Capital Allocation Across Regions, Sectors and Firms

Evidence from a Commodity Boom in Brazil*

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Abstract

We study the allocation of capital across regions, sectors and firms. In particular, we assess to what extent growth in agricultural productivity can lead to an increase in the supply of credit in industry and services. For this purpose, we identify an exogenous increase in agricultural profits due to the adoption of genetically engineered soy in Brazil. We find that regions with larger increases in agricultural productivity experienced larger increases in local bank deposits. However, there was no increase in local bank lending. Instead, capital was reallocated towards other regions through bank branch networks. This increase in credit supply affected firms' credit access through the extensive and intensive margin. First, regions with more bank branches receiving funds from soy areas experienced an increase in credit market participation of small and medium sized firms. In addition, banks experiencing faster deposit growth in soy areas increased their lending to firms with whom they had preexisting relationships. In turn, these firms grew faster in terms of employment and wage bill. Our estimates imply that the elasticity of firm growth to credit is largest in the manufacturing sector. These findings suggest that agricultural productivity growth can lead to structural transformation through a financial channel.

Keywords: Bank Networks, Banking, Structural Transformation, Financial Constraints.
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I Introduction

The process of economic development is characterized by a reallocation of production factors from the agricultural to the industrial and service sectors. The theoretical literature has highlighted several channels through which productivity growth in agriculture can foster growth in the industrial and service sectors. First, the labour channel: productivity growth in agriculture can release workers who find employment in other sectors. Second, the demand channel: growth in agricultural income can sustain demand for industrial goods and services. Third, the finance channel: larger agricultural profits can generate savings that are reinvested in industrial projects. However, previous literature has highlighted that the experience of several low income countries appears inconsistent with the idea that high agricultural productivity leads to economic development. The literature has proposed two sets of explanations. First, scholars noted that the positive effects of agricultural productivity on economic development occur only in closed economies. This is because in economies opened to international trade a comparative advantage in agriculture can slow down industrial growth as the country specializes in the exports of agricultural products. Similarly, a globalized banking sector can channel national savings towards other countries instead of relocating them towards the local industrial and service sectors. Second, there is a large theoretical literature highlighting how market failures can retard structural transformation in developing countries (Murphy et al. 1989, Galor and Zeira 1993, Banerjee and Newman 1993, Acemoglu and Zilibotti 1997). In particular, financial frictions might constrain the reallocation of capital and thus retard the process of labour reallocation. Despite the richness of the theoretical literature, there is scarce direct empirical evidence testing the mechanisms proposed by these models.

In this paper we study the effects of productivity growth in agriculture on the supply of credit to the industrial and service sectors through the formal banking sector. For this purpose, we identify an exogenous increase in agricultural profits and trace its effects on bank lending and firm growth. In particular, we study the widespread adoption of genetically engineered (GE) soy in Brazil. We first document that in areas where, due to weather and soil characteristics, the new technology had a larger impact on potential yields, there was a sharp increase in agricultural profits. Second, we show that these areas were characterized by a faster increase in bank deposits. Third, we exploit differences in the regional structure of bank networks to trace the effect of this increase in the supply of capital on local credit markets. We find that regions that do not produce soy but are served by branches of banks with larger presence in soy producing regions experienced an increase in the supply of credit. In addition, firms in the industrial and service sectors borrowing from banks more exposed to the soy boom experienced faster growth.

One of the main difficulties faced by the empirical literature studying the reallocation of capital across sectors is the separate identification of supply and demand shocks. In this paper, we identify exogenous increases in the supply of credit across regions in Brazil, as follows. First, we exploit the introduction of GE soy seeds to obtain exogenous variation in agricultural profits. As the new technology had a differential impact on yields depending on geographical and weather characteristics, we use differences in soil suitability across regions as a source of cross-sectional variation. In addition, we use the date of legalization of this technology in Brazil (2003) as a source of variation across time. Second, we exploit the bank branch network across Brazilian regions to identify bank and branch-level exogenous increases in the supply of funds. This permits to trace the flow of funds from soy producing (origin) municipalities to non-soy producing (destination) ones.

We start by documenting the local effects of the soy boom. For this purpose, we use data from FAO-GAEZ which reports potential yields under traditional and new agricultural technologies to obtain an exogenous measure of potential soy profitability that varies across geographical areas in Brazil. We find that municipalities that experience a larger increase in potential soy profitability after the legalization of GE soy seeds experienced a larger increase in the area planted with GE soy and agricultural profits. In addition, we investigate the effect of our exogenous measure of soy profitability on deposits and loans in local bank branches. This information is sourced from ESTBAN, a dataset of the Central Bank of Brazil covering all commercial banks registered in the country. We find that municipalities with a larger increase in potential soy profitability experienced a faster increase in bank deposits during the period under study.[1] In particular, municipalities with a one standard deviation higher potential soy profitability experienced a 4.2% larger increase in total bank deposits. On the other hand, we find no significant effect of our exogenous measure of soy profitability on credit supplied by the same local branches. If anything, our point estimates indicate a decrease in lending by local bank branches. This suggests that the increase in deposits driven by GE soy adoption does not affect local credit supply. A possible explanation of this finding is that banks' internal capital markets are integrated within the country, as we document in what follows.

