Barter Credit:
Warehouses as a Contracting Technology

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Abstract

A large Brazilian agribusiness lender introduces a new contracting technology: grain warehouses. Using runner-up warehouse locations as a control group, I find that lenders' access to these warehouses permits a new debt contract (i.e. a barter credit repayable in grain), increases borrowers' debt capacity and lowers borrowing costs. The effects are stronger when price insurance is important, for municipalities with weaker courts, and for financially-constrained borrowers. Overall, evidence suggests that creditors alter their organizational design to mitigate credit market imperfections.

Keywords: Organizational Design, Warehouses, Output Storage, Barter Credit, Price Insurance, Credit Enforcement

JEL Classification: D23, G32, G33, L22, L25

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1 Introduction

Little is known about *whether* and *how* creditors alter their organizational design to mitigate credit market imperfections. I attempt to fill this gap by studying the market of agricultural lending in Brazil, where lenders provide loans to farmers for their production inputs. Specifically, I focus on a large Brazilian agribusiness lender[1] that introduces a new contracting technology: *grain warehouses*.

There are several channels through which warehouses could improve credit outcomes. Warehouses could increase collateral liquidation value, since collateral – grain – can be quickly seized, stored in lenders' designated warehouses and rapidly liquidated (for instance, Smith 1987; Biais and Gollier 1997; Burkart and Ellingsen 2004; Donaldson et al. 2018). Warehouse ownership could also increase market power in the local grain market, which reduces farmers' temptation to default and renege on existing contracts (Kranton, 1996; Ghosh and Ray, 1996; Macchiavello and Morjaria, 2019).

Warehouses could also affect lending by permitting a new credit contract, barter credit, that is repaid in grain rather than cash.[2] First, this contract insures farmers' cash flows against fluctuations in grain prices, since it specifies the quantity of grain to be delivered to the lender's silo at the date of maturity. Second, this contract is easier to enforce than the standard cash credit contract. Barter contracts fall under a standardized loan contract in Brazil – Rural Product Notes (*Cedula de Produto Rural* in Portuguese). As a result, the duration of the enforcement process for these contracts through the judicial system is half as long as for the standard cash credit contract (which, similar to bank

[1] I use micro-level data from a large Brazilian agribusiness lender with sales of over 1 billion USD and a client base of 19,000 farmers in 2013. The agribusiness 1) sells farm production inputs such as fertilizer and pesticides, 2) provides trade credit to small farmers who have limited access to bank financing, and 3) collects, stores and trades grain produced by these farmers.

[2] This contractual feature also resonates with the literature on risk management with collateral constraints (most notably Rampini and Viswanathan (2010, 2013); Rampini et al. (2014)). These papers argue that a firm has to choose whether to pledge limited collateral for hedging or borrowing purposes. In these models, a borrower might borrow less than is optimal, due to limited collateral. Since hedging and borrowing are combined in the barter contract, the trade-off between borrowing and hedging is mitigated. In light of these models, access to a silo improves the pledgeability of limited collateral and, therefore, increases debt capacity.

loans, takes about five years).[3]

The Brazilian farming industry has several practical features that make it a good laboratory for analyzing how warehouses affect credit outcomes. Economically, the Brazilian agricultural market is significant not only for Brazil but also for the rest of the world, since it is a key player in the global agriculture commodity market.[4] Furthermore, 70 percent of farming activities in Brazil are financed through credit and more than half of this credit is provided by agribusiness lenders (Agrarian Markets Development Institute, 2011).

The Brazilian setting also provides several convenient features for my empirical design. Specifically, I exploit the staggered construction of grain silos and employ a difference-in-differences (DID) research design. An ideal experiment would require the construction of silos to be random. To come close to this setting, I follow an identification strategy that is similar in spirit to Greenstone et al. (2010). In particular, I rely on alternative locations that the lender considered "near equivalent" when the decision on where to locate the new silos was made. Thus, by knowing these alternatives, I can identify both the treated branch and the runner-up branches (i.e. the control branches). There are two arguments that highlight the merits of this experiment. First, the main purpose of constructing a silo is to enter the grain trading business rather than to issue more credit. A typical silo is used by roughly 800 farmers. An existing borrower, the unit of analysis, delivers a tiny 0.2 percent of the total grain volume, and as a group these borrowers still deliver only 16 percent. Thus, an existing borrower is an atomistic element and unlikely to drive the construction choice. Furthermore, 64 percent of the control branches are treated later on. This staggered construction arises from the substantial investment (8 million USD)

[3] For more details, see Section 2.1.

[4] For example, Brazil has been the second largest producer and the largest exporter of soybeans since 2010 (United States Department of Agriculture, 2014). Furthermore, the agricultural sector accounts for 33 percent of Brazil's gross domestic product and employs more than 40 percent of the workforce (Agrarian Markets Development Institute, 2011). In addition, globally, the agricultural sector employs more than 38 percent of the workforce (International Labour Organization, 2014), making the farming sector particularly important.

required to build a silo. Hence, the treated and control branches are "equal" except for the timing of the construction.

My main finding is that access to a storage facility, designed to stockpile borrowers' output, mitigates credit market imperfections. I find that the construction of grain silos increases lending to existing borrowers by about 18 percent. This increase in lending is facilitated through barter credit contracts, since the issuance of credit that is repaid in cash remains unchanged. I also find that the relationship with borrowers becomes more stable, since the attrition of existing borrowers declines by about 13 percent after the construction of a silo. In terms of contract performance, I find that the default rates remain the same and the markup of credit sales declines by 11 percent.[5]

The results are also similar for new borrowers (i.e., extensive margin). After the opening of a silo the number of new borrowers increases by about 68 percent in treated relative to runner-up branches. Total lending to these borrowers increases by about 48 percent. Like existing borrowers, these borrowers are more likely to borrow through barter contracts. New borrowers in treated and control branches seem to be indistinguishable on default rates, however, the markup in the treated branches is 13 percent lower. Overall, the results suggest that opening a silo significantly improves the lender's ability to offer more credit at a lower price not only to existing but also to new borrowers.

Of course, a concern might be that branches where silos were constructed first are different from branches where they were constructed later. To begin, I confirm that both branches where silos were built and their runner-ups are comparable on observable characteristics such as the total credit and the number of borrowers. Nevertheless, these two groups may still differ on unobservable characteristics. To alleviate this, I investigate the treatment effect between constrained and unconstrained borrowers within a branch. Constrained farmers are those who rent the farmland and, thus, cannot use it as a collateral for bank financing. Since this specification allows me to include branch interacted with

[5]The markup is calculated as the farmer's total payment for the inputs (fertilizer, seeds, etc.) sold on credit over the raw costs of those inputs.

month fixed effects, it non-parametrically controls for demand shocks, the construction choice, or investment opportunities that might confound the analysis. As predicted by the theory on relaxing financing frictions, I show that the results are more pronounced for the constrained farmers. A battery of cross-sectional tests provides additional support for my identification strategy. For instance, any alternative story would have to coincide with the distinct jump in outcome variables around the opening of a silo.

With regard to the mechanism, my evidence suggests that warehouses reduce credit market frictions through barter credit contracts rather than through collateral or market power channels. First, since barter contracts provide an embedded price hedge, I document that credit outcomes improve particularly in periods when price insurance is important. To document this, I exploit the Federal Minimum Price Guarantee Program that guarantees minimum purchasing prices for farmers' grain output. I find that in periods when the federally guaranteed price relative to the futures price of the same grain is low (i.e. the downside risk is high), lending through barter contracts is particularly strong. Furthermore, lending through barter credit increases particularly in periods of high price volatility, again corroborating the embedded price insurance channel in barter contracts. Reassuringly, neither of these effects is observed in lending through cash credit contracts.

Second, credit outcomes improve more for farmers located in municipalities with lower court quality. There are multiple ways in which barter contracts could improve credit outcomes in weak court areas. First, price insurance should reduce default risk, which is more valuable in areas where enforcement is weak. Second, the enforcement of barter contracts itself is easier due to their standardized nature. To investigate this, I closely follow the empirical strategy of Ponticelli and Alencar (2016). They characterize weak courts as overly busy due to a large number of pending cases per judge. Their empirical strategy exploits rules in the creation of judicial districts, to alleviate concerns with endogenous court quality. I find that credit outcomes improve particularly in areas with weak courts and these improvements are primarily achieved through barter contracts.

While my analysis highlights the benefits of barter contracts, improvement in credit outcomes could also be achieved through other mechanisms. For instance, access to storage could increase both collateral liquidation value and market power in the local grain market. It is difficult to reconcile these channels with the evidence that most of the results are driven by changes in the usage of barter credit contracts. The general increase in the collateral value (grain), as well as the increase in market power should affect both cash and barter contracts equally. Having said that, my analysis does not rule these channels out. My results suggest that at least some part of the improvement in credit outcomes is achieved through embedded mechanisms in the barter contracts.

I also find real effects for the economy. Since my data do not provide direct measures of total production and profitability at the farmer level, I measure the effect of access to storage at the municipality level. I find that the total output increases by about seven percent. Furthermore, the growth in output is stronger in municipalities with weaker courts. Thus, the access to a warehouse not only affects the supply of credit from the agribusiness's perspective, but also increases the production output at the municipality level. This result also rules out the concern that the increase in lending is driven by substitution of lenders.

In terms of generalizability, there are a few points worth highlighting here. First, it is very common for commodity traders to provide credit to producers in both developed and emerging economies. For instance, Cargill, Bunge, ADM, Glencore, and Troika Group all report billions of dollars of credit for procurement of physical commodities annually. Second, a similar setup is also common in modern banking. Custodian banks are analogous to a warehouse. These banks are responsible for safeguarding a firm's or an individual's financial assets such as stocks, bonds, and commodities. These securities would be deposited with the custodian bank. The lender then signs an agreement with both the custodian bank and the borrower that the collateral cannot be liquidated, i.e.

removed from the custodian bank, unless the debt contract is settled. This arrangement significantly improves collateralization and is common particularly in developed countries such as the US. Furthermore, the barter contract is one of the oldest forms of credit. Its history goes back long before the invention of modern banking, to Babylonian times when silver was borrowed against a repayment in grain (Goetzmann and Rouwenhorst, 2005). This is in line with the premise that such forms of financing are important when financial markets are underdeveloped and institutions are weak. Finally, while barter credit is one of the oldest forms of credit, barter trade has seen a rapid expansion nowadays, with many new online bartering platforms reaching collectively an annual turnover of around 12 billion USD (Keys and Malnight, 2012). I provide further discussion on the generalizability of my results in section 6.5.

My analysis contributes to several streams of the literature. First of all, I present evidence on how to mitigate credit market imperfections and improve access to finance. The law and finance literature argues that formal institutions such as courts are important for mitigating contracting frictions (La Porta et al., 1998; Levine, 1999). The prevailing view is that reforms improving creditor rights and facilitating the repossession of collateral in countries with poor contract enforcement lead to more debt financing (Djankov et al., 2007; Qian and Strahan, 2007; Davydenko and Franks, 2008; Haselmann et al., 2010; Assunção et al., 2014).[6] Others argue that market power improves repayment rates and credit outcomes, since borrowers are reluctant to renege due to limited outside options (Macchiavello and Morjaria, 2019; Blouin and Macchiavello, 2019; Sukhtankar, 2016). The novelty of this paper is that the improvement in credit outcomes in areas with weak contract enforcement comes from a company's intervention rather than a change in regulation.

The paper also relates to the literature examining the real effects of hedging. Rampini et al. (2014) and Cole et al. (2017) document that firms and households are under-insured

[6]It could also be that easy access to collateral could also lead to a liquidation bias (Vig, 2013).

either because of collateral constraints or trust issues. Others argue that hedging leads to lower spreads and higher valuations, investment levels, and productivity (Campello et al., 2011; Cornaggia, 2013; Pérez-González and Yun, 2013; Karlan et al., 2014). Almeida et al. (2017) document that firms use purchase obligations with suppliers as a risk management tool. This paper documents how real outcomes improve when a lender engages in risk sharing with borrowers by providing credit bundled with price insurance. By accepting borrowers' output as a debt repayment, the lender fully absorbs the price risk from the borrower.

My research also adds to the literature on organizational economics and firm boundaries. Since the seminal work of Coase (1937), an extensive theoretical literature has analyzed the determinants of firm boundaries and the effects of these boundaries on economic outcomes (most notably, Williamson, 1975, 1985; Klein et al., 1978; Grossman and Hart, 1986; Holmström and Milgrom, 1991, 1994; Baker et al., 2002). Some previous empirical studies have shown that asset ownership creates incentives to preserve asset value (Baker and Hubbard, 2004) and that vertical integration can lead to economies of scale (Hortaçsu and Syverson, 2007) and facilitate intra-firm transfer of intangible assets (Atalay et al., 2014). Others have analyzed the costs and benefits of consolidation in banking (Akhavein et al., 1997; Prager and Hannan, 1998; Berger et al., 1999; Sapienza, 2002) and the conglomerate structure (Rajan et al., 2000; Schoar, 2002; Seru, 2014). Liberti et al. (2016) find that banks change their organizational design by delegating more tasks to loan officers after the introduction of a centralized credit registry.[7] I, however, document that integrating a vertically related business into a lender's operations provides access to a contracting technology and improves lending outcomes. With this in mind, I do not claim that the integration of a grain warehouse is necessary. Whether it is possible to achieve similar results with a long-term lease contract is out of the scope of this paper.

