, and variability of purchases

The model suggests that more price inelastic consumers will be more loyal and we investigate that prediction with the following regression:

$$L_{iv} = E_{iv}\gamma + X_{iv}'\beta + \nu_v + \epsilon_{iv}. \tag{1}$$

The variable L_{iv} is an indicator for consumer i in village v being loyal, E_{iv} are proxies for the elasticity of milk demand, and X_{iv} is a vector of other control variables. Controls include log of wealth, the age of the household head, the years of schooling of the household head, the maximum years of schooling of any household member, and family size. Finally, ν_v is a village fixed effect and ϵ_{iv} is an error term.

As discussed in Section 4, we asked customers whether they would decrease milk purchases from their current supplier if a new supplier offered to bring them milk at a price that was 200 Gs per liter lower than what they usually pay, just for one week. Loyal customers are those who claim they would continue to buy the usual amount at the usual price from the usual seller.

Our main proxy for price elasticity is the number of extra liters a consumer claims they would buy in a month if the person from whom they usually purchase milk were to lower the price by 200 Gs per liter. We also explore other variables which we expect might be proxies for elasticity. This includes an indicator for the household not having any children between 1 and 5 years old, who are more likely to drink cow's milk on a daily basis. It also includes the number of risky choices made in the hypothetical risk game, since we expect those who make more risky choices to place less value on stability and be less loyal. We also explore the geographic distance between the buyer and seller as a measure of their ease in imposing sanctions on one another. In Section 6.6, we discuss the coefficient on the interlinked transaction variable and discuss why we find the alternative explanation of the pricing patterns as being due to interlinked transactions to be less plausible.

One might worry that price elasticity is endogenous to the choice of being in a relational contract, for example because the price is endogenous and affects the elasticity of demand. Not having any children between 1 and 5 years old is a proxy for elasticity of demand which has the advantage of not suffering from this potential endogeneity issues. The explicit survey-based price elasticity measure unfortunately comes from the answer to a question, how much more they would buy at a price that was 200 Gs lower, which conditions on the price the respondent currently pays. Under the assumption of linear demand, the phrasing of the question would not be a problem. The model in Appendix A shows that the prediction that less elastic consumers are more likely to have relational contracts holds with linear milk demand. But, if demand were not linear, this survey-based measure of elasticity would potentially be endogenous to being in a relational contract. Theory predicts that individuals in relational contracts will pay higher prices for milk on average. As price increases, elasticity also tends to increase, meaning that loyal buyers in relational contracts will pay higher prices which will increase their elasticity. This is the opposite of our theoretical hypothesis that less elastic consumers are more likely to be in relational contracts. Thus, we believe that any potential endogeneity of elasticity would cause our results to be conservative under-estimates of the true effect.

Table 4 shows the relationship between elasticity and loyalty. Column (1) shows that more price inelastic consumers are also more loyal. A one standard deviation (13.66 liter) increase in the consumer's elasticity, as measured by the number of extra liters they would want to buy at a lower price, is associated with a 10 percentage point decrease in loyalty. The coefficient on the indicator for the household not having a child aged 1-5 suggests that households without children in that age range are less loyal, potentially because those with young children place greater value on having a stable milk supply for child nutrition.

Table 4: Relationship between loyalty and elasticity

	(1) Loyal buyer	(2) Loyal buyer	(3) Loyal buyer	(4) Loyal buyer	(5) Loyal buyer	(6) Loyal buyer	(7) Loyal buyer
Extra milk (L) for 200Gs cheaper	-0.00754***					-0.00738***	-0.00657***
	(0.00241)					(0.00264)	(0.00246)
No 1-5 year-old children		-0.163*				-0.132	-0.0991
		(0.0902)				(0.104)	(0.0855)
Buyer within 300m			0.177**			0.163*	0.162**
			(0.0747)			(0.0833)	(0.0727)
Interlinked transaction				0.0978		0.0314	0.0335
				(0.0717)		(0.0883)	(0.0710)
# of risky choices made					-0.0142	-0.0129	
					(0.0241)	(0.0235)	
Observations	168	168	168	168	136	136	168
Outcome mean	0.73	0.73	0.73	0.73	0.70	0.70	0.73
RHS variable mean	9.04	0.55	0.58	0.41	1.63		
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Sample includes households who bought milk in at least one trimester. 'Loyal buyer' is an indicator for whether the buyer says she would continue to purchase the same amount from her usual seller if a new seller temporarily offered her milk at a lower price. 'Extra milk (L) for 200Gs cheaper' measures how many extra liters of milk a buyer would buy if her usual seller lowered the price by 200 Gs per liter. 'No 1-5 year-old children in HH' is an indicator for no children who are at least one year old and not older than five living in the household. 'Buyer within 300m' is an indicator for whether the buyer lives within 300 meters of the producer from whom she purchased. 'Interlinked transaction' is an indicator for whether the buyer and seller are linked in the social network. '# of risky choices made' is the number of risky choices made out of four in a hypothetical risk experiment, and excludes individuals who did not pass the test for understanding. Additional control variables include: log of wealth, age and years of schooling of household head, maximum years of schooling of household members, and household size. Heteroskedasticity-robust standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Consumers who purchase from a producer living no more than 300 meters away are more loyal in accord with findings in Ghani and Reed (2022), potentially because enforcement is easier at shorter distances. There is no significant correlation between risk aversion and loyalty.

6 Alternative Explanations

Section 5 presented evidence consistent with our hypothesis that the milk and cheese pricing puzzle is explained by relational contracts which allow inelastic consumers to avoid instability in milk consumption. While that framework is consistent with the data, other mechanisms might also explain the pricing puzzle. For example, there may be relational contracts for milk, but the rationale for these contracts could be concern over milk quality rather than concern over stability in quantity. Or, milk sellers could be colluding to keep the price high. Or perhaps markets in rural Paraguayan villages do not function more generally, and arbitrage opportunities exist for all integrated products. Or, perhaps cheese has a lower price because it is cheaper to transport and easier to store for extended periods of time compared with milk. Additional possibilities include altruistic cheese sellers, interlinked transactions, entry barriers to the fluid milk market, and the existence of other valuable by-products from cheese production. In this section, we discuss each of these possibilities in turn.

