Firm Boundaries and Financial Contracts

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Abstract

This paper documents how financial institutions alter their firm boundaries to overcome credit market frictions and relax financial constraints. Specifically, I examine the construction of new grain silos by a large agribusiness lender that provides credit to small farmers in Brazil, a market characterized by weak legal institutions. I exploit the staggered nature of the silo construction and employ a difference-in-differences research design to examine how this change in organizational design affects lending. I find that ownership of a silo allows the lender to significantly increase lending to both existing and new borrowers, with the effects being more pronounced for financially constrained borrowers and those exposed to more weather risk. Furthermore, it enables the lender to offer a new contract that provides a price hedge, an innovation that is particularly useful for periods with high commodity price volatility. Thus, the paper uncovers an alternative enforcement mechanism, designed by the lender, to overcome weak creditor rights.

Keywords: Credit Market Imperfections, Financial Contracts, Boundaries of the Firm, Pledgeable Cash Flows, Risk Management, Hedging

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1 Introduction

Credit markets play a critical role in fostering economic growth through allocation of capital in the economy. These markets, however, are characterized by imperfections such as information asymmetry between lenders and borrowers that create inefficiencies in the allocation process. Consequently, a large literature emphasizes the importance of financial contracts and legal institutions in mitigating these frictions (for example, La Porta et al. (1998)). In this paper, I document how lenders alter their firm boundaries to relax credit constraints in an economy with a weak legal infrastructure.

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). Despite this large theoretical literature, empirical research has lagged behind. There are several obstacles that hinder research in this area. In particular, the effects of organizational form are difficult to identify empirically, as firms do not choose their form randomly. A profit-maximizing firm optimizes its organizational structure to achieve the highest profit. Thus, to assess the effect on economic variables, one requires a laboratory providing a plausibly exogenous variation in the boundaries of a firm. Furthermore, a researcher needs detailed contract-level data to analyze the effects of firm boundaries on financial contracts.

In this paper, I use micro-level data from a large Brazilian agribusiness with sales of over 1 billion USD and a client base of 19,000 farmers in 2013. The agribusiness sells farm production inputs such as fertilizer and pesticides, provides credit to small farmers who have limited access to bank financing,[1] and collects, stores and trades grain. Such agribusinesses are the main creditors for these farmers in Brazil. For the expansion in the firm boundaries of the creditor, I utilize the construction of grain storage[2] units (i.e. silos) next to branch offices that provide credit.[3] It is important to note that the agribusiness has refused the use of third-party silos

[1] The size of a an average farm is 158 hectares or 390 acres with a gross revenue of 179,000 USD per harvest.

[2] The construction of a silo is a costly capital investment. The average construction cost is 8 million USD and the operating costs are roughly 1 million USD per year.

[3] From a farmer's perspective, the distance from a silo is important. A 30 km reduction in distance in one direction can save roughly 2 hours of travel time. Given that on average these farmers make 80 trips in each harvest period, this accounts for 160 hours of work or four full working weeks. During the harvest such delays

on the grounds of quality, trust and enforcement.[4] These silos enable a local branch office to improve the monitoring and enforcement of loans, as the harvested crop is directly delivered to the firm's silos; whereas, when borrowing from a branch without a silo, a farmer delivers and sells the grain to a third party and repays the debt only after receiving a cash payment. As a result, the repayment takes four to six weeks longer and effectively leaves the creditor without the collateral, i.e. grain, during that period. Furthermore, with a silo the firm can offer a new credit contract that is settled in grain rather than cash. In such a contract, the firm and a farmer fix the quantity of grain to be delivered at the date of maturity. Thus, this contract provides a hedge against commodity price risk and reduces the need to monitor the borrower's active hedging positions. Nonetheless, the extent to which the expansion in firm boundaries can relax credit constraints and affect financial contracts remains an empirical question.

The dataset is rich in detail and offers comprehensive information on the financial contracts of borrowers. Most importantly, it provides both time-series and cross-sectional variation in the expansion of firm boundaries. For identification, I exploit the construction of grain silos as a variation in the boundaries of the firm and employ a difference-in-differences (DID) research design. Thus, I examine how integrating a grain storage facility mitigates credit frictions to small farmers who have limited access to bank financing and affects financial contracts that are issued by an agribusiness lender.

Valid estimates of the boundaries of a firm require the identification of a branch that is, in effect, identical to the branch where the silo was constructed (henceforth, 'the treated branch'). A random branch can differ from the treated branch in terms of local demand, land productivity, sensitivity to weather shocks, quality of workforce and many other variables. I overcome this challenge by relying on alternative locations for silos that the owners of the firm considered near 'equivalent' at the time when the decision on where to locate the new silos was made. When the firm considers where to open a silo, it typically begins by examining several possible locations. Then it narrows the list to roughly four finalists. Thus, by knowing the finalists, I can

are particularly costly due to the rental cost of equipment. The delay can further reduce the quality of grain in cases of unanticipated rainfall.

[4]The firm named several reasons for not cooperating with third-party silos. For instance, in many cases, the equipment is worn out and does not meet the necessary quality standards for grain storage; and sometimes they find it difficult to enforce repayment by the silo operators. As a result they have strategically decided not to cooperate.

identify the treated branch as well as the runner-up branches (i.e. the control branches). It is important to note that 75 percent of the control branches are treated later on, which illustrates that these branches are 'equal' except for the timing of the construction, which makes it a staggered treatment. Furthermore, from an individual borrower's perspective – the main unit of analysis in this paper – the construction choice is exogenous, as it is unlikely to be driven by a single borrower (an average silo is used by roughly 800 farmers from which only a third are also borrowers).

The identifying assumption is that the borrowers in these alternative locations form a valid counterfactual for the borrowers in the treated branches. To confirm this, I formally tested for the differences between treated, runner-up and all non-treated branches in the period 18 to 0 months before the treatment. Compared to all non-treated branches, treated branches issued less credit and lent to fewer customers during the period prior to building a silo. But compared to runner-up branches, treated branches had similar trends in all variables such as total credit and number of borrowers. This convincingly shows that the average branch is not a credible counterfactual and that the runner-up branches do form a valid counterfactual for the treated sample. To ensure the robustness of my identification strategy, I also exploit the staggered nature of the treatment and run a DID specification, using the treated branches only. The identification assumption here is that all treated branches are 'equal' and differ only on the time dimension of when the silo is constructed. The results remain qualitatively the same.

Besides its unique laboratory, the Brazilian farming industry has several practical features that make it favorable for analyzing the effect of firm boundaries on financial contracts. First, 70 percent of farming activities in Brazil are financed through credit (Agrarian Markets Development Institute, 2011). Second, and more importantly, 60 percent of this financing is raised through a special contract – called a Rural Product Note – that is largely provided by non-banks. The contract was created so that non-bank financial institutions, such as the firm studied here, could provide financing for inputs that are necessary for farm production, as bank financing was difficult to obtain. Third, Brazil is a key player in the global agriculture commodity market.[5]

[5] For example, it has been the second largest producer and the largest exporter of soybean 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.

The main finding of this paper is that expanding the firm boundaries of the creditor mitigates credit market imperfections. I find that the construction of grain storage units significantly increases lending to existing borrowers. Specifically, I observe that the total value of loans increases by 30 percent at the borrower level. In terms of contract performance, I find that the default rates remain unchanged and the gross margin of credit sales declines by 9 percent. The gross margin is the gross profit that the firm earns over and above the raw costs of the fertilizer, seeds, etc. that it sells on credit and this margin includes the price of credit. Thus, existing borrowers benefit from a higher level of loan volume and, more importantly, lower prices. In terms of overall performance, the total revenue of the agribusiness increases by 20 percent per existing borrower. Importantly, I show that none of these results are driven by pre-treatment trends.

Furthermore, the firm not only increases lending to existing borrowers (i.e. the intensive margin) but also attracts new borrowers (i.e. the extensive margin). I find that the overall lending triples and the number of clients that take out a loan doubles at the branch level. In addition, the default rates of the total loan portfolio remain unchanged and the gross margin increases by 15 percent. Thus, the firm charges more to new borrowers than to existing ones.

Besides more lending, the lender is able to offer a new credit contract that is repaid in grain rather than cash. Such a contract, called a barter credit, allows borrowers to hedge the price risk, as the credit agreement comes with an embedded forward contract with physical delivery. Apart from providing a price hedge, it also reduces moral hazard and asymmetric information problems (Adams and Yellen, 1976; Laffont and Tirole, 1986; Holmström and Milgrom, 1991). For example, grain delivery starts before the maturity date, thereby improving credit enforcement.[6] In particular, the probability of issuing a barter credit increases by 8 percentage points or 30 percent from the mean probability at the borrower level. At the same time, the probability of issuing credit that is repaid in cash remains unchanged. Moreover, at the branch level, when new borrowers are also considered, the probability of issuing a barter credit increases by 29 percentage points or doubles when measured against the mean probability.

I also document that financially constrained borrowers, i.e. farmers who rent rather than

[6] If a farmer does not deliver the grain, the agribusiness can obtain a court order within two days and harvest the grain itself.

own their farmland, benefit more from the new silo. Furthermore, I show that this is true even after controlling for changes in branch-level demand, which lends additional support to my identification strategy. All in all, the agribusiness is able to increase lending to farmers with limited access to high-quality pledgeable assets. Such borrowers are often characterized as 'soft' information borrowers and suffer from more credit frictions (Petersen, 2004). Therefore, this finding shows how changes in the boundaries of a firm can alter the supply of credit to 'soft' information borrowers who are likely to be rationed by large and hierarchical banks (Berger et al., 2005; Liberti and Mian, 2009; Liberti et al., 2012; Skrastins and Vig, 2014).

With regard to mechanism, the evidence shows that a borrower is able to credibly pledge more cash flows and increase borrowing when the creditor has an integrated grain storage unit. I show that some of these gains are associated with the new credit instrument, i.e. barter credit. Specifically, there are two important mechanisms within the barter credit: hedging and product bundling. First, the embedded forward contract protects the borrower against commodity price risk (Smith and Stulz, 1985; Froot et al., 1993). Second, bundling the forward contract with credit can solve incentive problems, associated with both moral hazard and asymmetric information (Adams and Yellen, 1976; Laffont and Tirole, 1986; Holmström and Milgrom, 1991). Most importantly, these contracts have better enforcement, as grain delivery starts before the maturity date, accelerating repayment and improving monitoring. Furthermore, it increases the collateral value, as the grain is directly delivered to the firm instead to a third party.

All in all, the results are consistent with the idea of mitigating frictions in credit markets. First, the effects of expanding the firm boundaries are stronger for constrained borrowers. Second, the results are larger at times when commodity price volatility is high, which speaks directly to the hedging component in the barter contracts. Third, the findings are more pronounced in geographic regions with more volatile weather. This result shows that expansion in firm boundaries is especially important for geographic regions that suffer from more frictions in credit markets. I carry out a range of robustness tests and discuss some alternative explanations in Section 6.

This paper contributes to several streams of the literature. First of all, it presents evidence on how to mitigate credit market imperfections and improve access to finance. Law and finance literature argues that formal institutions such as courts are important for mitigating contracting frictions (La Porta et al., 1998; Levine, 1999; Benmelech et al., 2005; Djankov et al., 2007; Qian and Strahan, 2007; Benmelech and Bergman, 2008; Davydenko and Franks, 2008; Benmelech, 2009; Haselmann et al., 2010; Vig, 2013; Assuncao et al., 2013). Alternatively, similar effects can be achieved through informal institutions such as relationship (Petersen and Rajan, 1994), social capital (Karlan, 2005), trade credit (Fisman and Love, 2003), and even organizational hierarchy (Berger et al., 2005; Liberti and Mian, 2009; Liberti et al., 2012; Skrastins and Vig, 2014). This paper uncovers a new mechanism, designed by lenders, to overcome weak creditor rights, suggesting that markets invent alternative credit enforcement mechanisms where formal institutions fail to.

This paper also adds to the literature on firm boundaries.[7] Some previous 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). This paper, however, documents that integrating a vertically related business into a lender's operations mitigates credit market frictions and improves access to finance.