The paper also relates to the growing literature on the role of trade credit and captive

[7]Relatedly, Skrastins and Vig (2019) and Dlugosz et al. (2019) document benefits of delegation in the lending and the deposit side of bank business, respectively.

finance in the real economy (for instance, Petersen and Rajan (1997); Demirguc-Kunt and Maksimovic (2002); Fisman and Love (2003)). Some of the recent papers argue that trade credit is used to create barriers to entry (Barrot, 2016) and to provide liquidity (Garcia-Appendini and Montoriol-Garriga, 2013) and that limiting the contract space for trade credit terms can result in an integration of the customer (Breza and Liberman, 2017). Benmelech et al. (2017) provide evidence that the funding capacity of captive finance companies in the auto industry is important for fostering new car sales. Murfin and Pratt (2019) argue that captive finance is widespread because producers can increase the secondary market value of their production and, therefore, the asset pledgeability. I contribute by documenting that firms controlling the warehouses and distribution channels of their customers are more likely to extend trade credit.[8]

The rest of the paper is organized as follows. In the next section, I begin by providing an overview of the data and a description of the institutional details of the agribusiness lender and the farming industry in Brazil. In Section 3, I lay out my identification strategy. Section 4 describes the results on contract types, loan quantities, defaults, and prices; Section 5 analyzes potential mechanisms; and Section 6 rules out a range of alternative explanations, and discusses the real effects and generalizability of the results. Section 7 concludes the study.

2 Institutional Background and Data

The data provider for this study is a large agribusiness lender in Brazil, with an annual turnover of over 1 billion USD and a customer base of over 19,000 farmers as at December 2013. The firm operates in three lines of business: 1) sales of farm production inputs such as fertilizer and pesticides to farmers, 2) sales of these production inputs on credit, and 3) trading of agricultural commodities – buying and storing grain from farmers and selling to

[8]This result fits well with the theory of Frank and Maksimovic (2005), who argue that trade creditors value collateral more highly than banks do.

large purchasers both domestically and internationally. The firm provides these services to small and medium sized farmers who have limited access to bank finance. The average size of a farm in the sample is 158 hectares (roughly the size of 150 soccer fields), while the median is 50 hectares. To put this in perspective, farms less than 500 hectares in size constitute 98 percent of the number of farms and only 44 percent of the farm land area in Brazil (Berdegué and Fuentealba, 2011). This study focuses on the lending side of the business, where the firm operates as a creditor to farmers. Within the sample period, the firm issued over 300,000 credit contracts to over 7,000 borrowers.

The dataset is rich in detail. It contains detailed information on all loan contracts, as well as purchases and sales of production inputs and grain products at the invoice level. At the loan contract level, it includes the loan balance outstanding, whether it is a barter or cash credit, the maturity, and the number of days late in payment, among other details. On the production inputs front, it includes raw costs, purchased quantity, and an inventory of all the products bought by the agribusiness lender from its suppliers. It also contains information on all sales invoices from the firm to its clients – the quantity and the price by product. The sample spans seven years, from January 2006 to December 2012.

2.1 Agricultural Cycle and Credit

Each year there are two six-month agricultural cycles in the southern part of Brazil, the geographic area where the lender operates. The summer cycle lasts from around September to March, while the winter cycle lasts from around April to August. In my sample, the summer crops are soybeans and corn, and the winter crop is wheat. Farmers borrow to finance production inputs throughout the year (on average five loans per year). These include financing for seeds, chemicals, and fertilizer during plowing and seeding season. In the later stages of the season, it is common to borrow to finance herbicides, insecticides, and fungicides to protect against weeds, bugs, and other diseases. The majority of loans are repaid just after the harvest season in April and September

A farmer can purchase production inputs such as fertilizer or pesticides from the lender in two ways – either by paying cash or by borrowing on credit. When a client borrows to purchase the production inputs, there are two types of contracts with distinct modes of repayment. First, the borrower can repay the debt in cash on a predetermined date, making it a standard debt contract. Second, instead of repaying in cash, the borrower can agree to deliver grain at a price that is fixed upon the issuing of the contract. Essentially, such a loan agreement is a standard credit contract, combined with a forward contract with physical delivery on an agriculture commodity. For simplicity, I call this combined contract a *barter credit* because the lender and a farmer exchange production inputs for grain at two distinct points in time. A farmer chooses the form of repayment at the date of debt origination.

There are a few important differences between cash and barter contracts. First, a barter credit hedges price risk of farmers' production output. Since price fluctuation is a major risk in farming, the hedge mitigates price risk and reduces the probability of a default due to unfavorable price developments. Thus, the total supply of credit could increase because the bundled credit product reduces the likelihood of a default.[9]

The second important characteristic is the legal complexity behind enforcing these two types of contracts. The barter contract is part of a standardized loan contract for farmers – Rural Product Notes (CPR or *Cedula de Produto Rural* in Portuguese). The CPR is a debt contract that allows farmers to finance their production with a credit agreement, before their crops are ready for sale. The CPR represents a promise of rural product delivery.[10] These contracts are collateralized with future harvest and the lien

[9] Recent evidence suggests that farmers do not buy enough of insurance products for various reasons such as trust, liquidity constraints, or collateral constraints, even if such risk management instruments are available (Cole et al., 2013; Rampini et al., 2014).

[10] In Brazil, roughly 60 percent of external financing in farming is raised through CPR contracts, while the remaining 40 percent is raised through bank debt (Agrarian Markets Development Institute, 2011). For detailed legal documentation, the reader can refer to laws 8,929/94, 10,200/01, and 11,076/04, which govern these contracts. A detailed description of the financial instrument is provided by National Association of Financial Market Institutions (2009).

on this harvest is registered with the local real estate registry (*Cartorio de Registro de Imóveis*). Due to the lien and *de facto* grain ownership by the lender, the grain is difficult to sell to a third party without first repaying the debt and removing the lien. If a farmer defaults, the lender is permitted to repossess the grain both from the farmer's premises and from anyone who might have acquired this grain. These contracts are standardized and can be enforced fairly quickly. A court order to repossess grain can be acquired within days.[11] After the grain is repossessed, the lender still needs to go through a formal court process that recognizes the farmer's default and transfers ownership of the grain to the lender. In case of a default, these contracts are also collateralized by the next harvest.[12] Occasionally both cash and barter contracts are further backed by real estate collateral. Repossession of this collateral takes years, and compares directly to a bank credit.

The cash contracts do not fall under the special CPR category. While the repossession of the collateral is as fast as with the CPR contracts, the court process is longer and the liquidation of the collateral is more cumbersome. Since these contracts are less standardized than the CPR contracts, both judges and lawyers scrutinize the interpretation of each contract more thoroughly, increasing the duration of legal proceedings. Furthermore, once the court rules in favor of the lender, the collateral needs to be liquidated, since the settlement is in cash. This entails additional risks. The borrower has the right to challenge the liquidation process, since whatever remains after the liquidation is transferred to the borrower. The lender is also exposed to the price risk of the collateralized grain. This is difficult to hedge ex ante, since it is hard to predict the time period when the collateral is actually to be liquidated. In contrast, barter contracts have no ambiguity on the valuation of the collateral, i.e. grain. Since the settlement is defined in grain rather than monetary value, the judge simply transfers the formal ownership of the grain to the lender, avoiding a lengthy liquidation process. Overall, due to a lack of standardization

[11] In the firm's experience, the order to repossess the grain can be obtained within 10 days.

[12] This is a valuable provision that provides the lender with a credible threat, since the grain can be repossessed also during the following harvest. The borrower is effectively in default during the next harvest season.

and greater uncertainty around the liquidation of the collateral, the enforcement of cash contracts takes five years on average, compared to two and a half years for barter contracts (Table (A1)). Thus, barter contracts are easier to enforce.

Another benefit of a barter contract is that it improves enforcement through monitoring, because the lender can anticipate default earlier. Since barter contracts are repaid with delivery, the lender effectively expects the farmer to start delivering during harvesting when other farmers deliver grain (either to sell grain or repay barter), which is prior to maturity. If a borrower is not delivering, the lender follows up on the expected date of delivery. If lender suspects deviations, it contacts other local silo operators and warns them about the outstanding lien on the grain. In such situations it is common practice for silo operators to delay payment and share information about the delivery of grain. With cash contracts, such provision is difficult to implement, since a farmer first needs to receive cash proceeds from the sale of grain and the lender can only become aware of deviation when payment from borrower is overdue.

For illustrative purposes, bank credit is closest to cash credit contracts. However, there are two important differences. First, bank credit almost always requires a collateral on physical assets such as a farm. Second, the approval of bank credit is slow and more cumbersome, often spanning months.[13] Since time is critical during a harvest cycle, this deters farmers from obtaining bank financing for working capital.[14] The enforcement of bank credit is similar to that of cash credit contracts and also takes about five years (The World Bank, 2014).

[13]See, for instance, https://revistacafeicultura.com.br/?mat=16759 or https://www.canalrural.com.br/sites-e-especiais/projeto-soja-brasil/burocracia-emperra-credito-para-armazenagem/?uol=1.

[14]An alternative would be to open a credit line, but banks generally do not offer such a product for farmers of such small size.

3 Identification Strategy

3.1 Construction of Silos

Historically, the firm started as a distributor of production inputs by selling both on the spot and on credit. The firm grew in two ways. First, whenever it expanded its geographic reach, it did so by opening a branch that sold production inputs. Second, over time it also entered the grain business by constructing grain silos. At the end of 2013, the firm operated over 70 branch offices, of which about a half had a silo. The construction of a silo is a special case of vertical integration. The firm integrates a business unit that is vertically related in the farm supply chain. Thus, it is not the traditional vertical integration when a business absorbs either a customer or a supplier, but it integrates a downstream firm from a supply chain.

Besides grain silos the construction also involves the installation of a grain dryer, receiving and testing facilities, and a truck scale. All of these are necessary investments for a grain silo to be operational. Overall, the whole investment costs about 8 million USD. Besides these investments, there are no other major interventions. Branches are always located next to paved regional highways, so they do not invest in improving access to branches or transportation between branches. They also do not change any marketing expenses or incentive contracts for workers.

For identification, I exploit the staggered construction of grain silos and employ a difference-in-differences (DID) research design. The identification strategy is similar in spirit to Greenstone et al. (2010). An ideal experiment would require the construction of silos to be random. This clearly is not the case. Branches selected for treatment are likely to differ substantially from a randomly chosen branch, both at the time of opening and in future periods. Valid estimates require the identification of a branch that is identical to the branch where the silo was constructed. To come close to this setting, I rely on alternative locations that the lender considered "near equivalent" when the decision on where to locate the new silos was made (see Figure (1)). When the owners decide where to open a silo, they typically begin by considering several possible locations. Then they narrow the list down to roughly four finalists. Thus, by knowing the finalists, I can identify the branch where a silo was constructed (i.e. the treated branch), as well as the runner-up branches (i.e. the control branches). The runner-up branches provide a counterfactual for what would have happened to the borrowers in a branch in the absence of the construction of a silo. These alternative locations are derived from the firm's archives and interviews with the owner-managers of the lender. In my sample I examine fourteen construction cases.

While the experiment is not ideal, there are two arguments that highlight its merits. First, the main purpose of constructing a silo is to enter the grain trading business rather than to issue more credit. A typical silo is used by roughly 800 farmers. An existing borrower,[15] the unit of analysis, delivers a tiny 0.2 percent of the total grain volume, while as a group they still deliver only 16 percent. Thus, an existing borrower is an atomistic element and unlikely to drive the construction choice. Furthermore, 64 percent of the control branches are treated later on. This staggered construction arises from the substantial 8 million USD investment required to build a silo. Hence, the treated and control branches are "equal" except for the timing of the construction.

To confirm that the alternative locations form a valid counterfactual for the treated branches on observables, I formally test for the differences among treated, runner-up and other non-treated branches without a silo in the period 18 to 0 months before the treatment. This exercise provides an opportunity to assess the validity of the research design, as measured by preexisting observable branch characteristics. To the extent that these observable characteristics are similar among treated and runner-up branches, this should lend credibility to the analysis. Furthermore, the comparison between the treated branches and other non-treated branches provides an opportunity to assess the validity

[15] An existing borrower is a farmer who bought inputs on credit in the two-year window before the opening of a silo.

of the type of analysis that would be undertaken in the absence of a quasi-experiment.

Table (1) reports the results. I compare branches on the outstanding credit, new credit, number of borrowers with credit, outstanding barter credit, average size of a credit, and its maturity, all measured at the branch-month level. Compared to runner-up branches (column 4), treated branches have similar trends in all variables in the period 18 to 0 months before the treatment. However, compared to all other non-treated branches (column 5), treated branches issue less credit, lend to fewer customers, and issue less barter credit. This finding is consistent with both the presumption that the average branch is not a credible counterfactual and the identifying assumption that the runner-up branches form a valid counterfactual for the treated branch. In this spirit, I also show that my results do not have pre-treatment trends later in the paper.