6.1 Relational contract for milk quality

Milk can be watered-down by milk producers, which results in low-quality milk. Relational contracts may be in place, but may be meant to insure milk quality rather than quantity. Since milk quality is not recorded in our data-set, it is difficult to disprove this possibility directly. However, we consider this possibility as unlikely for three reasons.

First, milk is sold raw and is boiled by the purchaser. According to rural Paraguayans, watered-down milk can often be distinguished from pure milk because it boils and bubbles differently. Buyers who found themselves deceived would spread the word and would not purchase again from the unscrupulous seller. Thus, milk sellers have an incentive to provide unadulterated milk, decreasing the need for relational contracts for good quality milk. This assumes that consumers can actually detect adulterated milk. Rustagi and Kroell (2022) present evidence that Indian consumers are overly confident about their ability to detect adulterated milk and overly optimistic about the quality of milk they purchase. Still, in the presence of over-confidence there is no need to contract on milk quality.

Second, recall that 73% of buyers would not stop buying from their usual provider if *temporarily* (for one week) offered a 200 Gs lower price by another seller. We compare this with the lower share of 44% of buyers who said they would not stop buying from their usual provider if *permanently* offered a 200 Gs lower price if they had to travel one kilometer to get the milk. This second question unfortunately mixes travel costs with willingness to switch from one permanent provider to another. Still, the fact that so many more customers are willing to leave their usual provider for a permanently better deal (even with increased travel costs), but are not willing to do so for a temporarily better deal suggests that stable quantities of milk are more important to consumers than the identity of the partner and their trust in that partner's milk quality.

Finally, if reputation as a good-quality milk provider were necessary to sell milk, we might expect that more trustworthy milk producers would be more likely to become milk sellers. Thus, we investigate the relationship between being a milk seller and trustworthiness. Trustworthiness is measured by the share returned as a trustee in an incentivized trust game played in 2002 and then is standardized to have mean 0 and standard deviation 1 (for more detail, see Schechter (2007)). Since not all households in the 2007 survey played the trust

Table 5: Selling dairy products and social preferences

	Sold milk		Sold cheese	
	(1)	(2)	(3)	(4)
Trustworthiness (standardized)	-0.0232		0.0214	
	(0.0402)		(0.0455)	
Altruism (standardized)		0.0120		-0.0529
		(0.0309)		(0.0396)
Observations	110	210	110	210
Outcome mean	0.37	0.39	0.37	0.39
Controls	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes

Notes: The sample in columns (1) and (3) is all milk producers who have a measure of trustworthiness from 2002, and in columns (2) and (4) is all milk producers who have a measure of altruism from 2007. The dependent variables are an indicator for selling milk in at least one trimester in columns (1) and (2), and an indicator for selling cheese in at least one trimester in columns (3) and (4). Trustworthiness is the share returned as a trustee in a trust game in 2002, standardized to have mean 0 and standard deviation 1. Altruism is the amount transferred in a dictator game in 2007, standardized to have mean 0 and standard deviation 1. Additional control variables include: log of wealth, age and years of schooling of household head, maximum years of schooling of household members, and household size. Heteroskedasticity-robust standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

game in 2002, the sample size in those regressions is smaller. We run the following regression:

$$M_{iv} = T_{iv}\alpha + X_{iv}'\beta + \nu_v + \epsilon_{iv}$$

where M_{iv} is an indicator for being a milk seller, and T_{iv} is the standardized measure of trustworthiness. The results are shown in columns (1) and (3) of Table 5. The coefficient on standardized trustworthiness is small, of the wrong sign, and not statistically significantly different from zero. With the caveat that our regression results may be under-powered due to the smaller sample size, the results suggest that being trustworthy is not an important determinant of whether a milk producer becomes a milk seller.

6.2 Collusive milk sellers

An alternative explanation that does not involve relational contracts between buyers and sellers is the possibility that milk producers are colluding, either explicitly or tacitly, to keep the price of milk artificially high. Producers might do this because milk has relatively inelastic demand compared to cheese, and the small number of households selling milk might make this collusion possible. Limiting the supply of fluid milk by turning some of it into cheese could be a strategy to maximize milk prices and therefore profit.

Table 6: Variation across producers and time in cheese and milk prices

	Milk	Cheese
Within-trimester CV	0.299	0.172
Within-village-trimester CV	0.201	0.122
Within-producer CV	0.013	0.058
Producers w/ changing price	0.088	0.394

Note: Entries are average coefficients of variation (CV) for milk and cheese prices. For the within-trimester CV, we calculate the CV for each trimester and average over the three trimesters. For the within-village-trimester CV, we calculate the CV for each village and trimester, and average over all village-trimesters. For the within-producer CV, we calculate the CV for each producer and average over producers. The final row shows the share of producers who do not charge the same price in all trimesters. The last two rows are both conditional on the producer selling in at least two trimesters.

Patterns of variation in milk and cheese prices suggests that cheese markets are more competitive than milk markets. This could be caused by relational contracts, but it could also be caused by collusion in milk markets. Within-producer price variation is lower for milk than for cheese. In contrast, within-village-trimester price variation (the variation across different milk sellers) is higher for milk than for cheese. This suggests that milk prices are stickier (over time) than cheese prices, and that milk prices have more price dispersion (over space) than cheese prices. Both facts suggest that milk markets are less competitive than cheese markets.

Specific numbers can be found in Table 6. The average within-trimester coefficient of variation (CV) for prices in the whole sample is 74% greater for milk than for cheese, and the average within-village-trimester CV is 65% greater for milk than for cheese. Things appear quite different when looking instead at variation across producers for two reasons. First, within-producer variation is significantly lower than within-trimester variation. Second, within-producer variation in milk prices is lower than within-producer variation in cheese prices. Producers of both products tend to sell them at the same price in all trimesters, but this is more common for milk than cheese. In fact, while 91% of milk producers charge the same price in each trimester, only 61% of cheese producers charge the same price in each trimester. The within-producer CV is 78% smaller for milk than for cheese.

It is difficult to definitively rule out collusion because there is no single model of how collusion takes place. Bernasconi et al. (2023) highlight the difficulty of identifying collusive behavior more generally. Many models of collusion involve a uniform price due to the ease in monitoring. The fact that milk prices vary so much across producers rules out collusion which involves coordinating on a single price.

