

# Firm and Market Response to Saving Constraints: Evidence from the Kenyan Dairy Industry \*

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July 30, 2016

## Abstract

Failures in saving markets can spill over into other markets: When producers are saving constrained, trustworthy buyers can offer infrequent delayed payments—a saving tool—and purchase at a lower price, thus departing from standard trade credit logic. This paper develops a model of this interlinkage and tests it in the context of the Kenyan dairy industry. Multiple data sources, experiments, and a calibration exercise support the microfoundations and predictions of the model concerning: *i*) producers' demand for infrequent payments; *ii*) heterogeneity across buyers in the ability to supply low frequency payments; *iii*) a segmented market equilibrium where buyers compete by providing either liquidity or saving services to producers; *iv*) low supply response to price increases. We provide additional evidence from other settings, including labor markets, and discuss policy implications concerning contract enforcement, financial access, and market structure.

*Keywords:* Saving Constraints; Imperfect Contract Enforcement; Interlinked Transactions; Competition; Trust; Agricultural Markets.

*JEL Codes:* O12, L22, O16, Q13.

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# 1 Introduction

A growing body of literature documents the importance of saving constraints for households and enterprises in the developing world (see, e.g., Karlan et al., 2014). While prominent strands of literature have studied how financial markets’ imperfections affect other markets, they have mostly focused on insurance, and, particularly, credit markets.<sup>1</sup> This paper proposes a mechanism through which saving constraints can spill over into output markets: Producers may value buyers’ *infrequent* payments—which combine many small payments in one lump sum—as a saving device. Buyers may then compete for suppliers through the provision of infrequent payments. Under limited contract enforcement, however, only buyers who can *credibly* promise to pay producers at a later time can offer such payments. In a market with such features, delayed payments are then associated with lower unit prices—contrary to standard trade credit logic.

We provide theory and evidence on how this mechanism can affect producers’ sales choices, buyers’ competition strategies, and equilibrium prices and profits. By showing that output buyers also provide a saving device and that producers pay for this service, the research unveils interlinked transactions between saving markets and output markets. This form of interlinkage, to the best of our knowledge, had not been previously noted in the literature (Bardhan, 1991). This interlinkage may be relevant for a broad class of markets that feature saving-constrained producers, including agricultural value chains and labor markets.

The study focuses primarily on the dairy industry in Kiambu County in Central Kenya. Besides its intrinsic interest (dairy is the largest agricultural subsector in Kenya and many other developing countries), the setting is particularly suitable to test the proposed mechanism. First, the market features the required variation for the empirical analysis. Milk buyers that offer different frequencies of payments coexist in the market. Small traders, who pay relatively high prices on a daily basis, compete with a large buyer (a cooperative) that

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<sup>1</sup>Within the development literature, nowadays classical contributions are, e.g., explanations of sharecropping (Stiglitz, 1974; Braverman and Stiglitz, 1982), labor tying (Bardhan, 1983; Mukherjee and Ray, 1995), savings and credit associations (Besley et al., 1993; Banerjee et al., 1994; Anderson and Baland, 2002), joint liability lending (Ghatak and Guinnane, 1999; Ghatak, 2000), and risk-sharing networks (Coate and Ravallion, 1993; Udry, 1994). De Janvry et al. (1991) discusses how specific market failures can induce *prima facie* puzzling farmer behaviors. Bolton and Scharfstein (1990), Manova (2013), and Guiso et al. (2013) are influential examples from other fields studying how imperfections in the credit market affect firm competition, international trade, and labor markets, respectively.

pays at the end of the month. Many farmers sell milk to the buyer offering less frequent (and lower) payments and a large share of these farmers sell *every day* both to the large buyer and to traders. Second, like labor (and other products and services), milk is supplied daily and is non-storable. However, a distinctive advantage of our context is that, unlike labor markets, producers and buyers transact (nearly) identical milk independently.

The paper combines several tools to investigate the proposed mechanism: A theoretical model, two experiments, analysis of administrative and survey data, and a simple calibration. The model provides a framework to study the interlinkage between saving and output markets.<sup>2</sup> It builds on two microfoundations: *i*) Producers’ *demand* for infrequent payments (arising from a lumpy expense opportunity and a demand for commitment), *ii*) asymmetry across buyers in their ability to *supply* infrequent payments, based on their option to strategically default on the payment due to the producers (i.e., an incentive constraint). In the relational contracting equilibrium we characterize, only a subset of buyers can credibly offer infrequent payments and “charge” producers for this saving service by paying a lower output price. Producers with higher saving goals sort into different buyers and some contemporaneously sell to different buyers under radically different conditions to satisfy both liquidity needs and saving goals. The framework delivers additional predictions on producers’ response to price increases and to liquidity incentives, suggesting that the linkage between saving and output markets affects other dimensions of firm strategies, such as price competition.

The first part of the empirical analysis provides evidence on the producers’ demand for infrequent payments. We conduct two “choice experiments” in which the cooperative offers farmers the opportunity to choose between various payment frequencies. Through this design, we assess the value farmers assign to monthly payments, keeping constant the competitive environment (including other benefits the coop may provide). In the first choice experiment, farmers turn down a 15% price increase to access monthly payments (rather than daily ones). Results from the second one show that demand for commitment is an important driver of this preference for infrequent payments. Analysis of survey data confirms these findings.

Turning to the buyers’ supply of infrequent payments, we show that farmers trust the coop more than the traders. Farmers share little information about traders and express concerns

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<sup>2</sup>Although the model is developed with the output market application in mind, it can easily be reinterpreted as a model of the labor market in which large firms and self-employment coexist.

that they would default on purchases made on credit. A calibration of the traders' incentive constraint confirms that traders cannot commit to infrequent payments: Given prevailing prices, the temptation to default on the delayed payment due to the farmer is larger than the discounted future profits from sourcing through infrequent payments at lower prices.

The last part of the empirical analysis tests equilibrium predictions of the model. Analysis of administrative and survey data shows that farmers who sell to the cooperative are more likely to set saving goals and to reach them. Moreover, farmers use earnings paid at different frequencies for different purposes (i.e., food consumption vs. dairy inputs). Finally, a field experiment tests further predictions concerning the farmers' response to increases in prices and to the provision of additional liquidity. We find suggestive evidence that the delivery response to a large price increase is weaker when payments are made at a lower frequency (p-value=0.21-0.29), consistent with the predictions of the model.<sup>3</sup>

In order to make progress on the external validity of the proposed mechanism, the final part of the paper provides additional evidence from several other settings. Analysis of survey data from a tea contract farming scheme in Kenya, from manufacturing sector workers in Myanmar, and from seasonal workers in Rwanda provides results in line with the main findings of the study concerning demand and supply of infrequent payments. Our results are also consistent with other features of labor markets and firm-to-firm relationships: The role of large organizations in the historical shift from daily payments to less frequent ones; the existence of *Thirteenth Salaries*—an additional monthly salary paid around Christmas in many countries; trade credit flowing from small to large firms.

The linkage between saving and output markets, realized through infrequent payments, has several policy implications. First, low frequency payments can help farmers reach their saving goals, potentially fostering investment and consumption smoothing. This suggests potential benefits from *large* buyers and employers in the developing world, as those may be better-suited to supply low frequency payments. Many observers are concerned about the market power of large buyers in agricultural value chains. Our evidence suggests the ability to credibly promise low frequency payments may act as barrier to entry. However it also qualifies excessively negative views of large buyers if size is a prerequisite for such payments.

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<sup>3</sup>In addition, we provide evidence for a rule of thumb many producers follow—selling to the cooperative in the morning to save, selling to traders in the afternoon to get liquidity—and suggests this rule may further limit supply responsiveness to price changes.

Moreover, low prices paid to producers might reflect a willingness to pay for illiquidity rather than excessive market power downstream. The market under study looks also very different from a standard interlinked market in which farmers *borrow* from buyers. In such a market loans would be repaid through lower daily prices (the buyer would deduct the amount the farmer needs to repay). Furthermore, buyers' asymmetric access to liquidity and ability to punish defaulting farmers – rather than their credibility – would determine market structure. While these dimensions might be correlated, they yield different policy implications, e.g., with respect to the regulation of preferential creditors in bankruptcy procedures.

Second, limited contract enforcement interacts with missing saving markets: Because of limited enforcement, only a subset of buyers with enough credibility can offer low frequency payments to the producers, thus extracting a portion of the surplus in the output market transaction, with limited competition along this margin. This logic unveils a novel benefit of improving contract enforcement in agricultural markets. By increasing the number of buyers who can commit to low frequency payments, better enforcement may have an impact similar to better access to saving products, while potentially occurring in a cheaper and more decentralized fashion. Similarly, better access to (commitment) saving products may enable producers to capture a larger share of the output market surplus. More broadly, improving access to financial products may impact agricultural markets in ways so far unnoticed.

The paper studies the implications of the interaction between imperfect contract enforcement and saving constraints for the functioning of markets and it is, therefore, related to several strands of research. First, the paper contributes to the literature on interlinked transactions in developing countries by unveiling previously unnoticed interlinkages between saving and output markets. Bardhan (1980), Bardhan (1991), Bardhan and Udry (1999) and Bell (1988) summarize this theoretical literature. More recently, Casaburi and Reed (2014), Ghani and Reed (2014), Casaburi and Willis (2015) and Macchiavello and Morjaria (2015a) offer primarily empirical contributions.<sup>4</sup> Limited contract enforcement lies at the heart of our theoretical model and empirical evidence. Greif (1993), Ghosh and Ray (1996), and Dixit

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<sup>4</sup>Casaburi and Willis (2015) find that bundling an agricultural insurance product with a large contract farming scheme in Kenya leads to significantly higher take-up rates. Our findings complement theirs since insurance and saving markets both require small agents trusting larger service providers. Macchiavello and Morjaria (2015a) show that competition reduces the use of interlinked transactions, including deferred payments, in the coffee sector in Rwanda. Additional relevant studies on interlinked transactions in agricultural settings include Fafchamps and Minten (1999), Fafchamps and Minten (2002) and Maitra et al. (2014).

(2003) offer important theoretical analysis; while Fafchamps (2004) illustrates its relevance in agricultural markets.<sup>5</sup> Empirical studies on limited contract enforcement include Bubb et al. (2016) experimental analysis of rural markets for water in India and Macchiavello and Morjaria (2015b) study of relational contracts in the Kenyan flower market. The interaction of limited contract enforcement with saving constraints is novel to our paper.

Second, a large literature studies informal institutions, e.g., Roscas, overcoming saving barriers in developing countries (see, e.g., Besley et al., 1993; Anderson and Baland, 2002; Anderson et al., 2009). According to Hansmann (2000) credibility constraints explain the rise of formal savings and insurance mutuals in agricultural contexts (see Conning and Udry, 2007; Dupas et al., 2014; Karlan et al., 2014 on the role of trust in saving markets).<sup>6</sup> A growing body of evidence studies the demand for and the impact of saving products in developing countries (see, e.g., Ashraf et al., 2006; Dupas and Robinson, 2013; Kast et al., 2012; Brune et al., 2014; Breza and Chandrasekhar, 2015). The timing, frequency, and mode of payments have been argued to be effective saving tools theoretically (see, e.g., Banerjee and Mullainathan, 2010 and Bernheim et al., 2015) and empirically (Bertrand et al., 2004; Brune and Kerwin, 2014; Banerjee, 2016).

Third, the paper relates to the literature on the interaction among organizational forms, behavioral biases, and contract design. Although our research focuses on a specific agricultural market, its theoretical insights and empirical tools are relevant for the study of other markets as well, including the labor market. Kaur et al. (2010) and Kaur et al. (2014) build on Clark (1994) and argue that modern factories help self-control in effort provision. The ability of large factories to credibly promise regular monthly payments may also help address self-control issues in spending habits. Relatedly, Dupas and Robinson (2014) shows that

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<sup>5</sup>See also Deb and Suri (2013) and Bardhan et al. (2013) for recent theoretical contributions. Our model shares insights with the literature on barriers to entry. However, it does not fit within standard frameworks that study either preemption or predation (see, e.g., Tirole, 1988, and Wilson, 1992). The model is closer in spirit to Aghion and Bolton (1987) in which contracts are used as barriers to entry.

<sup>6</sup>In the credit market, Fischer and Ghatak (2010) explores theoretically the implications of time-inconsistent preferences for microfinance borrowing while Jack et al. (2015) studies collateralized loans for dairy farmers in rural Kenya. The paper is also related to, but distinct from, the literature on trade credit (see, e.g., Petersen and Rajan, 1997; Burkart and Ellingsen, 2004; Giannetti et al., 2011). Standard trade credit emerges from buyers' demand for credit and suppliers' advantage (e.g., better information, lower transaction costs) relative to other sources of finance. In our framework, suppliers' demand for infrequent payments drives delayed payments. A key distinction then is that suppliers receive *lower* prices for delayed payments (i.e., a negative interest rate). Moreover, we focus on asymmetries across buyers in the ability to supply infrequent payments, rather than asymmetries across multiple sources of finance.

income targets might help workers overcome temptations. Neither study considers the role of imperfect contract enforcement.<sup>7</sup>

The rest of the paper proceeds as follows. Section 2 provides background information on the study setting. Section 3 presents the model and relates it to the empirical strategy. Section 4 provides evidence on producers' demand for low frequency payments.. Section 5 presents results on the asymmetry across buyers in the supply of infrequent payments. Section 6 tests the model equilibrium predictions on buyers' coexistence in the market and on the supply response to price increases. Section 7 presents evidence on the relevance of the proposed mechanism for other markets and offers concluding remarks.

## 2 Study Setting

The dairy industry is the largest agricultural sector in Kenya, contributing to approximately 14% of agricultural GDP and 3.5% of total GDP (Government of Kenya, 2012). Small-scale farmers, owning up to three cows, are responsible for about 80% of the production (Wambugu et al., 2011). Our project takes place in Kiambu district, in Central Kenya. Two main types of buyers coexist in the region. The first is a large coop with about 2,000 members, one of the oldest in the industry. The coop collects milk at its 24 collection centers, which are open at fixed hours every day in the morning and in the afternoon. The second is a large number of informal traders purchasing smaller quantities of milk. These are primarily small itinerant traders who deliver milk to the nearby towns or local restaurants and to Nairobi (about one hour away).<sup>8</sup> Farmers milk cows twice a day (morning and afternoon). Since most farmers lack refrigerators, sales also typically occur twice a day. In the first stage of the value chain (i.e., the sale farmers make to the first buyer), there is no systematic quality testing or quality-based pricing. The coop and the traders then sell to processors or to final consumers (local or in Nairobi).

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<sup>7</sup>Finally, the mechanisms in this paper suggests that the ability of larger firms to offer low frequency payments might be another determinant of labor tying, in addition to the mechanisms emphasized by the previous literature. Bardhan (1983) and Mukherjee and Ray (1995), among others, model workers' lack of access to credit or insurance and incentives to renege on implicit contracts.

<sup>8</sup>The relationship between the coop and its members is governed by formal by-laws which forbid side-selling of milk. In practice, these formal by-laws are not fully enforced (see Casaburi and Macchiavello (2015)) The theory and results of the paper provide a rationale for why the coop may tolerate specific forms of side-selling (see, in particular, Appendix B.)

The frequency of payments varies substantially across buyers. The cooperative pays farmers at once for the deliveries of any given month in the first week of the subsequent month. Most traders instead pay farmers on a daily basis. Traders pay a significantly higher price than the coop.<sup>9</sup> The coop sources from a large share of farmers. Our estimates suggest that between 40% and 50% of dairy farmers in its catchment area sell to the coop. In addition, survey and administrative data suggest that at least half of the farmers selling to the coop also sell to traders *every day*. Farmers might use their dairy income for different purposes, including regular consumptions expenditures or lumpy purchases such as feed, veterinary expenses, farm upgrading, and school fees.

This paper combines two sources of data: Administrative data from the coop and original survey data. The administrative data include member-level deliveries of milk to the coop from June 2013 through September 2014. The deliveries are recorded separately for morning and afternoon. The surveys are structured as follows. There are three groups of farmers: (1) Farmers that sell to the coop in the morning but not in the afternoon; (2) farmers selling to the coop both in the morning and in the afternoon; and (3) farmers not selling to the coop. First, as baseline for the randomized controlled trial described in Section 6, we conducted a detailed survey of a sample of members in group (1).<sup>10</sup> Second, we conducted a shorter survey on a random sample of members in group (2).<sup>11</sup> Third, we conducted a listing of all dairy farmers in six random villages in the catchment area of the coop to collect basic information on group (3). The listing includes information on the number of cows owned, on whether farmers sell to the coop, and on their saving goal behavior.