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 firm and the farming industry in Brazil. In Section 3, I lay out my identification strategy. Section 4 describes the results of firm boundaries on contract types, loan quantities, defaults, and prices; Section 5 analyzes potential mechanisms; and Section 6 rules out a range of alternative explanations. Section 7 concludes the study.

2 Institutional Background and Data

The data provider for this study is a large agribusiness in Brazil, with annual turnover above 1 billion USD and a customer base of over 19,000 farmers as of December 2013. The firm operates

[7] Some of the notable recent contributions on the economic outcomes of firm boundaries are Mullainathan and Scharfstein (2001); Chipty (2001); Hastings (2004); Hastings and Gilbert (2005); Ciliberto (2006); Hortaçsu and Syverson (2007); Gil and Hartmann (2009); Gil (2009); Forbes and Lederman (2010); Gil (2014); Gil and Warzynski (2014); Atalay et al. (2014); Pérez-González (2014); Seru (2014).

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 agriculture commodities – buying and storing grain from farmers and selling to large purchasers both domestically and internationally (see Figure (1)). The firm provides these services to small and medium size farmers (the average farm size is 150 ha with a harvest-level revenue of 179,000 USD) who have limited access to bank finance. This study focuses on the lending side of the business, where the firm operates as a creditor to farmers.

The dataset is rich in detail. It contains detailed information on all loan contracts, hedging positions, purchases and sales of production inputs and grain products at the invoice level. At the loan contract level, it includes the loan balance outstanding, the fraction of each loan that is hedged, the maturity, and the number of days late in payment, among others. On the production inputs front, it includes raw costs, purchased quantity, and an inventory of all the products bought by the firm. It also holds information on all the sales invoices that the firm made to its clients – the quantity and the price by product. The sample spans 7 years – from January 2006 to December 2012.

2.1 Institutional Setup: Credit

A farmer can purchase production inputs such as fertilizer or pesticides from the firm in two ways – either by paying cash or by borrowing on credit (see Figure (2)). When a client borrows to purchase the production inputs, there are two ways in which the debt can be settled. First, the borrower can repay the debt in cash at 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 at the issue 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 contract a *barter credit* because the lender and a farmer exchange production inputs for grain at two distinct points in time. One important feature of the *barter credit* is that its embedded forward component protects the borrower against commodity price fluctuation, which is a major risk in farming (Harwood et al., 1999; OECD, 2009). Another important feature is that this contract bundles together credit and a price hedge. Such contracts can overcome moral hazard and asymmetric information issues (for instance, no need to monitor the true borrower's hedging position). Most importantly, these contracts have a better enforcement. As grain delivery starts before the maturity date, it accelerates repayment and improves monitoring. As a result, the repayment is four to six weeks shorter. Furthermore, it increases the collateral value, as the grain is directly delivered to the firm instead of a third party.

A few further details must be clarified. Both types of credit – cash and barter – are a special type of loan contract for farmers and are called 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 or cash payment. Both cash and barter contracts have the same collateral – future harvest – and are subject to the same enforcement and bankruptcy procedure. There are *three* important differences (see Figure (2)).[8] First, the cash CPR does not call for a physical delivery of the grain, while the barter credit does. Second, the barter credit fixes the commodity price. Third and more importantly, barter credit contracts are repaid during or shortly after the harvest. While cash credit contracts are repaid later, as the harvested grain has to be sold and transformed into cash which takes roughly four to six weeks in case it is delivered to a third party. In Brazil, roughly 60 percent of external financing in farming is raised through these contracts, while the remaining 40 percent is raised through bank debt (Agrarian Markets Development Institute, 2011).

2.2 Summary Statistics

I focus on farmers who bought production inputs on credit. Within the sample period, the firm issued roughly 300,000 such contracts. In Table (1), I present means, medians, standard deviations, and the 1st and the 99th percentile for the main variables of interest for both client-month and branch-month levels. The loan amounts are expressed in Brazilian reals.[9]

During the sample period 7,637 clients borrowed from the firm. Out of these, 2,951 clients (or roughly 40 percent) used credit with a forward contract to hedge the total repayment in terms of output quantity (i.e. in tons of soybean, corn or wheat). The average size of a farm in the sample is 158 hectares (which is roughly the size of 150 full size football pitches), while the

[8] For detailed legal documentation, the reader can refer to laws 8,929/94, 10,200/01, and 11,076/04, which govern these contracts.

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

median is 50 hectares. To put this in perspective, farms below 500 hectares in size constitute 98 percent of the number of farms and only 44 percent of the land area in Brazil (Berdegué and Fuentealba, 2011). The average total outstanding value of credit for a borrower is 34,200 reals a month, which is roughly 17,000 USD. Furthermore, the value-weighted default rate, defined as 1 if the loan is not repaid on time and is renegotiated or defaults, is 6.5 percent. The average maturity and markup, defined as the face value plus interest over raw costs of the inputs, are 192 days and 39 percent respectively. The average fraction of debt that a borrower hedges using a forward contract in a month is 31 percent. However, that fraction increases to 83 percent when only those months in which a borrower hedges at least a fraction of the total outstanding credit are considered.

At the branch-month level, an average branch issues 451,000 reals (or 241,000 USD) worth of new debt each month. On average, a branch issues new credit to 43 borrowers per month. The value-weighted default rate, defined as 1 if the loan is not repaid on time and is renegotiated or defaults, is 6.5 percent. The average maturity and markup are 164 days and 36 percent respectively. The average fraction of debt that is issued in combination with a forward contract is 31 percent.

Table (2) reports cross-sectional summary statistics based on whether a branch office has a silo or not. Both borrower-level and branch-level cross-sectional results (Panels A and B, respectively) suggest that a branch with a silo is associated with more lending and more barter contracts. At the borrower level, both total credit and the fraction of credit that is hedged are 50 percent higher in branches with a silo. At the branch-level, the difference in quantities is even greater. Total new credit and the number of borrowers taking out a loan are both at least twice as high in branches with a silo. In addition, the fraction of debt that is hedged is 50 percent higher in branches with a silo. Moreover, the kernel densities in Figure (3) show that cross-sectionally the amount of credit is larger in branches that have a silo.

That said, it should be noted that all these cross-sectional patterns may be driven by heterogeneity in types of borrowers in different branches or by the degree of firm competition. For instance, borrowers in a branch with a silo may have different risk appetite or lower borrower risk profile. Thus, to alleviate these concerns, I examine both within-borrower and within-branch variation in firm boundaries (i.e. access to a silo), allowing me to control for such cross-sectional differences.

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 sells production inputs. Second, over time it also entered the grain business by constructing grain storage units, i.e. silos (see Figure (4)). At the end of 2013, the firm operated 77 branch offices, of which 36 had a silo.

The construction of a silo is a special case of vertical integration (see Figure (5)). 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 integrates either a customer or a supplier, but it integrates a business from a vertical supply chain. In particular, having a silo enables the firm to offer two new products. First, it can buy, sell and store grain that is produced by farmers. Second, it can offer *barter credit* for clients of the branch office, since it has a facility where to store the delivered grain.

My identification strategy of firm boundaries hinges on the construction of silos. Because the decision on where to locate the new silo is made to maximize profits, the branch selected for treatment is likely to differ substantially from an average or randomly chosen branch, both at the time of opening and in future periods. Valid estimates of firm boundaries require the identification of a branch that is identical to the branch where the silo was constructed. That, however, is a difficult task. A random branch can differ from the treated branch in terms of local demand, land productivity, sensitivity to weather shocks, quality of workforce and many other variables.

This paper's solution is to rely on alternative locations for silos that the owners of the firm considered as 'equivalent' at the time of construction (see Figure (6)). When the firm decides where to open a silo, it typically begins by considering several possible locations. Then it narrows the list 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 are the ones that survived a long selection process but narrowly lost out to the treated branch. They provide a valid counterfactual for what would have happened to the borrowers in a branch in the absence of the construction of a silo. Furthermore, from an individual borrower's perspective the construction choice is exogenous, as it is unlikely to be driven by a single borrower. These alternative locations come from the firm's archives and interviews with the owner-managers of the firm.

The identifying assumption is that the runner-up branches form a valid counterfactual to the treated branches. To confirm this, I formally test for the differences among treated, runner-up and all non-treated branches 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 all non-treated branches provides an opportunity to assess the validity of the type of analysis that would be undertaken in the absence of a quasi-experiment.

Table (3) reports the results. Compared to all non-treated branches (column 5), treated branches issue less credit, lend to fewer customers, and issue less *barter credit* in the period 18 to 0 months before the treatment. But compared to runner-up branches (column 4), treated branches have similar trends in all variables. 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. The next section outlines the full econometric model.

3.2 Empirical Specification

My empirical strategy identifies the effect of firm boundaries on financial contracts. I employ a difference-in-differences (DID) strategy and compare borrowers in branches where a silo was constructed against a control group of borrowers in runner-up branches. The runner-up branches are those that have survived a long selection process but narrowly lost out to the treated branch. 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:

$$y_{jmi} = \tau_{jm} + \tau_i + \delta \cdot \text{Treat}_{jmi} + \eta_{jmi}, \quad (1)$$

where the dependent variable (e.g., total credit) is measured at the case-borrower-month level; j references case, m month, and i borrower. $Treat_{jmi}$ is a dummy variable equal to one if the branch, of which borrower i is a client, has a grain storage unit in month m. Thus, once a silo is built, this variable turns 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 time trends within a case. These fixed effects ensure that the impact of silo construction is identified from comparisons within a 'pair' of treated and runner-up branches.

This strategy identifies the effect of expanding firm boundaries (i.e. silo construction) on financial contracts, controlling for time and borrower invariant effects. The coefficient δ is my DID estimate of the effect of firm boundaries. 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 considering 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 what the effect of constructing a silo is 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 firm boundaries. 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.

It should be noted that if branch B is also treated at some later point, this would imply a staggered nature of treatment. The staggered nature of silo construction implies that all treated branches belong to both treated and control groups at different points in time. Therefore, equation (1) implicitly takes as a control group all borrowers from branches that are not subject to silo construction at month m in case j, even if they will be treated later on, or will not be treated at all. Essentially, this makes my identification strategy even stronger as 75% of the control branches are treated later on, ensuring that these branches are 'equal' except of the timing of construction.[10]

4 Results

This section is divided into two subsections. Section 4.1 reports the effect of firm boundaries (i.e. silo construction) on the borrower-level variables, utilizing the within-borrower variation. This provides results on the intensive margin. Section 4.2 explores the effect on total branch-level measures, thereby taking into account the extensive margin (i.e. lending to new borrowers).

4.1 Borrower-Level Results

In this subsection, I explore the effect of firm boundaries on borrower-level measures (i.e. intensive margin). First, I evaluate the changes in the contract types that the firm offers. Then, I investigate how silo constriction affects loan quantities, credit repayment (risk), and the prices charged for the products sold on credit.

New Financial Contracts: Barter Credit

To begin, cross-sectional statistics at the borrower level show that barter debt (repaid in grain rather than cash) constitutes approximately 30 percent of the total credit in branches with a silo, compared to only 20 percent in branches without a silo (Panel A in Table (2)). Even though the evidence suggests that having a silo enables the firm to offer credit with a price hedge, all cross-sectional results should be taken with a pinch of salt. As these findings may be driven by

[10]Important to note, a staggered specification using only treated branches is a weaker identification, as it assumes that all branches are similar, whereas this approach assigns a specific branch that is similar and is treated later on in most of the cases , making it a within-case staggered treatment.

a heterogeneity among borrowers, I evaluate the within-borrower variation.

As discussed above, I use the construction of a grain storage unit as a proxy for expansion in firm boundaries. Given a control group that consists of runner-up branches, forming a valid counterfactual of what would have happened without the silo, I can make causal inferences about the effects of firm boundaries on financial contracts. In particular, using a difference-in-differences research strategy, I exploit the within-borrower variation that allows me to control for borrower-specific, unobservable characteristics, thus mitigating the concern of endogenous choice of organizational form and heterogeneity among different types of borrowers.