A more subtle form of collusion could involve producers agreeing not to compete with one another, limiting search for buyers. Prices would vary across buyers, and producers would extract all rents from buyers. If producers extracted all the rent, then buyers would be pushed to pay their reservation price. The fact that we see that 73% of consumers claim they would not stop buying from their usual provider if another seller temporarily offered them milk that was 200 Gs (approximately 17%) cheaper suggests that consumers are getting surplus from the transaction and that producers are not colluding. In addition, remember that 58% of households produce milk, while only 11% of households sell milk. If milk sellers were colluding to keep the price of milk artificially high, then some milk producers who weren't selling their production could find it advantageous to do so, and consumer households would be willing to purchase from those new sellers entering the market. The fact that there are so many milk producers who don't sell their production is informative. Overall, we find it unlikely that milk sellers are colluding to keep fluid milk quantities artificially low and milk prices artificially high.

6.3 Easier storage and lower transportation costs of cheese

One obvious difference between milk and cheese is the fact that cheese is easier to transport and can be stored for longer periods of time. Milk is liquid and bulky, implying that the transportation cost of milk is higher than that of cheese. If the transportation costs were borne by milk sellers, then fluid milk prices would be higher than the marginal cost of production even in the absence of relational contracts. But, in fact, it is almost always the buyer, not the seller, who pays the transportation cost. We see 89% of milk buyers and 76% of milk sellers report that the buyer goes to the seller's residence to pick up the milk they purchase. Thus transportation costs can not explain the relatively high price of milk.

Milk is also quite perishable, while cheese has a longer shelf-life. Cheese production can be a way for a farmer to avoid selling milk at a low price or wasting it if he doesn't have any sales opportunities and can not preserve the milk safely for longer periods of time. Still, there should be an arbitrage criterion such that storage will occur until the price differential is eliminated (Hennessy and Roosen, 2003). The fact that the price differential is not eliminated suggests that storage can not be the explanation for the pricing puzzle.

In addition, because this cheese is generally sold to local consumers, and because villagers have issues with refrigeration, cheese is not stored for long periods of time. We asked respondents the longest period of time they had kept milk and cheese before using or selling it in the past year. Cheese does keep longer than milk, with 99% of households consuming or selling milk within a week, and 48% of households consuming or selling cheese within a week. That said, we do not find evidence that Paraguayans store cheese across seasons. The median of the longest number of days a household stores dairy products are 1 for milk and 8 for cheese. Even the 75th percentile figures are only 2 and 8 days, respectively. While this confirms that cheese is easier to store than milk, the possibility of storing cheese for one week rather than storing milk for one day is unlikely to explain the price puzzle.

6.4 Malfunctioning markets

Another possibility to explain the relatively low price of cheese could be that market mechanisms do not work in Paraguayan villages more generally. Information frictions, travel costs, and labor market imperfections may be so extreme as to render the law of one price irrelevant. To test this hypothesis, we look at another pair of integrated products: yuca and yuca starch. Yuca (also known as cassava or manioc) is a root and is the staple of Paraguayan eating. No meal is complete without yuca, and 91% of households in our data grow it. Yuca starch (also known as tapioca) is extracted from the yuca root.

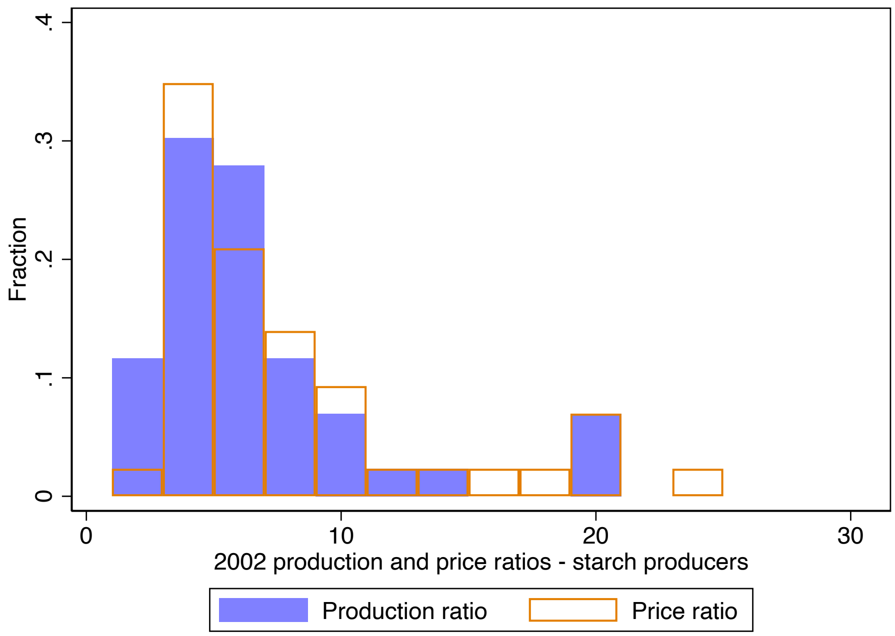
Figure 3 shows histograms of the production and price ratios of yuca and yuca starch in 2002 and 2007. According to the 2002 survey, 6.6 kilos of yuca yield approximately one kilo of tapioca starch. In that period, the price of a kilo of tapioca starch was 7.9 times higher than the price of a kilo of yuca.[9] The respective numbers in 2007 are a production ratio of 7.6 and price ratio of 8.9. On average, starch producers convert 1,000 Gs worth of yuca to 1,840 Gs worth of starch in 2002 (or 1,752 Gs worth in 2007). Considering the significant labor costs needed to make a kilogram of yuca starch, the costs of labor appear to be reasonably incorporated.[10] This gives evidence that prices in Paraguayan villages do equalize for other integrated goods. There must be something special about milk and cheese.

[9]These numbers exclude a few outliers in a village in which many households sell yuca at a significantly lower price to a large factory. If we were to include those observations, the price of a kilo of tapioca starch would be 14.9 times higher than the price of a kilo of yuca. The histograms including the outliers can be found in Appendix Figure B-1.