Of course, a concern might be that branches where a silo was constructed first are different on some unobservable dimension, such as demand for credit, from those where it was constructed later. To alleviate this, I investigate the treatment effect between constrained and unconstrained borrowers within a branch. Without going into too much detail at this point, this specification allows me to control for demand shocks, the construction choice, investment opportunities or any other unobservable characteristic that might confound the analysis. Here, I exploit the differential treatment effect between constrained and unconstrained farmers in the same branch in the same month. Please refer to Section 5.4 for more details.

3.2 Empirical Specification

My empirical strategy identifies the effect of access to a silo on credit outcomes, using a difference-in-differences (DID) research design. I compare borrowers in branches where a silo was constructed against a control group of borrowers in runner-up branches. I call each construction choice a "case" and compare treated borrowers against non-treated borrowers within each case. Thus, the empirical specification is given by:

$$y_{jmi} = \tau_{jm} + \tau_i + \delta \cdot \text{Treat}_{bm} + \eta_{jmi}, \tag{1}$$

where the dependent variable (e.g., total credit) is measured at the case-borrower-month level; j references case, m month, and i borrower. $Treat_{bm}$ is a dummy variable equal to one if the branch b, of which borrower i is a client, has a grain storage unit in month m. Thus, once a silo is built, this variable changes from zero to one. The other two terms in equation (1) control for unobserved determinants that might otherwise confound the construction of silos. The borrower fixed effects (τ_i) control for fixed differences between borrowers. The case-month dummies (τ_{jm}) control for all aggregate demand or supply shocks within each construction case. These fixed effects ensure that the impact of silo construction is identified from comparisons within a "pair" of treated and runner-up branches. The coefficient δ is my DID estimate of the effect of a grain warehouse. All reported standard errors are clustered at the branch level to account for the correlation in outcomes among borrowers in the same branch, both within periods and over time.

The identification approach can be understood via the following example. Suppose there are two branches, branch A and branch B, that the firm considers as "equal" among many when deciding where to build a silo within Case 1. However, they can build only one silo and they build it next to branch A in 2010, leaving branch B as a runner-up branch. I wish to estimate the effect of constructing a silo on total credit. For a borrower in branch A, I would compare the total credit after 2010 with the total credit before 2010. However, in 2010 other things, such as the economic environment, may have affected the size of total credit. Borrowers in branch B, as a control group, would help to control for changing economic conditions. The difference between those two differences would then serve as my estimate of the effect of a contracting technology. Essentially, borrowers in branch B act as a control group for borrowers in branch A in all months within Case 1.

Similar reasoning applies for all other "cases". Therefore, equation (1) implicitly takes as a control group all borrowers from branches that are not subject to the construction of a silo at month m in case j.

4 Results

4.1 Descriptive Statistics

Here, I present the descriptive statistics for the pre-treatment values for the samples used in this study. In Table (2), I present means, medians, and standard deviations for the main variables of interest for both existing and new borrowers in Panels A and B, respectively. The loan amounts are expressed in Brazilian reais.[16]

Sample of existing borrowers is defined as follows (Panel A). For the treated group, I select all borrowers who had an active lending relationship prior to the opening of a silo.[17] Within each case, I do the same selection procedure for my control group, i.e. runner-up branches. Thus, I select a group of borrowers who had an active relationship in the same time window prior to the opening of a silo within each construction case in both treated and control branches.

While during the whole sample the lender provided credit to over 7,000 borrowers, the sample of existing borrowers consists of 1,168 borrowers. The average total outstanding value of credit for a borrower is 28,800 BRL a month, which is roughly 15,000 USD. A borrower has an outstanding loan in more than half of a year (58 percent). Furthermore, the value-weighted default rate, defined as one if the loan is not repaid on time and is renegotiated or defaults, is 4.8 percent. The average markup, defined as the final payment over raw costs of the inputs, is 42 percent.[18] Prior to a silo, about 23 percent of borrowers

[16]The average exchange rate during the sample period was 0.534 USD per Brazilian real.

[17]The results are robust to other definitions of existing borrowers. For instance, if I assess existing borrowers who had active lending relationship in the one or two years prior to the opening of a silo within each case.

[18]I observe the raw costs of the inputs sold on credit and the final value paid for those inputs. Hence,

have an outstanding barter credit. Conditional on having barter credit, the outstanding barter balance is about 47,200 BRL, which is about 80.5 percent of their total borrowing from the firm.

Sample of new borrowers is defined as any borrower who obtains their first loan in a given month (Panel B). This sample is aggregated at the branch-month level, since it examines the extensive margin. An average branch issues 339,512 BRL (or 181,000 USD) worth of new debt to about 17 new customers every month. The size of an average loan is about 21,000 BRL and the value-weighted default rate, defined as one if the loan is not repaid on time and is renegotiated or defaults, is 2.9 percent. The average markup to new borrowers is 33 percent. Conditional on providing barter credit, the average issuance amount to new borrowers is 485,000 BRL.

4.2 Existing Borrowers

Loan Quantities

In this section, I explore the effect of accessing a grain silo on existing borrowers. Column 1 of Table (3) reports the effect of silo construction on total credit at the borrower level.[19] The coefficient on *Silo*, a dummy variable equal to one if the branch has a silo in that month, is the DID estimate. I find that lending to existing borrowers increases by 18 percent (column 1) once a silo is constructed. Figure (2) plots the dynamics of total credit around the construction of a silo after controlling for borrower specific characteristics and aggregate time trends. The "event study" style graph reveals much about the treatment and addresses issues of reverse causality that might be driving the shift towards barter credit and hence the construction of a silo.

In the months before the silo opening, trends among borrowers are the same in treated and runner-up branches. Since the firm issues credit in anticipation of a silo being opened,

I can calculate the markup, which is a better measure of overall profitability than just the interest rate.

[19] The results are similar if I aggregate at the branch or harvest levels (see Tables (A2) and (A3), respectively, in the Internet Appendix).

credit starts increasing about two months before opening. This squares well with the fact that most silos are completed one to two months before the harvest starts, implying that the company starts offering barter contracts about four months before the upcoming harvest, which is about the average maturity of a loan. This finding furthermore supports the validity of the identifying assumption that runner-up branches provide a valid counterfactual for treated branches. Any other confounding story would have to coincide exactly with the jump in lending activity around the opening of a silo.

I also find that the agribusiness lender is more likely to maintain an active relationship with a borrower. Column 2 reports the effect on the probability of any outstanding credit. The point estimate on the probability of an outstanding credit suggests that an existing borrower is 13 percent more likely to borrow from the lender compared to borrowers in the runner-up branches. Thus, the lender not only increases lending (intensive margin) but also maintains active relationships (extensive margin) with its pre-treatment borrowers.

Loan Repayment and Prices

So far, I have shown that integrating a silo enables the firm to provide more credit. An important question is whether the quality of these loans is affected. While more leverage could push some borrowers closer to distress, benefits associated with price insurance and better contract enforcement should improve borrowers' creditworthiness. Since the credit quantity has increased, it is sufficient to show that the default rates remain the same. This would mean that the lender is able to lend more for the same amount of risk. Such evidence would be consistent with a reduction in credit frictions.

I find that the quality of loans issued to existing borrowers remains unchanged. I measure default rates as whether or not a loan defaults or is renegotiated at some point. While the point estimate suggests that value-weighted[20] default rates decline by 1.9 percentage points (column 3 of Table (3)), the result is statistically insignificant. Overall,

[20]The results are almost identical using the equally weighted default rate.

these results suggest that loan quality remains the same.

Next, I examine the effect on the prices of products that are sold on credit. Like above with the default rates, lower credit risk should be reflected in lower prices. To assess the pricing of credit contracts, I evaluate the markup that the firm charges to farmers on the products sold on credit. This markup includes operating margin, interest rate, premium for the price hedge, and profit margin. Evaluating the total effect on price is important, since one does not need to worry that the creditor might mechanically record a lower interest rate and increase sales margin at the same time.

I compute the markup as the ratio between the ultimate repayment and the raw costs of the inputs that the lender sold to the farmer. To do this, I first convert barter contracts, where repayment is denominated in volume of grain, into Brazilian reais. I use the futures price, obtained from the Chicago Mercantile Exchange (CME), of the same commodity with the settlement date in the same month as the expected month of the upcoming harvest. Since the notional values in CME are in US dollars, I convert these values into reais, using currency exchange futures with the same settlement date as the commodity. This then gives me the market value in Brazilian reais of all barter contracts.

I find that the markup decreases by 4.7 percentage points, which is roughly 11 percent from the mean markup of 41 percent (column 4 of Table (3)).[21] Thus, the creditor is willing to provide more credit at a lower price (i.e., shift in the supply curve), which is consistent with a reduction in credit market frictions. A caveat of the analysis above is that I cannot differentiate each component of the markup – particularly, interest rate – separately. While the evidence is consistent with a lower interest rate, it could also be driven by changes in other components.

[21] In internet appendix Table (A4), I provide evidence that it is robust to controlling for loan size, so unlikely to be driven by quantity discounts.

4.3 New Borrowers

Next, I examine the effect of opening a silo on new borrowers. First, after opening a silo, the number of first time borrowers in any given month increases by about 68 percent in treated relative to runner-up branches (column 1, Table (4)). While the total lending to these borrowers increases by 48 percent in treated vs runner-up branches (column 2), the average loan seems to be somewhat smaller (column 3). The latter result, however, is statistically insignificant. Borrowers are also significantly increasing their borrowing through barter contracts by 47 percent (column 4). New borrowers in treated and control branches seem to be indistinguishable on default rates, however, the markup in the treated branches is 4.4 percentage points lower, which is 13 percent lower when measured against the mean markup of 33 percent (columns 5 and 6, respectively). Finally, new borrowers joining after the opening of a silo are six percent less likely to be financially constrained, as proxied by whether they rent rather than own their farmland. Overall, the results suggest that opening a silo significantly improves the lender's ability to attract new borrowers. These borrowers are somewhat smaller, less likely to be constrained, and pay lower premiums.

5 Mechanism

The broad array of results supports the view that the integration of a silo into a lender's business increases farmers' pledgeable cash flows. As a result, the creditor can issue more debt at a lower price against these cash flows. This section lays out evidence on the potential mechanisms that improve credit outcomes.

First, I examine the barter credit contracts (5.1). Then, I show that the benefits of a silo are larger in periods when price insurance is more important (5.2), for farmers in municipalities with weaker courts (5.3) and for constrained borrowers who have limited access to bank finance and, thus, suffer from more credit market imperfections (5.4).

5.1 Barter Contracts

To provide evidence on barter credit contracts, I begin by examining the cross-sectional differences among contract types. Barter credit contracts are ten times as large as the standard cash contracts. Figure (3) plots the kernel density functions of the loan size by contract type. The average size of a barter credit contract is about eighty thousand reais compared to much smaller cash contracts of seven thousand reais. Overall, barter contracts are cross-sectionally larger than cash credit contracts.

Columns 1 and 2 of Table (5) report the effect of the construction of a silo on barter credit. I provide results on two measures. First, I report the effect on the probability of issuing a barter credit, defined as 1 if a borrower has a barter credit in a given month. Second, I evaluate the effect on the natural logarithm of the total value of barter credit plus one. I find that both the probability of issuing a barter credit and the value of that credit increase significantly. To be specific, the probability of issuing a barter credit increases by 7.2 percent and the value increases by about 80 percent (columns 1 and 2, respectively).[22] Finally, there is no effect on cash credit contracts (column 3), suggesting that barter contracts are central for the increased debt capacity.

These results have no pre-trends as documented by Figure (4), which plots the dynamics of the probability of issuing a barter credit. Since the lender starts issuing barter contracts in anticipation of a silo completion, issuance increases about three months before the actual opening. This squares well with the fact that most silos are completed one to two months before the harvest starts, implying that the company starts offering barter contracts four to five months before the upcoming harvest, which is about the average maturity of a loan and almost the duration of a harvest cycle.

To further show that the increase in lending is driven by the barter credit contracts, I examine cross-sectional variation among borrowers who already had a barter contract

[22] The interpretation of the quantity result is difficult, as it puts substantial weight on the existing borrowers who start using barter credit only after the treatment.

against those who did not have one before the construction of a silo. The borrowers who had such a contract before the construction of a silo are located in close proximity to another of the lender's silos where they can deliver the grain. If barter credit contracts deliver a significant increase in lending, then the effects should be particularly strong for the borrowers who had no access to these contracts before the opening of a silo. Roughly 75 percent of all borrowers did not have a barter contract prior to the construction of a silo.

I find that borrowers without prior barter contracts benefit the most. The total credit for borrowers who had no access to barter credit ex-ante increases by 20 percent more than for those who had access (column 4 of Figure (4)). There is no differential effect on the probability of having an outstanding credit (column 5). The probability of issuing a barter contract and its quantity increase particularly for borrowers without previous access to barter credit (columns 6 and 7). In summary, the increase in total credit seems to come from the introduction and greater use of barter contracts.