Columns 1 and 2 of Table (4) report the effect of the construction of a silo on *barter credit*. The coefficient on *Silo*, a dummy variable equal to one if the branch has a silo in that month, is the DID estimate. 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. Before taking the logarithm, I add 1 to each observation so that zeros do not become missing values. The logarithm accounts for the skewness of the data. To estimate the effect on existing borrowers, I only consider the clients that have a loan in a given month. Thus, the borrowers who never had a loan before the treatment are not captured by the DID estimate.

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 8 percent and the value increases by more than 80 percent (columns 1 and 2, respectively).[11] This constitutes strong evidence that the the integration of a silo allows the firm to offer new credit instrument with an embedded price hedge.

Figure (8) plots the dynamics of the probability of issuing a *barter credit* around the construction of a silo. The 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. One concern might be that, as the farmers are more concerned about price risk, the effect on issuing barter credit is a borrower-specific time trend rather than an effect stemming from the silo construction. To make sure my results do not suffer from any pre-trends, I evaluate the

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

treatment effect within a 16 month event window.

The figure reveals three important features. First, in the months before the silo opening, trends among borrowers are the same in treated and runner-up branches. Indeed, the dynamics of the effect is flat and indistinguishable from zero before the treatment. This finding furthermore supports the validity of the identifying assumption that runner-up branches provide a valid counterfactual for treated branches. Second, beginning in the month of the silo opening, there is a sharp increase in the difference in both variables between borrowers in treated and runner-up branches. Third, the significant difference between borrowers in treated and runner-up branches remains strong in the long run as well. Overall, these graphs reveal much of the paper's primary finding that the construction of a silo allows the firm to offer new financial contracts that include a commodity price hedge.

Analogous to the figures above, columns 3 and 4 of Table (4) document similar findings in tabular form. I replace the *Silo* with five variables to track the effect of the construction of a silo before and after the construction of a silo: Before^{-2} is a dummy variable that equals 1 if a silo is due to be opened in one or two months; After^{0} is a dummy variable that equals 1 if a silo was opened this month or one month ago; After^{2} and After^{4} are dummy variables that equal 1 if a silo was opened two or three and four or five months ago, respectively; After^{6+} is a dummy variable that equals 1 if a silo was opened six months ago or more. The variable Before^{-2} allows me to assess whether any effects can be found prior to the opening of a silo. Finding a significant effect could suggest that my results are driven by factors other than the integration of a silo. In fact, the estimated coefficients on that variable are economically small and statistically insignificant. Furthermore, I find that the coefficient on After^{0} is smaller than those on After^{2}, After^{4} and After^{6+}. Thus, there are no signs of any pre-trends and the documented effect amplifies over time and persists in the long-run.

Loan Quantities

Cross-sectional evidence shows that the total borrower-level credit is larger in branches with a silo (see Table (2) and panel (a) in Figure (3)). Moreover, comparing the total credit before and after the construction of a silo, it is higher once a silo is open (Figure (7)). Thus, all cross-sectional evidence suggests more lending in branches with a silo.

To control for both heterogeneity among borrowers and time trends, I utilize within-borrower variation. Column 1 of Table (5) reports the effect of silo construction on total credit. I find that lending to existing borrowers increases by 32 percent (column 1) once a silo is constructed. Furthermore, as the borrowed funds are used to finance the purchases of products sold by the firm, this result also suggests that borrowers increase their level of investment in working capital.[12]

Column 2 evaluates the dynamic effects of silo construction and finds no pre-trends. In fact, effects before the treatment are nonexistent and the effect becomes significant only 4 months after. A more extensive study of dynamics is plotted in Figure (9), which also shows no pre-trends. All in all, this evidence shows that expansion in firm boundaries significantly increases lending to existing borrowers.

Loan Repayment

So far I have shown that integrating a silo enables the firm to offer a new credit instrument with a price hedge and provide more credit for borrowers. An important question is whether the quality of these loans improves, remains the same, or worsens. This is hard to predict. More leverage could push some borrowers closer to distress, while the embedded hedging component in barter credit might improve the borrower's risk profile.

I find that the quality of the loans, if anything, remain unchanged at the borrower-level. I measure default rates as whether or not a loan defaults or is renegotiated at some point. In fact, equally weighted default rates decline by 1.8 percentage points (column 1 of Table (6)), that is, by 27 percent when measured against the mean default rate. Meanwhile, the value-weighted default rates decline by 1.4 percentage points (column 2), that is, by 21 percent when measured against the mean. While the result is significant for the equally-weighted measure, it is marginally insignificant for the value-weighted defaults, as the p-value is 0.15. Overall, these results suggest that loan quality, if anything, remains the same.

[12]This finding assumes that the borrowers did not switch from other suppliers.

Prices

Next, I examine the effect on the prices of products that are sold on credit. Theories of the boundaries of firm predict that integrating two units into one can lead to higher prices (for example, Salinger (1988)) or, on the contrary, to lower prices (for instance, Spengler (1950)). Furthermore, prices may also decrease if a silo significantly reduces credit market imperfections, for example, through cheaper monitoring. Thus, the ultimate effect is not certain. To assess the pricing of these contracts, I evaluate the markup that the firm charges to farmers on the products sold on credit. I compute the markup as the total sales value of a credit contract with the farmer over the total raw costs of the products sold. This markup includes the operating margin, the financing markup (interest rate), and the profit margin, among others.[13]

I find that the markup goes down by 3.5 percentage points, which is roughly by 9 percent from the mean markup of 38.8 percent (column 1 of Table (7)). Moreover, the finding is robust to pre-trends as documented in the column 2. This finding is important, as it shows that borrowers can benefit not only from higher borrowing and purchasing quantities but also lower prices. Important to note, as the lending volume increases by 32 percent and prices decline by 9 percent, the total revenue per borrower increases by 20 percent.

4.2 Branch-Level Results

In this subsection, I explore the effect of boundaries of firm on branch-level measures. In contrast to the subsection above, these results take into account lending to both existing borrowers (i.e. intensive margin) and new borrowers (i.e. extensive margin). Similarly to the subsection above, I first describe the results on contract types, then provide evidence on credit quantities, quality, and prices.

New Financial Contracts: Barter Credit

To begin, cross-sectional statistics at the branch-level show that barter debt (repaid in grain rather than cash) constitutes approximately 34 percent of the total credit in branches with a silo, compared to only 25 percent in branches without a silo (Panel B in the Table (2)). This

[13] Unfortunately, the firm does not separate these values out in its dataset.

result suggests that having a silo enables the firm to offer more credit with a price hedge. To account for heterogeneity among borrowers and time trends, I analyze within-branch variation.

Columns 1 and 2 of Table (8) report the effect of construction of a silo on both the probability of issuing and the value of a *barter credit*, respectively. First, I report the effect on the probability of issuing a barter credit, defined as 1 if a branch issues barter credit in a given month. Second, I evaluate the effect on the natural logarithm of the total value of barter credit that is issued in a month. Before taking the logarithm, I add 1 to each observation so that zeros do not become missing values. The logarithm accounts for the skewness of the data.

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 29 percent and the value increases more than threefold (columns 1 and 2, respectively). In addition, both results are robust to pre-trends (columns 3 and 4). These findings further fortify the previous results indicating that the construction of a silo enables the firm to offer new hedging contracts to both existing and new borrowers.

Loan Quantities

Cross-sectionally, branches with a silo lend significantly more than those without a silo (see panel (b) in both Figure (3) and Table (2)). Moreover, comparing lending before and after opening a silo, I find that branches lend more after opening a silo (see Figure (10)). The smoothed kernel density of the log of monthly new credit shifts to the right after opening a silo, indicating more lending in that period. The two distributions are different with 1% significance using the Kolmogorov-Smirnov test.

To account for systematic differences among branches, I exploit the within-branch variation. Columns 1 to 3 in Table (9) report the effect of a silo on loan quantities. At the branch-level, I find that having a silo increases total lending more than threefold (column 1).[14] Furthermore, the number of clients who take out a new loan more than doubles (column 2). Moreover, the mean loan remains unchanged at the branch-level (column 3). Given that the loan size increases for existing borrowers, for the net effect to be zero the new borrowers should be getting smaller

[14] As the estimate on *Silo* is large, the log transformation is a weak proxy for the actual percent change. Therefore, the percent change is obtained as follows: $\left(e^{\delta} - 1\right) \cdot 100\%$.

loans. Finally, all these findings are robust to pre-trends (columns 4 and 5). Clearly, these results suggest that the effects on credit volume are large.

Loan Repayment

Although construction of a silo leads to an increased supply of external finance to farmers, its effect on the default rates is difficult to predict in the total loan portfolio. On the one hand, the default rates for existing borrowers remain unchanged. On the other hand, more lending enables riskier borrowers, who were previously rejected to obtain credit. Thus, the newly admitted cohort of riskier borrowers may increase the default rates of the total loan portfolio. I find that the default rates of the total loan portfolio remain unchanged (column 1 of Table (10)), even though the firm has both reached out to new customers and increased its lending to existing borrowers.

Prices

Perhaps more interestingly, the prices in the total loan portfolio increase (column 2 of Table (10)). The markup, defined above, increases by 5.3 percentage points, which is by 15 percent from the mean markup of 35.6 percent. In combination with the finding that the markup decreases for existing borrowers (column 1 in Table (7)), the increase in the branch-level measure implies that the firm is able to generate more revenue per borrower by charging more to new borrowers who were previously rationed out. Most importantly, they can do so by maintaining the same level of risk in the loan portfolio. Again, these findings are robust to pre-trends.

To sum up the branch-level results, I find that after vertically integrating a silo a branch issues more *barter credit*. Furthermore, it increases its lending to both existing and new borrowers. Moreover, the risk level of the loan portfolio remains the same while the markup increases, as the firm is charging more to new customers.

5 Mechanism

This broad array of results provides support for the view that the integration of a silo into lender's business enables the farmer to increase the pledgeable cash flows. As a result, the creditor can issue more debt against these cash flows. Furthermore, the creditor can offer new credit instrument with an embedded hedge against price risk once a silo is available. In this section, I provide evidence that the gains are attributable to mitigation of credit frictions and are to a large part explained by the new contractual innovation, i.e. barter credit.

At first, I show that constrained borrowers who have limited access to bank finance and, thus, suffer from more credit market imperfections benefit more (5.1). Then, I provide direct evidence on the barter credit contracts (5.2). After that, using cross-sectional interaction with price volatility (5.3) I identify strong evidence towards a hedging channel that is embedded in the barter contract. Furthermore, using weather shocks (5.4) I identify evidence that supports the information and enforcement channels that are enabled through a silo and barter contracts.

5.1 Constrained Borrowers

An extensive theoretical literature (for example, Harris and Raviv, 1991; Aghion and Bolton, 1992; Shleifer and Vishny, 1992; Bolton and Scharfstein, 1996) 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. If the construction of a silo is about eliminating some credit market frictions that are not associated with the valuation of assets in place, then the marginal benefit of these changes should be larger for borrowers whose total value of pledgeable assets is lower. Thus, the financier should increase its 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 the ones who lease it. Farmers who own the farmland have more pledgeable assets in comparison to the ones who lease it. Thus, the effects on lessors should be larger. More importantly, this cross-sectional variation allows me to control for the aggregate time-varying branch-level demand by including the case-month-branch fixed effects.[15]

As expected, the group of constrained borrowers is affected more (Table (11)). The results suggest that the total lending to farmers who lease the land increases twice as much (column 1) and that they are more likely to issue barter credit than the landowners (column 2). More

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

importantly, the results remain strong even after controlling for the aggregate changes in the demand (columns 3 and 4). This result provides additional support for my identification strategy.

This finding is important, as it relates to the issue of 'hard' versus 'soft' information borrowers. High quality collateral is a typical example of 'hard' information that is favored by banks (Petersen, 2004). Finding that 'soft' information borrowers benefit more from the institutional change points towards the important role of non-bank financial institutions to serve these customers. It resonates to the notion that large and hierarchical banks are less fit to provide credit for 'soft' information borrowers such as small and medium enterprises (Berger et al., 1998; Stein, 2002; Berger et al., 2005; Liberti and Mian, 2009; Skrastins and Vig, 2014).