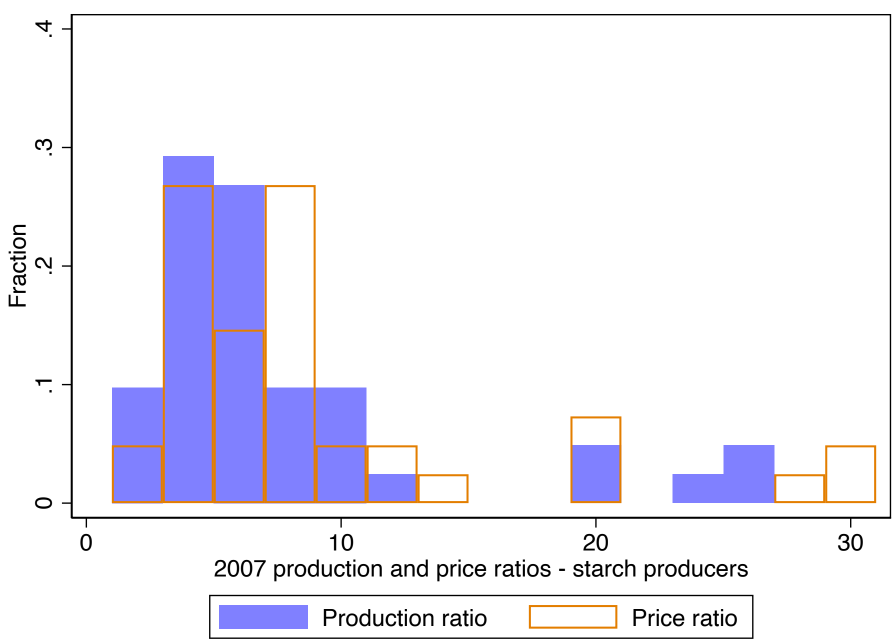
[10]The process of making tapioca starch involves peeling, grating, and washing - all of which are usually done manually.

Figure 3: Production and price ratios for yuca and starch

(a)



(b)



Notes: Panel a shows how many kilos of yuca it took to make a kilo of starch (the production ratio) and how much a kilo of starch costs compared to a kilo of yuca (the price ratio) in 2002 for all households that produced starch. Panel b shows the same ratios for 2007. These figures exclude outliers with ratios over 30. See Appendix Figure B-1 for the histogram including the outliers.

6.5 Altruistic cheese sellers

Prices for cheese might be low if altruistic milk producers make cheese and sell it to poor households at a lower price. Cheese could be seen as an effective transfer from the rich to the poor. However, it would be unusual for altruism to be shown only in cheese markets, not in other markets. And, it would be much less work for an altruistic dairy producer to sell milk at lower prices rather than spending the extra effort to turn it into cheese. If this explanation were true, we would expect cheese sellers to be more altruistic than other milk producers. To investigate this possibility, we measure altruism as the amount transferred out of 14 thousand Gs in an incentivized dictator game (for details, see Ligon and Schechter (2012)). We then standardize altruism to have mean 0 and standard deviation 1 for ease in interpreting the magnitudes of the coefficients. The results are shown in columns (2) and (4) of Table 5. We find no correlation between altruism and selling cheese and conclude that it is unlikely that altruistic behaviors explain the pricing puzzle.

6.6 Interlinked transactions

Given that dairy transactions often take place between individuals who live close geographically, it may be the case that dairy transactions are interlinked with other financial transactions (Bardhan, 1980). For example, as a result of selling cheese at a low price, cheese sellers may benefit in other ways such as being able to borrow money or receive gifts. Or it may be that milk sellers obligate consumers to buy milk from them at a high price, in exchange for being willing to lend the consumer money when needed.

We test whether consumers who have interlinked transactions with the producer are more likely to be loyal in column (4) of Table 4. There is a positive but insignificant correlation between having an interlinked transaction and being a loyal buyer. In columns (6) and (7), we additionally concurrently control for the geographic distance between the buyer and seller being under 300 meters. The coefficient on the geographic distance indicator barely changes, while the coefficient on having an interlinked transaction gets smaller. This suggests that households that live close to one another are more likely to be interlinked, and the coefficient on interlinkages may have been large due to omitted variable bias. In results not shown here, we control for each relationship type within interlinkages (co-godparenting relationships, borrowing and lending relationships, gift exchange relationships, and land transaction relationships) separately one at a time while also controlling for the geographic distance indicator. Only the coefficient on land transaction relationships (which are quite rare, at only 1% of buyer-seller pairs) is a statistically significant predictor of being a loyal buyer. The other relationships do not have statistically significant coefficients, though some are relatively large economically.[11] It appears that the relatively low price of liquid milk is unlikely to be fully due to benefits provided by other interlinked transactions, though we can not rule out some influence of interlinked transactions and the reciprocity that go along with them.

6.7 Entry barriers to selling milk

Barriers to entry to sell in fluid milk markets would increase the market power of fluid milk sellers, allowing them to raise milk prices without relational contracts. Such barriers for milk producers seem unlikely, since it would imply barriers that are higher for milk compared to cheese producers. Conditional on having a cow and producing milk, producers do not require a large initial investment to sell fluid milk; at most they need some empty bottles.

6.8 By-products from cheese production

In the process of making cheese, milk is separated into curds and whey. While only the curds are further processed to make cheese, whey is also nutritious and is used in cooking and to feed pigs. If whey were an important by-product of cheese production, the high value of whey could compensate for the lower price of cheese. Although Paraguayans do make use of whey, it is not a highly valued product. Our survey asked about by-products of animal production and not a single respondent ever mentioned whey. Whey is not a commodity that is ever sold. Therefore, we do not believe that whey can explain the price puzzle.

Ultimately, we have discussed eight interesting factors which potentially contribute to the milk-cheese price puzzle. We believe that relational contracts for stable milk supply can explain the puzzle, but we can not rule out that some of these alternative explanations are additionally at play.

[11]For example, the coefficient on borrowing and lending relationships is 0.11 with a standard deviation of 0.08.

7 Conclusion

Individuals living in rural areas commonly purchase locally-produced consumption goods directly from the producer. In the case of rural Paraguayan dairy markets, a liter of fluid milk costs 58% more than the same amount of milk would cost after being converted to cheese. Given that converting milk to cheese is labor-intensive, this price differential is puzzling.

We propose relational contracts as an explanation for this differential. Individual producers have milk production levels which vary across the year, while consumers with inelastic demand prefer to purchase the same amount year round. In order to ensure access to a stable supply of milk, they pay a price premium. Using new empirical survey-based measures of elasticity and loyalty, we find that consumers with more price inelastic demand for fluid milk are more loyal to their usual trading partner.