The survey covers a variety of aspects related to household characteristics and dairy farming. In particular, the survey elicited information on different types of buyers, their relationships with farmers, and the benefits farmers receive by selling to each type of buyer. Table 1 presents basic farmer descriptive statistics from the main survey sample. The survey

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<sup>9</sup>The coop's payments differ from those of the traders along three dimensions: They are *monthly*, *delayed*, and (mostly) paid through *direct deposits* to farmers' bank accounts. As described below, the combination of these features may help farmers to reach their saving goals. In the rest of the paper, we combine these three features in the expression *low frequency payments* without unbundling these components. The experiment presented in Section 4.2 sheds light on the commitment value low frequent payments provide.

<sup>10</sup>As this sample served as baseline for the experiments presented in Section 6.2, we excluded farmers in the bottom and top delivery deciles to reduce dispersion and increase power. The final sample, which is representative of this subpopulation, included 654 farmers, of which 596 (91%) were successfully interviewed.

<sup>11</sup>These are the other members targeted for the two choice experiments described in Section 4.



targeted the household member in charge of managing milk production. Of the respondents, 43% are men. The average respondent has 1.5 active cows producing milk. Average production is 11.95 kg (afternoon production is about two-thirds of morning production). Of the households, 20% hire at least one worker on dairy farming. Dairy farming is just one of the income-generating activities farmers undertake. About 50% of respondents report crop farming as their main other source of income.<sup>12</sup>

The theory in Section 3 illustrates the implications of producers' demand for infrequent payments on market outcomes. Section 4 provides evidence for such demand, using choice experiments where the competitive environment—including the other benefits the coop may provide to its members—is kept constant. It is nevertheless important to discuss these other potential benefits. First, farmers may take loans from the coop. However, survey data suggest only 7.5% do and “loans” mostly take the form of advances on milk *already* delivered.<sup>13</sup> The coop also sells inputs at some of its collection centers: This may reduce transaction costs, but 90% of farmers report being unsatisfied with the inputs' quality and prices. Second, while farmers report that most traders are available every day, the coop's demand may be more reliable in peak production season. However, since the coop does not condition present purchases on past deliveries, coop's purchase guarantee in the peak season cannot explain sales to the coop in other months. Third, about one-quarter of the farmers report they have attended a training organized by the coop over the last year. Fourth, 75% of respondents report a sense of pride from selling to the coop. Finally, we note the cooperative does not make second payments at the end of the year. In sum, there are certainly other benefits farmers may obtain from the coop, but their extent seems to be limited. This mixed view on governance and performance of cooperatives is consistent with evidence in Kenya (Muriuki, 2011) and studies such as Banerjee et al. (2001) and Sukhtankar (2015) in India.

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<sup>12</sup>The shorter survey that targeted farmers selling to the coop both in the morning and afternoon reveals that these farmers have similar demographics, though they have more cows on average: 2.2 vs. 1.5.

<sup>13</sup>The coop does not offer asset-collateralized loans such as the ones described in Jack et al. (2015).

### 3 A Theory of Interlinkages between Saving and Output Markets

This section presents a model of the interlinkage between saving markets and output markets. While the model draws from the study setting, it provides a more general framework to study this interlinkage in other markets, including the labor one. The model builds on two microfoundations. First, (some) producers have a demand for infrequent payments as a saving tool to purchase an indivisible good. Second, buyers differ in their ability to supply infrequent payments based on their ability to credibly commit not to default. In equilibrium, those buyers offering infrequent payments pay producers a *lower* price than those paying more frequently. The model delivers additional testable predictions on the sorting of farmers into different marketing channels and on the mitigated impact of price competition strategies when the saving-output interlinkage occurs (relative to a market with no interlinkage). Appendix A presents proofs. Appendix B provides several extensions.<sup>14</sup>

#### 3.1 Setup

##### *Demand for Infrequent Payments*

Consider a market with a continuum of mass  $N$  of producers indexed by  $i$ . Time is an infinite sequence of months,  $m$ . Each month is divided into four *periods*,  $t = 1, 2, 3, 4$ . Farmers have quasi-hyperbolic preferences across periods, with  $\beta < 1$  and  $\delta < 1$ . They are sophisticated about their time inconsistency.<sup>15</sup> In each of periods  $t = 1, 2$ , producers are endowed with one unit of non-storable output. Producers cannot borrow. They can save cash from one period to the next within the same month, earning interest rate  $(1 + r) = 1/(\delta + \epsilon)$ , with  $\epsilon \rightarrow 0$ . In periods  $t = 1, 2, 3$ , producers derive utility  $u(c) = c$  from consumption of a perfectly divisible

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<sup>14</sup>These include, among others, price discrimination, bundling of daily and infrequent payments, large buyer objective function, small buyers' heterogeneity, producer access to credit, personal rules, and heuristics.

<sup>15</sup>We microfound the demand for low frequency payments assuming farmers *do* have access to a saving technology but are time-inconsistent. Demand for commitment can then arise from internal saving constraints (i.e., the current-self makes her saving choice based on the constraint imposed by the future-self preferences) or from external saving constraints (i.e., the need to make income not accessible to family members, friends, or neighbors). While this microfoundation appears to be borne out in the data, the key results of the model can also be obtained in a framework with time-consistent farmers that do not have access to a (sufficiently good) saving technology.

good  $c$  (whose price is normalized to one).<sup>16</sup> Following Besley et al. (1993) and Anderson and Baland (2002), we introduce a demand for an indivisible good that is purchased and consumed in the last period,  $t = 4$ . The indivisible good costs  $D$  and gives utility  $\Delta_i$ . Producers' utility from the indivisible good  $\Delta_i$  is distributed according to a strictly increasing and twice continuously differentiable cumulative function  $G(\Delta_i)$  on support  $\Delta_i \in [0, \infty)$ . Producers cannot afford to buy the indivisible good just by saving one period worth of sales but they can if they save the entire production.

### *Supply of Infrequent Payments*

Producers sell output to an infinite supply of buyers who maximize discounted profits (at common discount factor  $\delta$ ) by reselling at exogenous price  $v$ . Buyers compete on prices and on whether they pay producers in each period  $t = 1$  and  $t = 2$  (i.e., daily payments) or at  $t = 4$  (i.e., infrequent payments).<sup>17</sup> Daily payments are paid cash, subject to no contractual hazard. In contrast, low frequency payments are potentially subject to strategic default: at  $t = 4$  the buyer can renege on the promised payment and default. Low frequency payments then require a credible (i.e., self-enforcing) promise of future payments in which buyers satisfy an incentive constraint. If multiple buyers offer the same payment frequency they compete à la Bertrand—subject to the above incentive constraint, for the case of infrequent payments—and split the market equally.

Buyers can operate one of two technologies: small ( $S$ ) and large ( $L$ ). The two technologies differ with respect to fixed costs and what happens following a default. The small technology has fixed costs  $\kappa_S = 0$ . Given there is no fixed capital involved, upon renegeing on a promise made to a producer for payment at  $t = 4$ , a buyer using the small technology (henceforth, a small buyer) moves to an identical outside market. In each period after a default the small buyer has a probability  $\gamma_S = \gamma \leq 1$  of being matched with a producer not informed about his past cheating and, therefore, willing to sell to him. In contrast, the large buyer requires fixed capital  $\kappa_L = \kappa > 0$ . Because the technology is fixed, upon renegeing on the contract, it is not possible to move it to the outside market and, therefore,  $\gamma_L = 0$ .<sup>18</sup>

<sup>16</sup>These assumptions imply that producers always prefer to consume the divisible good in earlier periods and that they only save to purchase the indivisible good. Section 3.4 relaxes these assumptions to study price responses under a more realistic scenario.

<sup>17</sup>For notational simplicity we assume buyers pays interest rate  $1/\delta$  for period one deliveries. This eliminates a trade credit motive and delivers a more transparent algebra. All results are unaffected.

<sup>18</sup>It is straightforward to allow  $0 < \gamma_L < \gamma_S$ . Note that we are bundling two assumptions: the monitoring

### *Timing of Events and Equilibrium*

At the beginning of time, buyers decide whether to enter the market and make an irreversible decision on which technology to operate. Then, within each month, the timing of events is as follows. Before any production takes place, large buyers first (if any has entered) and then small buyers post a contract type (either daily payment or low frequency payment) and a price. Second, producers then make their sales, consumption, and saving decisions. Third, if any low frequency payment has been promised, buyers decide whether to renege or not. Finally, producers purchase the indivisible good if they have sufficient funds. We are interested in deriving conditions for the existence of equilibria in which large buyers offer low frequency payments and do not default. For expositional simplicity we start by considering the subgame perfect equilibrium in the stage game assuming there is only one large buyer and that he never defaults.<sup>19</sup> We then consider (pure strategy) stationary subgame perfect equilibria of the infinitely repeated game, deriving conditions under which the large buyer can indeed credibly offer low frequency payments while small buyers cannot. Finally, we endogenize the number of large buyers that enter the market.

## **3.2 The Stage Game**

The stage game can be solved by backward induction. Since in the last period small buyers would always default on low frequency payments, producers will never accept low frequency payments from them. Thus, small buyers only offer daily payments and competition drives the daily price  $p_D^S$  to  $v$ . Assume the large buyer has decided to offer low frequency payments at price  $p^L$ . For the large buyer to make any profit, it must be that  $p^L < v/\delta^2$ . Whether producers use the large buyer as a saving tool or save part of the income from their sales to small buyers depends on preference parameters and on the relative prices, which producers take as given in the second step of the stage game. Denoting with  $s_t$  the amount saved by the producer from selling to small buyers (and receiving daily payments) and with  $x_t$  the amount sold to the large buyer (with low frequency payments) in period  $t = 1, 2$ , the producer utility

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and the difference in costs/scale. This assumption can also be easily microfounded. Finally, it is possible to extend the model to endogenize equilibrium in the outside market without much further insight.

<sup>19</sup>For expositional simplicity, we also solve the stage game assuming that producers can save either by selling to the large buyer *or* by saving income from selling to small traders, but cannot do both. In the infinitely repeated game this assumption is derived as an equilibrium outcome.

at  $t = 1$  is given by

$$U_1 = c_1 + \beta\delta(c_2 + \delta c_3 + \mathbf{I}\delta^2\Delta_i), \quad (1)$$

where  $c_1 = v(1 - x_1) - s_1$ ;  $c_2 = v(1 - x_2) - s_2 + \frac{s_1}{\delta}$  and  $c_3 = \frac{s_2}{\delta} - \mathbf{I}\delta D$ ,  $\mathbf{I}$  is an indicator function equal to 1 if the producer purchases the indivisible good.

In order for low frequency payments offered by the large buyer to help producers buy the indivisible good, two conditions must be met. First, producers must care enough for the indivisible good. Second, they must not be able to save on their own. Producers with  $\Delta_i < \frac{D}{\beta}\underline{\Delta}(p^L) \equiv \frac{D}{\beta}\frac{v}{(2-\beta)p^L\delta^2}$  do not value the indivisible good sufficiently to buy it given the relatively low price paid by the large buyer. Producers with  $\Delta_i > \frac{D}{\beta}$  do not need the large buyer to buy the indivisible good: they are able to resist temptations and save out of their cash sales. Denoting by  $x_1(\Delta_i, p^L)$  and  $x_2(\Delta_i, p^L)$  the quantities supplied to the large buyer by farmer  $i$ , the large buyer sets  $p^L$  to maximize profits given by

$$\max_{p^L} \Pi(p^L) = N \int_{\frac{D}{\beta}\underline{\Delta}(p^L)}^{\frac{D}{\beta}} (v - \delta^2 p^L) (x_1(p^L, \Delta_i) + \delta x_2(p^L, \Delta_i)) dG(\Delta_i).$$

Producers with  $\Delta_i \in [\frac{D}{\beta}\underline{\Delta}(p^L); \frac{D}{\beta}]$  sell quantities just sufficient to buy the indivisible good, i.e.,  $(x_1(\Delta_i, p^L) / \delta + x_2(\Delta_i, p^L)) p^L = D$ . Substituting this expression in the profit function yields

$$\max_{p^L} \Pi(p^L) = \underbrace{\delta^3 D}_{\text{per-producer deliveries}} \times \underbrace{(v/\delta^2 - p^L)}_{\text{unit margin}} \times \underbrace{\Gamma(p^L)}_{\text{supplier base}}$$

with supplier base  $\Gamma(p^L) = N(G(D/\beta) - G(D\underline{\Delta}(p^L)/\beta))$  an increasing function of  $p^L$ .<sup>20</sup> This problem has a well defined solution, denoted  $\hat{p}^F$ , which is independent of  $N$  and satisfies  $\hat{p}^F < \frac{v}{\delta^2}$ . Provided  $\Pi(\hat{p}^F) > \kappa$ , the large buyer decides to enter. We summarize this discussion stating

**Proposition 1:** *The price paid by the large buyer  $\hat{p}^F$  is smaller than the (discounted) price paid in the market for cash deliveries. In equilibrium, only farmers with intermediate levels of  $\Delta$  sell to the large buyers.*

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<sup>20</sup>For  $\beta \rightarrow 1$  the mass of farmers demanding infrequent payments goes to zero.

### 3.3 The Repeated Game

An infinite repetition of the equilibrium in the stage game, with the large buyer as the only provider of low frequency payments, is obviously one of the equilibria of the repeated game. However, in an infinite horizon, small buyers may be able to commit not to default. We characterize an equilibrium in which the large buyer sets prices so that small buyers are *not* able to credibly promise low frequency payment.

#### 3.3.1 Small Buyers

Consider a deviation in which a small buyer offers a producer low frequency payments at price  $\hat{p}^S$  and denote with  $\hat{x}_t^S$  the resulting quantity the trader buys in period  $t = 1, 2$ . If the producer accepts the small buyer's offer she is punished by the large buyer who will refuse to purchase from her in the future. To attract the producer, then, the small buyer must offer a deal that allows the farmer to purchase the indivisible good solely from his promised low frequency payment. The deviating small buyer faces the maximum temptation in  $t = 4$ , once he has already purchased the output and needs to pay for deliveries  $\hat{x}_1^S$  and  $\hat{x}_2^S$ . Let's consider a one-period deviation where he defaults for one month and then reverts to pay future sales with low frequency payments upon meeting in the outside market a producer willing to sell to him (which happens in each period with probability  $\gamma$ ).<sup>21</sup>

The net present value of such a relationship with a producer is given by  $V^S = \sum_{s=0}^{\infty} \delta^{4s} (v - \delta^2 p^S)(x_1^* + \delta x_2^*)$ . The small buyer's offer is credible if paying the promised amount and continuing the relationship gives a higher discounted value than defaulting and then searching for an uninformed producer in the outside market. Given that an uninformed producer is found after  $m$  months with probability  $\Gamma_m = (1 - \gamma)^m \gamma$ , the small buyer offer is credible if

$$-p(x_1^*/\delta + x_2^*) + \delta V^S \geq \delta \sum_{m=0}^{\infty} \Gamma_m \delta^{4m} V^S. \quad (2)$$

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<sup>21</sup>That is, we consider the strategy profile in which *i*) the small buyer do not default, *ii*) informed producers in the outside market accept offers only from small buyers who have never defaulted before, and *iii*) uninformed producers accept offers from small buyers they have not yet interacted with and punish those who defaulted on them in a previous relationship. This provides the harshest punishment and, therefore, the maximum degree of commitment for the small buyer.

which can be rearranged as:

$$p \leq \hat{p}^S \equiv \delta^2(1 - \gamma)v. \quad (3)$$

Note that, the larger the  $\gamma$ , the share of uninformed producers, the easier for the small buyer to find an uninformed producer and, therefore, the lower the value of the relationship with the current producer. The deviating small buyer will make an offer that maximizes his profits subject to the above incentive constraint and the producer's participation constraint, which depends on the price set by the large buyer at the beginning of the period. The following proposition is obtained:

**Proposition 2:** *Given  $p$  and  $p_D = v$ , a trader would be able to credibly offer low frequency payments to the producer if  $p^L \leq \hat{p}^S$ .*

### 3.3.2 The Large Buyer

The large buyer posts a price taking into account the incentive constraint of the small buyer described in Equation 3.<sup>22</sup> The large buyer sets the price to maximize profits subject to two constraints. First, unless the large buyer offers more than the largest price small buyers can credibly offer she will not be able to buy any output. Second, the large buyer must also be credible. Unlike the small buyer, however, if the large buyer defaults against a producer she is unable to get any future deliveries. Adapting the notation and algebra used above to derive the incentive compatibility with the small buyer, the highest price the large buyer can credibly offer is given by

$$p^L \leq \hat{p}^M \equiv \delta^2v. \quad (4)$$

A comparison of the two incentive constraints shows that the large buyer has a reputational advantage: he can always deter competition from small buyers while still being credible, i.e.,  $\hat{p}^M > \hat{p}^S$ . The following proposition then summarizes the large buyer pricing behavior in the repeated game:

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<sup>22</sup>To be precise, at the beginning of the game the large buyer posts a plan, i.e., a sequence of prices and buying policies for all future periods *on-* and *off-* the equilibrium path. As is well-known, in the optimal stationary equilibrium of this game the two formulations are equivalent (Abreu, 1988) and we therefore avoid the unnecessary notational complexity associated with the plan.