5.2 Barter Contracts

There are two important mechanisms within the barter credit: hedging and product bundling. First, the embedded forward contract protects the borrower from the downside risk when commodity price falls low (Smith and Stulz, 1985; Froot et al., 1993). Second, bundling the forward contract with credit can solve multidimensional incentive problems associated with both moral hazard and asymmetric information (Adams and Yellen, 1976; Laffont and Tirole, 1986; Holmström and Milgrom, 1991). For instance, the barter credit reduces the information asymmetry between the lender and the borrower about the outstanding hedging positions. Alternatively, product bundling might reduce the adverse selection problem, as the bundled barter credit could be attractive to certain types of customers only.

To provide evidence on barter credit contracts, I begin by examining the cross-sectional differences among contract types. Barter credit contracts are thrice as large as the standard cash contracts (panel A of Table (12)). Similarly, Figure (11) plots the kernel density functions of the loan size by contract type, which are different with 1 percent statistical significance. Furthermore, a branch issues more barter credit than cash credit (panel B of Table (12)). Overall, these results suggest that loans are larger when using credit contracts that include an embedded forward contract. Nevertheless, these cross-sectional patterns might be driven by, for example, the heterogeneity among borrowers, which I address next.

To further show that the increase in lending is to a large extent driven by the availability of the new financial contracts, I examine cross-sectional variation among borrowers who already had a *barter contract* 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 silo where they can deliver the grain. If these are barter credit contracts that deliver the increase in lending, then I should see particularly strong effects for the borrowers who had no access to these contracts before the opening of a silo.

I find that borrowers who had no access to barter credit contracts before the construction of a silo benefit significantly more (Table (13)). First, the total credit for borrowers who had no access to *barter credit* ex-ante increases by 20 percent more than for those ones who had access (column 1). Second, the probability of issuing a barter contract increases by almost 17 percent for borrowers without previous access to barter credit. Both these results suggest that access to barter credit contracts plays an important role in increasing the total outstanding credit.

In the next two subsections, I analyze the heterogeneity in commodity price volatility and weather volatility to further strengthen the evidence, especially, in favor of barter credit contracts. If borrowers are concerned about price risk and exploit barter credit to hedge against fall in prices in order to borrow more, they should be inclined to use more of these contracts in times when price volatility is high. Furthermore, if the expansion in firm boundaries mitigate frictions in credit markets, then these effects should be stronger in geographic regions that suffer from more credit imperfections, for instance, high weather uncertainty.

5.3 Commodity Price Volatility

Commodity price volatility is a major risk in farming, as it significantly affects the cash flow that a farmer can achieve at the end of the harvest season (Harwood et al., 1999; OECD, 2009). Theoretical literature (Smith and Stulz, 1985; Froot et al., 1993; Leland, 1998; Holmström and Tirole, 2000) argues that in the presence of market frictions, the debt policy critically depends on whether a firm can protect itself against bankruptcy and costly liquidation. Clearly, a forward contract hedges the commodity price risk and gives the farmer more certainty about the cash flow that she can expect at the end of the season. If farmers are greatly concerned about price volatility, one should observe that the availability of a price hedge is more important at times when commodity markets are volatile.

To provide additional evidence that the integration of a silo allows farmers to use hedges against price risk, I evaluate how the treatment effect interacts with price volatility. To begin, I construct domestic, daily price indices. Using the firm's grain purchase data, I obtain daily prices for all commodities that are accepted as the in-kind payment for *barter credit*: soybean, wheat, and corn. Then, I compute daily returns for each commodity. Using these returns, I calculate both monthly and harvest commodity price volatilities as the standard deviation of those returns within each month and harvest, respectively. Second, I use the firm's data to establish which commodity each farmer specializes in. I do this by looking at the seeds that they buy from the firm and at the grain that they deliver or sell. Thus, I am able to obtain domestic price volatilities for all types of grain that the firm accepts as a payment in-kind for the *barter credit* and I know which commodity each farmer grows.

To control for differences among the three types of grain, I augment my main specification (1) by replacing case-month fixed effects with case-grain-month fixed effects. In this way, I capture all time invariant characteristics that are associated with each type of grain. Thus, I can exploit the time-series variation of volatility within each commodity.

I find that the effect of the construction of a silo is stronger when the current and recent historic market volatility is higher (see Table (14)). I use five measures of price volatility: 1) lagged monthly volatility, 2) monthly volatility lagged by six months, 3) the current harvest's volatility, 4) the last harvest's volatility, and 5) the volatility two harvests ago. The first four measures show that after integrating a silo, a farmer is more likely to both issue a *barter credit* and borrow more at times when the commodity markets are more volatile or recently have been such (columns 1 through 4 and 6 through 9, respectively). By contrast, the volatility two harvests ago does not affect neither the probability of issuing a barter credit nor total outstanding credit (columns 5 and 10, respectively), which suggests that borrowers are concerned only about current or recent price volatility and not by distant price volatility. Clearly, this evidence suggests that farmers respond to price volatility and adjust their risk management policy to reduce their exposure to price risk when market volatility is high. All in all, this result strongly supports the notion of a hedging channel.

Overall, this result provides new evidence for why firms hedge.[16] Campello et al. (2011)

[16] See, for example, Tufano (1996); Stulz (1996); Campello et al. (2011); Lins et al. (2011); Cornaggia (2013); Saretto and Tookes (2013); Pérez-González and Yun (2013); Rampini et al. (2014); Bodnar et al. (2014) among others.

show that hedging leads to lower credit spreads and higher investment levels. Pérez-González and Yun (2013) show that hedging leads to higher valuation and investments, while Cornaggia (2013) finds a positive relation with productivity. This result isolates and examines the debt channel as a potential source of value creation.

5.4 Weather Shocks

Weather shocks are another major risk in farming, as they affect the yield of a harvest (The World Bank, 2005).[17] Geographic regions with high weather uncertainty suffers from more credit frictions than a region with highly predictable weather. Thus, finding evidence that effects of a silo are stronger in volatile weather areas would lend strong support for information and enforcement channels, especially, if these effects are stronger for probability of issuing a barter credit contract.

The effect on the probability of issuing a barter credit is particularly important. As low levels of output, resulting from adverse weather conditions, would push regional prices up, a forward contract would harm these farmers. In other words, a forward contract would make this state of the world even worse as it limits all the potential upside from the price increase. For this reason, farmers located in geographic regions of high weather volatility should be less inclined to commit to deliver a fixed quantity of grain, as formally shown by Rolfo (1980). Thus, finding that the probability of issuing a barter credit is higher in more volatile weather areas clearly provides a strong support for the information and enforcement channels through barter contracts.

To analyze how the construction of a silo interacts with weather shocks, I exploit two spatial measures: monthly deviations in 1) temperature and 2) precipitation from the long-term monthly means of that month. Firstly, I obtained a time-series of maps of both global monthly land surface temperatures and global monthly precipitation data from NOAA.[18] The same source

[17] This includes both quality and quantity risk. If the quality of the crop is very low, the farmer would have to buy and deliver the high quality crop that was agreed to be delivered initially. Essentially, the prediction for quality risk is the same as for the quantity risk.

[18] The methodology for measuring land surface temperature was developed by Fan and Van den Dool (2008) and the methodology for measuring precipitation was developed by Chen et al. (2002). The temperature data can be downloaded from `http://www.esrl.noaa.gov/psd/data/gridded/data.ghcncams.html` and the precipitation data can be downloaded from `http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP/.CPC/.PRECL/.v1p0/.deg0p5/`.

also provides estimates of long-term monthly means of both measures for each month in the year. Monthly mean temperature is calculated as the mean daily temperature within a month, measured in Celsius, and monthly mean precipitation is calculated as the mean daily rainfall within a month, measured in millimeters. The spatial resolution of both datasets is 0.5 x 0.5 degrees. For illustration, Figure (12) plots the mean temperature in December 2009 and the long-term mean temperature in December in Brazil. Figure (14) illustrates the precipitation data in similar vein.

To obtain the deviation from the long-term mean, each month I deduct the long-term mean from the monthly mean at the pixel level. For illustration, Figure (13) plots the monthly temperature deviation from the long-term mean for December 2009 in Brazil (an analogous map for precipitation data is available in Figure (15)). As a result, I obtain a monthly time-series of such maps ranging from January 2006 to December 2012 for both temperature and precipitation measures. Then, I extract the monthly deviation for each branch, depending on its location on the map. Eventually this gives me a branch-level time-series of monthly deviation in both temperature and precipitation.

As a final step, I compute the standard deviation of both of these measures at the branch-level to capture the weather volatility differences among branches. The larger the deviation, the more volatile the location of the branch. Consequently, farmers in branches located in areas of high weather uncertainty suffer from more frictions in credit markets. If expansion in boundaries of a firm is about mitigating these frictions, the results should be stronger in these volatile regions.

Table (15) shows that the effects of a silo are stronger in regions with more volatile weather. I report the results on the probability of issuing barter credit (columns 1 and 2), the value of barter credit (columns 3 and 4), and the total outstanding credit (columns 5 and 6). Both temperature and precipitation measures show that the effects on all three variables are stronger for volatile weather areas, most importantly, it is stronger for the probability of issuing a barter credit contract. All in all, these results further strengthen the argument that expanding boundaries of firm can mitigate frictions in credit markets and increase the pledgeable cash flows of borrowers.

Besides identifying some of the channels, this section makes another important conclusion. Specifically, through expansion in the boundaries of firm the lender is able to increase lending to a market segment that is more challenged to raise external funds. Besides the borrowers with less ‘hard’ information (see Section 5.1), the firm lends more in riskier time periods (price volatility) and in uncertain geographic regions (weather). Thus, vertically integrating a silo enables the lender to reach out to customers that could be particularly deprived from access to credit.

6 Alternative Explanations and Robustness Tests

My main empirical finding in Section 4 is that integration of a silo mitigates credit market imperfections and leads to significant changes in financial contracts. Then, in the section above, I show that at least part of these changes are likely to be driven by barter contracts. Specifically, the introduction and bundling of hedging instruments through integration of a silo is associated with a substantial increase in lending to both existing and new borrowers, relative to the borrowers in branches that narrowly missed out on the integration of a silo. Nevertheless, the possibility remains that these results are driven by alternative channels. Consequently, this section provides some robustness tests and rules out several alternative explanations.

6.1 Staggered Specification

A concern might be that the alternative locations are a weak counterfactual for the treated branches. For robustness, I rerun my tests using the sample of treated branches only. This specification exploits the staggered nature of the construction of silos. Thus, it hinges on the time-series variation in the completion date. The identification assumption here is that all treated branches are ‘equal’ and only differ on the time dimension of when the silo is constructed. As a result, I perform a staggered DID estimation and augment my main specification (1) by replacing case-month with month fixed effects. The results remain qualitatively the same (see Table (16)).

6.2 Economies of Scale and Contract Type

This section attempts to rule out other alternative stories such as economies of scale by focusing on the differential effects between cash credit and barter credit contracts. To fix ideas, economies of scale might reduce the cost per unit, as fixed costs such as administrative overheads are split between more operations. That could lead to a reduction in prices. As lower prices increase borrower's free cash flows, economies of scale would deliver the same predictions that I document above: more borrowing without changes in the default rates. Nevertheless, a pure economies of scale argument remains agnostic about the contract type – the cost savings are there irrespective of the contract. Thus, finding the effects for only one contract type suggests that economies of scale cannot fully explain the results.

This is exactly what I find: there is no change in lending through contracts that are settled in cash (Table (17)). First, the total outstanding cash credit does not change at the borrower level (column 1). Second, the probability of issuing a cash credit remains the same (column 2). Thus, vertically integrating a silo does not have an effect on cash credit, while it has a significant and positive effect on barter credit (see Table (4)). Overall, the results suggest that contract type is important for the observed effects.

Important to note that this result does not rule out economies of scale as such. For instance, it may be the case that borrowers endogenously self-select between the two contract types, and all positive effects, stemming from economies of scale, are present only in barter contracts. This test, however, shows that contract type matters and a pure economies of scale argument cannot explain the results.