Other explanations such as relational contracts for milk quality, collusion between milk sellers, the relative ease of transporting and storing cheese compared to milk, and more general market imperfections do not seem to fit the data as well. We do not deny the possibility that there are multiple coexisting factors that could rationalize the price puzzle; we simply argue that relational contracts for stable milk supply is a plausible mechanism consistent with the evidence provided.

References

Anagol, S., Etang, A., and Karlan, D. (2017). Continued existence of cows disproves central tenets of capitalism? *Economic Development and Cultural Change*, 65(4):583–618.

Antić, N., Morjaria, A., and Talamas Marcos, M. A. (2024). Task clarity and credibility in relational contracts. Unpublished Manuscript.

Attanasio, O. and Augsburg, B. (2018). Holy cows or cash cows? The economic return to livestock in rural India. *Economic Development and Cultural Change*, 66(2):307–330.

Bailey, K. (2001). *Marketing and Pricing of Milk and Dairy Products in the United States.* Wiley-Blackwell, New Jersey.

Bardhan, P. K. (1980). Interlocking factor markets and agrarian development: A review of issues. *Oxford Economic Papers*, 32(1):82–98.

Bernard, T., Hidrobo, M., Le Port, A., and Rawat, R. (2018). Nutrition-based incentives in dairy contract farming in northern Senegal. *American Journal of Agricultural Economics*, 101(2):404–435.

Bernasconi, M., Espinosa, M., Macchiavello, R., and Suarez, C. (2023). Relational collusion in the Colombian electricity market. Unpublished Manuscript.

Blackmore, E., Guarín, A., Alonso, S., Grace, D., and Vorley, B. (2020). *Informal milk markets in Kenya, Tanzania and Assam (India): An overview of their status, policy context and opportunities for policy innovation to improve health and safety.* CGIAR Research Program on Agriculture for Nutrition and Health. ILRI Research Report Nr 62.

Blayney, D. and Manchester, A. (2001). *Milk Pricing in the United States.* Number 761 in Agriculture Information Bulletin. United States Department of Agriculture.

Cajal-Grossi, J., Macchiavello, R., and Noguera, G. (2023). Buyers' sourcing strategies and suppliers' markups in Bangladeshi garments. *Quarterly Journal of Economics*, 138(4):2391–2450.

Casaburi, L. and Macchiavello, R. (2019). Demand and supply of infrequent payments as a commitment device: Evidence from Kenya. *American Economic Review*, 109(2):523–555.

Cox, T. L. and Chavas, J.-P. (2001). An interregional analysis of price discrimination and domestic policy reform in the U.S. dairy sector. *American Journal of Agricultural Economics*, 83(1):89–106.

Ferreira, N., Cattoni, C. J., Cáceres, S. C., and Frutos, J. (2007). An economic opportunity survey of small dairy farms in Paraguay. *Tropical Animal Health and Production*, 39:603–610.

Filmer, D., Friedman, J., Kandpal, E., and Onishi, J. (2023). Cash transfers, food prices, and nutrition impacts on ineligible children. *Review of Economics and Statistics*, 105(2):327–343.

Ghani, T. and Reed, T. (2022). Relationships on the rocks: Contract evolution in a market for ice. *American Economic Journal: Microeconomics*, 14(1):330–365.

Headey, D., Hirvonen, K., and Hoddinott, J. (2018). Animal sourced foods and child stunting. *American Journal of Agricultural Economics*, 100:1302–1319.

Hennessy, D. A. and Roosen, J. (2003). A cost-based model of seasonal production with application to milk policy. *Journal of Agricultural Economics*, 54:285–312.

Hoddinott, J., Headey, D., and Dereje, M. (2015). Cows, missing milk markets, and nutrition in rural Ethiopia. *Journal of Development Studies*, 51(8):958–975.

Ligon, E. and Schechter, L. (2012). Motives for sharing in social networks. *Journal of Development Economics*, 99(1):13–26.

Lininger, F. F. (1929). Seasonal adjustments of production and consumption in fluid milk areas. *Journal of Farm Economics*, 11(1):152–163.

Macchiavello, R. (2022). Relational contracts and development. *Annual Review of Economics*, 14:337–362.

Macchiavello, R. and Miquel-Florensa, J. (2018). Vertical integration and inter-firm relationships: Evidence from the Costa Rica coffee chain. *Unpublished working paper*.

Macchiavello, R. and Miquel-Florensa, J. (2019). Buyer-driven upgrading in GVCs: The sustainable quality program in Colombia. *Unpublished working paper*.

Macchiavello, R. and Morjaria, A. (2015). The value of relationships: Evidence from a supply shock to Kenyan rose exports. *American Economic Review*, 105(9):2911–2945.

Manchester, A., Weimar, M., and Fallert, R. (1994). *The U.S. Dairy Pricing System*. Number 695 in Agriculture Information Bulletin. United States Department of Agriculture.

Rustagi, D. and Kroell, M. (2022). Measuring honesty and explaining adulteration in naturally occurring markets. *Journal of Development Economics*, 156.

Schechter, L. (2007). Theft, gift-giving, and trustworthiness: Honesty is its own reward in rural Paraguay. *American Economic Review*, 97(5):1560–1582.

Song, Y. and Ma, M. (2023). Relational contracts in well-functioning markets: Evidence from China's vegetable wholesale market. Unpublished Manuscript.

Weisbuch, G., Kirman, A., and Herreiner, D. (2000). Market organisation and trading relationships. *Economic Journal*, 110(463):411–436.

A Model of relational contracts

Assume milk consumers and producers play a multi-period infinitely repeated game. There are two seasons: a high production season and a low production season. Each is realized with 50% probability. Denote milk production in the high season as $y_h = y + \nu$ and in the low season as $y_l = y - \nu$, where a positive constant ν is the deviation from mean production y. Production costs are the same in the two seasons. Let $\delta < 1$ be the common discount factor of both consumers and producers.