**Proposition 3:** *In the repeated game, the large buyer offers low frequency payments at price  $\hat{p}^L = \max[\min\{\hat{p}^F, \hat{p}^M\}, \hat{p}^S]$ . Small buyers offer daily payments at price  $p_D = v$ .*

The key result of the theory is thus that the price paid by buyers offering monthly payments is lower than the daily price. In other words, as opposed to standard trade credit logic, in equilibrium producers accept a *negative* interest rate on buyers' delayed payments. The model also suggests that, in a given period, the same producer sells part of her output for daily payment and part for monthly payment.<sup>23</sup>

### 3.3.3 Endogenous Technology Choice and Competition among Large Buyers

So far we have solved for the subgame perfect equilibrium assuming that only one large buyer entered the market. Given payoffs, it is straightforward to characterize pure strategy symmetric equilibria of the initial entry game. Denote with  $\mathcal{B}$  the number of large buyers entering the market at the initial stage and with  $p^e(\mathcal{B})$  the equilibrium price for low frequency payments. Given Bertrand competition (subject to the credibility constraint in Equation 4),  $p^e(\mathcal{B}) = \hat{p}^L$  if  $\mathcal{B} = 1$  and  $p^e(\mathcal{B}) = \hat{p}^M$  otherwise. Moreover, each large buyer receive supply from an identical segment of producers of mass  $N/\mathcal{B}$ . The number of entrants in pure strategy equilibria is given by  $\mathcal{B}^*$  such that  $\frac{\Pi(p^e(\mathcal{B}^*+1))}{\mathcal{B}^*+1} < \kappa < \frac{\Pi(p^e(\mathcal{B}^*))}{\mathcal{B}^*}$ . Importantly, this extension preserves the key results of the theory: *i*) small traders do not offer low frequency payments; *ii*) the price paid by large buyers for low frequency payments is lower than the price for cash deliveries.

## 3.4 Supply Responses to Contract Changes

The fact that (some) firms compete simultaneously on the output market and on the saving market may affect the impact of standard firm competition strategies. Here, we consider price competition focusing on a *temporary* price increases. When the buyer providing low frequency payments raises its price, this generates an income effect: Farmers can achieve their saving goals with fewer purchases. This income effect may reduce deliveries to the buyer. On the other hand, the standard price effect may increase them.

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<sup>23</sup>In the model, no producer sells only to the large buyer. A simple extension in which (some) producers have access to alternative sources of daily income and the desired amount of saving increases with income accommodates this feature.



To shed light on this ambiguous effect of price increases, we modify slightly our model to allow farmers to smooth the consumption of the divisible good across periods (in the baseline version, a farmer will only save to purchase the durable good). We consider a general concave utility for the divisible, good,  $u(c)$ , rather than the linear one used so far. We derive a final set of testable predictions concerning the farmers' response to price and liquidity incentives provided by the cooperative. The results are summarized in *Proposition 4*:

**Proposition 4:** *Consider a temporary (for  $t = 1$ ) large increase in the price paid by the large buyer from  $p$  to  $p' > p_D$*

P4.1 *The impact on deliveries to the large buyer at  $t = 1$  is ambiguous.*

P4.2 *If the option to be paid in cash (i.e., a liquidity incentive) is added to the price increase, deliveries at  $t = 1$  increase by a larger amount (and equal production levels).*

The proposition shows that, in response to a price increase, deliveries might increase or decrease depending on whether the (positive) price effect or the (negative) income effect dominates. If farmers are also given the option to be paid in cash, they will simply switch all the deliveries to the large buyer and the above income effect no longer holds.

### 3.5 Bringing the Theory to the Data

The empirical work presented in the remainder of the paper follows closely the steps of the theory. The table below summarizes the empirical strategy to test each key assumption and prediction of the model. In the first two empirical sections (i.e., Section 4 and Section 5), we provide evidence in support of the two microfoundations of the model: *i*) Farmers have a demand for low frequency payments, which arises (at least in part) from a demand for commitment (*Proposition 1*); *ii*) traders face credibility concerns which affect their ability to supply monthly payments (*Proposition 2*). The evidence relies on a combination of incentivized choice experiments, survey and administrative data analysis, and a simple calibration exercise.

The second part of the empirical work (i.e., Section 6) focuses on the equilibrium predictions (*Proposition 3*) and the comparative statics of the model (*Proposition 4*). First, using administrative and survey data, we provide additional evidence on the patterns of coexistence

of buyers who purchase with very different terms. Second, we run a randomized experiment to test the impact of an increase in the prices paid by the large buyer and to assess how this interacts with the frequency of payments.

*Roadmap Table: From Theory to Empirics*

Theory Prediction	Empirics
<b>Proposition 1:</b> Producers' demand for infrequent payments as a saving tool.	<b>Section 4:</b> Choice Experiments.
<b>Proposition 2:</b> Buyers' supply infrequent payments depends on their credibility.	<b>Section 5:</b> Survey data, model calibration.
<b>Proposition 3 (§ 1): Equilibrium:</b> Buyers coexist across and within farmers, who sort based on their demand for saving.	<b>Section 6.1:</b> Survey and administrative data.
<b>Proposition 4: Comparative Statics:</b> In a saving-output interlinked market, the impact of price competition is mitigated.	<b>Section 6.2:</b> Experiments, administrative data.

## 4 Producers' Demand for Low Frequency Payments

This section provides evidence on *Proposition 1*: Farmers may have demand for low frequency payments provided by credible buyers. We present results from two experiments where the coop offered farmers the opportunity to choose between different payment frequencies and additional survey evidence.

### 4.1 Demand for Low Frequency Payments

In a preliminary step, we compare payments made by the coop to those made by the small traders. Figure 1 reports the share of traders that pay daily or weekly for the milk (as reported by farmers) and it shows that, for the vast majority of the respondents, all traders pay more frequently than monthly (and, mostly, daily). Figure 2 provides preliminary evidence on the fact that deferred (monthly) payments are associated with *lower* purchasing prices. The figure compares the mean of the highest prices paid by traders in June 2014 (as reported

by farmers) with the coop price.<sup>24</sup> The evidence, consistent with extensive focus groups run prior to the survey, is that traders pay significantly higher prices than the coop. The price paid by the coop is approximately 7 Kenyan shillings lower than the average price paid by the traders. This corresponds to a 25% price gap.<sup>25</sup>

As mentioned in Section 2, there are certainly other potential reasons the cooperative may purchase milk at a significantly lower price. To assess the specific extent to which low frequency payments are an important determinant of farmers' willingness to sell to the coop, we would want to manipulate the timing of payments to farmers while holding constant the type of buyer and the other services (or lack of) provided. The experiments described below implement such a test. In the first experiment, the coop offered a representative sample of 102 active members the option to receive payment for their deliveries on a daily basis for the subsequent month.<sup>26</sup> The daily payment method mimicked the traders' one. Farmers opting for the daily payment would be paid at the collection center, in cash or through mobile money, upon delivery. In addition, the coop offered farmers a price increase of 5 Kenyan shillings per liter (a 16% increase) if they chose the daily payment, thus substantially reducing the gap between coop and traders' prices.

The experiment was completed for 96 of the 102 targeted members (94.1%). The first bar in Figure 3 summarizes the results. We find that only 14% of the farmers choose the daily payment option. A large majority of farmers (86%) are willing to forgo a substantial increase in price in order to retain the monthly payment option. The evidence, therefore, is

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<sup>24</sup>We asked farmers about the highest price paid by these traders. Asking about the highest price provides a more accurate description of a farmer's outside option and allows for a much more accurate benchmarking of the incentive interventions in Section 6. The resulting upward bias is unlikely to qualitatively alter the results since the price paid by the coop is in the left tail of the reported traders' price distribution. Appendix Figure C.1 shows that the gap is even larger once we account for differences in transport costs farmers face to deliver milk to the two types of buyers.

<sup>25</sup>The graph refers to prices in June 2014. Analysis of data from other months delivers very similar patterns. Focus groups confirm the large price gap is a persistent feature of the market. Figure 2 also highlights a dispersion in traders' prices. This is likely to reflect both measurement error (e.g., rounding) and real variation. We note that our model can be easily extended to generate price dispersion across villages, for instance by allowing for different traders' resale costs (see Appendix B for a discussion). Consistent with heterogeneity in transport costs and other village characteristics, we find that about 40% of the variance is explained by village fixed effects. On the other hand, farmers' covariates have a negligible predictive power.

<sup>26</sup>In practice, the coop management informed farmers the coop was piloting new payment systems to increase its deliveries. For the piloting phase, the farmer was offered the option to enter a lottery that would determine actual daily payments for the following month.

consistent with farmers having a high demand for low frequency payments from the coop.<sup>27</sup> When asked the motivation for their choice to select the monthly payments, farmers reported the following as the main reasons: *i*) They try to achieve saving targets (47%); *ii*) they do not trust themselves to handle the cash properly (26%); *iii*) the spouse wants to receive money on the coop account at the end of the month (14%).<sup>28</sup> Interestingly, lack of trust in workers delivering milk, lack of proper saving technology, and pressure to share income with family members, friends, and neighbors were rarely cited as reasons. The nature of the motivations provided by the farmers (i.e., mostly related to saving targets and cash management) supports the theory and alleviates concerns that a *status quo* bias among respondents may be the primary driver of the results.

As a complement to these experimental results, the baseline survey provides insights into farmers' attitudes regarding savings and into the role the coop's low frequency payments play in helping farmers reach their saving goals. Figure 4 summarizes this evidence. First, 82% of the farmers state that they set saving goals, and 87% of these state they reach these goals most of the time. Second, farmers perceive the coop as an important device to meet these goals. Of the farmers who state they set saving goals, 71% say that the coop's monthly payments help in reaching these goals. In addition, 79% say that they would reach these goals less often if the coop paid weekly (instead of monthly). Moreover, while 77% of farmers report that traders' immediate payments provide them with the liquidity they need for daily purchases, 95% of farmers report that coop's infrequent payments allow them to save.<sup>29</sup>

Finally, correlation analysis between farmer characteristics and the demand for the coop low frequency payments provides additional evidence. Table 2, Column (1) shows that the likelihood that farmers set saving goals is higher for farmers who earn regular income from another occupation and for those who report saving in a bank. In addition, present bias is positively correlated with this outcome, suggesting a certain degree of sophistication in our population. Column (2) also shows that farmers who report saving in a bank are more likely

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<sup>27</sup>The experimental evidence is also consistent with the financial diaries of Collins et al. (2009), ch. 7, which suggests that poor households often receive negative interest rates on savings. For instance, in West Africa, participants of *osusus*—a form of saving group—often pay deposit collectors a share of their savings, thus earning negative interest rates (Besley et al., 1995).

<sup>28</sup>When eliciting the motivations, enumerators coded the respondent's answer without prompting answer options.

<sup>29</sup>Focus groups with dairy farmers in several areas of Kenya provide additional suggestive evidence consistent with the above findings (Morton et al., 2000).

to reach these goals. Turning to the relation between the coop and the saving goal outcomes, Column (3) shows that having another regular occupation reduces the likelihood the farmer states that the coop helps reaching the saving goals. When looking at those farmers who claim they would reach the goals less frequently if the coop made weekly payments (Column 4), a pattern of several interesting correlations emerges. First, larger milk producers, as measured by the number of cows, claim they would be less affected by this change. Second, regular income from another occupation lowers again the mean outcome. Third, the impact of the payment frequency on achieving the saving goals is particularly large for present-biased farmers, consistent again with a degree of sophistication. To summarize, the survey evidence indicates that the monthly payments offer an additional service to the farmers.<sup>30</sup>

## 4.2 Low Frequency Payments as a Commitment Device

The survey evidence reported above suggests low frequency payments could act as a commitment device. A second choice experiment, which targeted another random sample of 100 active members (reaching 95 of these), delves into the demand for commitment. The coop offered these farmers the opportunity to choose every day whether they wanted to be paid in cash or at the end of the month for their deliveries. Regardless of the option chosen, farmers received an extra of KSh 5 per liter of milk delivered for that month.<sup>31</sup> The farmer retained control every day on whether to exercise the option to be paid daily or not.

The flexible payment can always replicate the cash flow profile of the monthly payment (if the farmer never exercises the cash option) and it is strictly better if there is minimal uncertainty on traders' availability or prices. In addition, the KSh 5 price increase is higher than the trader prices for about half of the farmers. Although farmers already resist temptation by bringing milk to the coop, the flexibility option still makes it harder to commit since offering cash at the point of sale induces a stronger temptation. Unless farmers need to tie their hands, the monthly payments represent a dominated choice compared to the flexibility option.<sup>32</sup>

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<sup>30</sup>The very high share of farmers choosing the monthly option prevents us from detecting strong correlations between farmers' covariates and the choice experiments.

<sup>31</sup>While the specific determinants of the demand for low frequency payments are not necessary to derive the resulting implications for output markets, understanding the effects of policy changes, including cooperative sourcing strategies, requires a fuller picture of the sources of such demand.

<sup>32</sup>Farmers may dislike the flexibility option because they want to avoid a daily "cost of thinking" (see,

The second bar in Figure 3 summarizes the results. An extremely high share of farmers, 93%, turns down the flexibility option.<sup>33</sup> Further survey evidence supports the above results. Approximately 42% of those choosing the monthly option state that the main reason for doing so is that they want to reach a specific saving target. Another 36% of the farmers state that they don't trust themselves to handle cash properly. Finally, 17% of the farmers mention that their spouse wants to receive the money at the end of the month on the cooperative account.

The results of this second choice experiment show that farmers have a strong demand for commitment devices. Obviously, other factors such as lower transaction costs and safety concerns may still play a role. However, it is not surprising that lack of alternative saving technologies alone does not explain the preference for infrequent payments: More than 70% of the farmers are members of saving groups or hold a bank account. While a growing body of literature has documented demand for commitment (see, e.g., Ashraf et al., 2006), the share of farmers turning down the flexibility option in our second choice experiment is higher than in most other studies. As the model clarifies, however, farmers selling to the coop should precisely be selected based on their demand for commitment.<sup>34</sup>

Both individual time-inconsistent preferences and the desire to hide money to other household members or to family and friends can generate a demand for commitment. As discussed in section 3, in our model,  $\beta$  can capture both sources of demand for commitment and we do not aim at distinguishing them in the experiment. Additional survey evidence however suggests that pressure from (extended) family members, friends, and neighbors is not a primary concern in this setting. Approximately 30% of farmers had been approached by others for financial help within the three months preceding the survey. The timing of these requests

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e.g., Dekel et al., 2001; Ergin and Sarver, 2010; Ortoleva, 2013). However, if this was the only motivation driving the results of the second choice experiment, as opposed to a demand for a commitment device, farmers should chose once and for all the daily payment over the monthly option in the choice experiment presented in Section 4.1.

<sup>33</sup>The results of the two choice experiments are not directly comparable since a relative price increase to incentivize switching was offered only in the first experiment. Note that such asymmetric design is directly derived from the model given the different purposes of the two choice experiments.

<sup>34</sup>The choice to save through the coop is part of broader portfolio allocation strategy in which farmers also have access to other more liquid sources of earnings. The model shows that the availability of monthly illiquid payments is valuable even in the presence of small buyers who pay daily because it allows producers to develop an incentive compatible saving plan that disciplines her future selves across the month.

for help however is not correlated with the timing of payment of the coop.<sup>35</sup>

Finally, we discuss why farmers may prefer infrequent payments to other forms of commitment and why traders cannot solve the credibility problem by transferring farmers' daily payment to a bank account. First, farmers value the lumpiness of monthly payments, but local bank products (e.g., certificates of deposit) typically feature a fixed amount between the time of deposit and the time of payment and thus do not provide the lumping.<sup>36</sup> Second, the coop is in a particular good position to induce commitment since, in the spirit of the equilibrium described in Section 3.3, it puts pressure on the farmers to ensure deliveries. Finally, payment withholding implies the farmer cannot access funds till the end of the month, which would be the case if the farmer had to make deposits in a (commitment) account.<sup>37</sup>

## 5 Buyers' Supply of Infrequent Payments

This section discusses the asymmetry across buyers in the supply of low frequency payments. As documented in Figure 1, essentially all traders (93%) pay more frequently than monthly. If farmers value infrequent payments, why don't traders also provide them? The question is even more puzzling if one considers that small traders are likely to be liquidity constrained and would presumably benefit from delaying payments to the farmers.<sup>38</sup> *Proposition 3* of the model states that, given the equilibrium prices, traders cannot credibly promise low frequency payments. An experimental approach is not well suited for testing this prediction.<sup>39</sup> Instead, we provide evidence supporting the mechanism in the model in three

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<sup>35</sup>Indeed, between 75% and 85% of farmers reports that friends and neighbors wouldn't know how much the coop pays them. The survey also suggests that concerns over workers handling cash do not seem to play an important role to prefer monthly payments over daily payments.