5.2 Price Insurance

Commodity price volatility is a major risk in farming, as it significantly affects the cash flow that a farmer can generate at the end of the harvest season. Clearly, a barter contract hedges the commodity price risk, which might also increase the debt capacity (Smith and Stulz, 1985; Froot et al., 1993; Rampini and Viswanathan, 2010, 2013; Rampini et al., 2014). To provide evidence consistent with this, I evaluate how the treatment effect varies with the exposure to the price risk, using two empirical approaches.

To begin, I exploit a federal government program that insures downside of the price risk. Specifically, the Minimum Price Guarantee Program (*Política de Garantia de Preços Mínimos*) sets the prices at which the government buys agricultural commodities. The program was established in 1966 and one of its primary purposes is to reduce fluctuations in farmers' income. The government intervenes by purchasing the production surplus when the product price is below the minimum price, which is set annually around three to five months before the harvest. The program is managed by the National Supply Company (*Companhia Nacional de Abastecimento*). Every year this agency prepares a proposal for the minimum prices for the main farming commodities produced in Brazil. This proposal is then discussed and approved by a council, consisting of the Ministry of Agriculture, Livestock and Supply, the Ministry of Finance, the Ministry of Planning, Budgeting and Management, and the National Monetary Council. The prices are updated at most once a year: in September for summer crops to be harvested around March, and in May for winter crops to be harvested around August.[23]

I obtain the data on the minimum prices for each harvest from CONAB.[24] I then compare this price against the futures price, obtained from the Chicago Mercantile Exchange, for the same commodity with the settlement date in the same month as the expected month of the upcoming harvest.[25] The ratio between the federally set minimum price and the futures price reflects the portion of the expected price of the commodity that is insured.[26] The higher this value, the weaker the incentive for a farmer to buy an instrument that fully hedges the price. Thus, the price hedge embedded in the barter contract would be less attractive. If the hedging channel is important, we should see reduced usage of barter contracts when the government provided price insurance is generous relative to the futures price.

In the second approach, I examine how the ability to offer barter contracts interacts with the commodity price volatility. If price risk is important, we should expect the treatment effect to be strongest in periods of high price volatility. To begin, I construct local daily price indices. Using the lender's grain purchase data, I obtain daily prices

[23] In my sample, the summer crops are soybeans and corn, the winter crop is wheat. For summer crops, the prices are valid from the beginning of January until the end of December (both of the following year). For summer crops, the prices are valid from the beginning of the July in the announcement year until the end of June in the following year.

[24] I thank Thome Guth from CONAB for providing me with access to this data.

[25] Since the notional values in CME are in US dollars, I convert these values into Brazilian reais, using currency exchange futures with the same settlement date as the commodity.

[26] On average the minimum price was 59 percent of the futures price during my sample.

for all commodities that are accepted as in-kind payment for barter credit: soybeans, wheat, and corn. Then, I compute daily returns for each commodity. Using these returns, I calculate the price volatility for each commodity as the standard deviation of those returns within each agricultural cycle.[27] The empirical prediction is that the higher the price volatility in an agricultural cycle, the more attracted the farmers are to the barter credit contract.

In the empirical setup, I select the price insurance ratio and the price volatility for the commodity that each farmer grows in each period. To control for all time varying differences among the three types of grain, I augment my main specification by replacing case-month fixed effects with case-grain-month fixed effects. Thus, I compare farmers who grow the same crop in the same time period.

I find that the effect of the construction of a silo is stronger when price risk is more important (see Table (6)). Specifically, in the periods when the ratio of guaranteed minimum price relative to the futures price is below the median, total borrowing increases by an additional 8.6 percent (column 1), while it does not affect the probability of overall borrowing (column 2). The probability of using a barter credit rises by 2.4 percentage points and quantity increases by a further 24 percent (columns 3 and 4). In the same time, there is no effect (or a somewhat opposite effect) for cash credit contracts that do not provide price insurance (column 5). Similarly, when price volatility in the agricultural cycle is higher, the treatment effect is stronger. The point estimates suggest that in periods of above median price volatility the treatment effect on barter credit usage increases by an additional 2 percent (column 8). Borrowers seem to substitute cash credit for barter credit in periods of high price volatility (columns 9 and 10). The effect on total credit, however, is inconclusive, using this estimation strategy (column 6). Like with the other proxy for insurance demand, the probability of outstanding credit is unaffected (column

[27] I find similar effects using monthly price volatility. There are two agricultural cycles in Parana and Sao Paulo states: the summer cycle lasts from around September to March, the winter cycle lasts from around April to August.

7). All in all, the evidence is consistent with barter contracts providing benefits from hedging price risk.

5.3 Court Enforcement Quality

It is widely accepted that contract enforcement depends on the quality of legal institutions and creditor protection. If barter contracts (and silos) mitigate credit market frictions associated with weak contract enforcement and court quality, then the effect of building a silo should be particularly strong in areas where formal institutions are weaker. There are multiple channels through which the positive effects of barter contracts could be stronger in areas where contract enforcement is weak. First, a price hedge should reduce the default risk, which is particularly valuable where enforcement is weak, since it avoids costly liquidation. Second, as described above, barter contracts are easier to enforce, due to their standardized nature and monitoring benefits.

To measure the court enforcement quality, I follow Ponticelli and Alencar (2016) and collect all the necessary data from *Justiça Aberta* of the National Justice Council, covering all courts and judges working in the Brazilian judiciary.[28] I focus my analysis on the civil courts of first instance, since these usually deal with bankruptcy cases. The measure of the court enforcement quality is the speed in closing bankruptcy cases, calculated using the number of pending cases per judge in each judicial district in each month.[29] This measure proxies for the time taken to solve a case: the larger the proxy, the longer it takes to solve a case. Then, I take the average of the monthly values for each judicial district and obtain a measure of court congestion.

A remaining concern with the analysis above is that the endogenous court quality is correlated with local market characteristics such as access to hedging instruments. To address this concern, I use the empirical strategy proposed by Ponticelli and Alencar (2016).

[28] The data can be accessed here: http://www.cnj.jus.br/corregedoria/justica_aberta/.

[29] Brazil is divided in 2,738 judicial districts. A judicial district can map onto a single municipality or it can enclose multiple municipalities. To obtain a measure of court enforcement quality for each branch, I match the municipality of a branch with the corresponding judicial district.

Their strategy exploits pre-determined rules that affect the quality of local courts through potential extra-jurisdiction. In brief, using pre-determined rules, a municipality that is the seat of a judicial district deals with cases from territorially adjacent municipalities that are not the seats of a judicial district, thereby increasing the workload for courts in the seat of the judicial district.

Brazil's over 5,500 municipalities are organized into roughly 2,500 judicial districts, where a judicial district is at least as large as a municipality. The size of these districts is determined by state laws that establish the minimum requirements that a municipality must satisfy to become the seat of a judicial district. These requirements are expressed in observable municipality characteristics such as the population, the number of voters in the last election, the number of judicial cases originated in a municipality, the amount of tax revenues, or a combination of the above.[30] Jurisdiction over municipalities that do not meet the requirements is assigned to an adjacent municipality that is the seat of a judicial district. Thus, courts in the municipalities that are the seats of judicial districts may receive cases originated in the neighboring municipalities that are not the seats of judicial districts, potentially making these courts more congested.

To proxy for court efficiency, I exploit the cross-sectional variation in the potential extra-jurisdiction of courts. This measure is equal to the number of adjacent municipalities that do not meet the requirements to become a judicial district. This empirical strategy is based on two assumptions. First, the number of judges and other resources do not adjust according to the additional workload of cases originated in neighboring municipalities. If this is true, court congestion should increase with the potential extra-jurisdiction. Confirming this assumption, Ponticelli and Alencar (2016) document that the potential extra-jurisdiction is a good predictor of court congestion in a representative sample in Brazil. I also find qualitatively the same relationship in my data (column 1 in

[30]My sample spans Parana and Sao Paulo states. For a municipality to be considered to receive its own court, Parana requires at least 30,000 inhabitants, 10,000 voters, and 400 originated court cases (*Lei Estadual n.* 14277). Sao Paulo requires at least 10,000 voters (*Decreto-Lei Complementar n.* 3). For other states, please refer to Table A2 in Ponticelli and Alencar (2016).

Table (7)).[31] Specifically, one adjacent municipality that does not meet the criteria for its own judicial district is associated with a 14 percent higher court congestion.

The second assumption is that potential extra-jurisdiction is exogenous with respect to the location choice for silos. I assess this concern in column 2 of Table (7). When I compare the area where a silo was constructed to the runner-up areas, I find that potential extra-jurisdiction does not correlate with the choice of location. Overall, the measure of potential extra-jurisdiction is a good predictor of local court congestion and the location of silos is unrelated to the quality of local courts.[32]

In what follows, I estimate the treatment effect of constructing a silo across municipalities with different degrees of court efficiency. Table (8) reports the results for the log of total credit, the probability of any outstanding credit, the probability and quantity of an outstanding barter credit as well as the quantity of cash credit. For all outcomes, the odd columns report the cross-sectional estimates using the continuous court efficiency measure, defined as the log of backlog of cases per judge, while the even columns report the cross-sectional estimates using the potential extra-jurisdiction measure. Following Ponticelli and Alencar (2016), I control for the total number of neighbors of each municipality, as well as other municipality and neighbors' observable characteristics.[33]

I find that the treatment effect of opening a silo is stronger in municipalities with weaker courts. Farmers receive more credit and use more barter contracts after opening a silo in municipalities with weaker courts. This is true for both the court congestion measure and the potential extra-jurisdiction. The estimated coefficients suggest that in areas with a one standard deviation more congested courts (or more potential extra jurisdiction) the increase in credit is about thirteen to fifteen percent higher, borrowers are

[31] Following Ponticelli and Alencar (2016), I control for the total number of neighbors of each municipality, as well as other municipality and neighbors' observable characteristics. I omit bankruptcy court dummy, since there is no municipality with a specialized bankruptcy court in my sample.

[32] Please refer to the original paper by Ponticelli and Alencar (2016) for additional details and robustness tests for this empirical design.

[33] Unlike Ponticelli and Alencar (2016), I omit bankruptcy court dummy since none of the court districts in my sample have a specialized bankruptcy court.

about nine percent more likely to have an outstanding credit, and the likelihood of using a barter contract is about three to five percent higher. There is no effect on cash credit contracts, however. This suggests that contracting outcomes improve due to the insurance and enforcement benefits within the barter contract.[34] Since my empirical setup limits the ability to differentiate between the enforcement and insurance channels, the stronger effects in weaker court areas can be interpreted through either of the two channels.

5.4 Financially Constrained Borrowers

An extensive theoretical literature argues that optimal debt policy critically depends on the value of pledgeable assets. Thus, all else equal, a borrower possessing a high value collateral is more likely to obtain the necessary funding than a borrower owning a collateral with lower valuation. Put differently, constrained farmers should have more difficulties in accessing alternative sources of financing, in particular bank debt, than farmers with more pledgeable assets. If the construction of a silo results in the elimination of some credit market frictions, then the marginal benefit of these changes should be larger for borrowers whose total value of pledgeable assets is lower. Thus, the agribusiness lender should increase lending especially for the more constrained borrowers.

To show that the effects of the construction of a silo are particularly strong for constrained borrowers, I examine the cross-sectional variation between farmers who own their farmland and those who rent it. Since landowners have more pledgeable assets than renters, the effect on renters should be larger. Furthermore, this cross-sectional variation allows for a strengthening of my identification strategy. In particular, I can control for the aggregate time-varying branch-level demand or supply, by including the branch-month fixed effects.[35] Such a specification examines the treatment effect between constrained and unconstrained borrowers within the same branch, controlling for all ag-

[34] Reassuringly, I find that the estimates remain robust when I include empirical designs for both price insurance and contract enforcement in one regression model (Table (A5)).

[35] Please note that this specification absorbs the *Silo* variable.

gregate time-varying branch-specific characteristics.

As expected, farmers who rent their farmland benefit more (Table (9)). The results suggest that the total lending to those farmers increases twice as much (column 1) but it does not affect their propensity to borrow (columns 2) relative to landowners. Renters are more likely to issue barter credit (column 3 and 4), while there seems to be no effect on the quantity of cash credit contracts (column 5) in comparison to landowners. More importantly, the results remain strong even after controlling for the time-series changes in branch-specific characteristics, such as the demand, the investment opportunities, and the location of the silo (columns 5 through 10). In these columns, I saturate the specification with branch-month fixed effects that absorb the treatment dummy. These findings lend strong support to my identification strategy and to the central message of the paper that access to a warehouse mitigates credit market frictions.