On the consumer side, we denote the consumer's Hicksian demand for milk by a linear willingness-to-pay function: $p(y) = (\beta_0 - y)\beta_1$, where p is the price the consumer is willing to pay for y units of milk; $\beta_1 > 0$ is the slope of the demand curve and is proportional to the consumer's demand elasticity for milk, and $\beta_0\beta_1 > 0$ is the lowest price at which a consumer would demand no fluid milk (the choke price). Consumers with more elastic demand have smaller β_1 (meaning they are more responsive to price). Consumers choose between establishing a relational contract with a producer and buying milk in the spot market. We assume that reneging on the relational contract results in the termination of the relationship and the producer and consumer will trade on the spot market forever after. Finally, consumers pay an additional per-period cost, κ, for transactions on the spot market, which captures the cost of searching for new sellers and negotiating prices and quantities.[12]

A.1 Spot market prices

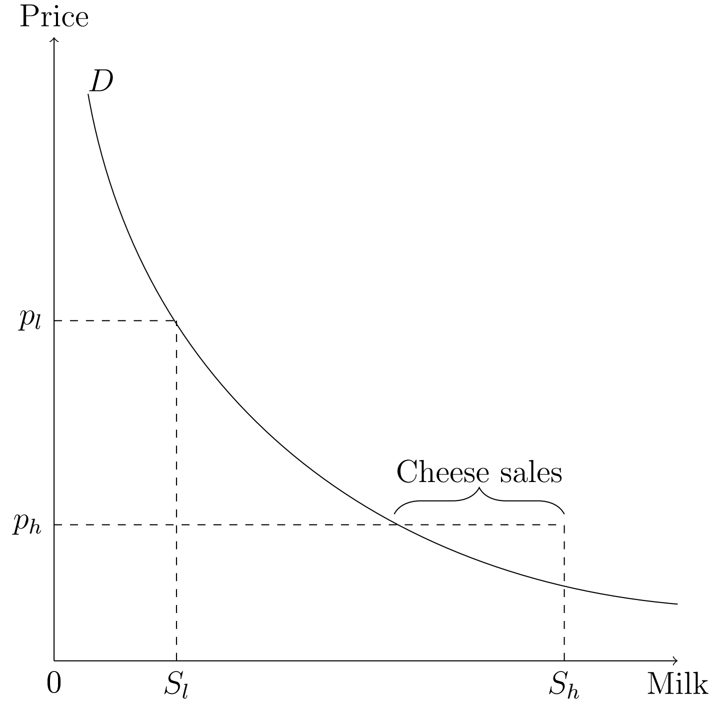
We assume that spot market milk prices are determined by aggregate demand and supply and that individuals do not account for their decision's effects on those aggregates. In other words, we consider a partial equilibrium model. Aggregate demand in the spot market is the sum of milk demanded by all consumers who do not have relational contracts. Aggregate supply is the sum of milk produced minus the amount of milk sold through relational contracts. Denote aggregate demand as D and low- and high-season aggregate supply as S_l and S_h respectively. Milk producers also have the option to use their milk production to produce cheese and can sell that on the spot market for an exogenously given price. They may choose this option when the spot-market milk price is too low.

Milk prices are determined as shown in Figure A-1. In the low season, the price of milk, p_l, is determined by milk demand and supply. In the high season, the price of milk p_h has a

[12] This type of cost on the buyer's side on the spot market has been assumed in Macchiavello and Morjaria (2015) as transport and intermediation costs and in Song and Ma (2023) as rationing on the spot market.

floor anchored by the cheese price since producers can choose to sell cheese if the milk price is too low. Here, p_h is determined by the milk to cheese conversion rate and the market price of cheese. We assume that the choke price of consumers is higher than the low-season price: $\beta_0\beta_1 > p_l$. This implies that demand will still be positive when the price is high in the low season.

Figure A-1: Aggregate demand and supply of milk



A.2 Relational contracts

Given the price of milk on the spot market, we ask in what case consumers and producers would prefer to establish relational contracts. We call the contracted price of milk $\bar{p}$.[13]

On the consumer side, the consumer surplus per period from the relational contract is

$$S_R = \frac{1}{2}(\beta_0\beta_1 - \bar{p})\left(\beta_0 - \frac{\bar{p}}{\beta_1}\right) = \frac{(\beta_0\beta_1 - \bar{p})^2}{2\beta_1}.$$

[13]This does not mean that the contracted price of milk is exogenously given. The price can be determined through negotiation. See below for more discussion.

The consumer's expected per-period consumer surplus on the spot market is

$$S_S = \frac{1}{2}\left\{\frac{(\beta_0\beta_1 - p_l)^2}{2\beta_1} + \frac{(\beta_0\beta_1 - p_h)^2}{2\beta_1}\right\} = \frac{(\beta_0\beta_1 - p_l)^2 + (\beta_0\beta_1 - p_h)^2}{4\beta_1}.$$

In a relational contract, a consumer prefers to keep his contract rather than renege this period and purchase in the spot market from the next period onward. For the incentive compatibility constraint, it is sufficient to consider consumer deviations in the high season since that is when the milk price in the spot market is lower. This constraint is formalized as

$$\frac{1}{1-\delta}S_R > \frac{(\beta_0\beta_1 - p_h)^2}{2\beta_1} + \frac{\delta}{1-\delta}S_S - \frac{1}{1-\delta}\kappa,$$

where the last term captures the additional cost buyers have to pay for transactions in the spot market.

For a price $\bar{p}$ to satisfy this condition it must satisfy one of the following two inequalities:

$$\bar{p} < \beta_0\beta_1 - \sqrt{\left(1-\frac{\delta}{2}\right)(\beta_0\beta_1 - p_h)^2 + \frac{\delta}{2}(\beta_0\beta_1 - p_l)^2 - 2\beta_1\kappa}, \quad \text{or}$$

$$\bar{p} > \beta_0\beta_1 + \sqrt{\left(1-\frac{\delta}{2}\right)(\beta_0\beta_1 - p_h)^2 + \frac{\delta}{2}(\beta_0\beta_1 - p_l)^2 - 2\beta_1\kappa}.$$

However, the latter would imply that the price in the relational contract is higher than the choke price, hence no consumer would establish the contract. Therefore, the condition for the relational contract price $\bar{p}$ so that the consumer prefers to establish and stay in a relational contract is

$$\bar{p} < \beta_0\beta_1 - \sqrt{\left(1-\frac{\delta}{2}\right)(\beta_0\beta_1 - p_h)^2 + \frac{\delta}{2}(\beta_0\beta_1 - p_l)^2 - 2\beta_1\kappa}.$$

On the producer side, first we assume that only farmers who can deliver the promised amount of milk to their customers even in the low season can have contracts. Specifically, we assume that only farmers with $y - \nu - \bar{y} > 0$ can have contracts, where $\bar{y}$ is the amount of milk promised to be sold to the customer. If a consumer knows that he will not be able to buy the promised amount of milk from a producer in the low season, the consumer will not want to have a relational contract with that farmer. Also, for simplicity, we assume that a farmer can have a contract with at most one consumer.