<sup>36</sup>Commitment saving products are available in Kenya (Ravi and Tyler, 2012). However, they often feature additional fees or reduced interest for early withdrawals, rather than a full limitation of access. As an example, the mobile based *M-Shwari Lock Saving Account*, recently launched by Safaricom, penalizes early withdrawals with a mere interest rate reduction of one percentage point. In addition, saving accounts with commitment features offered by commercial banks require an average initial deposit of \$430, an order of magnitude larger than the monthly revenues for most coop members.

<sup>37</sup>Traders could emulate this feature by making daily transfers to a bank, but then both traders and farmers would have to incur transaction costs to transfer the money daily or to verify the payments, respectively.

<sup>38</sup>In principle, the coop also has a demand for trade credit since a large share of its sale payments are on a monthly basis. As noted above, the evidence of lower prices paid by the coop is inconsistent with an equilibrium driven solely by its demand for trade credit.

<sup>39</sup>Consider a trader who offers a farmer the option to be paid at the end of the month (for a portion of the sales). The farmer may reject the monthly payment for many reasons besides lack of credibility, for instance

steps. First, survey evidence shows that farmers do not trust traders ability to commit to low frequency payments. Second, while farmers share information with each other about the coop sourcing policies, they lack information about traders. This may prevent them from punishing traders in case of default. Finally, a simple calibration of the traders’ incentive constraint shows that, given prevailing prices in the market, traders are indeed not able to commit to infrequent payments for broad ranges of plausible parameters.<sup>40</sup>

## 5.1 Survey Evidence

Survey modules elicited farmers’ perceptions of buyers’ ability to credibly promise low frequency payments. Figure 5 presents several findings in this regard. First, farmers *do not want* the traders to provide less frequent payments: Only 18% of the farmers would like traders to pay less often. Moreover, when asked about the main reason for this preference, 56% of the respondents (and 68% of those who said they did not want traders to pay less frequently) state that they are worried traders would default on the contract (“escape”) if left with holding too much money from the farmers.<sup>41</sup> Second, farmers trust traders much less than (members of) the coop: Trust in other coop members or in members of the coop’s board averages 2.4. In contrast, trust in traders averages 1.6, significantly lower. In addition, 78% of the respondents report that the coop is more reliable in payments.

The model suggests the difference between the coop and the traders in offering low frequency payments arises from differences in farmers’ information following a default. By construction, it is hard to provide direct evidence on farmers information following a default.<sup>42</sup> The survey, however, provides evidence on the level of farmers’ information sharing concerning different buyers.

The average respondent reports discussing issues related to coop pricing policies and management with 2.3 other members from the village. This is significantly higher than members’ interaction about dairy practices (1.16). An interesting information episode provides further

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if the implicit interest rate offered with the monthly price is too low. Furthermore, working with many small buyers would present many logistical challenges.

<sup>40</sup>Appendix B endogenizes entry and investment costs to lower  $\gamma$  as well as why small traders might not offer payments at shorter frequencies (e.g., weekly).

<sup>41</sup>The second most frequent reason is that farmers use traders’ payments as a source of day-to-day liquidity.

<sup>42</sup>In equilibrium neither the coop nor the traders default. Should the traders default, the majority of farmers shouldn’t be informed about it.



evidence on farmers' communications about coop policies and pricing schemes. In March 2014, the cooperative issued a letter to some farmers to remind them of the statutory provision according to which members are supposed to sell all milk to the cooperative (Casaburi and Macchiavello, 2015). Around 45% of the farmers in our sample received the letter. An additional 23% of farmers report knowing about it from other farmers. Farmers who had not received the letter were more likely to report having knowledge of it in villages where *i)* they report knowing a higher share of other villagers and *ii)* a higher share of farmers received the letter. In the language of our model, the coop's  $\gamma$  (i.e. the likelihood to find new uninformed farmers after a default) is equal or close to zero: Defaulting against one farmer would then trigger punishment from many farmers and be very costly for the coop.<sup>43</sup> This form of community enforcement lends credibility to the coop.<sup>44</sup>

On the other hand, traders are small: 92% of the farmers report that none of the traders that purchased milk in their village is an agent (or buys on behalf) of another larger buyer. Traders are mostly small itinerant buyers who sell milk either to restaurants in the local area or in Nairobi. They can default on one farmer and then move to a different village where information about the default has not spread. Indeed, when asking the number of traders operating in a village, we find relatively little agreement across respondents (81.5% of the farmers report there is at least one trader in the village, with a conditional average of 5.2): Village fixed effects explain only 9.5% of the variance in the reported number of traders in the village. Analysis of traders' names also finds low levels of agreement. Finally, the data suggest high levels of turnover: When asked about the trader that has operated in the village for *longest*, the median answer is just five years.<sup>45</sup> This suggests relatively little community enforcement available to coordinate punishment against defaulting traders.

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<sup>43</sup>The coop may, however, also have more to gain by defaulting simultaneously on all farmers. So, why doesn't this happen? First, the coop would then incur a loss by not being able to utilize invested capital. Second, such a default by the coop would trigger bankruptcy procedure, i.e., a costlier form of punishment triggered by the legal system. Finally, the fact the farmers own the cooperative might offer an additional deterrent.

<sup>44</sup>See, e.g., Bernheim and Whinston, 1990; Kandori, 1992; Levin, 2002 for similar logic.

<sup>45</sup>Furthermore, assuming the exit of a representative trader is distributed according to an exponential function, and using the formula for the expected value of the maximum of  $N$  such independent random variables, we can estimate an annual probability of trader exit of around 0.4. A high likelihood of exit makes it even harder for traders to be credible.

## 5.2 Trader Incentive Constraint Calibration

This section presents a back-of-the-envelope calibration of the trader incentive constraint associated with an offer of low frequency payments. To this purpose, we adapt the model developed in Section 3 to mimic empirical features of the study setting: A month now includes 30 days ( $t = 0, 1, \dots, 29$ ); production and consumption of the divisible good occur every day; deliveries to the coop do not vary systematically across days of the month,  $x_1^* = x_2^* = \dots = x_{29}^*$ .<sup>46</sup> The modified incentive constraint, adapted from *Proposition 2* (and derived in Appendix A), shows the conditions under which a trader would *not* be able deviate and offer low frequency payments, given (observed) equilibrium prices:

$$p > \frac{1}{30} \delta (1 - \gamma) \frac{1 - \delta^{30}}{1 - \delta} v \equiv p_{empirical}^T \quad (5)$$

*Proposition 3* suggests that, in equilibrium, the coop will set prices so that the inequality will be (weakly) satisfied. Thus, the model provides a tool to check which values of  $\gamma$  (the likelihood a trader finds an uninformed farmer after defaulting on a previous low frequency payment) are compatible with observed prices being an equilibrium of the model. We use the survey data to calibrate the prices,  $p = 31$  and  $p_D = 38$ . For each (annualized)  $\delta$ , we then compute the *minimum* level of  $\gamma$  that would prevent traders from credibly committing.

Figure 6 presents the results. A trader defaults if  $\gamma$  is below the frontier described by the dashed line in the figure. The frontier for  $\gamma$  spans between 0.14 and 0.18: The graph thus shows that, unless farmers are (implausibly) well-informed about traders' default, traders would not be able to commit to monthly payments. The results are not sensitive to discount factors that imply annual interest rates spanning the plausible range of annual returns to capital to traders (from 5% to 233.33% in the figure). Appendix Figure C.2 shows robustness when *i*) the monthly price traders could offer were higher than the coop's (for instance because the current monthly price reflects other benefits the coop provides) and *ii*) traders are time-inconsistent (i.e. their  $\beta < 1$ ).

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<sup>46</sup>We discuss this last point in greater detail in Section 6.2. We also no longer assume that buyers pay interest  $1/\delta$  for deliveries in period 1 (see footnote 17).

## 6 Equilibrium Predictions

This section focuses on the equilibrium predictions and the comparative statics of the model. First, using administrative and survey data, we provide additional evidence on the patterns of coexistence across buyers (*Proposition 3*). Second, we run a randomized experiment to test the impact of an increase in the prices paid by the large buyer and to assess how this interacts with the frequency of payments (*Proposition 4*).

### 6.1 Buyer Coexistence

About half of the farmers in the catchment area of the coop sell to the coop. Table 3 presents results from the listing of dairy farmers conducted in six villages in the catchment area of the cooperative. According to Column (1), farmers who set saving goals are 20 percentage points more likely to sell to the coop (86% vs. 66%). The results are robust when controlling for the number of cows owned by the farmers and then for village fixed effects, Column (2) and Column (3). Column (4) focuses on how often farmers reach these goals (on a 1 to 6 scale). The average score is 3.55 for those selling to the coop and 3.2 for those who do not. The coefficient on the coop dummy shrinks when controlling for the number of cows, Column (5), and it becomes non-significant when including village fixed effects. Overall this correlational evidence is consistent with the theory prediction of an extensive margin sorting of farmers between the coop and the traders on the basis of their saving goals. When interpreted through the lens of the model, the results suggest that among farmers not selling to the coop, those for which  $\Delta_i < \frac{D}{\beta} \underline{\Delta}(p^L)$  (rather than  $\Delta_i > \frac{D}{\beta}$ ) are relatively more prevalent. Those are farmers that either derive low utility from saving (i.e., low  $\Delta_i$ ) or have a degree of time inconsistency such that they cannot commit to save even through the coop (i.e., low  $\beta$ ).

We then focus on sorting along the intensive margin asking to which extent farmers who sell to the coop also sell part of their milk to other buyers. Milk is produced (and sold) twice a day, in the morning and in the afternoon. While afternoon production is around two-thirds of morning production, afternoon deliveries to the coop are about one-third of the morning deliveries. Figure 7 shows the distribution of the number of days with deliveries across members in May 2014 (conditional on more than 10 deliveries). Among these farmers,

80% sell to the coop in the morning at least 29 days. On the other hand, the afternoon distribution is quite bimodal: Of the members, 45% never delivered milk in the afternoon while 27% delivered at least 29 days, with little mass at intermediate values. We interpret this as *prima facie* evidence that many farmers sell to other buyers in the afternoon.

Survey data shed additional light on this pattern. For farmers in the main sample, we can construct measures of “loyalty” to the coop, defined as the ratio between sales to the coop and the production available for sales. Production available for sales is the difference between total production and home consumption (including feeding calves), as reported by farmers in the survey. Figure 8 illustrates the distribution of this measure of loyalty. About 85% of the farmers in the sample sell at least some milk to other buyers.<sup>47</sup> Conditional on selling to other traders, the average sold to other buyers is 45% of the available milk. Consistent with Figure 7, both measures of loyalty are much higher in the morning than in the afternoon (details available on request).<sup>48</sup> Transport costs, driven by the time required to deliver the milk (Figure C.1), are a likely explanation for this pattern. As a result of these travel costs, it is efficient for most farmers to travel to the coop only once a day.

Finally, we consider the model insight that farmers choose a portfolio of buyers to meet both their liquidity needs and their saving goals. This view is supported by the different ways farmers use the money earned from the traders and from the coop. The survey asked how farmers spent the income generated by sales to traders and to the coop in May 2014. Figure 9 illustrates the results. The lump payment from the coop is predominantly (almost 40%) used to finance lumpy expenses in the dairy business, such as purchase of feed and equipment. The corresponding figure for sales to the traders is only 16%. Similarly, larger shares of the coop’s lump payments are used for savings, 15%, or for school fees, 10%, against 6% and 5%, respectively, for income derived from traders. On the other hand, the largest share of the income derived from traders is spent on current expenses, such as purchasing food (55%). The corresponding share for the coop is much lower, at 21%. To summarize, farmers use money paid with different frequency by different buyers for different purposes.<sup>49</sup>

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<sup>47</sup>When looking at self-reported figures, we find that 37% of the farmers sell to other traders.

<sup>48</sup>Importantly, there is no marked difference in buyer availability between morning and afternoon. The coop collection centers open at both times. Survey data suggest that about 50% traders are available to purchase both in the morning and the afternoon. Among those available only part of the day, about 40% (60%) are available only in the morning (afternoon).

<sup>49</sup>Results are similar when restricting the analysis to the subset of respondents who report selling to

## 6.2 Supply Responses to Price Changes: Price and Liquidity

The final part of the paper studies how, in an interlinked saving-output market, producers' sales respond to price and liquidity incentives. *Proposition 4* guides the empirical approach. Specifically, as the coop would like to increase afternoon deliveries, we designed an experiment to test the impact of price and liquidity incentives on afternoon deliveries. In the experiment, 398 farmers surveyed at baseline were randomly assigned to three groups: Two treatments (150 in each) and one control group (98). In the first treatment, farmers were informed that for the subsequent three days they will receive a bonus of KSh 10 per liter (an increase of approximately 30% relative to the baseline price) for afternoon deliveries. For most farmers, the bonus makes the coop price higher than the traders'. In the second treatment, in addition to the price increase, farmers were given the option to choose on a daily basis whether, for the deliveries in that day, they wanted to receive payment in cash on the spot or to retain the standard monthly payment. The farmers were given the opportunity to be paid in cash for morning and/or afternoon deliveries for the three days according to their choice. The model predicts *i*) an ambiguous response of deliveries to the first treatment, and *ii*) a larger and unambiguously positive response to the second treatment.<sup>50</sup>

The randomization was stratified by farmer location (i.e., four zones) and baseline delivery levels. Table 4 confirms that the randomization worked overall. However, the proportion of male respondents differs across the two treatment groups (p-value=0.052) and the proportion of farmers reporting access to traders differs across the flexibility and the control group (p-value=0.079). Around 6% of the treatment farmers could not be reached before the intervention (comparable across treatment groups). The empirical analysis follows an *intention-to-treat* difference-in-differences specification with farmer fixed effect:

$$y_{it} = \eta_i + \beta Post_{it} + \gamma Bonus_i * Post_{it} + \delta(Bonus + Flexibility)_i * Post_{it} + \epsilon_{it}, \quad (6)$$

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traders. The findings are consistent with the model of Banerjee and Mullainathan (2010) and with evidence from Haushofer and Shapiro (2013), who find that monthly transfers from an unconditional cash transfer program are more likely than lump-sum transfers to improve food security, while lump-sum transfers are more likely to be spent on durables.

<sup>50</sup>The choice of paying higher prices for afternoon deliveries only was driven by two considerations. First, those are deliveries that farmers most likely sell to traders. Second power calculations showed that it would have been impossible to detect even potentially large effects on morning deliveries. See below for a discussion of results on morning deliveries.

where the outcome variable captures farmer  $i$  (afternoon) deliveries to the coop in day  $t$ . For each farmer, we include the three days of the intervention ( $Post_{it} = 1$ ) and the same three calendar days of the month before the treatment ( $Post_{it} = 0$ ). Note that the model includes farmer fixed effects, which subsume the treatment group dummies.

Figure 10 summarizes the findings. The *bonus* treatment (the large price increase) has a positive but only small impact on the afternoon deliveries. The impact of the *bonus+flexibility* treatment is about twice as large, though still small in absolute value. Table 5 confirms the results. We first focus on kilograms delivered to the coop in the afternoon. Column (1) presents an OLS using only observations from the three days of the experiment. Column (2) shows results from a difference-in-differences model. Column (3) reports the estimation of the model presented in Equation 6. Consistent with *Proposition 4.1*, which predicts an ambiguous impact of a price increase due to the opposite effect of income and substitution effects, the large bonus treatment has a small impact on afternoon deliveries (0.12 kg).

The flexibility group—where 30% of the farmers choose the afternoon flexibility option—displays an increase in afternoon deliveries of 0.25 kg per day and an increase in the likelihood that farmers deliver any afternoon milk of 6.8 percentage points, compared with a baseline level of zero. While, as per the prediction in *Proposition 4.2*, the point estimate on this treatment is larger than the one on the bonus treatment, the p-value of the difference in coefficients is 0.21-0.29 and the overall impact is still quite small.