7 Conclusion

In an area where empirical evidence remains scarce due to problems of endogeneity and reverse causality, this paper provides strong evidence that firm boundaries can significantly reduce frictions in credit markets and improve access to finance. I find that the ownership of a silo allows the agribusiness lender to significantly increase lending to both existing and new borrowers, with the effects being more pronounced for financially constrained borrowers and those exposed to more weather risk. Furthermore, it enables the lender to offer a new contract that provides a price hedge, an innovation that is particularly useful for periods with high commodity price volatility. Thus, this paper uncovers a new mechanism, designed by lenders, to overcome weak creditor rights, suggesting that markets invent alternative credit enforcement mechanisms where formal institutions fail to. I also show that the findings can be explained to a large extent by the embedded mechanisms in barter credit contracts. However, I cannot rule out the potential importance of other mechanisms such as economies of scale.

I would like to conclude by noting that one should be careful when trying to generalize these results to other industries or markets. Changes in firm boundaries are driven by various factors, of which financial contracts may or may not be one. Nevertheless, this paper convincingly shows that a vertically related business can mitigate information asymmetry and enforcement problems. Furthermore, such financing models in farming are widely used, not only in emerging markets but also in developed markets, including the US (for instance, by multibillion firms such as Cargill and ADM).[19] Last but not least, these findings shed light on the large popularity of trade credit[20] and non-bank financing that are particularly popular among 'soft' information and constrained borrowers.

[19]Both Cargill and ADM sell production inputs such as fertilizer on credit and trade grain worldwide. Similarly as 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).

[20]Fisman and Love (2003) argue that trade credit is particularly important for poorly developed financial markets.

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Figure 1: Agribusiness Description

The figure below illustrates the three lines of business that the firm operates in: 1) sales of production inputs, 2) sales of these inputs on credit, and 3) trading in agriculture commodities (soybean, corn, and wheat).

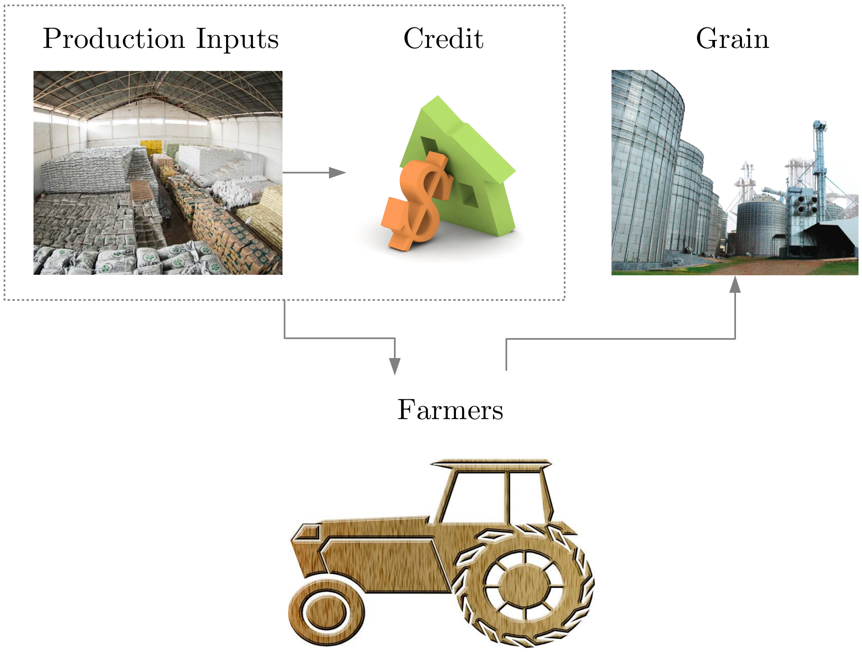


Figure 2: Sales of Production Inputs,Credit and Grain Storage Unit

This figure illustrates the flowchart of how production inputs are sold to farmers. They can be sold either in cash or on credit. Then, credit can be repaid in cash or in grain (measured in bags) at a pre-specified date. The credit that is repaid in grain differs from the cash credit on two dimensions: 1) it requires a silo where the grain can be delivered and stored and 2) it fixes the commodity price.

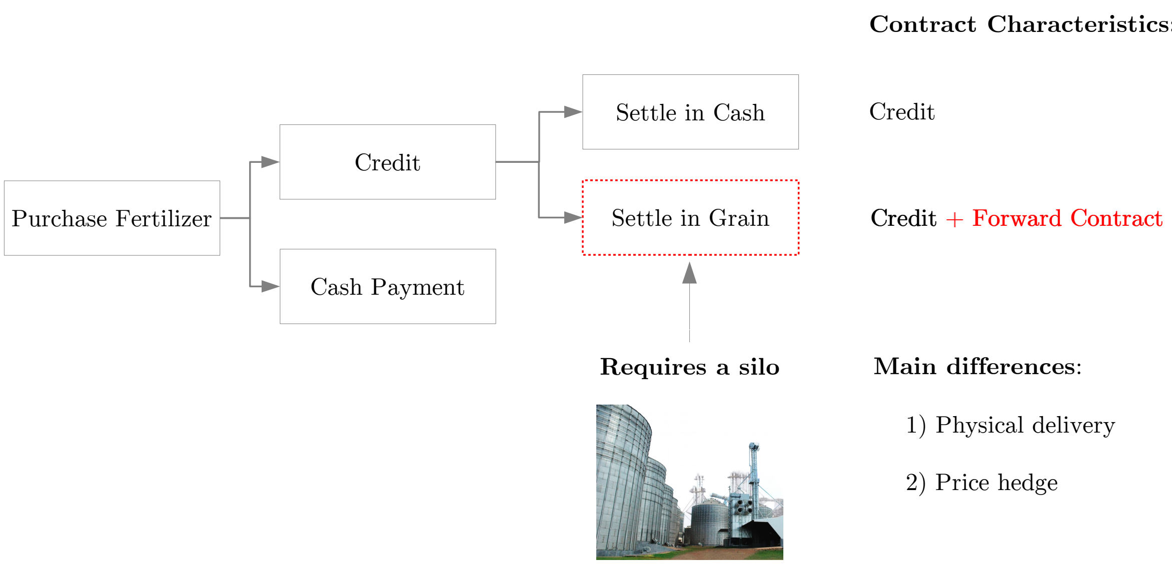
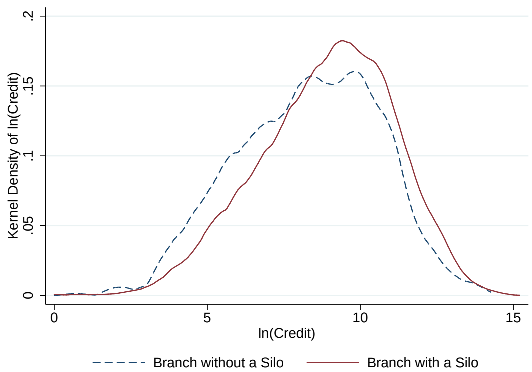


Figure 3: Cross-Sectional Variation: A Branch with and without a Silo

This figures illustrates the differences in cross-sectional loan size depending on whether the branch office has a silo. I report the results at both borrower- and branch-level in panels (a) and (b), respectively. Both figures plot smoothed kernel density functions. The vertical axis measures the smoothed estimate of the density function of the natural logarithm of credit, while the horizontal axis measures the natural logarithm of the loan size. The dashed line represents a branch without a silo, the solid line a branch with a silo.

(a) Borrower-Level



(b) Branch-Level

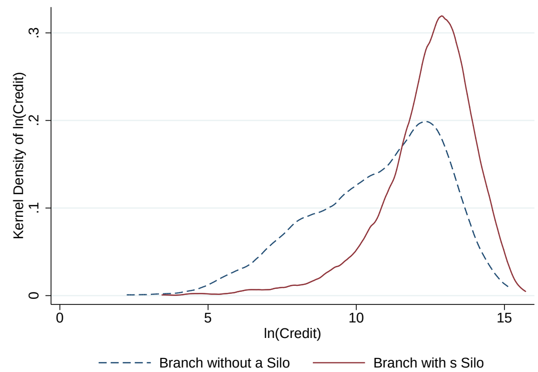


Figure 4: Identification Strategy

The figure below illustrates the three lines of business that the firm operates in: 1) sales of production inputs, 2) sales of these inputs on credit, and 3) trading in agriculture commodities (soybean, corn, and wheat). My identification exploits the construction of grain storage units next to branches selling production inputs, such as fertilizer, and providing credit to farmers.

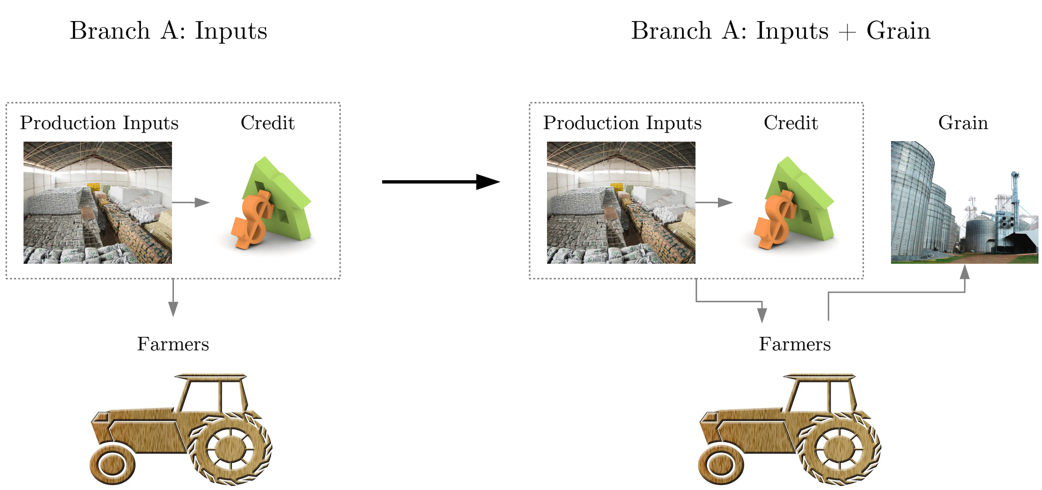


Figure 5: Vertical Integration and the Supply Chain

This figure illustrates the supply chain in farming. At first, the firm provides inputs and credit to farmers. Then, by using these inputs farmers produce grain that is then later bought by the traders and sold further. In this case, the business integration is between two vertically related entities: the branch office providing credit and inputs (top) and the grain business (bottom).

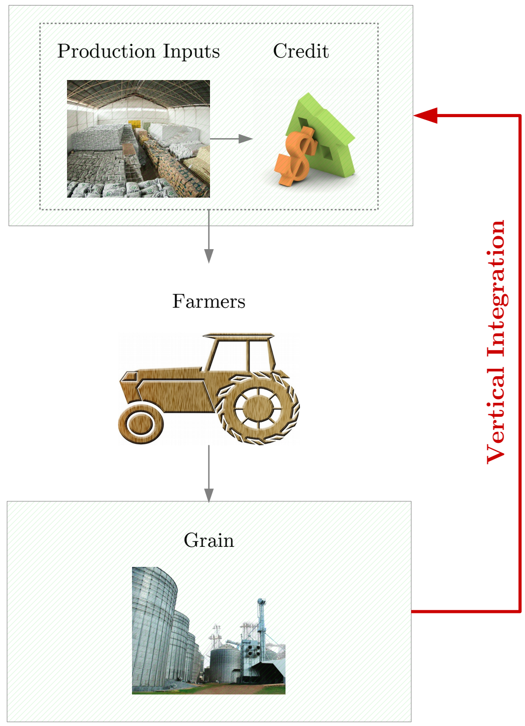


Figure 6: Identification Strategy – Control and Treatment Groups

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

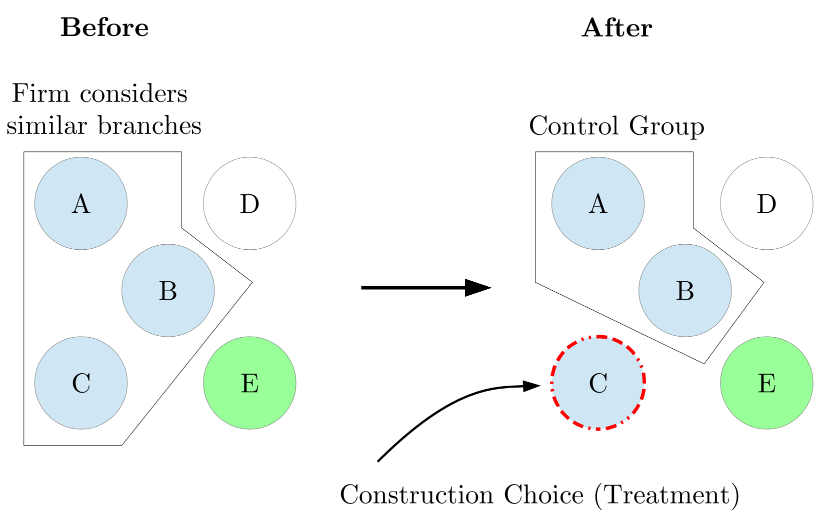


Figure 7: Total Credit Pre- and Post-treatment: Borrower-level

The figure below illustrates the effect on total outstanding borrower-level loan value before and after vertically integrating a silo. The figure plots smoothed kernel density functions. The vertical axis measures the smoothed estimate of the density function of the natural logarithm of the total credit outstanding in a month, while the horizontal axis measures the natural logarithm of the total credit outstanding in a month. The dashed line represents the period before the construction of a silo, the solid line the period after construction.