The producer's expected per-period profit from having a relational contract is

$$\pi_R = \frac{1}{2}\left(p_l(y - \nu - \bar{y}) + p_h(y + \nu - \bar{y})\right) + \bar{p}\bar{y}$$

and the producer's per-period expected profit without a contract is

$$\pi_S = \frac{1}{2}\left(p_l(y - \nu) + p_h(y + \nu)\right).$$

We assume production costs do not vary across the two methods for selling milk and so ignore them. The producer will choose to keep a relational contract rather than renege if the present-value of the profit from keeping the promise is larger than the payoff from selling in the spot market this period and in the future. Suppose that the deviation in the low season when the spot market price is high is more profitable than that in the high season: $p_l(y - \nu) > p_h(y + \nu)$. Then, it is sufficient to consider the following incentive compatibility condition with respect to deviating in the low season:

$$\frac{1}{1-\delta}\pi_R > p_l(y - \nu) + \frac{\delta}{1-\delta}\pi_S.$$

The case where the high-season deviation is more profitable provides the same testable hypotheses.

The above condition can be transformed in the following way:

$$\begin{aligned}
&\frac{1}{1-\delta}\pi_R > p_l(y - \nu) + \frac{\delta}{1-\delta}\pi_S \\
&\Leftrightarrow \frac{1}{2}\left(p_l(y - \nu - \bar{y}) + p_h(y + \nu - \bar{y})\right) + \bar{p}\bar{y} > (1-\delta)p_l(y - \nu) + \frac{\delta}{2}\left(p_l(y - \nu) + p_h(y + \nu)\right) \\
&\Leftrightarrow p_l(y - \nu - \bar{y}) + p_h(y + \nu - \bar{y}) + 2\bar{p}\bar{y} > 2(1-\delta)p_l(y - \nu) + \delta\left(p_l(y - \nu) + p_h(y + \nu)\right) \\
&\Leftrightarrow -p_l\bar{y} + p_h(y + \nu - \bar{y}) + 2\bar{p}\bar{y} > (1-\delta)p_l(y - \nu) + \delta p_h(y + \nu) \\
&\Leftrightarrow (2\bar{p} - (p_l + p_h))\,\bar{y} > (1-\delta)\left(p_l(y - \nu) - p_h(y + \nu)\right) \\
&\Leftrightarrow (2\bar{p} - (p_l + p_h))\left(\beta_0 - \frac{\bar{p}}{\beta_1}\right) > (1-\delta)\left(p_l(y - \nu) - p_h(y + \nu)\right) \\
&\Leftrightarrow (2\bar{p} - (p_l + p_h))\left(\bar{p} - \beta_0\beta_1\right) < -\beta_1(1-\delta)\left(p_l(y - \nu) - p_h(y + \nu)\right) \\
&\Leftrightarrow 2\bar{p}^2 - (p_l + p_h + 2\beta_0\beta_1)\bar{p} + (p_l + p_h)\beta_0\beta_1 + \beta_1(1-\delta)\left(p_l(y - \nu) - p_h(y + \nu)\right) < 0.
\end{aligned}$$

Hence, this condition is satisfied when

$$\frac{(p_l + p_h + 2\beta_0\beta_1) - \sqrt{(2\beta_0\beta_1 - (p_l + p_h))^2 - 8\beta_1(1-\delta)\left(p_l(y-\nu) - p_h(y+\nu)\right)}}{4} < \bar{p}$$
$$< \frac{(p_l + p_h + 2\beta_0\beta_1) + \sqrt{(2\beta_0\beta_1 - (p_l + p_h))^2 - 8\beta_1(1-\delta)\left(p_l(y-\nu) - p_h(y+\nu)\right)}}{4}$$

Let

$$A \equiv \beta_0\beta_1 - \sqrt{\left(1 - \frac{\delta}{2}\right)(\beta_0\beta_1 - p_h)^2 + \frac{\delta}{2}(\beta_0\beta_1 - p_l)^2 - 2\beta_1\kappa},$$
$$B \equiv \frac{(p_l + p_h + 2\beta_0\beta_1) - \sqrt{(2\beta_0\beta_1 - (p_l + p_h))^2 - 8\beta_1(1-\delta)\left(p_l(y-\nu) - p_h(y+\nu)\right)}}{4}, \quad \text{and}$$
$$C \equiv \frac{(p_l + p_h + 2\beta_0\beta_1) + \sqrt{(2\beta_0\beta_1 - (p_l + p_h))^2 - 8\beta_1(1-\delta)\left(p_l(y-\nu) - p_h(y+\nu)\right)}}{4}.$$

Combining the consumer and producer sides, a consumer and producer are willing to establish a relational contract if there exists a contract price $\bar{p}$ such that

$$B < \bar{p} < \min\{A, C\}.$$

Since $p_l(y-\nu) > p_h(y+\nu)$, then

$$B > \frac{p_l + p_h + 2\beta_0\beta_1 - (2\beta_0\beta_1 - (p_l + p_h))}{4} = \frac{p_l + p_h}{2} > \frac{p_h + p_h}{2} = p_h,$$

where the first inequality used $\beta_0\beta_1 > p_l > \frac{p_l + p_h}{2}$, that is, the choke price is higher than the average spot market price. Remember that p_h is the milk price in the high season, which is assumed to be the equivalent milk price of cheese since producers can sell redundant milk as cheese. Hence, we obtain the following hypothesis:

H1. The relational contract price for milk is higher than the equivalent milk price of cheese.