Using a binary indicator equal to one if the farmer sold any afternoon milk delivers similar results (Columns (4)-(6)). Columns (7)-(9) show results for morning deliveries. The point estimate of the bonus is negative. While the large standard errors prevent us from drawing any conclusion, this is consistent with farmers substituting so to keep their *total* revenues from coop constant (which would occur in *Proposition 4.1* with linear utility).<sup>51</sup>

Overall, the evidence is qualitatively consistent with the predictions of the model. The response of afternoon deliveries to the flexibility treatment, however, appear to be quantitatively smaller than predicted. Several factors could explain the discrepancy. First, the very large price increase may still not be large enough to match the trader net prices, inclusive of transport costs. Survey evidence, however, suggests that this could be an issue for at most

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<sup>51</sup>In other words, “gaming” of the treatment in which farmers simply *substitute* morning deliveries for afternoon ones is coherent with the logic of the model in which farmers might *reduce* deliveries as higher price allows them to reach their saving target more easily.

a small minority of farmers. Second, some farmers may not have enough milk to sell, once accounting for consumption and other domestic usages. However, at least 45% of the farmers report selling milk in the afternoon to the traders and this estimate is likely to be a lower bound because of under-reporting. Third, if farmers sell to traders with whom they have relationships, the farmer might be unwilling to jeopardize the relationship with the trader to earn a substantial price increase from the coop for a limited amount of time. However, this hypothesis is at odds with survey evidence. While we do not know whether farmers always sell to the same trader, 90% of the farmers report that the traders do not provide any additional service, which we would expect if relationships were important. Consistent with some of the above explanations, Table 6 shows suggestive evidence that the impact of the *Bonus + Flexibility* treatment is stronger for farmers with higher (morning) delivery levels (Column 1), for those who are less loyal to the coop (Column 2, though this is not significant at conventional levels), and for those who report access to another trader (Column 3).

Another potential explanation for the limited responsiveness of both treatments is that farmers follow a simple heuristic: They sell to the coop in the morning and to traders in the afternoon. Simple heuristics might help time-inconsistent agents resist temptations.<sup>52</sup> Additional evidence support this interpretation. Figure 11 shows a *flat* profile in coop deliveries across days of the month. In addition, very few farmers deliver amounts of milk that systematically differ between the beginning and the end of the month; a fact consistent with Figure 7. Appendix B discusses further evidence, an additional (incentivized) framed field experiment, and the implications for organizational change.<sup>53</sup> This evidence also alleviates concerns that the short duration may have driven the low responsiveness we detected (see, e.g., Jayaraman et al., 2016).<sup>54</sup> An implication of such a rule of thumb is that it would be a potentially risky decision for the coop to extend flexible payment to farmers as it might lead farmers to change their perception of the coop as provider of low frequency payments.<sup>55</sup>

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<sup>52</sup>See, e.g., Bénabou and Tirole (2004) and Bernheim et al. (2015) for a theoretical discussion and Dupas and Robinson (2014) for empirical evidence on rules of thumb. The constant allocation of sales to different buyers is reminiscent of naive diversification (or “1/n” allocation rule) extensively documented in consumption and saving decisions (Simonson, 1990 and Benartzi and Thaler, 2001).

<sup>53</sup>A fixed transport cost could explain why farmers bring their semi-daily output to only one buyer but not why they split in the same way across all the days of the month.

<sup>54</sup>The rule of thumb is consistent with narrow-bracketing but the other results point at demand for saving commitment, suggesting that such narrow-bracketing indeed arises from time-inconsistency: Sophisticated agents use it to reach saving goals.

<sup>55</sup>These risks add to difficulties in implementing change when practices are complementary, as emphasized

## 7 External Validity and Concluding Remarks

The paper has studied how saving market imperfections spill over into other markets. In accord with a theoretical framework of this interlinkage, the empirical analysis—based on administrative data, surveys, and multiple experiments—provided evidence on producers’ demand for low frequency payments; buyers’ asymmetry in their ability to credibly supply them; an output market in which many producers sell contemporaneously to buyers offering different purchasing terms; and implications for firm competition strategies, such as price increases. A range of welfare and policy implications arise from the relationship among missing saving markets, output market structure, and imperfect contract enforcement.

While the study is based on a specific setting, its findings are of interest for a broad class of markets featuring saving-constrained producers. In the spirit of Deaton (2010), the theory presented in the paper plays a key role for any external validity consideration. The empirical analysis (including, but not limited to, randomized experiments) is designed to test theoretical predictions that, under the stated assumptions, are valid beyond the specific context. In addition, the close link between the model and the empirics provides a battery of (related) tests to assess the actual relevance of the proposed mechanisms in other settings.

In this final section, we present original survey evidence from a variety of contexts lending support to the mechanisms described in this paper. Figure 12 considers producers’ demand for infrequent payments in the Kenya tea sector and among line supervisors in large garments factories in Myanmar. In both cases, the graph reports patterns remarkably consistent with those documented for our dairy farmers. In many agricultural value chains large buyers source through low frequency payments. An ideal example is provided by smallholder tea contract farmers selling to large companies (UNCTAD, 2009). Tea farmers pick leaves and sell them multiple days per month (10-20 days depending on the timing of the season). The high frequency at which tea leaves are picked opens up the possibility for the existence to both frequent and infrequent payments. We conducted a survey on a random sample of 100 such farmers in Western Kenya. Figure 12 shows that 81% of the respondents mention monthly payments as their preferred payment frequency and 95% say monthly payments help with saving.

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in the management literature (see, e.g., Brynjolfsson and Milgrom, 2013).



The proposed mechanism has several implications for other important markets, including the labor one. The model in Section 3 can almost literally be reinterpreted with producers being workers supplying one unit of labor per period. Selling to traders would correspond to (informal) self-employment and selling to large buyers would correspond to employment in a large firm. Thus, it is useful to explore the extent to which the proposed mechanism might apply to a labor context. Figure 12 also reports results from a survey of 34 Myanmar garment factory workers (specifically, line supervisors). All the respondents mention that monthly is the preferred payment frequency and 84% state that monthly payments help reach their saving goals. The striking similarity with the answer provided by our farmers suggest that implementing our choice experiment within this context would likely yield very similar results. In a broader historical perspective, the establishment of the factory system was accompanied by a shift toward (semi-)monthly payments (Engerman and Goldin, 1991). Clark (1994) argued that the monitoring associated with the factory system helped worker dealing with self-control in effort provision. Our results suggest that it can also help with self-control in saving and spending habits.<sup>56</sup>

The second ingredient of our analysis is that larger firms are better positioned to offer such low frequency payments. In the tea setting, the survey shows that large buyers (cooperatives and large estates) pay monthly but smaller traders predominantly (68%) pay daily. Figure 13 provides further support. In a survey of 198 coffee mills in Rwanda, the graph documents a strong correlation between firm size and the likelihood the firm pays its (seasonal) workers on a monthly basis: 71% of the firms in the top quartile of the size distribution pay monthly but only 30% of the firms in the bottom quartile do. The figure is qualitatively consistent with the evidence from the dairy and tea markets in which large buyers (cooperatives and estates) pay less frequently than small traders.<sup>57</sup> We believe this mechanism unveils an

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<sup>56</sup>A variety of labor markets institutions aim at helping workers save, e.g., in anticipation of high expenses during festivities. These include *Employee Christmas Clubs*, which are common in the United States, Eid Bonuses paid by government and large firms in Bangladesh ahead of Eid-al-Fitr, and *Thirteenth Salaries*, which employers pay to workers in December in Brazil, Germany, and Philippines, among other countries. In Italy, a recent policy (*Legge di Stabilità 2015*) gave some workers the option to cash a portion of their severance pay. Media reports suggest that less than 1% took up this opportunity (*La Repubblica*, 2015). Existing literature studies consumption smoothing across paychecks (see, e.g., Stephens, 2003 and Shapiro, 2005) and the effects of earnings frequency on consumption (see, e.g., Parsons and Van Wesepe, 2013 and Berniell, 2015).

<sup>57</sup>Beyond agricultural value chains and labor markets, our evidence is also relevant for the analysis of trade credit contracts. Trade credit often flows from small to large firms (Petersen and Rajan, 1997; Klapper et al.,

additional benefit of larger, modern organizations in fostering growth, by increasing saving and asset accumulation.<sup>58</sup> To summarize, the interlinkage described in this paper may apply to several markets that feature saving-constrained producers, thus affecting their structure and functioning. While we are aware the examples in this section are just a first step, we hope they will provide motivation for future research.

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2011). Our paper suggests that, among other reasons (e.g., buyer market power), this may arise because small producers have a demand for “trade saving.”

<sup>58</sup>While we recognize this pattern is only suggestive and could be accounted for by other mechanisms, it runs counter to the intuition that larger firms would be less credit constrained and could pay suppliers and workers *more* frequently. We thank Ameet Morjaria for sharing the data.

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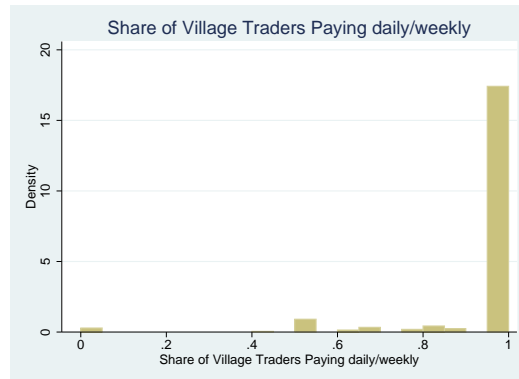
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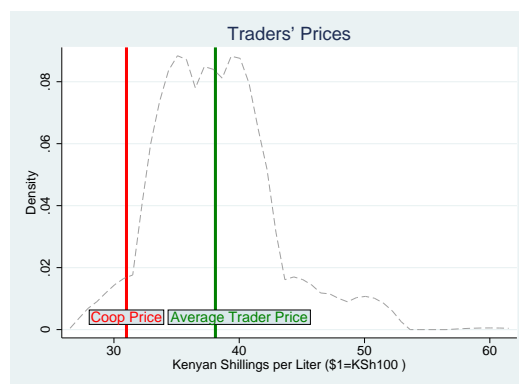
# Figures

Figure 1: Payment Frequencies



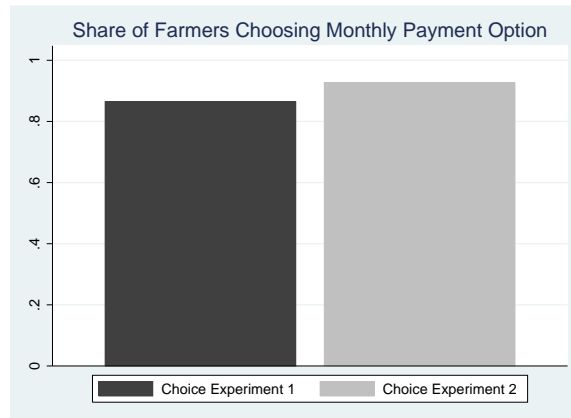
*Notes:* The figure presents the distribution of traders payment frequency. and it shows that traders pay less frequently than the coop. For each farmer, we compute the share of traders paying more frequently than once a month among all traders buying in the village, as reported by the farmer in the baseline survey. The sample is restricted to farmers reporting at least one trader in the village.

Figure 2: Prices



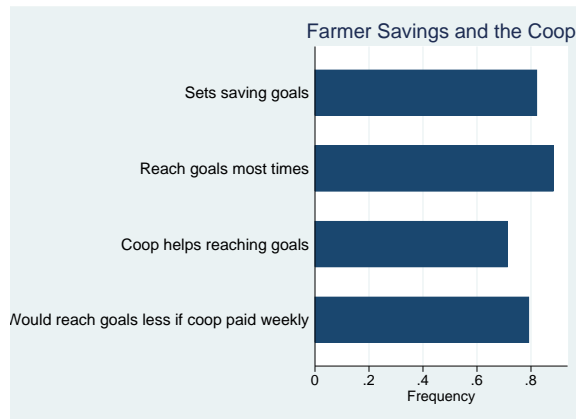
*Notes:* The Figure shows that traders pay higher prices than the coop. The figure reports the price per liter of milk paid by the coop (Ksh. 31, red line), the average price paid by the best trader in the village (Ksh. 38, green line), and the distribution of best traders' prices in June 2014. Traders' prices were reported by the farmers in the baseline survey described in Section 2.

Figure 3: Choice Experiments



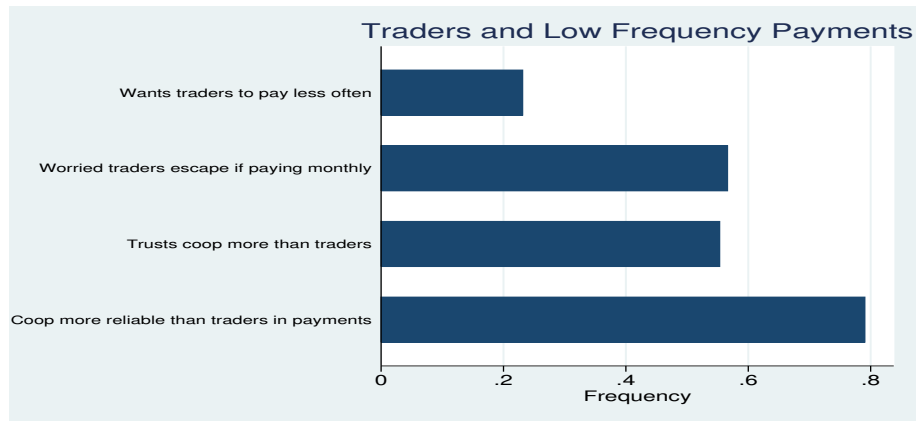
*Notes:* The figure presents results from the choice experiments reported in Section 4. The first bar focuses on the first choice experiment. It reports the share of farmers who choose monthly payments over daily payments with a bonus of KSh 5 (from a baseline of Ksh31). The second bar focuses on the second choice experiment. It reports the share of farmers who chose monthly payments over the “flexibility” option, which would allow them to choose every day whether to be paid daily or monthly. The two experiments are not directly comparable since a bonus of Ksh 5 was offered in the second experiment regardless of choice.

Figure 4: Savings and the Coop



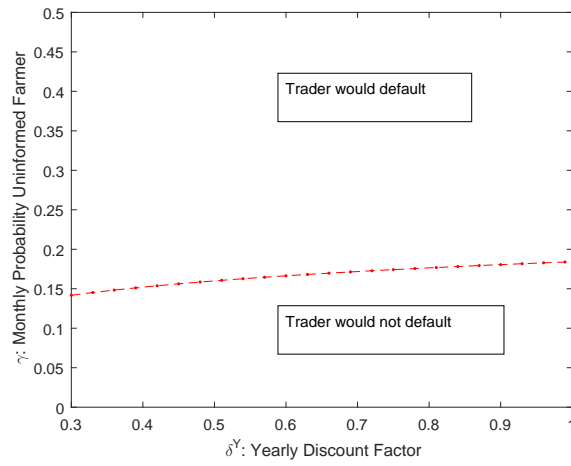
*Notes:* The figure presents summary statistics on farmer savings behavior and on the role of the coop in helping savings. All the variables are binary indicators and the horizontal bars display the frequency of farmers agreeing with the statement in the baseline survey. For the first variable, “*Set saving goals*”, we use the entire baseline sample. For the other variables, we restrict the sample to those farmers who state they set saving goals. “*Would reach goals less if coop paid weekly*” takes value one if a farmer answers “less often than I do currently” to the question “If the coop paid every week, how often would you reach your saving goals?”

Figure 5: Traders



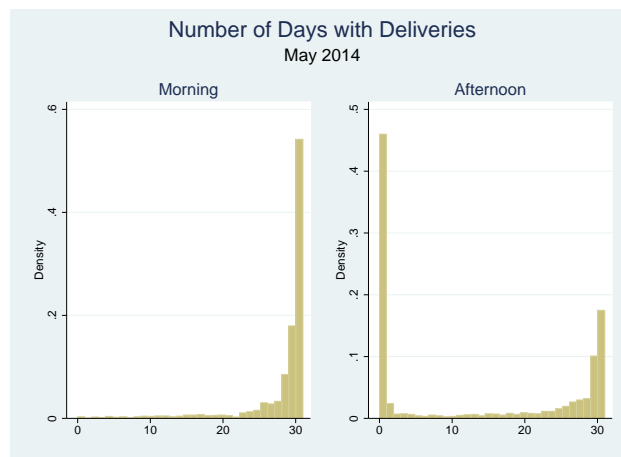
*Notes:* The figure presents summary statistics on farmer attitudes toward traders other than the coop. The binary indicators “*Trusts coops more than traders*” and “*Coop more reliable than traders in payments*” are equal to one if the trust score or the payment reliability score are strictly larger for the coop than for other buyers, respectively. In the survey, the variable *Trust* for either the coop and the buyer is measured on an index from 1 to 4 and the average difference between the two is 0.853.