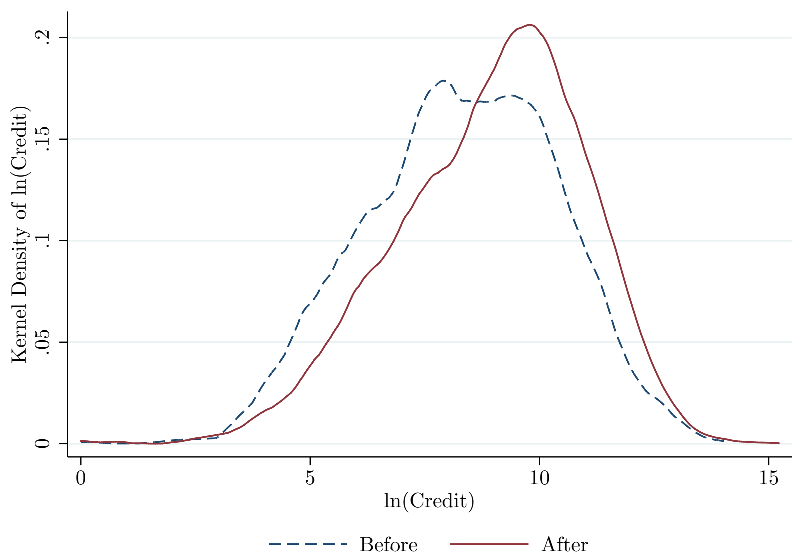


Figure 8: Dynamics Plot: Credit with Forward Contract

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 (credit with embedded forward contract) at the borrower-month-case level. The coefficients are estimated using equation (1). The effect is estimated only on the intensive margin, i.e. all existing borrowers. The dashed lines indicate a 95% confidence interval.

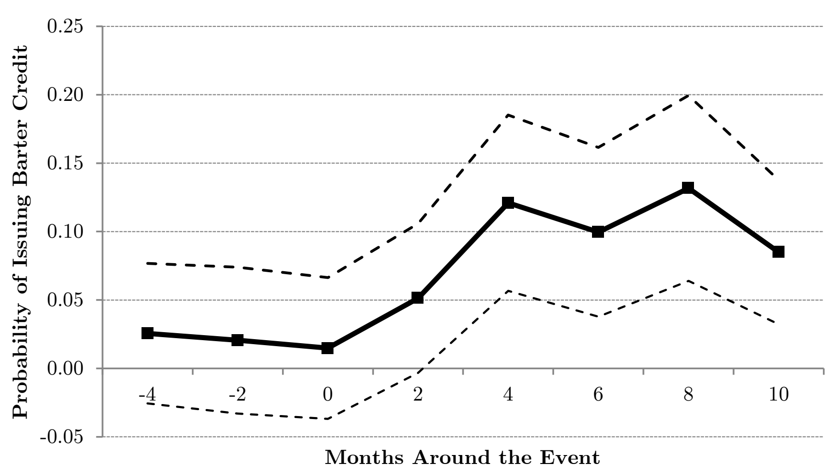


Figure 9: Dynamics Plot: Total Credit

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 credit at the borrower-month-case level. The coefficients are estimated using equation (1). The effect is estimated only on the intensive margin, i.e. all existing borrowers. The dashed lines indicate a 95% confidence interval.

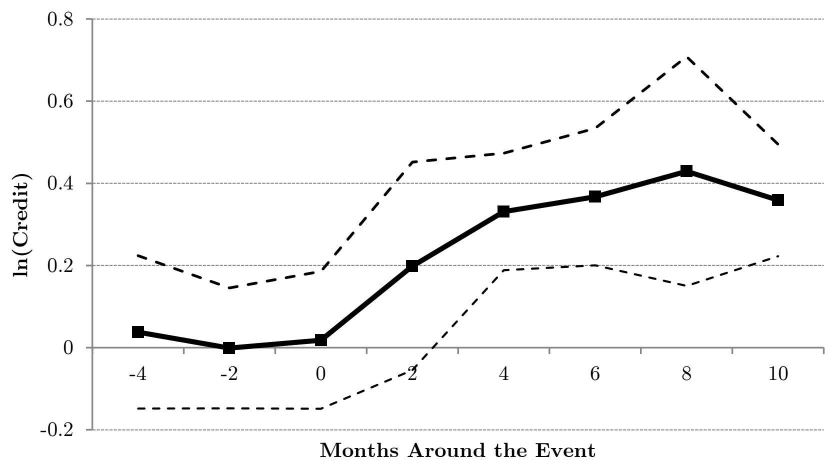


Figure 10: Total Credit Pre- and Post-treatment: Branch-level

The figure below illustrates the effect on total outstanding branch-level loan value before and after vertically integrating a silo. The figure plots smoothed kernel density functions. The vertical axis measures the smoothed estimate of the density function of the natural logarithm of total issued credit in a month, while the horizontal axis measures the natural logarithm of total issued credit in a month. The dashed line represents the period before the construction of a silo, the solid line the period after construction.

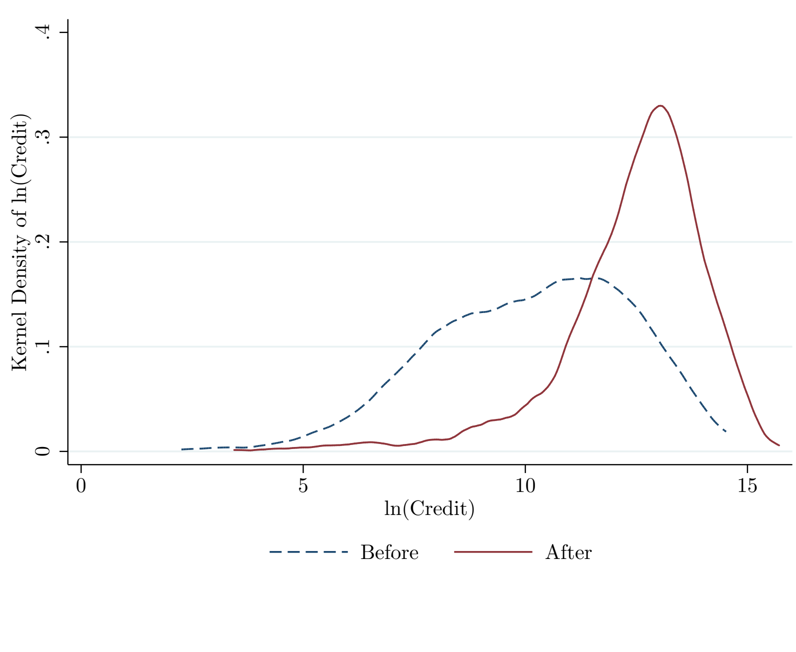


Figure 11: Cross-Sectional Variation: Debt vs Debt with a Forward Contract

The figure below illustrates the differences in cross-sectional loan size between traditional credit and credit with an embedded forward contract, i.e. barter credit. The figure plots smoothed kernel density functions. The vertical axis measures the smoothed estimate of 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 credit without a hedge, the dashed line credit with a hedge.

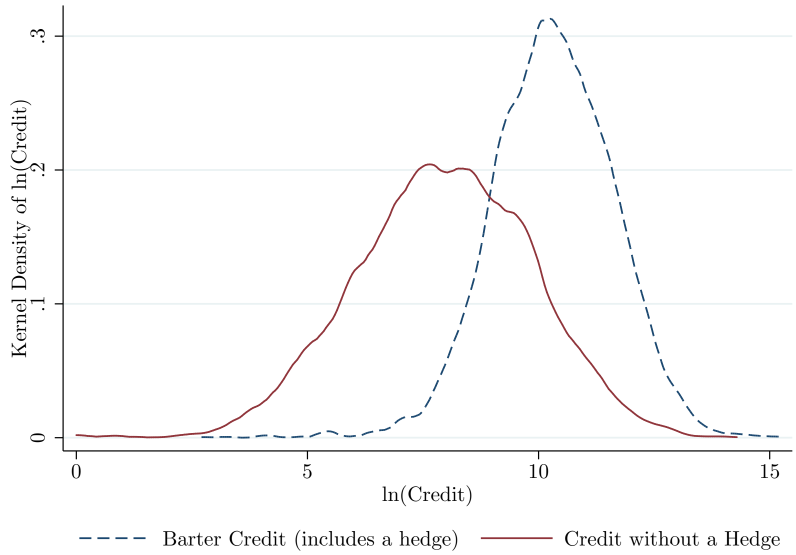


Figure 12: Mean Monthly Temperature in Brazil

The figures below plot the heat maps of the long-term mean temperature of December (left map) and the monthly mean temperature in December 2009 (right map) in Brazil. The spatial resolution of the heat map is 0.5 x 0.5 degrees.

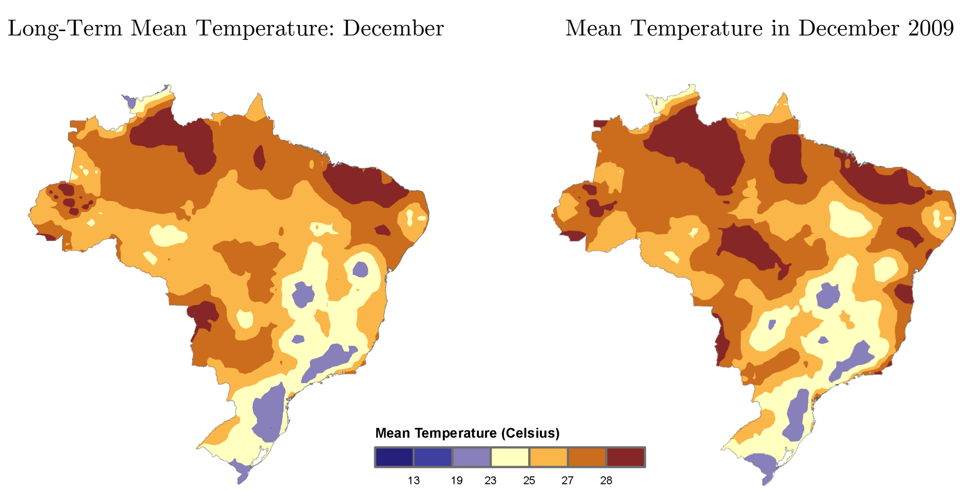


Figure 13: Deviation from the Long-Term Mean Temperature (December, 2009)

The figure below plots the heat map describing the deviation of the monthly mean temperature in December 2009 from that of the long-term mean temperature in December in Brazil. The difference between the two monthly measures is calculated at a pixel level with resolution of 0.5 x 0.5 degrees (both original maps are plotted in Figure (12)). In terms of scale, deviation of 0.5 Celsius represents roughly one standard deviation of the deviation from the long-term mean.