5.5 Other Interpretations and Limitations

In the analysis above, I focus on the benefits achieved through barter contracts. Nevertheless, improvement in credit outcomes could also be achieved through other mechanisms. For instance, access to storage could increase collateral liquidation value, since collateral can be quickly seized, stored in lenders' designated warehouses and rapidly liquidated (for instance, Smith (1987); Biais and Gollier (1997); Burkart and Ellingsen (2004); Donaldson et al. (2018)). Another channel could be through increased market power in the local grain market. Limited alternative trading opportunities for farmers could reduce their temptation to default and renege on existing contracts (Kranton, 1996; Ghosh and Ray, 1996; Macchiavello and Morjaria, 2019).[36]

It is difficult to reconcile these two channels with the evidence that most of the results are driven by changes in the usage of barter credit contracts. The general increase in

[36]While analyzing market power is difficult, the evidence in the paper is somewhat inconsistent with the market power channel. First of all, markups seem to have declined after the construction of a silo, suggesting that market power has declined rather than increased.

the collateral value (grain), as well as the increase in market power, should affect cash and barter contracts equally. Since my analysis above documents that the improvements are largely focused in the barter contracts, these channels are less consistent with this differential effect. Having said that, my analysis does not rule these channels out. My results suggest that at least some part of the improvement in credit outcomes is achieved through embedded mechanisms in the barter contracts.

6 Robustness

My main empirical finding in Section 4 is that the integration of a silo leads to significant changes in credit outcomes. Then, in the section above, I show that access to a warehouse mitigates credit market frictions associated with price insurance and contract enforcement. Overall, the results are consistent with the view that access to a warehouse that can store borrowers' output increases the pledgeability of borrowers' cash flows. Nevertheless, the possibility remains that these results are driven by alternative channels. This section provides some robustness tests and rules out several alternative explanations. I also discuss real effects on the economy and the external validity of the results.

6.1 Trends

One concern might be that the alternative silo locations are a weak counterfactual for the treated branches. While the dynamic effects that I report alleviate this concern, I perform an additional robustness test. Specifically, I add a borrower-specific time trend. This specification absorbs the linear trend for each borrower separately. My results remain qualitatively similar (Table (A6)). The estimates on all credit quantities – total credit, barter credit and cash credit – are similar to those in the benchmark specification. The only exception is the effect on markup that becomes statistically insignificant. This could be partially a power issue, since this econometric specification saturates my model with a linear time-trend for each borrower. Overall, it is unlikely that my results are driven by trends in the data.

6.2 Storage Capacity

Lack of storage capacity might restrain farmers from borrowing more and increasing their production. Clearly, a new silo expands the total storage capacity in a municipality. Consequently, farmers might borrow more, as there is free storage space after the opening of another silo.

To examine how constructing a silo interacts with the available storage capacity, I obtain the total storage capacity (in tons) from the Brazilian census of agriculture, 2006. As municipalities differ in their size, I scale the total capacity by two proxies for potential total output: 1) the total farmland in a municipality measured in hectares, and 2) the total quantity of soybeans, corn, and wheat produced in tons. The larger any of these proxies, the more storage space there is.[37]

I find that it does not matter whether a municipality has a deficit or unutilized storage space (Table (A7)). I report the results on total credit volume, probability of an outstanding credit, probability of issuing barter credit, and the total outstanding barter credit. None of the four proxies are significant. Thus, the results remain robust to insufficient storage capacity.

6.3 Borrower Exit

The results in Section 4.2 suggest that a silo improves the lender's ability to maintain an active lending relationship with existing borrowers. While this is a valuable implication in itself, it does create a selection concern, since more borrowers remain in treated branches. To investigate how borrowers who exit compare in treated vs runner-up branches, I com-

[37]The results are qualitatively identical if I scale by the total area of a municipality or the total planted area (both in hectares).

pare them on pre-treatment characteristics. I define exit as when a borrower does not borrow for a continuous twelve-month period.[38] On average, borrowers who exit are smaller and less likely to default (coefficient on *Exit* in Table (A9)). There is no difference, however, between exiters in treated relative to runner-up branches (coefficient on *Exit x Silo* in Table (A9)). Since the exit rate is larger in runner-up branches, this suggests that treated branches are able to sustain a relationship with somewhat smaller and safer borrowers. While selection towards smaller borrowers biases against my finding that credit increases after opening a silo, the slight decline in default rates in my main results (statistically insignificant) might be driven by the ability to maintain a relationship with safer borrowers.

6.4 Real Effects

I have documented how a lender improves credit outcomes by accessing a warehouse. Although this increases the supply of credit from the lender's point of view, I have not yet analyzed the real effects on farmers. While the dataset is comprehensive, it includes only the contracts between the farmers and the lender. Clearly, farmers could be contracting with other parties that are out of my sample. To overcome this and shed some light on the real effects, I analyze the significance of opening a silo at the municipality level.[39]

The agribusiness lender plays a significant role in each of its municipalities. For instance, the grain storage capacity of a branch corresponds to about 24 percent of a municipality's annual production volume of soybeans, corn and wheat. The agribusiness' total credit supply scaled by the total number of farms in a municipality is around 10,219 reais in the pre-treatment period, and an average branch serves roughly 23 percent of the number of farms in a municipality.[40]

[38] Using this definition, I find that borrowers in the treated branches are by about 20 percent less likely to stop borrowing from the agribusiness lender (see Table (A8)).

[39] The analysis is done at annual frequency, since the municipality level information is available only at annual frequency.

[40] The annual output data are obtained from the statistics bureau of Brazil (IBGE); the number of

To understand how the additional credit supply affects the farming output, I perform an instrumental variable estimation, where the branch level credit supply is instrumented with whether or not a silo is open at a branch. Thus, the first stage measures the additional credit supply associated with the opening of a silo. The second stage then explores the relationship between the municipality level outcomes and the additional credit supply coming from opening a silo.

The first stage results suggest that opening a silo increases the credit supply by about 57 percent (Panel A in Table (10)). I examine the effect on four real economic outcomes that are particularly relevant for the farming sector. These are the total production of soybeans, corn and wheat in bushels and in Brazilian reais, the total harvested area and the agricultural GDP. I find that the 57 percent increase in credit supply corresponds to about a 7 percent ($= 57\% \cdot 13\%$) higher output (columns 1 and 2 in Panel B) and harvested area (column 3 in Panel B).[41] This suggests that output grew by more planting rather than higher yield. While the effect on agricultural GDP is positive, it is statistically insignificant. Finally, evidence suggests that the improvements in real outcomes are stronger in areas with more congested courts. While the effects are positive across all measures, they are statistically significant for the area harvested and agricultural GDP. In terms of economic magnitudes, a one standard deviation increase in potential extra-jurisdiction increases the harvested area by 5 percent and agricultural GDP by 3 percent.

To better understand the economic magnitudes, I perform a back of the envelope calculation. Using the aggregated statistics from the Central Bank of Brazil and Census of Brazil, the average per farm credit is 45,624 reais in my sample of municipalities in 2006.[42] Thus, the 5,824 ($= 57\% \cdot 10,219$) reais increase in per farm credit corresponds to about a thirteen percent (=5,824/45,624) increase in total credit. In the same period, the

total farms from the Brazilian Agricultural Census 2006.

[41]These results agree with the previous finding by Butler and Cornaggia (2011), who show that higher access to finance leads to an increase in productivity, measured by crop yields.

[42]The estimates of total rural credit are provided by the Central Bank of Brazil and the total number of farms by the Brazilian Agricultural Census 2006.

average per farm revenue was about 76,978 reais.[43] Thus, the seven percent[44] increase in agricultural output translates into about 5,388 reais more farm revenue. Thus, the estimates suggest that a one real increase in credit supply transforms into a 0.93 reais (=5,388/5,824) increase in farm revenue. It is not surprising that the elasticity is below one. For instance, farm investment might exhibit decreasing returns to scale, or the additional credit supply may crowd out other sources of funding such as farmers' own funds or bank credit.

6.5 Generalizability

Here, access to a warehouse mitigates credit market frictions and boosts the real economy. Nevertheless, as with all empirical studies of this nature, one should be careful when trying to generalize these results to other industries or markets. Therefore, I briefly discuss the broader applicability of the findings.

From an agricultural perspective, such financing models, including barter credit contracts, are widely used not only in emerging but also in developed markets, including the US (for instance, by multibillion agribusiness firms such as Cargill, Bunge, ADM, and OLAM).[45] Bunge and OLAM reported 1.2 and 2.3 billion USD in prepaid expenses used for procurement of physical commodities in 2013.[46]

These contracts are used not only in farming but also in other commodity related

[43]The data is from the Brazilian Agricultural Census 2006.

[44]This is the multiplication of column 2 of Panel B in Table (10) and column 1 of Panel A of the same table.

[45]Both Cargill and ADM sell production inputs such as fertilizer on credit and trade grain worldwide. Similarly to the agribusiness here, they allow the credit to be repaid both in grain and in cash. For more details on credit applications in the US please see here: http://www.cargillag.com/Marketing/ProductServices/crop-inputs/crop-inputs-financing (Cargill) and https://www.e-adm.com/corpcredit/creditapplform.asp (ADM).

[46]It is difficult if not impossible to extract exact numbers about these credit contracts from the public statements, since they could be classified both as accounts receivables and as prepaid expenses. Additionally, firms seldom discuss the credit contracts that they provide in detail. Thus, any measure is likely to significantly under-report the true situation. Furthermore, as farming is cyclical, the numbers that are reported at the end of the fiscal year might fall between harvesting and plowing seasons when most of debt is settled. One would need to know the total flow of funds during the year to determine an accurate number for the volume of credit contracts.

industries, such as metal mining and oil. In 2013, Glencore, the world's largest producer and trader of metals, reported 4.1 billion USD in prepaid expenses. These prepayments were largely repaid by future production of the counterparty. To add to this, Troika Group and Noble Group, leading oil and metal traders, reported prepaid expenses of over 2 billion and 6 billion USD, respectively, in the same period.[47] The Economist (2015) also highlights that besides the more traditional forms of bank financing, such as structured commodity trade finance, firms engage in direct lending that requires large funds from these firms. In fact, The Economist (2015) stresses that it is very common for traders to lend money to their commodity suppliers. Thus, the mechanism documented in this paper for the farming industry could be generalized to the cross-section of commodity sectors.

Relatedly, Almeida et al. (2017) document that 21.5 percent of all non-financial Compustat firms use purchase obligations. Purchase obligations are non-cancelable contracts with suppliers for materials or services, generally over one-year to three-year horizons. On average, these obligations amount to 11.8 percent of total assets and 21.4 percent of COGS for firms that use them. While these contracts are not trade credit, they highlight the vast variety of contracts that firms use to secure their inputs, including firms operating in non-commodity industries.

In modern banking, custodian banks serve a similar role to a warehouse.[48] These banks hold assets such as stocks, bonds, and commodities in safekeeping. The actual owner of these securities, which is not the custodian bank, can pledge them to any lender. These securities would then be deposited with the custodian bank. The lender then signs an agreement with the custodian bank and the borrower that the collateral cannot be liquidated, i.e. removed from the custodian bank, unless the debt contract is settled. This arrangement significantly improves collateralization and is particularly common in

[47] Like the agribusinesses above, firms are quite obscure when it comes to disclosing details of their trade credit contracts. These contracts could be broadly categorized as prepaid expenses or accounts receivables. Thus, any disclosed number is likely to be an underestimate.

[48] Most major US banks such as Goldman Sachs and Bank of America offer these services.

developed countries such as the US.[49]

Furthermore, the global agricultural sector employed approximately 38% of the available global workforce in 2011.[50] This fraction was over 80% for regions such as Africa and other developing regions that suffer severely from credit market frictions. Since access to a warehouse is likely to be more important for markets with a weak institutional environment, the findings could be helpful for mitigating enforcement problems and improving welfare in these regions.

These findings shed light on the great popularity of trade credit. Fisman and Love (2003) argue that trade credit is prevalent in poorly developed financial markets. I have documented that trade creditors that are able to store borrowers' output are more likely to extend credit. This resonates well with the notion that this form of trade credit has advantages in increasing the pledgeability of borrowers' cash flows when the institutional environment is rather weak. Last but not least, a barter credit is a very old type of contract with a history going back long before the invention of modern banking. For example, in Babylonian times silver was borrowed against a repayment in grain (Goetzmann and Rouwenhorst, 2005). This is in line with the above point that such forms of financing are important when financial markets are underdeveloped. Finally, while barter credit is one of the oldest forms of credit, barter trade has seen a rapid expansion nowadays with many new online bartering platforms reaching annual turnover of around 12 billion USD (Keys and Malnight, 2012). This suggests that barter might regain its attractiveness due to the rising importance of sharing economy.

[49]For instance, Supernova, a US based online lender, offers loans against securities that are deposited in a custodian bank: https://www.supernovacompanies.com/lending/briteline/.

[50]This data was obtained from The World Factbook, Central Intelligence Agency: https://www.cia.gov/library/publications/the-world-factbook/fields/2048.html.