Figure 6: Trader Incentive Constraint Calibration



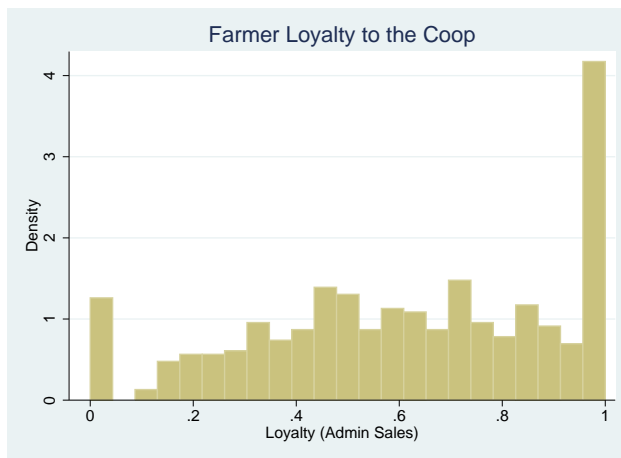
*Notes:* The figure shows pairs  $(\delta^Y, \gamma)$  that satisfy the inequality of the incentive constraint of the empirical model (Equation 5)—where  $\delta^Y$  is the annual discount factor and  $\gamma$  is the likelihood a trader matches with an *uninformed farmer* after a default.  $p$  and  $v$  are calibrated at KSh 31 and 38, respectively. A trader defaults if  $\gamma$  is below the frontier described by the dashed line in the figure. The Figure shows that unless farmers are (implausibly) well-informed about traders default, traders would not be able to commit to monthly payments. The result is not sensitive to discount factors that imply annual interest rates spanning the plausible range of annual returns to capital to traders (from 5% to 233.33% in the figure). Appendix Figure C.2 provides several robustness checks.

Figure 7: Number of Days with Deliveries



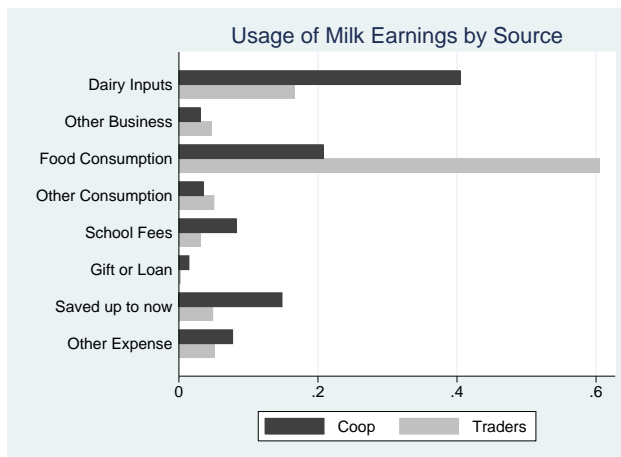
*Notes:* The left (right) histograms present the distribution of the farmer-level number of days with positive deliveries to the coop in the morning (afternoon) in a month (measured in May 2014). The Figure shows that many farmers sell to the coop (almost) every day of the month and (almost) never in the afternoon.

Figure 8: Farmers' Loyalty to the Coop



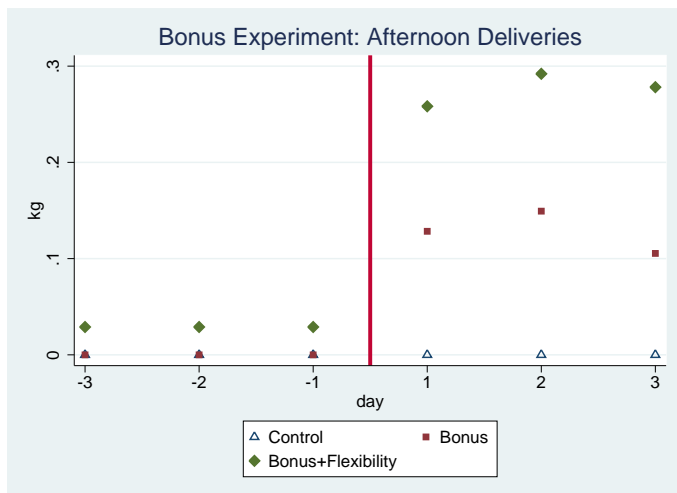
*Notes:* The *Loyalty* variable is defined as the ratio between sales to the coop and production available for sales among farmers in the main survey sample. Production available for sales is defined as the difference between production and home consumption (including feeding calves). Deliveries to the coop are obtained from cooperative records.

Figure 9: Usage of Milk Earnings



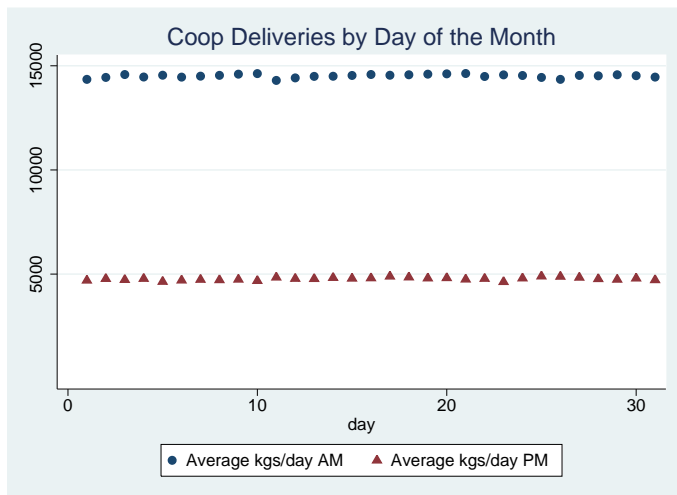
*Notes:* The figure describes how farmers use milk earnings from the coop and from other buyers, respectively. For each type of buyer, we compute the share of expenses on an item, relative to the total earned by the farmer from that buyer.

Figure 10: Bonus Experiment Afternoon Deliveries



*Notes:* The figure reports average afternoon deliveries for the randomized experiment presented in Section 6.2. Days 1 to 3 refer to the days of the experiment. Days -3 to -1 refer to the same calendar days of the month before the experiment.

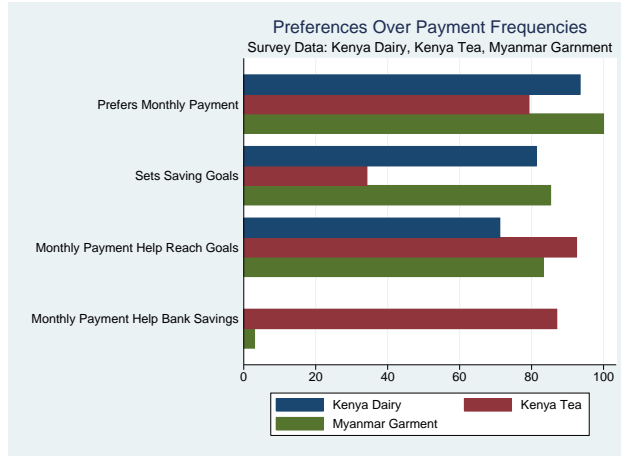
Figure 11: Average Coop Milk Deliveries by Day of the Month



*Notes:* The figure shows 2014 milk deliveries to the coop by day of the month (1st to 31st), for both morning and afternoon deliveries (measured in kilograms). For each day, we average deliveries among the months that include that day. We obtain similar results when removing month fixed effects to account for the fact that months have different end days.

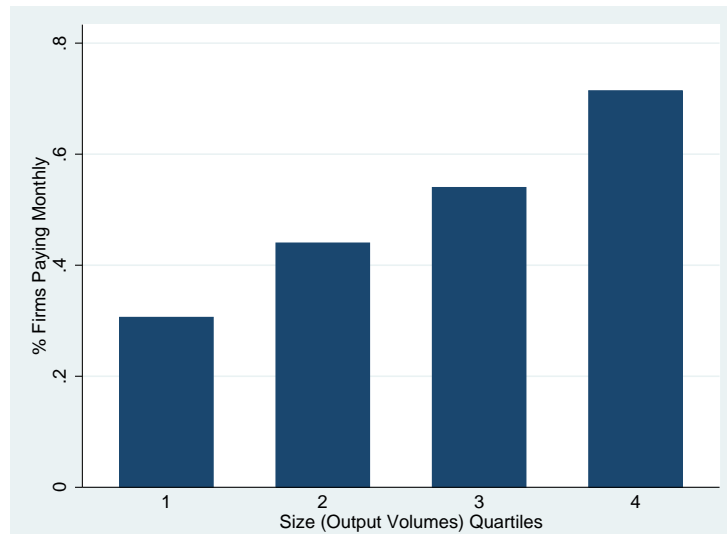


Figure 12: Pay Period Preferences: Three Surveys



*Notes:* The figure reports percentage of respondents agreeing with the four statements in three different surveys: dairy farmers in Kiambu, (Central) Kenya; tea growers in Kericho, (Western) Kenya; and line supervisors in garments factories in Yangon, Myanmar.

Figure 13: Rwanda Coffee Mills Survey



*Notes:* The figure reports the percentage of coffee mills in Rwanda paying monthly wages (as opposed to biweekly, weekly and daily wages) to seasonal employees during the 2015 harvest season. The figure shows larger mills pay *less* frequently. We thank Ameet Morjaria for sharing the data.

## Tables

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Male Respondent	0.425	0.495	0	1	583
Respondent Age	55.635	15.685	18	94	578
Household size	5.091	2.073	1	14	592
Number of Cows	1.446	1.292	0	25	592
Dairy Production (kg)	11.951	7.483	1	64	568
Avg Deliveries (kg) in June 2014	4.327	2.628	0	20.027	595
Loyalty	0.621	0.292	0	1	544
Loyalty AM	0.714	0.282	0	1	558
Loyalty PM	0.501	0.491	0	1	549
Hire workers for dairy	0.268	0.443	0	1	594
Any Other Village Trader	0.815	0.389	0	1	594
Present Biased	0.122	0.328	0	1	565
Difference Trust Coop-Trader	0.853	1.135	-2	3	539
Saves in Saving Groups	0.702	0.458	0	1	591
Saves in Bank	0.74	0.439	0	1	589
Regular Income from Other Occupation	0.201	0.401	0	1	596
HH member manages money not cows	0.295	0.456	0	1	543

*Notes:* The table presents summary statistics from the farmers targeted in the main baseline survey. 2014. *Avg Daily Deliveries* are from coop administrative data. Both production and delivery variables are measured in kilograms. *Loyalty* variables are defined as ratios between sales to the coop and production available for sale (defined as the difference between production and home consumption, including feeding calves). A farmer is defined as *present biased* if she is more impatient when splitting money between today and next week than when splitting money between next week and the subsequent one. *Trust* for either the coop and the buyer is measured on an index from 1 to 4. Therefore, their difference can span -3 to 3. *Regular Income from Other Occupation* refers to permanent employee, civil servant, artisan, trader, and self-employed.

Table 2: Baseline Correlations

	Set Saving Goals	Reach Goals	Coop Helps Goals	Reach Less if Weekly Pyt
	(1)	(2)	(3)	(4)
Number of Cows	-0.003 (0.014)	0.002 (0.005)	0.009 (0.013)	-0.026** (0.010)
Avg Deliveries (kg) in June 2014	0.003 (0.007)	0.009* (0.005)	0.008 (0.008)	0.007 (0.008)
Loyalty	0.071 (0.067)	0.058 (0.057)	0.141* (0.085)	-0.041 (0.075)
Any Other Village Trader	0.025 (0.042)	-0.046 (0.036)	0.100* (0.056)	0.098* (0.054)
Present Biased	0.087** (0.039)	0.033 (0.039)	0.008 (0.063)	0.103** (0.045)
Difference Trust Coop-Trader	0.022 (0.014)	-0.006 (0.012)	0.004 (0.018)	0.036** (0.016)
Saves in Saving Groups	0.137*** (0.039)	-0.037 (0.034)	0.075 (0.048)	0.067 (0.044)
Saves in Bank	0.074* (0.040)	0.097** (0.041)	-0.016 (0.048)	-0.096** (0.040)
Regular Income from Other Occupation	-0.004 (0.040)	-0.023 (0.037)	-0.113** (0.056)	-0.098* (0.052)
HH member manages money not cows	0.095*** (0.031)	0.040 (0.031)	0.015 (0.046)	-0.033 (0.042)
$R^2$	0.075	0.049	0.056	0.082
Dependent Variable Mean	0.821	0.883	0.712	0.789
Observations	591	495	496	497

*Notes:* The table presents correlation between several measures of saving behavior, as measured in the baseline survey, and other farmer covariates. Refer to Table 1 for a description of the covariates. For each of the covariates, the regression also includes a binary indicator for whether that covariate is missing (and missing values in the variables are replaced with an arbitrary negative value). Standard errors are robust to heteroskedasticity. \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

Table 3: Farmer Saving Behavior and Sales to the Coop

	Set Saving Goals			Reach Goals		
	(1)	(2)	(3)	(4)	(5)	(6)
Sells to Coop	0.206*** (0.040)	0.184*** (0.042)	0.206*** (0.047)	0.358*** (0.131)	0.255* (0.133)	0.173 (0.149)
Y Mean (No-Coop)	0.664	0.664	0.664	3.207	3.207	3.207
N.Cows	N	Y	Y	N	Y	Y
Village FE	N	N	Y	N	N	Y
Observations	408	408	408	302	302	302

*Notes:* The analysis uses data from the dairy farmer listing exercise, which targeted a random sample of dairy farmers. The binary variable “Set saving goals” is not missing for 408 of these farmers. The variable “Reach Goals” takes value from 1 (never reach the goals) to 6 (always reach them). The variable is defined only for those farmers who state that they set saving goals. Standard errors are robust to heteroskedasticity. \*p<0.1, \*\*p<0.05, \*\*\*p<0.01.

Table 4: Price and Liquidity Experiment: Balance Table

	Bonus [M]	Bonus+Flex [F]	Control [C]	P-value [M-F]	P-value [M-C]	P-value [F-C]	N
Male Respondent	.3706 (.4846)	.4765 (.5011)	.4123 (.4948)	.052*	.825	.319	389
Respondent Age	58.39 (15.90)	54.96 (15.98)	56.12 (15.05)	.136	.323	.455	387
Household size	4.945 (2.185)	5.306 (1.928)	5.163 (2.064)	.133	.73	.425	395
Number of Cows	1.383 (.6874)	1.346 (.6754)	1.448 (.6904)	.849	.426	.28	394
Average Daily Deliveries in Sep 2014	3.963 (2.257)	4.051 (2.413)	4.216 (2.262)	.826	.199	.302	398
Loyalty	.6632 (.2476)	.6582 (.2516)	.6713 (.2529)	.597	.881	.618	376
Loyalty AM	.7814 (.2225)	.7669 (.2221)	.7611 (.2210)	.405	.659	.743	383
Loyalty PM	.4978 (.5004)	.5057 (.4997)	.5429 (.4943)	.552	.742	.213	378
Hire workers for dairy	.2229 (.4176)	.2516 (.4354)	.2551 (.4381)	.314	.625	.835	397
Any Other Village Trader	.8367 (.3708)	.8807 (.3251)	.7755 (.4193)	.25	.468	.079*	396
Present Biased	.1313 (.3390)	.1103 (.3144)	.1086 (.3129)	.62	.538	.816	374
Difference Trust Coop-Trader	.7591 (1.121)	.9851 (1.126)	.9418 (1.109)	.158	.488	.523	358
Saves in Saving Groups	.6418 (.4810)	.7302 (.4452)	.7395 (.4411)	.121	.09*	.831	396
Saves in Bank	.7260 (.4475)	.7105 (.4550)	.7938 (.4066)	.822	.274	.224	395
Regular Income from Other Occupation	.2094 (.4083)	.2105 (.4090)	.2142 (.4124)	.961	.572	.897	398
HH member manages money not cows	.2463 (.4324)	.2739 (.4475)	.3333 (.4739)	.694	.271	.146	377

*Notes:* The table reports summary statistics and balance tests for the randomized experiment presented in Section 6.2. Farmers in the *Bonus* group received an increase in milk price of 10 Kenyan shillings for afternoon deliveries. Farmers in the *Bonus+Flexibility* group received the same price increase and the option to be paid daily. The randomization was stratified by farmer location (i.e., four zones) and baseline delivery levels (i.e., above/below median). We report p-values based on specifications that include stratum fixed effects. \*p<0.1, \*\*p<0.05, \*\*\*p<0.01.