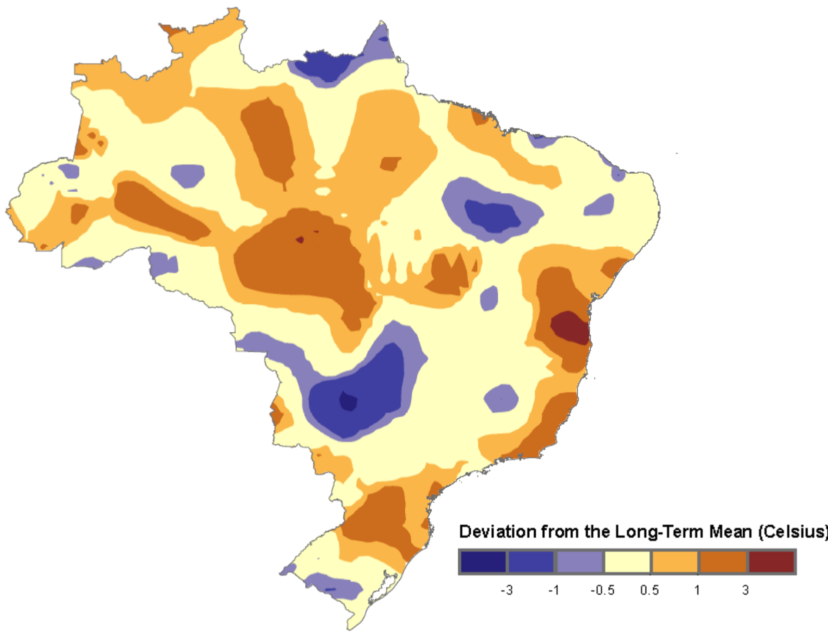


Figure 14: Mean Daily Precipitation in Brazil

The figures below plot the heat maps of the long-term mean daily precipitation in December (left map) and the monthly mean daily precipitation in December 2009 (right map) in Brazil. The spatial resolution of the heat map is 0.5 x 0.5 degrees.

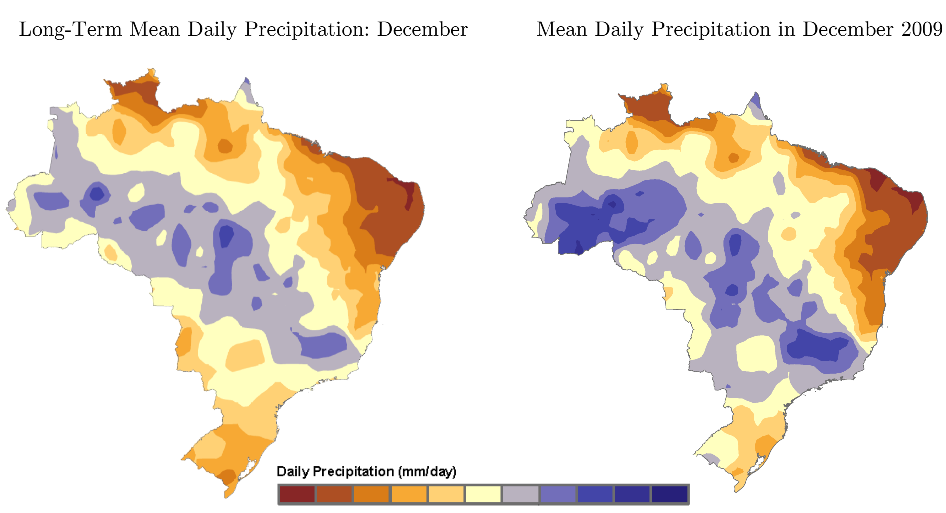


Figure 15: Deviation from the Long-Term Mean Precipitation (December, 2009)

The figure below plots the heat map describing the deviation of the monthly mean daily precipitation in December 2009 from that of the long-term mean daily precipitation in December in Brazil. The difference between the two monthly measures is calculated at a pixel level with resolution of 0.5 x 0.5 degrees (both original maps are plotted in Figure (14)). In terms of scale, deviation of 1 mm/day represents roughly one standard deviation of the deviation from the long-term mean.

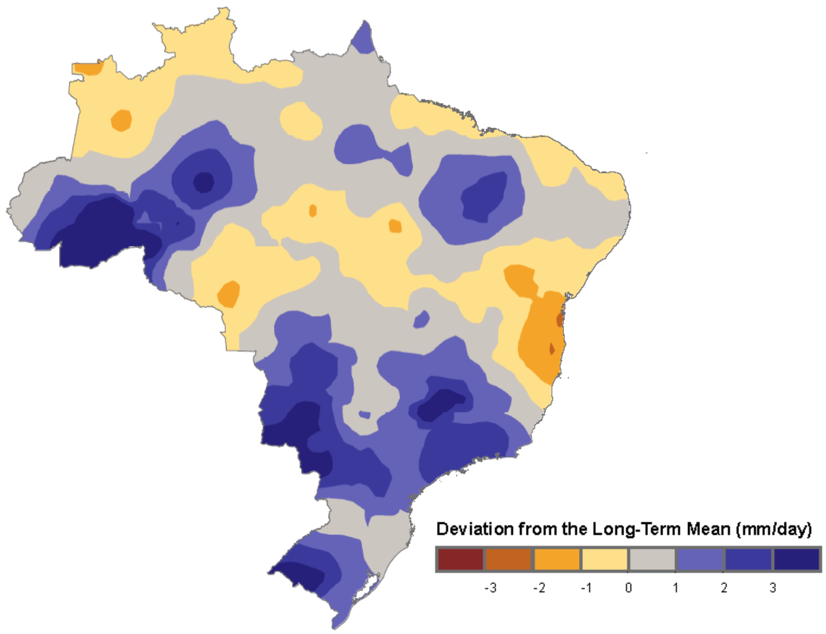


Table 1: Summary Statistics

The table below reports client-month (Panel A) and branch-month (Panel B) summary statistics. I report the mean, standard deviation, the 1st percentile, median, and the 99th percentile for all the variables.

	Mean	Std. Dev.	p1	p50	p99
Panel A: Client-Month statistics					
Total credit (1,000 reals)	34.2	114.6	0.04	8.21	508.40
Fraction of debt in default	0.065	0.224	0.000	0.000	1.000
Markup	0.388	0.337	-0.194	0.356	1.235
Maturity (days)	192.73	107.24	34.00	181.22	576.42
Fraction of credit with hedge	0.308	0.417	0.000	0.000	1.000
Fraction of credit with hedge if hedge>0	0.826	0.216	0.066	0.913	1.000
Panel B: Branch-Month statistics (New Credit)					
Total new credit (1,000 reals)	451.48	641.78	0.26	235.66	2,859.97
Number of clients borrowing	42.58	39.29	1.00	34.00	174.00
Fraction of debt in default	0.065	0.154	0.000	0.006	0.976
Markup	0.356	0.190	-0.035	0.332	0.935
Maturity (days)	164.40	53.12	47.55	161.48	314.00
Fraction of credit with hedge	0.311	0.334	0.000	0.181	1.000

Table 2: Summary Statistics: Cross-Section – Branch Type

The table below reports client-month (Panel A) and branch-month (Panel B) summary statistics across branch types: 1) all branch types, 2) a branch without a silo, and 3) a branch with a silo. I report the mean and the standard deviation for all the variables.

	All Branch Types		No Silo		Combined (incl. silo)	
	Mean	Sd	Mean	Sd	Mean	Sd
Panel A: Client-Month statistics						
Credit (1,000 reals)	34.2	114.6	23.4	83.3	36.9	121.0
Defaults	0.065	0.224	0.064	0.228	0.065	0.223
Fraction of credit with a hedge	0.308	0.417	0.208	0.369	0.318	0.415
Panel B: Branch-Month statistics (New Credit)						
Total New Credit (1,000 reals)	451.5	642.7	213.2	361.0	555.4	703.1
Number of Borrowers	42.58	39.28	24.34	29.87	52.04	38.83
Fraction of credit with a hedge	0.311	0.334	0.253	0.345	0.344	0.327

Table 3: Branch Characteristics by Treatment Status

The table below reports branch characteristics by 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 All branches. Columns 4 and 5 calculate the average difference between groups within a case (i.e. it uses 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 *All branches* includes all non-treated branches. All variables are aggregated at the branch-month level. 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)	All non-treated branches (3)	Difference (Col. 1- Col. 2) (4)	Difference (Col. 1- Col. 3) (5)
ln(Total Credit)	10.03	10.55	11.67	-0.299	-1.498***
				(0.379)	(0.447)
ln(# borrowers)	1.34	2.07	3.01	-0.532	-1.578***
				(0.331)	(0.315)
ln(Barter Credit+1)	4.54	5.84	6.91	-0.698	-2.094**
				(0.331)	(0.320)
ln(Mean Credit)	8.70	8.48	8.66	0.232	0.080
				(0.166)	(0.189)
Maturity	152.76	158.70	153.19	-4.890	-2.082
				(5.790)	(6.271)

Table 4: Financial Contracts – Barter Credit (Borrower-level)

The table below reports the effect of the construction of a silo on the probability of issuing barter credit (columns 1 and 3) and the value of barter credit (columns 2 and 4). The probability of issuing a barter credit is equal to 1 if the borrower has an outstanding barter credit in that month. The value of barter credit is measured as the total sum of barter credit that is outstanding in that 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. Before^{-2} is a dummy variable that equals 1 if a silo is due to be opened next to the branch in one or two months. Before^{0} is a dummy variable that equals 1 if a silo was opened next to the branch this month or one month ago. After^{2} and After^{4} are dummy variables that equal one if a silo was opened next to the branch two or three and four or five months ago respectively. After^{6+} is a dummy variable that equals 1 if a silo was opened next to the branch six months ago or more. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	P[BarterCred]	ln(BarterCred+1)	P[BarterCred]	ln(BarterCred+1)
	(1)	(2)	(3)	(4)
Silo (Treat)	0.077***	0.852***		
	(0.020)	(0.214)		
Before^{-2}			0.016	0.174
			(0.025)	(0.249)
After^{0}			0.011	0.133
			(0.028)	(0.272)
After^{2}			0.048*	0.481*
			(0.028)	(0.278)
After^{4}			0.117***	1.211***
			(0.031)	(0.344)
After^{6+}			0.085***	0.960***
			(0.026)	(0.288)
Obs	259,450	259,450	259,450	259,450
Adj-R2	0.620	0.628	0.620	0.628
Month-Case-FE	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y

Table 5: Total Credit (Borrower-level)

The table below reports the effect of the construction of a silo on total outstanding credit. The unit of analysis is case-borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. Before^{-2} is a dummy variable that equals 1 if a silo is due to be opened next to the branch in one or two months. Before^{0} is a dummy variable that equals 1 if a silo was opened next to the branch this month or one month ago. After^{2} and After^{4} are dummy variables that equal one if a silo was opened next to the branch two or three and four or five months ago respectively. After^{6+} is a dummy variable that equals 1 if a silo was opened next to the branch six months ago or more. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	ln(Credit)
	(1)	(5)
Silo (Treat)	0.321***	
	(0.046)	
Before^{-2}		-0.007
		(0.069)
After^{0}		0.013
		(0.086)
After^{2}		0.193
		(0.133)
After^{4}		0.326***
		(0.073)
After^{6+}		0.359***
		(0.068)
Obs	259,450	259,450
Adj-R2	0.732	0.732
Month-Case-FE	Y	Y
Borrower-FE	Y	Y

Table 6: Default Rates, Borrower-level

The table below reports the effect of the construction of a silo on equally- and value-weighted default rates in columns 1 and 2, respectively. The loan is classified as defaulted if it defaults or is renegotiated at some point. 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 standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	Defaults	
Weights:	Equal	Value
	(1)	(2)
Silo (Treat)	-0.018*	-0.014
	(0.009)	(0.010)
Obs	259,450	259,450
Adj-R2	0.57	0.57
Month-Case-FE	Y	Y
Borrower-FE	Y	Y

Table 7: Prices (Borrower-level)