7 Conclusion

This paper documents that creditors alter their organizational design to mitigate credit market imperfections. In particular, I study a storage technology – a warehouse – for borrowers' grain output and a new debt contract, repayable in grain rather than cash. Using the staggered construction of grain silos by a large agribusiness lender in Brazil for my empirical design, I find that the lender's access to warehouses that can store borrowers' output permits a new debt contract, repayable in grain, and increases borrowers' debt capacity. Access to the silo is more valuable when output price insurance is more important, for farmers located in municipalities with weak courts, and for financially constrained borrowers. My results suggest that the improvement in credit outcomes is primarily achieved through the new barter credit contract that embeds price insurance as well as stronger enforcement rights than the traditional cash credit contract.

While there has been much theoretical work on the Coasian topic of organizations and their boundaries, there has been far less empirical work on this subject. My analysis contributes to the debate by documenting that the lender expands its boundaries to access a warehouse. However, an important question remains: is ownership of a silo necessary or can the same results be achieved through a long-term lease contract? In a rational world, if replicating a transaction outside a firm is no different from performing it inside, a firm should be indifferent between the two options. Since the agribusiness lender never utilizes a third-party silo, I implicitly assume that performing this outside the firm is sufficiently costly to make it economically unattractive.[51] This is a conjecture that would greatly

[51] The agribusiness lender has refused the use of third-party silo operators, based on the considerable risk in enforcing repayment from them. Upon receipt of the grain, a silo operator becomes an "effective" owner of the grain. If the silo operator defaults or decides to expropriate the grain, the bankruptcy procedure to repossess this grain is cumbersome and inefficient. This is the hold-up problem, as discussed by transaction-cost economics (Williamson, 1975, 1985; Klein et al., 1978). The lender also argues that writing a long-term lease contract with a silo operator is risky. It is difficult both to contract on all possible states of the world ex-ante and to renegotiate if the operator fails to respond to unforeseeable market developments. Thus, the lender may be burdened with silos that are inappropriate to serve farmers' future needs. For example, the offloading mechanisms may be significantly slower than those of a competitor. As delays in harvesting can be excessively costly, farmers will shy away from the lender in favor of competitors. Thus, it might be optimal for the lender to integrate the silos, as proposed by

benefit from further empirical investigation.

From the policy perspective, it is important to understand whether banks could benefit from access to such a contracting technology and whether they should own warehouses.[52] Since the funding costs of banks are generally lower than those of trade creditors, they could provide cheaper credit. However, trade creditors are likely to have more expertise and information about their borrowers, making the screening costs very low. While anecdotal evidence suggests that this type of lending exists in modern banking (e.g., custodian banks as warehouses), I leave the task of understanding the particular costs and benefits for future research.

the property-rights theories of the firm (Grossman and Hart, 1986). For these two reasons, the lender constructs its own silos.

[52]For instance, it has been reported that both Goldman Sachs and JP Morgan Chase own aluminum warehouses around the world: http://www.bloomberg.com/news/articles/2015-03-04/goldman-sachs-jpmorgan-dropped-from-aluminum-antitrust-lawsuit.

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Figure 1: Identification Strategy – Control and Treatment Groups

The figure below illustrates my identification strategy. Each time the lender considers building a new silo, they consider several alternative locations. As a counterfactual to the treated branches, I consider the branches that the lender considered as "equal" when deciding where to locate the silos (i.e. the runner-up branches).

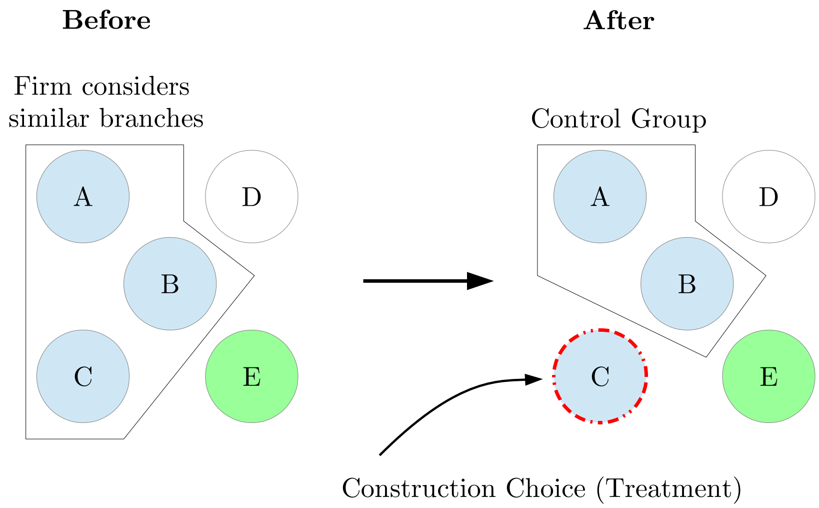

Figure 2: Dynamics Plot: Total Credit

The graph below plots the evolution of the treatment effect (construction of a silo) on the total credit outstanding at the borrower level. The horizontal axis measures time, in months, since the construction of a silo (0 represents the opening of a silo). The vertical axis measures the log total value of total outstanding credit at the borrower-month-case level. The coefficients are estimated using equation (1) and represent the effect on existing borrowers (100,204 observations for the years 2006 – 2012). The horizontal lines indicate a 95% confidence interval.

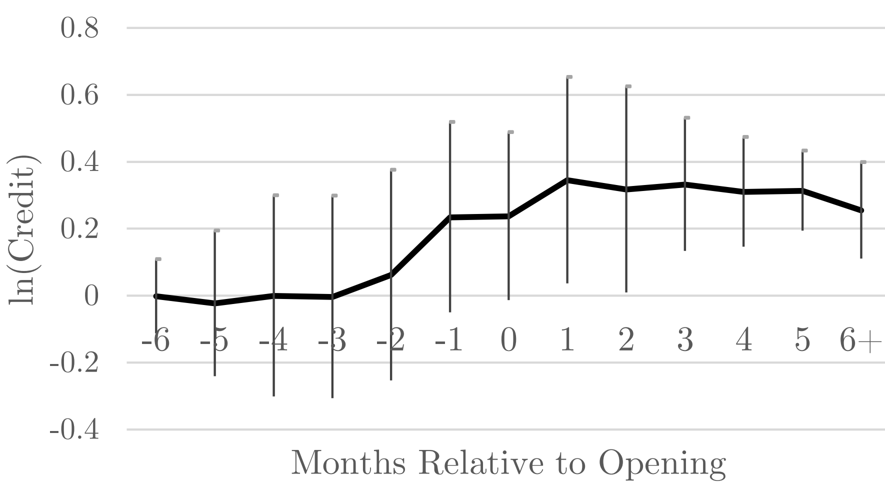

Figure 3: Cross-Sectional Variation: Cash Credit vs Barter Credit

The figure below illustrates the differences in cross-sectional loan size between cash and barter credits. The figure plots smoothed kernel density functions. The vertical axis measures the smoothed estimate for the density function of the natural logarithm of credit, while the horizontal axis measures the natural logarithm of the loan size. The solid line represents cash credit, the dashed line – barter credit. Estimated using the sample of all credit contracts (338,290 observations) between 2006 and 2012.

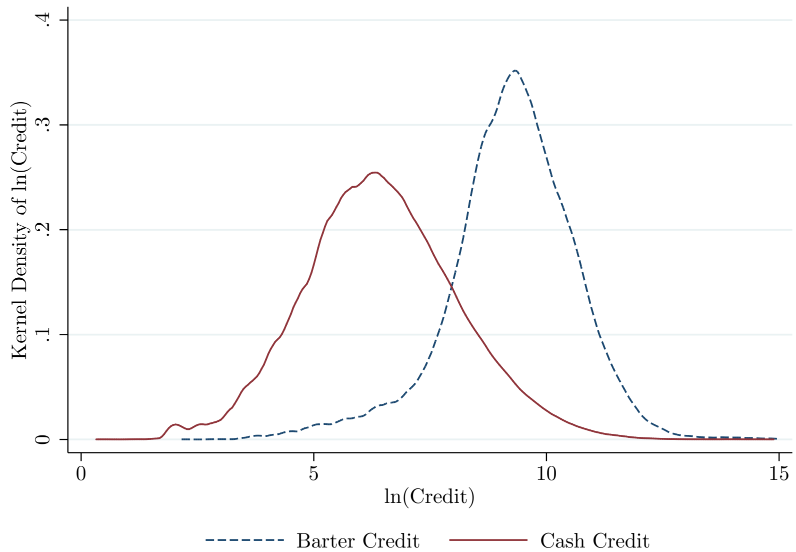

Figure 4: Dynamics Plot: Barter Credit

The graph below plots the evolution of the treatment effect (construction of a silo) on the probability of issuing a barter credit contract at the borrower level. The horizontal axis measures time, in months, since the construction of a silo (0 represents the opening of a silo). The vertical axis measures the probability of issuing a barter contract at the borrower-month-case level. The coefficients are estimated using equation (1) and represent the effect on existing borrowers (100,204 observations for the years 2006 – 2012). The horizontal lines indicate a 95% confidence interval.

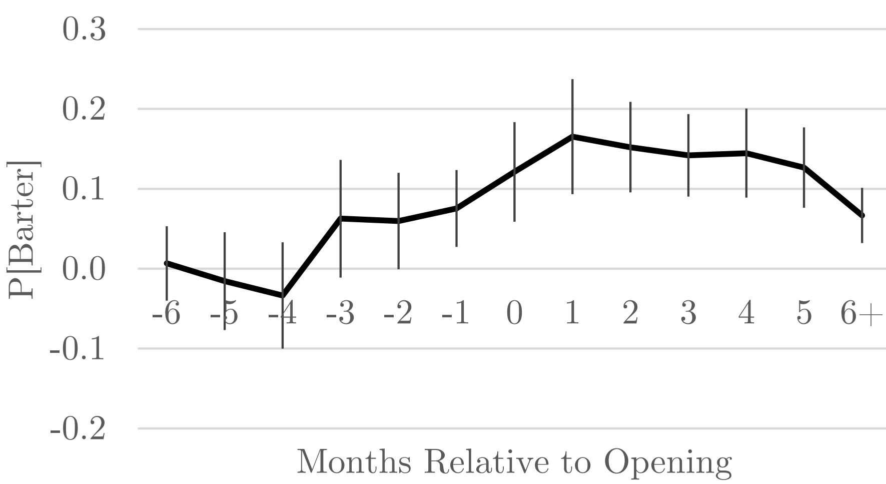

Table 1: Branch Characteristics by Treatment Status

The table below reports branch characteristics by the treatment status 18 to 0 months prior to the opening of a silo. Columns 1 to 3 compute mean values for all variables within each group: Treated, Runner-up, and Other non-treated branches. Columns 4 and 5 calculate the average difference between groups within a case (i.e. they use case fixed effects to account for differences between cases). *Treated branches* are those next to which a silo was constructed, *Runner-up branches* are those that were considered as alternative locations for the silos, and *Other non-treated branches* includes all other non-treated branches. ln(Total Credit) and ln(New Credit) measure the logarithm of the total outstanding and new credit in a branch each month, respectively. ln(# borrowers) is the logarithm of the total number of borrowers with outstanding credit each month. ln(Barter Credit +1) measures the logarithm of total outstanding barter credit plus one. ln(Mean Credit) is the average outstanding credit per borrower. Maturity is the average debt maturity in days. All variables are aggregated at the branch-month level. The sample ranges from 2006 to 2012 and consists of 36 branches. Standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	Treated branches (1)	Runner-up branches (2)	Other non-treated branches (3)	Difference (Col. 1- Col. 2) (4)	Difference (Col. 1- Col. 3) (5)
ln(Total Credit)	12.34	12.02	14.19	0.327	-1.917**
				(0.563)	(0.900)
ln(New Credit)	10.73	11.01	12.50	-0.047	-1.779***
				(0.346)	(0.500)
ln(# Borrowers)	2.11	2.06	3.49	0.062	-1.393**
				(0.391)	(0.576)
ln(Barter Credit)	9.67	8.24	12.66	1.555	-3.102*
				(1.072)	(1.673)
ln(Mean Credit)	10.21	9.94	10.70	0.264	-0.531
				(0.362)	(0.425)
Maturity	156.22	162.11	148.21	-7.434	6.016
				(6.534)	(7.406)
Observations	217	648	2,119	865	2,336

Table 2: Summary Statistics

The table below reports pre-treatment descriptive statistics for existing (Panel A) and new borrowers (Panel B). The data in Panel A are aggregated at client-month level and consist of 1,168 borrowers with 43,498 observations. The data in Panel B are aggregated at the branch-month level and consists of 995 observations out of 19 branches. Existing borrower is defined as a borrower who had an active relationship in the two years prior to the opening of a silo within a case. Sample of new borrowers is defined as any borrower who obtains their first loan in a given month. I report the mean, standard deviation, and median for all the variables. The sample ranges from 2006 to 2012.