Table 5: Price and Liquidity Experiment: Main Results

	Kg PM			Kg PM (dummy)			Kg AM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post*Bonus ( $\gamma$ )		0.128** (0.050)	0.128** (0.050)		0.043*** (0.015)	0.043*** (0.015)		-0.223 (0.283)	-0.223 (0.283)
Post*(Bonus+Flexibility) ( $\delta$ )		0.245** (0.098)	0.245** (0.098)		0.068*** (0.020)	0.068*** (0.020)		-0.009 (0.316)	-0.009 (0.316)
Post		-0.008 (0.008)	-0.008 (0.008)		-0.004 (0.004)	-0.004 (0.004)		-0.218 (0.211)	-0.108 (0.205)
Bonus	0.153** (0.062)	-0.000 (.)		0.047*** (0.017)	-0.000 (0.000)		-0.319 (0.259)	-0.336 (0.304)	
Bonus+Flexibility	0.286*** (0.105)	0.029 (0.029)		0.074*** (0.022)	0.007 (0.007)		-0.281 (0.293)	-0.420 (0.302)	
$R^2$	0.186	0.028	0.038	0.252	0.038	0.054	0.506	0.008	0.011
p-value $\gamma = \delta$	0.211	0.287	0.286	0.235	0.315	0.315	0.886	0.496	0.496
Control Group Mean (Post Period)	0.000	0.000	0.000	0.000	0.000	0.000	4.110	4.110	4.110
Farmer FE			X			X			X
Farmers	398	398	398	398	398	398	398	398	398
Observations	1194	2388	2388	1194	2388	2388	1194	2388	2388

*Notes:* The table presents the results of the randomized experiment presented in Section 6.2. The table reports three measures of daily deliveries: kilograms delivered in the afternoon; a dummy for whether the farmer delivers any milk in the afternoon; kilograms delivered in the morning. For each farmer, the regression includes a maximum of six observations. Three observations come from the experiment days ( $Post = 1$ ) and three from the same calendar days in the previous month ( $Post = 0$ ). For each outcome, the first model (Columns (1), (4), (7)) is an OLS run only on the three  $Post$  observations, controlling for the average level of the outcome in the three baseline observations. The second model (Columns (2), (5), (8)) is a difference-in-differences. The third model (Columns (3), (6), (9)) adds farmer fixed effects to the difference-in-differences, as in Equation 6. In Columns (1), (4), and (7), the row “p-value  $\gamma = \delta$ ” reports the p-value from testing equality of the coefficients on *Bonus* and *Bonus+Flexibility*. In the other columns, the row “p-value  $\gamma = \delta$ ” reports the p-value from testing equality of the coefficients  $Post*Bonus$  and  $Post*(Bonus+Flexibility)$ . Standard errors are clustered at the farmer level. \*p<0.1, \*\*p<0.05, \*\*\*p<0.01.

Table 6: Price and Liquidity Experiment: Heterogeneous Treatment Effects

	(1)	(2)	(3)
Post*Bonus ( $\gamma$ )	-0.009 (0.066)	0.059 (0.036)	0.294 (0.182)
Post*(Bonus+Flexibility) ( $\delta$ )	-0.273 (0.223)	0.413** (0.197)	0.046 (0.045)
Post*Bonus*Average Daily Deliveries in Sep 2014	0.034 (0.023)		
Post*(Bonus+Flex)*Average Daily Deliveries in Sep 2014	0.128* (0.074)		
Post*Bonus*Loyalty PM		0.093 (0.087)	
Post*(Bonus+Flex)*Loyalty PM		-0.314 (0.205)	
Post*Bonus*Any Other Village Trader			-0.235 (0.185)
Post*(Bonus+Flex)*Any Other Village Trader			0.228* (0.121)
$R^2$	0.087	0.051	0.043
Dependent Variable Mean	0.082	0.080	0.076
Farmer FE	X	X	X
Farmers	398	378	396
Observations	2388	2268	2376

*Notes:* The table presents heterogeneous treatment effects for the randomized experiment presented in Section 6.2. We report results from the difference-in-differences model with farmer FE from Table 5, Column (3). The dependent variable is the kilograms of milk the farmer delivers to the coop in the afternoon. Refer to the notes of Table 5 for further details on the specification. Refer to Table 1 for a description of the covariates. Standard errors are clustered at the farmer level. \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

# Appendix

## A Proofs

The following proposition summarizes the unique subgame perfect equilibrium of the stage game with homogeneous farmers and underpins the formulation in the main text:

### Preliminary Observations and Proof of Proposition 1

Before offering a proof of Proposition 1 we first characterize the farmers supply function to the large buyer. *Self 3* incentive constraint puts a cap on the amount of savings *Self 2* can leave:  $\frac{s_2}{\delta^2} - D + \beta\delta\Delta \leq \frac{s_2}{\delta}$ . Given  $s_2 = D\delta^2$ , the constraint is binding if  $\beta < \frac{D}{\Delta}$ . If the constraint is not binding, then the farmer can save by herself.

Consider a farmer who purchases the indivisible by saving through sales to the large buyer, so that  $p(x_1/\delta + x_2) = D$ . *Self 1* of such a farmer sets deliveries  $x_1, x_2$  to maximize her utility, conditional on the incentive constraint of *Self 2*. For a given monthly price  $p$ , the incentive constraint of *Self 2* is  $(1 - \hat{x}_2)v + \beta\delta^2\Delta_i \geq v$ . Since *Self 1* always wants to anticipate consumption as much as possible (subject to implementing a saving plan that induces *Self 2* and *Self 3* to buy the indivisible) the constraint must be binding:  $x_1^* = \delta \frac{Dv - p\beta\delta^2\Delta_i}{pv}$  and  $x_2^* = \frac{\beta\delta^2\Delta_i}{v}$  (*Proposition 1.3*).

To induce the farmer to sell (part of) her output through monthly payments, the monthly price must be such that her utility when purchasing the indivisible is larger than the utility when not purchasing it:  $U_1^x \equiv v - x_1^*v + \beta\delta(v - x_2^*v + \delta^2\Delta_i) = U_1^s - v(x_1^* + \beta\delta x_2^*) \geq v(1 + \beta\delta)$ . The inequality holds if  $p \geq \frac{D}{\beta\delta^2\Delta_i(2-\beta)}v$ . This provides the minimum threshold  $\Delta_i$  such that the farmer is willing to sell to the large buyer. This completes the derivation of the farmers' supply function.

The proof of Proposition 1 is then straightforward. If the large buyer sets price  $p = v/\delta^2$  profits are equal to zero. If price  $p \rightarrow 0$  then profits are also zero as no farmer delivers. In between there will be a (generically) unique maximizing price. This completes the Proof. ||

### Proofs of Proposition 2

In the last period of a given month,  $t = 4$ , a trader can resist the temptation to default on the amount due to the farmer if:  $-p(x_1^*/\delta + x_2^*) + \delta \sum_{s=0}^{\infty} \delta^{4s}(v(x_1^* + \delta x_2^*) - \delta^3 p(x_1^*/\delta + x_2^*)) \geq \delta \sum_{m=0}^{\infty} \delta^{4m}(1 - \gamma)^m \sum_{s=0}^{\infty} \gamma \delta^{4s}(v(x_1^* + \delta x_2^*) - \delta^3 p(x_1^*/\delta + x_2^*))$ . Given  $p(x_1^*/\delta + x_2^*) = D$ , substituting for  $x_1^*$  and  $x_2^*$  and simple algebra delivers the inequality in (3). For the large buyer the constraint is given by the same expression after



setting  $\gamma = 0$ . ||

#### Proof of Proposition 4

The proposition is proved in steps. First, we solve by backward induction the problem of the producer. Second, we analyze comparative statics on deliveries  $x_1$  with respect a temporary increase in prices. To do so we solve the model distinguishing between price  $p_1$  and  $p_2$  and then perform comparative statics with respect to  $p_1$  when  $p_1 = p_2$ .

##### Step 1: Consumption $c_3$ and Self-2 Incentive Constraint

Since the producer must buy the indivisible out of savings from deliveries to the large buyer, S2 savings are used by S3 to purchase  $c_3$  only, i.e.,  $c_3 = s_2/\delta$  and  $\hat{x}_2 = \frac{D-(p_1x_1)/\delta}{p_2}$ . In turn, S1 must set  $x_1$  and  $s_1$  such that S2 wants to buy the indivisible good. Denoting with  $s_{2\Delta}$  ( $s_{2N}$ ) the level of saving on- (off-) the equilibrium path, the IC of Self 2 is given by

$$u\left(\frac{s_1}{\delta} - s_{2\Delta} + (1 - x_2)v\right) + \beta\delta u\left(\frac{s_{2\Delta}}{\delta}\right) + \beta\delta^2\Delta \geq u\left(\frac{s_1}{\delta} - s_{2N} + v\right) + \beta\delta u\left(\frac{s_{2N}}{\delta}\right).$$

##### Step 2: Self-1 Problem

The budget constraint  $\hat{x}_2 = \frac{D-(p_1x_1)/\delta}{p_2}$  implies that S2 takes  $y_{2E}$  as given both on and off the equilibrium path. The problem of the S1 is then given by

$$\begin{aligned} \max_{s_1, x_1} & u((1 - x_1)v - s_1) + \beta\delta u\left((1 - x_2)v - s_2 + \frac{s_1}{\delta}\right) + \beta\delta^2 u\left(\frac{s_2}{\delta}\right) \\ & x_2 = \frac{D}{p_2} - \frac{x_1 p_1}{\delta p_2} \\ \text{s.t.} & \quad s_{2E} \in \arg \max u(y_E - s_{2E}) + \beta\delta u\left(\frac{s_{2E}}{\delta}\right) \text{ for } E \in \{\Delta, N\} \\ & \text{and (A).} \end{aligned}$$

Saving decisions  $s_{2E}$  are functions of  $y_E$ , for  $E \in \{\Delta, N\}$ , with  $y_\Delta = \frac{s_1}{\delta} + v(1 - x_2)$  and  $y_N = \frac{s_1}{\delta} + v$ . Assuming an utility function in the class  $u(c) = \frac{c^{1-\alpha}}{1-\alpha}$ , for  $\alpha \leq 1$ , the saving decisions of S2 take the form  $s_{2E} = \phi y_E$ , for some constant  $\phi \in (0, 1)$ . The problem of S1 can then be simplified to

$$\begin{aligned} \max_{x_1, s_1} & u((1 - x_1)v - s_1) + \beta\delta u((1 - \phi)y) + \beta\delta^2 u\left(\frac{\phi y}{\delta}\right) \\ & y = \frac{1}{\delta} \left( s_1 + v x_1 \frac{p_1}{p_2} + v \left( \delta - \frac{\delta D}{p_2} \right) \right) \\ \text{s.t.} & \quad u((1 - \phi)y) + \beta\delta u\left(\frac{\phi y}{\delta}\right) + \beta\delta^2\Delta \geq U_2\left(\frac{s_1}{\delta} + v\right) \end{aligned}$$

Recalling that saving's optimization by S2 imposes  $u'_2 = \beta u'_3$ , the first order conditions can be written as

$$\begin{aligned} -u'_1 + \frac{p_1}{p_2} u'_2 \left( (\beta(1 - \phi) + \phi) + \frac{\Lambda}{\delta} \right) &= 0 \\ -u'_1 + (\beta(1 - \phi) + \phi) u'_2 + \frac{\Lambda}{\delta} (u'_2 - \bar{u}'_2) &= 0 \end{aligned}$$

*Step 3: Comparative Statics*

We can distinguish two cases, depending on whether the constraint binds (i.e.,  $\Lambda > 0$ ) or not (i.e.,  $\Lambda = 0$ ). Consider first  $\Lambda = 0$ . In this case, if  $p_1 = p_2$ , the two conditions are the same. The producer is therefore indifferent between any combination that leaves the sum ( $s_1 + vx_1$ ) unchanged. If  $p_1 > p_2$  the solution must then be at the corner  $x_1^* = 1$  giving a positive response of deliveries to temporary price increase.

If the constraint binds (i.e.,  $\Lambda > 0$ ) it is in general not possible to sign the effect of an increase in  $p_1$  on deliveries  $x_1$ . To see why, note that the first order conditions imply

$$u'_2 \frac{\frac{p_1}{p_2} (\beta (1 - \phi) + \phi) \bar{u}'_2}{\left(\frac{p_1}{p_2} - 1\right) u'_2 + \bar{u}'_2} = u'_1.$$

where  $u'_2$  and  $\bar{u}'_2$  denote marginal utility of consumption in period  $t = 2$  on- and off- the equilibrium path respectively.<sup>59</sup> The effect of an increase in  $p_1$  on  $u'_1$  (and, therefore,  $x_1$  depends on the curvature of the utility function:

$$\text{sign} \left| \frac{\partial u'_1}{\partial \left(\frac{p_1}{p_2}\right) \Big|_{p_1=p_2}} \right| = \text{sign} \left| \left( \underbrace{-(u'_2)^2 + u'_2 \bar{u}'_2}_{>0 \text{ as } \bar{u}'_2 > u'_2} + \underbrace{\bar{u}'_2 \bar{u}'_2}_{\text{by } \bar{u}'_2 < 0} \right) \right| \leq 0.$$

**Derivation of empirical trader IC constraint (Equation 5)**

Denoting with  $\delta$  the daily discount rate and with  $\gamma$  the monthly probability of finding an uniformed after a previous default, the incentive constraint for a trader sourcing  $x$  units of milk every day for a month and paying unit price  $p$  at the end of the month is given by

$$\begin{aligned} & -30px + \delta \sum_{s=0}^{\infty} \delta^{30s} \left( \sum_{t=0}^{29} \delta^t vx \right) - 30\delta^{29} px \\ & \leq \delta \sum_{u=0}^{\infty} \delta^{30u} (1 - \gamma)^u \sum_{s=0}^{\infty} \gamma \delta^{30s} \left( \sum_{t=0}^{29} \delta^t vx \right) - 30\delta^{29} px \end{aligned}$$

This inequality simplifies to

$$\begin{aligned} -30p + \frac{\delta}{1 - \delta^{30}} \left( \frac{1 - \delta^{30}}{1 - \delta} v - 30\delta^{29} p \right) & < \frac{\delta}{1 - \delta^{30}} \frac{\gamma}{1 - \delta^{30}(1 - \gamma)} \left( \frac{1 - \delta^{30}}{1 - \delta} v - 30\delta^{29} p \right) \\ & \Leftrightarrow p > \frac{1}{30} \delta (1 - \gamma) \frac{1 - \delta^{30}}{1 - \delta} v \equiv p_{\text{empirical}}^T \end{aligned}$$

as reported in the text. ||

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<sup>59</sup>Note that if  $p_1 = p_2$ , then  $u'_2 ((\beta (1 - \phi) + \phi)) = u'_1$  and consumption in  $t = 1$  is distorted *upward* (since reducing savings left to S2 makes it easier to provide incentives due to the concavity of the utility function).

## B Model Assumptions and Extensions

This Appendix discusses several extensions to the baseline model presented in Section 3, as well as a discussion of some of its main assumptions. We cover: *i*) assumptions (and related extensions) on the large buyers' strategies and contractual space, including price discrimination, bundling of daily and infrequent payments, and objective functions; *ii*) assumptions on small buyers, including heterogeneity and multiple payment frequencies; *iii*) assumptions on producers, including access to credit, personal rules (across months) and heuristics.

### B.1 Large Buyers: Price Discrimination, Bundling, and Credit

#### B.1.1 Price Discrimination

We assumed large buyers cannot discriminate across producers with different utility from the indivisible good,  $\Delta_i$ . It is easy to see that the model is robust to (perfect) price discrimination. In the case of one large buyer, he would offer each producer either the price that makes her indifferent between purchasing the indivisible or not,  $p^F(\Delta_i)$ , or the threshold price that prevents small buyers from competing,  $\hat{p}^S$ , provided these are below the threshold credible price for the large buyer,  $\hat{p}^M$ . We can modify *Proposition 3* and state that, with price discrimination, the large buyer will pay the following price to a producer with  $\Delta_i$ :  $\hat{p}^L(\Delta_i) = \max[\min\{p^F(\Delta_i), \hat{p}^M\}, \hat{p}^S]$ . In the case with multiple large buyers, competition would obviously prevent discrimination.

At this point, it is also worth to note that, in our study setting, price discrimination is ruled out by the cooperative bylaws. The cooperative management is reluctant to introduce forms of price discrimination because of prevailing norms and the fear of upsetting farmers that would receive a worse deal. The concern is that farmers paid lower prices would perceive to be treated unfairly and withdraw their deliveries to the coop. We conjecture that such bylaws provisions (and the norms they possibly generate) are used to limit abuse and rent-seeking within the cooperative (see Casaburi and Macchiavello, 2015, for a discussion).

#### B.1.2 Bundling and Cash Payments

So far we have assumed that the large buyer does not offer daily payments. We now consider whether the large buyer could possibly profit from offering a bundling contract to the farmer in which deferred payments are offered only to those farmers that supply all their production in both periods. We start by considering a simplified version of the model with homogeneous farmers. Denoting with  $T_1$  and  $T_2$  the cash payments the large buyer offers to meet liquidity needs, the problem of the buyer offering a contract bundling cash and deferred payments can be written as

$$\begin{aligned} \max_{T_1, T_2} \Pi^b(T_1; T_2) &= N(v(1 + \delta) - T_1 - \delta T_2 - \delta^3 D) \\ \text{s.t. } T_1 + \beta \delta T_2 + \beta \delta^3 \Delta &\geq \max\{(1 + \beta \delta)v, U(p)\} \quad \text{and } T_2 + \beta \delta^2 \Delta \geq v, \end{aligned}$$

where  $U(p)$  is the outside option of the farmer when selling to the traders for deferred payments at price  $p$ .