To make the model tractable and derive meaningful model predictions, here we consider the comparative statics when the discount factor is close to 1.[14] Note that

$$C - A \to_{\delta \to 1} \frac{(p_l + p_h + 2\beta_0\beta_1) + (2\beta_0\beta_1 - (p_l + p_h))}{4} - \beta_0\beta_1 \\ + \sqrt{\frac{1}{2}\left((\beta_0\beta_1 - p_h)^2 + (\beta_0\beta_1 - p_l)^2\right) - 2\beta_1\kappa} \\ = \sqrt{\frac{1}{2}\left((\beta_0\beta_1 - p_h)^2 + (\beta_0\beta_1 - p_l)^2\right) - 2\beta_1\kappa} > 0.$$

Therefore, $C > A$, and the relational contract price must satisfy the following condition

$$\frac{p_l + p_h}{2} < \bar{p} < \beta_0\beta_1 - \sqrt{\frac{1}{2}\left((\beta_0\beta_1 - p_h)^2 + (\beta_0\beta_1 - p_l)^2\right) - 2\beta_1\kappa}. \tag{2}$$

There exists $\bar{p}$ satisfying this condition if and only if

$$\beta_1 > \frac{(p_l - p_h)^2}{8\kappa}.$$

This means that more elastic consumers (consumers with smaller β_1) are less likely to establish a relational contract since there does not exist a contract price satisfying the condition for such customers. This provides the following hypothesis:

H2. Less elastic consumers are more likely to have relational contracts.

Note that, for the relational contract to hold, the price can be anywhere in the given range. Buyers and sellers can negotiate over the contract price such that the condition is satisfied.

By assumption, farmers who cannot deliver the promised amount of milk to their customers in the low season will have to sell in the spot market. This implies that producers with more variable production, or higher ν, will not enter into relational contracts. This leads to the following hypothesis:

H3. Producers with more variable production are less likely to have relational contracts.

[14]This is reasonable in our study context as villagers transact repeatedly for a long period of time.

B Appendix Tables and Figures

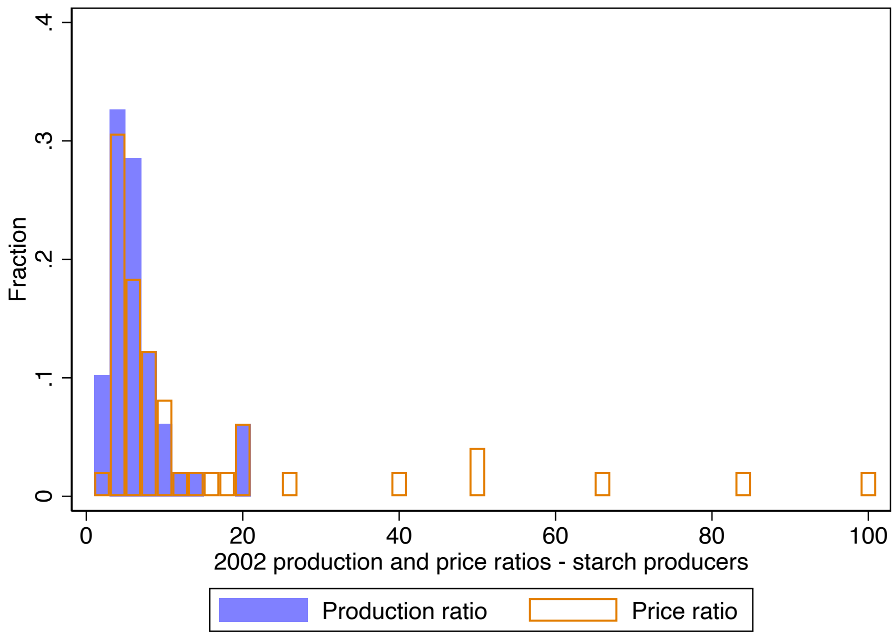
Table B-1: Summary statistics (household control variables)

	Mean	SD	Count
Log of wealth (1,000 Gs)	10.18	1.90	445
Schooling years of household head	4.74	2.92	445
Age of household head	53.49	14.88	445
Maximum schooling years of the household members	8.30	3.73	445
Household size	4.92	2.39	445
Trustworthiness	0.42	0.20	158
Altruism	8.94	2.66	369
# of risky choices made	1.57	1.62	361

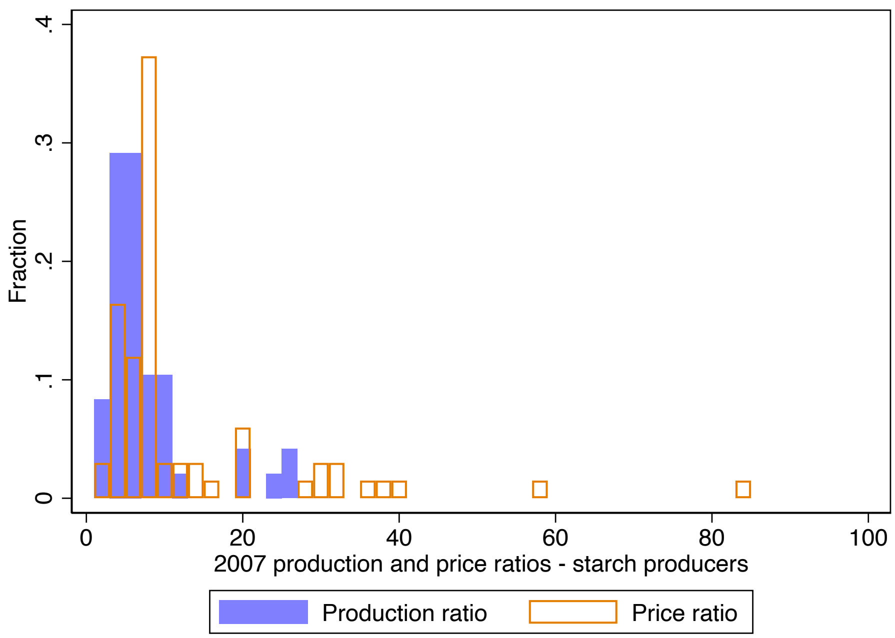
Notes: Sample includes all households. All variables are from 2007 except for trustworthiness. Trustworthiness is the share returned as a trustee in a trust game in 2002. Altruism is the amount transferred out of 14 thousand Gs in a dictator game. # of risky choices made is the number of risky choices made out of four in a hypothetical risk experiment, and excludes individuals who did not pass the test for understanding.

Figure B-1: Production and price ratios for yuca and starch

(a)



(b)



Notes: Panel a shows how many kilos of yuca it took to make a kilo of starch (the production ratio) and how much a kilo of starch costs compared to a kilo of yuca (the price ratio) in 2002 for all households that produced starch. Panel b shows the same ratios for 2007. These figures include outliers with ratios over 30.