	Mean	Std. Dev.	p50
Panel A: Existing Borrowers			
Total credit (1,000 reais)	28.809	53.943	5.020
Probability of an outstanding credit	0.586	0.492	1.000
Fraction of debt in default	0.048	0.214	0.000
Markup	0.415	0.951	0.261
Fraction of borrowers with a hedge	0.228	0.419	0.000
Fraction of credit with hedge if hedge>0	0.805	0.226	0.896
Barter credit (1,000 reais)	47.230	50.562	25.095
Panel B: New Borrowers			
Total new credit (1,000 reais)	339.512	1,009.435	62.260
Number of new clients	17.174	22.207	6.000
Average loan	20.923	41.001	6.759
Fraction of debt in default	0.029	0.131	0.000
Markup	0.328	0.468	0.264
Barter Credit	485.151	1,426.684	76.984
Fraction renters	0.570	0.322	0.568

Table 3: Existing Borrowers

The table below reports the effect of the construction of a silo on total outstanding credit (column 1), the probability of an outstanding credit (column 2), the fraction of credit that is in default at any point in the future (column 3), and markup (columns 4) for existing borrowers. The loan is classified as defaulted if it defaults or is renegotiated at some point. Markup is defined as the total reais value of a credit contract with the farmer over the total raw costs of the products sold. The unit of analysis is case-borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	P[Credit]	Defaults	Markup
	(1)	(2)	(3)	(4)
Silo (Treat)	0.176***	0.136***	-0.019	-0.047*
	(0.035)	(0.041)	(0.030)	(0.027)
Obs	100,204	186,703	100,204	100,204
Adj-R2	0.747	0.513	0.370	0.463
Month-Case-FE	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y

Table 4: New Borrowers

The table below reports the effect on first-time borrowers, aggregated at the branch-level: the log of the number of borrowers, the log of the total credit, the log of the average loan size, the log of barter credit +1, the value-weighted default probability, the average markup, and the fraction of new borrowers who rent their farmland in columns 1 through 7, respectively. The unit of analysis is case-branch-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(# New Brwrs)	ln(New Credit)	ln(Avg Loan)	ln(Barter)	Defaults	Markup	% Renters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Silo (Treat)	0.681***	0.481*	-0.172	0.469*	-0.008	-0.044*	-0.060*
	(0.159)	(0.266)	(0.179)	(0.254)	(0.009)	(0.023)	(0.032)
Obs	2,366	2,366	2,366	2,366	2,366	2,366	2,366
Adj-R2	0.325	0.603	0.556	0.574	0.477	0.603	0.201
Month-Case-FE	Y	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y

Table 5: Financial Contracts – Barter Credit

The table below reports the effect of the construction of a silo on the probability of an outstanding barter credit (columns 1 and 6), the natural logarithm of the value of barter credit plus one (columns 2 and 7), the natural logarithm of the value of cash credit plus one (column 3), the total outstanding credit (column 4), and the probability of outstanding credit (column 5) for existing borrowers. The unit of analysis is case-borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	P[Barter]	ln(Barter)	ln(Cash)	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Silo (Treat)	0.072***	0.786***	0.008	0.039	0.125***	-0.062***	-0.416*
	(0.014)	(0.137)	(0.102)	(0.084)	(0.034)	(0.014)	(0.239)
Silo x No Barter Before				0.258*	0.015	0.221***	1.985**
				(0.014)	(0.035)	(0.025)	(0.274)
Obs	100,204	100,204	100,204	100,204	186,703	100,204	100,204
Adj-R2	0.559	0.586	0.618	0.754	0.513	0.561	0.587
Month-Case-FE	Y	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y

Table 6: Price Insurance

This table reports the heterogeneous treatment effect with respect to exposure to price risk. First, I exploit the State Minimum Price Guarantee program that sets a minimum price at which the government buys the agricultural output from farmers in Brazil. The *Minimum Price Guarantee* is the ratio between the minimum price and the futures price of the commodity, capturing the fraction of the expected price of the commodity that is insured (columns 1 through 5). Second, *Price Volatility* is the standard deviation of the local commodity prices within an agricultural cycle (columns 6 through 10). Both measures are dummy variables equal to one when the value is above the sample median. I report the estimated effect on total outstanding credit (columns 1 and 6), the probability of an outstanding credit (columns 2 and 7), the probability of an outstanding barter credit (columns 3 and 8), the natural logarithm of outstanding barter credit plus one (columns 4 and 9), and the natural logarithm of outstanding cash credit plus one (columns 5 and 10). The unit of analysis is case-borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	Minimum Price Guarantee					Price Volatility				
	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)	ln(Cash)	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)	ln(Cash)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Silo (Treat)	0.231***	0.110**	0.080***	0.906***	-0.078	0.227***	0.133	0.057***	0.679***	0.093
	(0.026)	(0.039)	(0.015)	(0.151)	(0.175)	(0.033)	(0.043)	(0.013)	(0.132)	(0.101)
Silo x *High P Guarantee*	-0.086*	0.033	-0.024**	-0.241*	0.109					
	(0.044)	(0.029)	(0.012)	(0.131)	(0.171)					
x *High Volatility*						-0.024	-0.012	0.020**	0.222***	-0.102**
						(0.026)	(0.009)	(0.008)	(0.063)	(0.045)
Obs	100,204	186,703	100,204	100,204	100,204	100,204	186,703	100,204	100,204	100,204
Adj-R2	0.752	0.515	0.563	0.592	0.561	0.744	0.515	0.563	0.592	0.651
Month-Case-Grain-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 7: Potential Extra-Jurisdiction, Judicial Efficiency, and Silo Location

This table examines whether potential-extra jurisdiction predicts court congestion and silo location. The table closely follows Table V of Ponticelli and Alencar (2016), estimating the same model on the sample of municipalities in this study. *Potential extra-jurisdiction* is the number of adjacent municipalities that do not meet the requirements to become a seat of a judicial district. Other control variables include the total number of neighboring municipalities, the number of bank branches per 100,000 inhabitants and the following observable characteristics of neighbors: average income per capita, average area in square km, average manufacturing share in local GDP. The dependent variable in column 1 is the natural logarithm of the number of pending court cases per judge and in column 2 *Construction Choice* is equal to one if a silo was constructed next to a branch within a construction case. Municipality characteristics are observed in the year 2000. All specifications include case fixed effects. The sample ranges from 2006 to 2012 and consists of 19 branches. Robust standard errors are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

	Log Backlog per Judge	Construction Choice
	(1)	(2)
Potential extra-jurisdiction	0.143**	0.096
	(0.070)	(0.104)
Number of neighbors	-0.115*	-0.007
	(0.057)	(0.094)
Bank branches per 100,000 inhab.	-0.008*	0.018**
	(0.005)	(0.008)
Log income per capita	-0.252	0.427
	(0.256)	(0.469)
Log avg. income per capita neighbors	7.759***	-0.127
	(2.296)	(3.339)
Log avg. area neighbors	0.157	0.006
	(0.164)	(0.279)
Manufacturing value added share	0.559	-0.680
	(0.946)	(1.433)
Obs	50	50
R2	0.732	0.311
Case-FE	Y	Y

Table 8: Court Quality

This table reports the effect of the construction of a silo depending on court quality. To measure court enforcement quality, I collect the necessary data from *Justiça Aberta* of the National Justice Council. *Court congestion* is the log of the average number of pending cases per judge in a judicial district during the whole sample. *Potential extra-jurisdiction* is the number of adjacent municipalities that do not meet the requirements to become a seat of a judicial district. Other control variables include the total number of neighboring municipalities, the number of bank branches per 100,000 inhabitants and the following observable characteristics of neighbors: average income per capita, average area in square km, average manufacturing share in local GDP. All measures are standardized with mean zero and variance of one. I report the estimated effect on total outstanding credit (columns 1 and 2), the probability of an outstanding credit (columns 3 and 4), the probability of an outstanding barter credit (columns 5 and 6), the natural logarithm of outstanding barter credit plus one (columns 7 and 8), and the natural logarithm of outstanding cash credit plus one (columns 9 and 10). The variable *Silo* is equal to 1 if a branch has a silo in that month. The unit of analysis is case-borrower-month. Municipality characteristics are observed in the year 2000. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)		P[Credit]		P[Barter]		ln(Barter)		ln(Cash)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Silo (Treat)	0.178***	0.235***	0.120***	0.161***	0.069***	0.073***	0.782***	0.740***	0.012	0.127
	(0.051)	(0.066)	(0.043)	(0.020)	(0.013)	(0.022)	(0.129)	(0.238)	(0.120)	(0.085)
Silo x *Court congestion*	0.158*		0.096*		0.039*		0.453**		0.097	
	(0.091)		(0.021)		(0.022)		(0.209)		(0.115)	
x *Potential extra-jurisdiction*		0.132**		0.083***		0.050***		0.484***		0.102
		(0.059)		(0.019)		(0.015)		(0.154)		(0.064)
x *Number of neighbors*		-0.072		0.002		0.001		0.032		0.173
		(0.085)		(0.035)		(0.019)		(0.191)		(0.104)
x *Bank branches per 100,000 inhab.*		0.118**		-0.017		-0.048***		-0.495***		0.267***
		(0.047)		(0.017)		(0.013)		(0.134)		(0.050)
x *Log income per capita*		0.166*		0.008		-0.032*		-0.337		0.224***
		(0.083)		(0.020)		(0.017)		(0.200)		(0.069)
x *Log avg. income per capita neighbors*		-0.238**		-0.114***		0.001		0.066		-0.453***
		(0.105)		(0.025)		(0.017)		(0.194)		(0.088)
x *Log avg. area neighbors*		0.108**		0.003		-0.063***		-0.194		-0.046
		(0.049)		(0.032)		(0.014)		(0.157)		(0.088)
x *Manufacturing value added share*		-0.122**		-0.111***		0.0303***		-0.635***		-0.013
		(0.053)		(0.025)		(0.005)		(0.153)		(0.063)
Obs	100,204	100,204	186,703	186,703	100,204	100,204	100,204	100,204	100,204	100,204
Adj-R2	0.751	0.748	0.514	0.515	0.559	0.560	0.588	0.582	0.566	0.55
Month-Case-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 9: Financially Constrained vs Unconstrained Borrowers

The table reports the effect of the construction of a silo depending on whether the farmer owns (unconstrained) or rents (constrained) the farmland. I report the estimated effect on total outstanding credit (columns 1 and 6), the probability of an outstanding credit (columns 2 and 7), the probability of an outstanding barter credit (columns 3 and 8), the natural logarithm of outstanding barter credit plus one (columns 4 and 9), and the natural logarithm of outstanding cash credit plus one (columns 5 and 10). *Renter* is a dummy variable equal to one if a farmer rents the farmland. The unit of analysis is case-borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. Columns 1 through 5 control for time trends within a case (month-case fixed effects), whereas columns 6 through 10 control for all time-variation for each branch, therefore absorbing the *Silo* variable and controlling for all aggregate changes in the demand (month-case-branch fixed effects). The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in the parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)	ln(Cash)	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)	ln(Cash)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Silo (Treat)	0.137***	0.127**	0.051***	0.496***	-0.030					
	(0.043)	(0.057)	(0.014)	(0.144)	(0.096)					
Silo x Renter	0.134*	0.027	0.048**	0.674**	0.180	0.235***	0.027	0.056*	0.712**	0.232
	(0.071)	(0.083)	(0.021)	(0.271)	(0.164)	(0.054)	(0.083)	(0.027)	(0.303)	(0.174)
Obs	100,204	186,703	100,204	100,204	100,204	100,204	186,703	100,204	100,204	100,204
Adj-R2	0.75	0.51	0.56	0.59	0.63	0.76	0.51	0.57	0.60	0.64
Month-Case-FE	Y	Y	Y	Y	Y	-	-	-	-	-
Month-Branch-FE	N	N	N	N	N	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 10: Real Effects

This table reports the real effects on agricultural output in an Instrumental Variable strategy. Panel A reports the first stage regression, analogue to the main specification, of the log of total new credit at the branch-year level on whether or not this branch has a silo in that year. Panel B reports the second stage results where log of total new credit at the branch-year level is instrumented through whether or not a branch has a silo. The table reports the effect on the total production output measured in bushels (columns 1 and 5), Brazilian reais (columns 2 and 6), harvested area in hectares (columns 3 and 7), and agricultural GDP (columns 4 and 8) at the municipality-year level. The annual output data are obtained from the statistics bureau of Brazil (IBGE). The unit of analysis is case-branch-year. The variable *Silo* is equal to 1 if a branch has a silo in that month. *PotExtra* is the number of adjacent municipalities that do not meet the requirements to become a seat of a judicial district. *NrNeighbors* is the total number of neighboring municipalities. Both variables are standardized to mean zero and standard deviation of one. Observations are weighted by the pre-treatment per farm credit in municipality, measured as the total credit provided by a branch over the number of farms in a municipality. The sample ranges from 2006 to 2012. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)
	(1)
Panel A: First Stage	
Silo (Treat)	0.567**
	(0.184)
Obs	338
AdjR2	0.947
Year-Case-FE	Y
Branch-FE	Y

	ln(Volume)	ln(Output)	ln(Area)	ln(AgriGDP)	ln(Volume)	ln(Output)	ln(Area)	ln(AgriGDP)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel B: Second Stage								
$ln(\widehat{Credit})$	0.134***	0.130**	0.123**	0.015	0.083**	0.076	0.071	-0.024
	(0.036)	(0.036)	(0.038)	(0.035)	(0.028)	(0.044)	(0.043)	(0.042)
$\widehat{ln(Credit) \cdot PotExtra}$					0.050	0.038	0.050**	0.032**
					(0.030)	(0.021)	(0.025)	(0.011)
$\widehat{ln(Credit) \cdot NrNeighbours}$					0.028	0.032	0.028	0.023*
					(0.025)	(0.025)	(0.017)	(0.009)
Estimation	IV	IV	IV	IV	IV	IV	IV	IV
Obs	338	338	338	338	338	338	338	338
F-stat	9.47	9.47	9.47	9.47	14.05	14.05	14.05	14.05
Year-Case-FE	Y	Y	Y	Y	Y	Y	Y	Y
Branch-FE	Y	Y	Y	Y	Y	Y	Y	Y

Internet Appendix for Barter Credit:

Warehouses as a Contracting Technology

A Additional Tables

Table A1: Duration of Legal Enforcement Process in Years

The table below reports how long it takes in years, how long it takes to enforce a contract from the date of default until the court proceedings are completed and the contract is settled. The sample consists of contracts that were finalized between 2010 and 2012 (data on other years is not available). The last column tests for the statistical difference in mean duration of enforcement process between cash and barter credit contracts. *** indicates statistical significance at 1%.