Simple algebra shows that the large buyer has no incentives to offer a bundling contract in the baseline model. Consider first the case in which  $(1 + \beta \delta)v > U(p)$ . It is easy to see that both constraints bind and,

therefore,

$$T_1 = (1 + \beta\delta)v - \beta\delta T_2 - \beta\delta^3\Delta \text{ and } T_2 = v - \beta\delta^2\Delta.$$

After some simple algebra, this gives profits equal to

$$\Pi^b = \delta^3 N (\Delta (2 - \beta) \beta - D)$$

which is identical to the profit under the no bundling contract  $\Pi(p) = \delta D N (\frac{v}{p} - \delta^2)$  computed at the optimal price  $p = p^F = \frac{D}{\Delta} \frac{v}{\delta^2 \beta (2 - \beta)}$ .

Consider now the case in which  $(1 + \beta\delta)v < U(p)$ . By definition,  $U(p) = (1 - x_1^T)v + \beta\delta(1 - x_2^T) + \beta\delta^3\Delta$  where  $x_1^T$  and  $x_2^T$  are the quantities sold to the trader paying  $p^T$  in period 1 and 2 respectively. Simple algebra gives  $U(p) = (2 - \beta)\Delta\beta\delta^3 - v\delta D/p^T$ . Both constraints are still binding, implying

$$T_1 = v + \beta\delta^3\Delta - v\delta D/p^T \text{ and } T_2 = v - \beta\delta^2\Delta.$$

Substituting into the large buyer profit function this gives  $\Pi^b = \delta N D (\frac{v}{p^T} - \delta^2)$  which is exactly the profit of the large buyer that doesn't offer a bundled contract and sets  $p = p^T$ . In both cases, the intuition for the result is simple: farmers' participation constraint already binds in the no-bundling contract and there are no production or consumption distortions. In addition, the large buyer promises the same deferred payment worth  $D$  and therefore faces the same credibility constraint as under the no-bundling contract. The same logic suggests that the large buyer would not benefit from offering a bundling contract when farmers have heterogeneous  $\Delta_i$  if price discrimination is possible.<sup>60</sup>

### The organizational costs of paying cash

Offering farmers daily payments would also entail higher operating costs and might, therefore, not be profitable. We extend the model to study (agency) costs that arise when large buyer's employees (milk collectors) pay farmers cash at the collection center. Assume that large buyers needs to employ a (risk neutral) milk collector at a wage  $w$ . Assuming the wage  $w$  is paid at the end of the third period (see below), the incentive constraint for the large buyer becomes:

$$p \leq p^M = \delta^2 v \frac{ND}{ND + \delta^3 w}. \tag{B.1}$$

The collection center technology enables the large buyer to commit to higher deferred payment prices than the traders if  $\frac{ND}{(ND + \delta^3 w)} > 1 - \gamma$ .<sup>61</sup>

Let's now consider the case in which the large buyer also offers daily cash payments. In order for the large buyer to be able to offer cash payments, the milk collector must handle the necessary cash to pay the farmers. The milk collector is subject to the same agency problems of traders: she could run away with the

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<sup>60</sup>If farmers are heterogeneous and price discrimination is not possible the large buyer might benefit from a bundling contract in which farmers must deliver minimum volumes to be eligible for deferred payments as specified in the by-laws. As noted, such provision is not enforced in practice.

<sup>61</sup>This condition, which we assume to hold throughout, is more likely to be satisfied if there are more farmers in the location (higher  $N$ ), if the cost of the indivisible good (and, therefore, deliveries) are larger (higher  $D$ ), if the operating costs of the collection center are lower (lower  $w$ ) and if the proportion of uninformed farmers is higher (higher  $\gamma$ ).

money destined for the daily payments to the farmers. The assumption that the collector and the traders face the same agency problem captures the idea that, in practice, the trader themselves could be employed by the large buyer as collectors.

To pay daily, therefore, the large buyer needs to make sure the milk collector doesn't run away with the cash for the farmers. Consider the problem of the milk collector: he handles money at  $t = 1, 2$  and gets paid  $w$  at  $t = 3$ .<sup>62</sup> The largest temptation to default is at  $t = 1$ , when the wage is a bit further away. If the milk collector runs away with the cash intended to pay the farmers, she gets her outside option  $u$  forever. The wage paid to the collector to handle cash properly,  $w^D$  must then satisfy

$$\frac{\delta^2 w^D}{1 - \delta^4} \geq (1 - x_1^*) v N + \frac{\delta^2 u}{1 - \delta^4}.$$

Setting the constraint to equality, substituting into the large buyer incentive constraint and ignoring the possibility the large buyer can default on wage payments to the collector, we obtain the new incentive compatibility constraint for the large buyer. Denoting with  $\hat{p}^D$  the price the large buyer pays for monthly deliveries when also offering cash payments, we obtain

$$\hat{p}^D \leq \alpha p^M$$

for  $p^M$  defined in (B.1) and some constant  $\alpha < 1$ . This implies that the largest price the large buyer can pay for monthly deliveries when also offering cash payments is lower than when only offering monthly payments. To deter the milk collector from embezzling the cash destined to farmers, the large buyer ends up having higher costs in the cash market. Given free entry of traders paying a daily price  $v$ , the large buyer cannot make profits on daily deliveries. To prevent default, however, the large buyer must still achieve a certain level of profits across its cash and monthly purchases.

There exist configurations of parameters such that  $\hat{p}^D \leq \hat{p}^T \leq \hat{p}^M$ . This means the large buyer can credibly deter entry of traders if it offers monthly payments but not if it offers both monthly and daily payments. When this happens, the large buyer *endogenously* decides not to offer cash payments.<sup>63</sup> Since the large buyer decides not to provide cash payments, it tolerates farmers selling to traders for the purpose of daily consumptions (but not for the purpose of savings). This possibility might explain the commonly observed reluctance of cooperative institutional forms to enforce sanctions against defecting members (see Ostrom, 1990, for famous examples and Casaburi and Macchiavello, 2015, for an empirical analysis in our context.)

The pattern of deliveries documented in Section 6.2 (flat profile during the month; regularly split between morning and afternoon deliveries) is also consistent with a relational contract with the large buyer. The relational contract with the large buyer allows the farmer to keep some production for own consumption (and, in our model, also side-sell to satisfy liquidity needs). In practice, it is impossible for parties to agree and monitor own consumption needs. Under this imperfect monitoring, a much easier relational contract to

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<sup>62</sup>Paying the milk collector at  $t = 3$  is optimal as the same wage can be used to deter deviations in both  $t = 1$  and  $t = 2$ .

<sup>63</sup>The logic not only offers a microfoundation for one of our assumption, but it also provides an example of complementarity in management practices (e.g., Brynjolfsson and Milgrom, 2013) and helps explain the contractual structure observed in the market under examination.

implicitly agree upon and monitor is for farmers to deliver their morning production to the coop and keep afternoon production for themselves.

### B.1.3 Large Buyer’s Objective Function

We have assumed all buyers maximize profits. Since in our study setting the large buyer is a cooperative, this deserves additional discussion. First, we note that our framework can be extended to allow the large buyer to have an objective function that includes producers’ welfare, as well as buyer profits. The main results—i.e., monthly prices are lower than the daily prices and producers sort depending on their utility from indivisible good—still hold. Second, we believe the assumption that the large buyer (i.e., the coop) maximizes profits is reasonable in the environment under study. Evidence on cooperatives in Kenya (Muriuki, 2011) and studies such as Banerjee et al. (2001) and Sukhtankar (2015) support the view that often cooperatives do not maximize welfare of all members.

## B.2 Small Buyers: Heterogeneity and Payment Frequencies

### B.2.1 Heterogeneity

The model assumes that small buyers are homogeneous. They could however be heterogeneous in both the cash price they pay and/or in the highest credible price they can promise for deferred payments. It is easy to extend the model along both dimensions and generate additional implications. As discussed in Section 4.1, the empirical evidence displays significant variation in prices paid by traders. Approximately 40% of the observed variation can be explained by village fixed effects. This suggests an extension of the model with multiple locations differing with respect to (iceberg) transport costs. Denoting by  $\tau_\ell$  the iceberg transport costs in location  $\ell$ , the cash price paid by traders in the village would be given by  $p_\ell^D = v(1 - \tau_\ell)$ . If the large buyer cannot price discriminate across locations this would introduce an endogenous choice of which villages the large buyer operates and an additional margin along which farmers respond to its price. Finally, an extension in which large and small buyers have different resale prices  $v$  would look qualitatively identical to the baseline model.

Traders and/or locations ( $\ell$ ) may also differ with respect to their credibility parameter  $\gamma_\ell$  and, therefore, in the highest price they can promise,  $p_\ell^T$ . In equilibrium the large buyer might set a price that is lower than  $p_\ell^T$  in certain locations  $\ell$ . In these locations, the large buyer would not be able to source any milk and small traders would be offering infrequent payments.

### B.2.2 Payment Frequencies

The model focuses on the case in which there are only two payment frequencies: daily and monthly. This is in line with evidence from our context suggesting that the vast majority of traders do not offer any delayed payment - even at weekly frequencies. While the logic of the model wouldn’t change if multiple payment frequencies were allowed, the calibration exercise in Section 5.2 would and, therefore, a natural question is why traders in practice do not offer delayed payments with shorter – e.g., weekly, or bi-weekly – frequencies. This would reduce the amount they promised to pay to farmer and give them more credibility. While we do not have conclusive evidence on this, we conjecture the following as a plausible explanation.

Time-inconsistent farmers might not be able to carry forward intermediate amounts of money resulting from, e.g., weekly sales to buy indivisible goods at the end of the month. That is, farmers would only be able to buy smaller indivisible goods, for which they might not have a demand. This lack of demand could be in itself the result of farmers' longer exposure to the monthly payments from the coop.

## **B.3 Producers: Credit, Personal Rules, and Heuristics**

### **B.3.1 Access to Credit**

While the model emphasizes the role of saving constraints, it also makes the stark assumption that producers cannot borrow. The logic of the model survives the introduction of an informal credit market in which farmers borrow from lenders (including buyers). The reason is as follows. In the presence of limited contract enforcement, an informal credit market will develop only if the farmer can commit to repay the informal lender. It can be shown that there are parameters configurations such that a farmer isn't able to credibly borrow to purchase the lumpy good, but can stick to a saving plan that allows him to (and vice versa).

When the farmer can both credibly borrow in the informal market as well as stick to a saving plan, her welfare under the two scenarios depends on two opposing forces: competition vs. over-borrowing. Buyers do not face credibility issues when extending loans. If multiple buyers can offer loans, competition pushes prices up. On the other hand, time-inconsistent farmers might end up borrowing for lumpy goods their future selves regret if intra-personal rules are not powerful enough. So, even when an informal borrowing market is available, farmers might prefer the discipline provided by saving through the large buyer.

Furthermore, the presence of large buyers offering a saving tool undermines farmers' credibility when borrowing from traders: in the event of a default against a trader, the farmer can still buy desired lumpy goods in the future by selling to the large buyer. By offering this saving service, the large buyer prevents competition from traders offering credit without having to take on any default risk. In our context, producers have limited access to well-functioning formal credit markets, but they could borrow from either the large buyer, traders, or other informal sources to finance their lumpy consumption. Evidence from the survey reveals however that only 26% of farmers borrow from any source for their dairy business; and very few borrow from either traders or the coop. Finally, as discussed in Section 1, it must be noted that a market in which farmers borrow from buyers would look very different from the market under study under several dimensions.

### **B.3.2 Personal Rules**

In the main text, we abstracted from producers' personal strategies across periods (see, e.g., Strotz, 1955; Laibson, 1997; Bernheim et al., 2015). These strategies could allow the producer to save the necessary amount to buy the indivisible good without infrequent payments. The intuition is as follows. Consider a producer that decides to follow a plan in which she saves sufficient funds to purchase the indivisible good on her own. Should any of her selves ever deviate, all future selves consume all their endowment every period and the indivisible good is never purchased again. This section offers an informal discussion of such an extension.

While changing the parametric conditions under which our analysis is valid, allowing for such personal

rules wouldn't change qualitative features of the equilibrium we study but would provide further insights. First, note that given liquid savings, producers with sufficiently low  $\beta$  would not be able to implement the plan by themselves. That is, they would still demand infrequent payments from the large buyer. Second, it would still be in the large buyer interest to punish any farmer that saves by selling to traders. Third, along a stationary equilibrium path the producer would behave as described in the text: sell to small buyers for liquidity and to the large buyer to purchase the indivisible good. As in the baseline model, the producer would not react to a temporary increase in prices paid by the large buyer if not accompanied by a liquidity option. A temporary increase with a liquidity option would also see the producer sticking to her plan and adjust deliveries accordingly. A sufficiently permanent increase in price with the offer of liquidity, however, could trigger the producer's default against her future selves and abandoning the plan. This would destroy the equilibrium in which the large buyer makes positive profits. Finally, note that the punishment embedded into the relational contract with the large buyer helps the farmer overcome her self-commitment problem.

### B.3.3 Heuristics

As documented in Section 6.2, deliveries to the coop take a remarkably flat profile during the course of the month. While the theoretical model predicts that deliveries can either increase or decrease during a month depending on parameters, it is generically inconsistent with a flat profile for the majority of farmers. Besides the relational contract explanation described above, the pattern could be explained by simple heuristic used by farmers to overcome temptations: Farmers sell to the coop in the morning as a saving tool and to traders in the afternoon for liquidity. The role of simple heuristic in helping overcome temptations has been discussed in the literature (see, e.g., Bénabou and Tirole (2004) and Bernheim et al. (2015) for theoretical perspectives, and Dupas and Robinson (2014) for empirical evidence).<sup>64</sup>

To further investigate this explanation, we conducted an additional (incentivized) framed field experiment. Farmers were randomly assigned to choose between monthly and daily payments in a scenario where they had to sell milk to the coop in the morning or afternoon for that day. We conjectured the heuristic might imply lower willingness to pay for commitment in the afternoon than in the morning. Results, however, show no difference in the required price to accept daily payments between morning and afternoon. It is plausible that the experimental design did not achieve the desired framing effect.<sup>65</sup>

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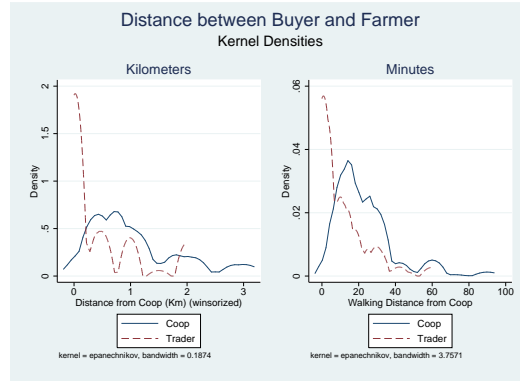
<sup>64</sup>A question of interest is why the heuristic involves selling to the coop in the morning and to traders in the afternoon, rather than vice versa. Although we lack conclusive evidence, it is possible that the desired amount to be saved is large enough that afternoon deliveries wouldn't suffice.

<sup>65</sup>The results of the framed field experiment are however very consistent with the choice experiments described in Section 4: 3.5% of the farmers accepted a daily price lower than the coop prevailing monthly price; most farmers required at least 5 Ksh (29.3%), 8 KSh. (18.3%) or 10 Ksh (27.2%) above the current price to choose the daily payment. The share of farmers willing to accept a 5 Ksh price increase for daily payments is larger in the framed field experiment than in the choice experiments, though still small: This is consistent with the fact that the former concerned payment frequency for only one *day* of sales and the latter concerned one *month* of sales.



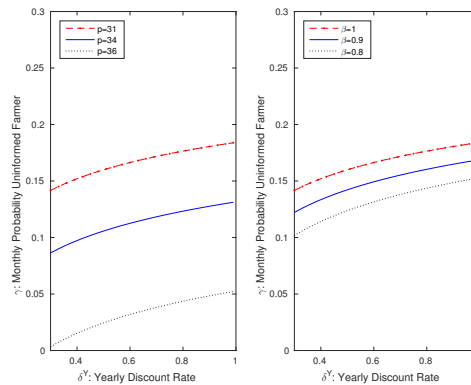
## C Appendix Figures

Figure C.1: Distances to Sale Point



*Notes:* The figure presents kernel densities of the distance between the farmer and the buyer, as reported by the respondents in the baseline survey. The sample is restricted to farmers reporting at least one trader in the village. The left panel reports distance in kilometers. The right panel reports distance in minutes.

Figure C.2: Trader Incentive Constraint Calibration: Robustness



*Notes:* The figure presents robustness check to Figure 6. In the *left graph*, we vary the purchase price a trader would be able to offer when paying at low frequency. If part of the observed price gap comes from other benefits the coop offers, the trader will have to offer a higher price. This reduces the  $\gamma$  threshold that makes the trader unable to commit. In the *right graph*, we allow the trader to be  $\beta\delta$  and show to which extent an increase in time-inconsistency (i.e., lower  $\beta$ ) reduces the threshold  $\gamma$  threshold.