The table below reports the effect of the construction of a silo on the markup. Markup is defined as the total sales 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. Before^{-2} is a dummy variable that equals 1 if a silo is due to be opened next to the branch in one or two months. Before^{0} is a dummy variable that equals 1 if a silo was opened next to the branch this month or one month ago. After^{2} and After^{4} are dummy variables that equal one if a silo was opened next to the branch two or three and four or five months ago respectively. After^{6+} is a dummy variable that equals 1 if a silo was opened next to the branch six months ago or more. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	Markup	
	(1)	(2)
Silo (Treat)	-0.035**	
	(0.017)	
Before^{-2}		-0.028
		(0.020)
After^{0}		-0.056**
		(0.024)
After^{2}		-0.035***
		(0.012)
After^{4}		-0.033**
		(0.016)
After^{6+}		-0.039**
		(0.020)
Obs	259,450	259,450
Adj-R2	0.550	0.550
Month-Case-FE	Y	Y
Borrower-FE	Y	Y

Table 8: Financial Contracts – Barter Credit (Branch-level)

The table below reports the effect of the construction of a silo on the probability of issuing barter credit (columns 1 and 3) and the value of barter credit (columns 2 and 4). The probability of issuing a barter credit is equal to 1 if the branch issues barter credit in that month. The value of barter credit is measured as the total sum of barter credit that is issued in that month. The unit of analysis is case-branch-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. Before^{-2} is a dummy variable that equals 1 if a silo is due to be opened next to the branch in one or two months. Before^{0} is a dummy variable that equals 1 if a silo was opened next to the branch this month or one month ago. After^{2} is a dummy variable that equal one if a silo was opened next to the branch two or three months ago. After^{4+} is a dummy variable that equals 1 if a silo was opened next to the branch four months ago or more. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	P[BarterCred]	ln(BarterCred+1)	P[BarterCred]	ln(BarterCred+1)
	(1)	(2)	(3)	(4)
Silo (Treat)	0.285***	3.180***		
	(0.040)	(0.526)		
Before^{-2}			0.013	0.181
			(0.099)	(1.016)
After^{0}			-0.045	-0.453
			(0.070)	(0.843)
After^{2}			0.428***	4.296***
			(0.096)	(0.817)
After^{4+}			0.322***	3.693***
			(0.046)	(0.663)
Obs	3,826	3,826	3,826	3,826
Adj-R2	0.430	0.487	0.444	0.487
Month-Case-FE	Y	Y	Y	Y
Branch-FE	Y	Y	Y	Y

Table 9: Credit Quantities (Branch-level)

The table below reports the effect of the construction of a silo on the total outstanding credit (columns 1 and 4), number of borrowers borrowing (columns 2 and 5), and the mean loan (column 3). The unit of analysis is case-branch-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. Before^{-2} is a dummy variable that equals 1 if a silo is due to be opened next to the branch in one or two months. Before^{0} is a dummy variable that equals 1 if a silo was opened next to the branch this month or one month ago. After^{2} is a dummy variable that equal one if a silo was opened next to the branch two or three months ago. After^{4+} is a dummy variable that equals 1 if a silo was opened next to the branch four months ago or more. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	ln(# Clients)	ln(mean loan)	ln(Credit)	ln(# Clients)
	(1)	(2)	(3)	(4)	(5)
Silo (Treat)	1.506***	1.330***	0.176		
	(0.281)	(0.189)	(0.221)		
Before^{-2}				0.607	-0.022
				(0.379)	(0.174)
After^{0}				0.824**	0.470**
				(0.365)	(0.175)
After^{2}				1.660***	1.028***
				(0.251)	(0.164)
After^{4+}				1.734***	1.544***
				(0.325)	(0.198)
Obs	3,826	3,826	3,826	3,826	3,826
Adj-R2	0.705	0.854	0.315	0.710	0.865
Month-Case-FE	Y	Y	Y	Y	Y
Branch-FE	Y	Y	Y	Y	Y

Table 10: Loan Repayment and Prices (Branch-Level)

The table below reports the effect of the construction of a silo on value-weighted defaults (column 2), and value-weighted markup (columns 2 and 3). The value-weighted default rates are measured as the fraction of debt that is renegotiated or that defaults at some point, weighted by its size in reals. The markup is the gross profit that the firm earns over and above the raw costs of the production inputs that it sells on credit. The unit of analysis is case-branch-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. Before^{-2} is a dummy variable that equals 1 if a silo is due to be opened next to the branch in one or two months. Before^{0} is a dummy variable that equals 1 if a silo was opened next to the branch this month or one month ago. After^{2} is a dummy variable that equal one if a silo was opened next to the branch two or three months ago. After^{4+} is a dummy variable that equals 1 if a silo was opened next to the branch four months ago or more. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	Default	Markup	Markup
	(1)	(2)	(3)
Silo (Treat)	-0.006	0.053**	
	(0.036)	(0.021)	
Before^{-2}			0.015
			(0.038)
After^{0}			0.045
			(0.031)
After^{2}			0.120***
			(0.043)
After^{4+}			0.056**
			(0.023)
Obs	3,826	3,826	3,826
Adj-R2	0.197	0.705	0.444
Month-Case-FE	Y	Y	Y
Branch-FE	Y	Y	Y

Table 11: Financially Constrained vs Unconstrained Borrowers

The table reports the effect of the construction of a silo depending on whether the farmer owns or rents the farmland. I report the estimated effect on total outstanding credit (columns 1 and 3) and the probability of issuing barter credit (columns 2 and 4). *Lessee* 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 and 2 control for time trends within a case (month-case fixed effects), whereas columns 3 and 4 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 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[BarterCred]	ln(Credit)	P[BarterCred]
	(1)	(2)	(3)	(4)
Silo (Treat)	0.199**	0.045*		
	(0.089)	(0.025)		
Silo x Lessee	0.254**	0.057*	0.341***	0.100**
	(0.113)	(0.030)	(0.119)	(0.047)
Obs	259,450	259,450	259,450	259,450
Adj-R2	0.733	0.622	0.735	0.622
Month-Case-FE	Y	Y	N	N
Month-Case-Branch-FE	N	N	Y	Y
Borrower-FE	Y	Y	Y	Y

Table 12: Summary Statistics: Cross-Section – Contract Type

The table below reports client-month (Panel A) and branch-month (Panel B) summary statistics across loan types: 1) combined, 2) cash credit, and 3) Barter Credit (credit + forward).

	Combined		Cash Credit		Barter Credit	
	Mean	Sd	Mean	Sd	Mean	Sd
Panel A: Client-Month statistics						
Credit (1,000 reals)	34.2	114.6	19.7	71.8	60.0	120.6
Defaults	0.065	0.224	0.043	0.192	0.067	0.220
Panel B: Branch-Month statistics (New Credit)						
Total New Credit (1,000 reals)	451.5	642.7	248.9	349.0	306.4	518.7
Number of Borrowers	42.58	39.28	40.34	37.87	8.59	11.23

Table 13: Barter Credit Contracts

The table reports the effect of the construction of a silo depending on whether the borrower already used a *barter contract* before a silo was built next to the treated branch. I report the estimated effect on total outstanding credit (column 1) and the probability of issuing barter credit (column 2). The unit of analysis is case-borrower-month. The variable *Silo No Barter Before* is a dummy variable equal to 1 if a borrower did not have a *barter contract* before the treatment. 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)	P[BarterCred] (2)
Silo (Treat)	0.190**	-0.092
	(0.094)	(0.055)
Silo x No Barter Before	0.202**	0.259***
	(0.097)	(0.080)
Obs	259,450	259,450
Adj-R2	0.732	0.621
Month-Case-FE	Y	Y
Borrower-FE	Y	Y

Table 14: Commodity Price Volatility

The table below reports the heterogeneous effect of the construction of a silo depending on domestic commodity price volatility. I report the effect on the probability of issuing barter credit (columns In each column, I use one of five measures of volatility: 1) lagged monthly volatility, 2) monthly volatility lagged by six months, 3) the current harvest's volatility, 4) the last harvest's volatility, and 5) the price volatility two harvests ago, respectively. Commodity price volatility is measured as the standard deviation of daily returns at the month- or the harvest-level. 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 specification controls for case-month-grain fixed effects to account for differences across commodities that the farmers grow. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	P[BarterCred]					ln(Credit)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Silo (Treat)	0.062***	0.053***	0.050***	0.040**	0.070***	0.274***	0.279***	0.220***	0.271***	0.346***
	(0.021)	(0.019)	(0.019)	(0.017)	(0.022)	(0.057)	(0.053)	(0.060)	(0.052)	(0.076)
Silo x Vol$_{t-1}$	0.230**					1.014*				
	(0.090)					(0.577)				
Silo x Vol$_{t-6}$		0.551***					0.940**			
		(0.144)					(0.374)			
Silo x Vol$_{harvest}$			0.582**					2.603**		
			(0.237)					(1.029)		
Silo x Vol$_{harvest-1}$				0.979***					1.225	
				(0.309)					(0.833)	
Silo x Vol$_{harvest-2}$					0.038					-1.160
					(0.211)					(1.302)
Obs	238,471	238,471	238,471	238,471	238,471	238,471	238,471	238,471	238,471	238,471
Adj-R2	0.603	0.603	0.603	0.603	0.603	0.696	0.696	0.696	0.696	0.696
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 15: Weather Shocks: Temperature and Precipitation

This table reports the effect of the construction of a silo depending on the weather shocks. I report the estimated effect on the probability of issuing barter credit (columns 1 and 2), volume of barter credit (columns 3 and 4), and total credit (columns 5 and 6). The unit of analysis is case-borrower-month. The variable *Treat* is equal to 1 if a branch has a silo in that month. High Temperature Deviation is a dummy variable equal to 1 if the branch is located in an area where the variation in monthly mean temperature relative to the long-term monthly mean is above the median of this variation among all branches. High Precipitation Deviation is a dummy variable equal to 1 if the branch is located in an area where the variation in monthly mean precipitation relative to the long-term monthly mean is above the median of this variation among all branches. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	P[BarterCred]		ln(BarterCred+1)		ln(Credit)	
	(1)	(2)	(3)	(4)	(5)	(6)
Silo (Treat)	0.027***	0.028***	0.315***	0.307***	0.252***	0.281***
	(0.005)	(0.007)	(0.056)	(0.038)	(0.039)	(0.023)
Silo x High *Temperature* Deviation	0.091***		1.080***		0.154**	
	(0.018)		(0.251)		(0.077)	
Silo x High *Precipitation* Deviation		0.079***		0.974***		0.090
		(0.021)		(0.260)		(0.074)
Obs	259,450	259,450	259,450	259,450	259,450	259,450
Adj-R2	0.620	0.620	0.64	0.64	0.733	0.733
Month-Case-FE	Y	Y	Y	Y	Y	Y
Borrower-FE	Y	Y	Y	Y	Y	Y

Table 16: Staggered Specification

This table reports the effect of the construction of a silo, using only the sample of treated branches. The specification exploits the staggered nature of the construction and augments specification (1) by replacing case-month with month fixed effects. I report the estimated effect on the total outstanding credit (column 1), value of barter credit (column 2), the probability of issuing a cash credit (column 3), and the markup (column 3). The unit of analysis is borrower-month. The variable *Silo* is equal to 1 if a branch has a silo in that month. The standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(Credit)	ln(barter+1)	P[Barter]	Markup
	(1)	(2)	(4)	(5)
Silo (Treat)	0.359***	0.815***	0.073***	-0.036**
	(0.066)	(0.192)	(0.021)	(0.018)
Obs	56,095	56,095	56,095	56,095
Adj-R2	0.732	0.620	0.324	0.550
Month FE	Y	Y	Y	Y
Borrower FE	Y	Y	Y	Y

Table 17: Economies of Scale

This table reports the effect of the construction of a silo on cash credit contracts. I report the estimated effect on total outstanding cash credit (column 1) and the probability of issuing a cash credit (column 2). 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 standard errors are reported in parentheses and clustered at the branch level. * significant at 10%; ** significant at 5%; *** significant at 1%

	ln(CashCred+1)	P[CashCred]
	(1)	(2)
Silo (Treat)	0.083	-0.012
	(0.170)	(0.016)
Obs	259,450	259,450
Adj-R2	0.550	0.422
Month-Case-FE	Y	Y
Borrower-FE	Y	Y