	N. Obs	Mean	p50	Difference
Cash Credit	229	4.54	4.81	1.079***
Barter Credit	122	3.47	3.41	(0.247)

Table A2: Branch Level

The table below reports the effect of the construction of a silo on existing borrowers aggregated at the branch-month level. The dependent variable in column 1 is the log of the average outstanding credit. Column 3 measures the fraction of credit that is in default at any point in the future. Markup (column 3) is the average markup charged for existing borrowers. Column 4 is the average probability of an outstanding barter credit. Columns 5 and 6 reports the average outstanding barter credit and cash credit plus one respectively. The unit of analysis is case-branch-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	Defaults	Markup	P[Barter]	ln(Barter)	ln(CashCr)
	(1)	(2)	(3)	(4)	(5)	(6)
Silo (Treat)	0.187*	-0.033**	0.008	0.173***	1.560**	0.055
	(0.110)	(0.014)	(0.056)	(0.073)	(0.722)	(0.274)
Obs	3,608	3,608	3,608	3,608	3,608	3,608
Adj-R2	0.727	0.694	0.302	0.573	0.607	0.458
Month-Case-FE	Y	Y	Y	Y	Y	Y
Branch-FE	Y	Y	Y	Y	Y	Y

Table A3: Harvest Level Aggregation

The table below reports the effect of the construction of a silo on existing borrowers aggregated at the borrower-harvest level. The dependent variables in columns 1 and 2 are the log of outstanding credit and the probability of any outstanding credit, respectively. Columns 3 measures the fraction of credit that is in default at any point in future. Markup (column 4) is defined as the total sales value of a credit contract with the farmer over the total raw costs of the products sold. Columns 5 and 6 analyze the effect on the probability of an outstanding barter credit and the log of outstanding barter credit +1, respectively. Column 7 measures the log of cash credit +1. The unit of analysis is case-borrower-harvest. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	P[Credit]	Defaults	Markup	P[Barter]	ln(Barter)	ln(Cash)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Silo (Treat)	0.206**	0.170***	-0.021	-0.039	0.087***	0.924***	0.029
	(0.094)	(0.041)	(0.023)	(0.031)	(0.019)	(0.181)	(0.154)
Obs	20,931	34,337	20,931	20,931	20,931	20,931	20,931
Adj-R2	0.755	0.503	0.311	0.406	0.546	0.577	0.629
Harvest-Case-FE	Y	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y

Table A4: Quantity Discounts

This table reports the effect of the construction of a silo on markup, controlling for loan size. Markup is defined as the total sales value of a credit contract with the farmer over the total raw costs of the products sold. *ln(Credit)* is defined as the log of a borrower's total credit in each month. The unit of analysis is case-borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%

	Markup
	(1)
Silo (Treat)	-0.048*
	(0.027)
ln(Credit)	0.003
	(0.003)
Obs	100,204
Adj-R2	0.479
Month-Case-FE	Y
Borrower-FE	Y

Table A5: Combined Effect

This table reports the heterogeneous treatment effect with respect to both exposure to price risk and local court quality. The *Minimum Price Guarantee* is the ratio between the minimum price and the futures price of the commodity, capturing the fraction of the expected price of the commodity that is insured. Second, *Price Volatility* is the standard deviation of the local commodity prices within an agricultural cycle. Both measures are dummy variables equal to one when the value is above the sample median. *Potential extra-jurisdiction* is the number of adjacent municipalities that do not meet the requirements to become a seat of a judicial district. Other control variables include the total number of neighboring municipalities, the number of bank branches per 100,000 inhabitants and the following observable characteristics of neighbors: average income per capita, average area in square km, average manufacturing share in local GDP. All measures are standardized with mean zero and variance of one. I report the estimated effect on total outstanding credit (cols 1 and 6), the probability of an outstanding credit (cols 2 and 7), the probability of an outstanding barter credit (cols 3 and 8), the natural logarithm of outstanding barter credit plus one (cols 4 and 9), and the natural logarithm of outstanding cash credit plus one (cols 5 and 10). The variable *Silo* is equal to 1 if a branch has a silo in that month. The unit of analysis is case-borrower-month. Municipality characteristics are observed in the year 2000. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	Minimum Price Guarantee					Price Volatility				
	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)	ln(Cash)	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)	ln(Cash)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Silo (Treat)	0.242***	0.135***	0.077***	0.769***	0.107	0.204***	0.157***	0.055**	0.548**	0.176
	(0.072)	(0.020)	(0.017)	(0.189)	(0.124)	(0.063)	(0.024)	(0.020)	(0.222)	(0.103)
Silo x *High P Guarantee*	-0.088	0.031	-0.023*	-0.218*	0.055					
	(0.057)	(0.030)	(0.012)	(0.119)	(0.116)					
x *High Volatility*						-0.017	-0.012	0.020**	0.209***	-0.078*
						(0.027)	(0.010)	(0.007)	(0.066)	(0.042)
x *Potential extra-jurisdiction*	0.115**	0.081***	0.041**	0.386*	0.074	0.117**	0.081***	0.042**	0.392*	0.072
	(0.054)	(0.018)	(0.017)	(0.186)	(0.061)	(0.054)	(0.018)	(0.017)	(0.186)	(0.060)
x *Number of neighbors*	-0.105	-0.004	-0.018	-0.190	0.049	-0.110	-0.002	-0.019	-0.197	0.050
	(0.079)	(0.024)	(0.020)	(0.215)	(0.098)	(0.079)	(0.036)	(0.020)	(0.215)	(0.093)
x *Bank branches per 100,000 inhab.*	0.109**	-0.019	-0.032**	-0.319**	0.405***	0.108**	-0.019	-0.033**	-0.322**	0.406***
	(0.042)	(0.017)	(0.013)	(0.139)	(0.076)	(0.042)	(0.017)	(0.013)	(0.140)	(0.076)
x *Log income per capita*	0.052	-0.012	-0.039	-0.433	0.225*	0.052	-0.012	-0.039	-0.431	0.224*
	(0.076)	(0.021)	(0.025)	(0.284)	(0.117)	(0.076)	(0.021)	(0.024)	(0.281)	(0.116)
x *Log avg. income per capita neighbors*	-0.058	-0.081**	0.008	0.175	-0.275**	-0.051	-0.083***	0.010	0.193	-0.280**
	(0.078)	(0.029)	(0.023)	(0.263)	(0.109)	(0.077)	(0.028)	(0.023)	(0.263)	(0.111)
x *Log avg. area neighbors*	0.109*	-0.003	-0.007	-0.089	0.072	0.111*	-0.004	-0.007	-0.087	0.072
	(0.055)	(0.032)	(0.016)	(0.174)	(0.070)	(0.055)	(0.032)	(0.016)	(0.174)	(0.069)
x *Manufacturing value added share*	-0.078	-0.101***	-0.062***	-0.629***	0.183**	-0.075	-0.101***	-0.062***	-0.626***	0.182**
	(0.046)	(0.024)	(0.014)	(0.152)	(0.073)	(0.046)	(0.024)	(0.013)	(0.150)	(0.073)
Obs	100,204	186,703	100,204	100,204	100,204	100,204	186,703	100,204	100,204	100,204
Adj-R2	0.749	0.517	0.564	0.587	0.645	0.749	0.517	0.564	0.587	0.645
Month-Case-Grain-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table A6: Borrower-Level Time Trend

This table reports the effect of the construction of a silo, controlling for farmer-level time trends. I augment the main specification (1) by adding a linear time-trend for each borrower. The dependent variables in columns 1 and 2 are the log of outstanding credit and the probability of any outstanding credit, respectively. Column 3 measures the fraction of credit that is in default at any point in the future. Markup (column 4) is defined as the total sales value of a credit contract with the farmer over the total raw costs of the products sold. Columns 5 and 6 analyze the effect on the probability of an outstanding barter credit and the log of outstanding barter credit plus one, respectively. Column 7 measures the log of cash credit +1. The unit of analysis is borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	P[Credit]	Default	Markup	P[Barter]	ln(barter)	ln(Cash)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Silo (Treat)	0.282***	0.112***	0.002	-0.029	0.078***	0.838***	0.084
	(0.052)	(0.027)	(0.031)	(0.035)	(0.023)	(0.247)	(0.118)
Obs	100,204	186,703	100,204	100,204	100,204	100,204	100,204
Adj-R2	0.816	0.623	0.579	0.612	0.660	0.682	0.734
Month-Case FE	Y	Y	Y	Y	Y	Y	Y
Borrower FE	Y	Y	Y	Y	Y	Y	Y
Borrower Trend	Y	Y	Y	Y	Y	Y	Y

Table A7: Storage Capacity

This table reports the effect of the construction of a silo depending on the available grain storage capacity in a municipality. I obtain the total grain storage capacity (in tons) in each municipality from the Brazilian census of agriculture, 2006. To obtain a measure of storage deficit/utilization I scale this variable by two proxies for total production, also obtained from the same source: 1) the total quantity produced of soybeans, corn, and wheat in tons (*Produced Quantity*) and 2) the total farmland in a municipality in hectares (*Total Farmland*). The dependent variables are the log of outstanding credit (columns 1 and 5), the probability of any outstanding credit (columns 2 and 6), the probability of an outstanding barter credit (columns 3 and 7), and the log of outstanding barter credit +1 (columns 4 and 8), respectively. The unit of analysis is case-borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The sample ranges from 2006 to 2012 and consists of 1,168 borrowers from 19 branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)	ln(Credit)	P[Credit]	P[Barter]	ln(Barter)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Silo (Treat)	0.170***	0.123***	0.071***	0.758***	0.177***	0.121***	0.073***	0.772***
	(0.031)	(0.039)	(0.016)	(0.150)	(0.033)	(0.039)	(0.016)	(0.153)
Silo x Capacity/Produced Quantity	-0.031	0.013	-0.013	-0.133				
	(0.050)	(0.027)	(0.015)	(0.153)				
Silo x Capacity/Total Farmland					-0.029	0.009	-0.008	-0.068
					(0.017)	(0.013)	(0.007)	(0.063)
Obs	99,034	184,797	99,034	99,034	99,034	184,797	99,034	99,034
Adj-R2	0.750	0.514	0.561	0.583	0.750	0.514	0.561	0.583
Month-Case-FE	Y	Y	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y	Y	Y

Table A8: Exit Rate

The table below reports the effect of the construction of a silo on borrower attrition. The unit of analysis is case-borrower, where the dependent variable *P[Exit]* equals one if a borrower with an active relationship when a silo was open within a case does not borrow for twelve consecutive months at any point after the construction. The variable *Silo* is equal to 1 if a branch obtained a silo within a construction case. The standard errors are reported in parentheses and clustered at the branch level. *** significant at 1%

	P[Exit]
	(1)
Silo (Treat)	-0.226***
	(0.038)
Obs	2,337
Adj-R2	0.042
Case-FE	Y

Table A9: Comparison of Borrowers who Exit

The table below examines the pre-treatment characteristics of borrowers who exit versus those who stay. The unit of analysis is case-borrower. Exit equals one if a borrower with an active relationship when a silo was open within a case does not borrow for twelve consecutive months at any time in the future. The dependent variables in column 1 is the log of outstanding credit, and in column 2 it is the fraction of debt that is late prior to the construction of a silo. The variable *Silo* is equal to 1 if a branch obtained a silo within a construction case. The standard errors are reported in parentheses and clustered at the branch level. *** significant at 1%

	ln(Credit)	Default
	(1)	(2)
Exit	-1.253***	-0.029**
	(0.101)	(0.011)
Silo (Treat)	0.459	0.026
	(0.328)	(0.034)
Silo x Exit	0.034	-0.006
	(0.311)	(0.028)
Obs	2,337	2,337
Adj-R2	0.154	0.064
Case-FE	Y	Y