Next, we analyze the role of bank branch networks in allocating funds from deposits in municipalities experiencing increases in agricultural profits (origin) to other municipalities (destinations). In particular, we attempt to identify the effect of faster increase in bank deposits on bank credit supply and its real effects on firm growth. For this purpose, we merge two datasets. First, we use loan-level data from the Credit Information System of the Central Bank of Brazil. This dataset allows us to investigate the effect of the GE-soy-driven increase in deposits of a given bank on the credit lines available to firms with pre-existing relationships with the same bank. Second, we use the Annual Social Information System (*Relação Anual de Informações Sociais*, RAIS) of the Brazilian Ministry of Labor, which provides detailed information on all formal workers and firms operating in Brazil.

[1]More specifically, we find that the effect on total deposits is driven by demand deposits and saving accounts.

Using fiscal identifiers, we are able to match firms in the RAIS dataset with firms in the Credit Information System. This combined dataset allows us to: (i) identify the *intensive margin* effect on firm growth of the GE-soy-driven credit supply shock, by exploiting pre-existing firm-bank relationships (ii) study the *extensive margin*, namely whether firms that have initially no access to bank credit are more likely to obtain it in regions that are relatively more exposed to the GE-soy-driven deposit shock through bank branch networks.

We start by analyzing the intensive margin. We trace the reallocation of capital from bank branches in soy producing (origin) municipalities to firms in non-soy producing (destination) ones. Our empirical strategy involves two steps. In the first step we estimate the exposure of each bank to the soy boom. For this purpose, we estimate the increase in deposits in each bank branch due to the local increase in agricultural productivity. Next, we aggregate predicted deposits across all branches of each bank. In the second step, we construct firm-level exogenous increases in the supply of credit and study their effects on firm growth. We find that firms with pre-existing relationships with the most affected banks took larger loans from those banks. These loans did not fully substitute for more expensive sources of finance as firms also increased aggregate borrowing from all financial institutions. In addition, firms who borrowed more also grew faster in terms of employment and wage bill. Interestingly, the effects of the credit supply shock on firm borrowing are similar for firms in the manufacturing and service sectors but the real effects on firm growth are larger for manufacturing firms. Thus, manufacturing is characterized by a larger elasticity of firm growth to credit. Finally, we find that the effects of the credit supply shock are similar for firms in different quartiles of the firm-size distribution.

Next, we analyze the extensive margin. That is, we quantify the effect of the credit supply shock on credit market participation for firms with no prior credit access. In this case we can not exploit pre-existing firm-bank relationships, thus we use a second empirical strategy. We use the bank branch networks to trace the reallocation of funds from deposits in municipalities experiencing increases in agricultural profits (origin) to other municipalities (destinations). To this end, we construct a measure of municipality exposure based on the geographical location of bank branches. We find that areas more exposed to the GE- soy-driven deposit shock through bank branch networks experienced a larger increase in bank lending. In addition, destination municipalities with larger increases in credit supply experienced faster growth in the share of firms with credit access, specially among small firms.

Our empirical findings are supportive of several mechanisms highlighted by the theoretical literature on finance and development discussed above. First, the fact that firms with pre-existing relationships with more affected banks borrow more than other firms of the same size operating in the same local credit market and industry suggests that informational frictions constrain the optimal allocation of capital by banks. Second, the finding that these firms use these extra funds to grow faster in terms of employment and wage bill suggests that they have profitable investment opportunities. Note that this does not imply that these firms are credit constrained, in the sense that they would desire to borrow more at the equilibrium interest rate. To understand whether this is the case we would ideally observe whether the interest rate at which they borrowed was reduced or they faced a higher credit limit. However this information is not available for the period under study. Still, the extensive margin results are highly suggestive on this respect: destination municipalities with larger increases in credit supply experienced faster growth in the share of firms with credit access. In addition, these effects are largest for small firms. Third, the finding that the elasticity of firm growth to credit is largest in the manufacturing sector is consistent with the claim that start-up costs or fixed costs of technology adoption are largest in this sector. These non-convexities in the production function can lead to large effects of credit frictions on firm growth, as highlighted by Buera et al. (2011).

More importantly, our empirical findings imply that agricultural productivity growth can lead to structural transformation through a financial channel. The finding that the adoption of new agricultural technologies can generate larger profits and savings deposits in local bank branches which are reallocated to other areas of the country and other sectors suggests that international capital markets are not fully integrated. As a result, an increase in national savings can lead to an increase in national investment. We find that this additional investment generates larger output growth in the manufacturing sector, and some growth in services.

Related Literature

A large literature in economics has studied the relationship between financial development and economic growth (see Levine 2005, 1997 for a detailed review), starting from the seminal contributions of Bagehot (1888) and Hicks (1969), who study the role played by financial markets during the industrial revolution in England. Related to our paper are the works by Crafts (1985) and Crouzet (1972), who explore whether agricultural productivity growth due to new technologies has been an important source of capital for other sectors during the industrial revolution. Their analysis based on historical data finds that agriculture both released and absorbed capital during the industrial revolution, so that its net contribution is ambiguous. Our paper contributes to this literature on capital reallocation across sectors, and in particular from agriculture to industry, by bringing new micro evidence from a developing country that experiences a major technological revolution in agriculture.

The first part of our empirical analysis focuses on local effects of agricultural productivity shocks. In this sense, our work is related to the empirical literature studying the links between agricultural productivity and local development. Related papers in this literature include: Foster and Rosenzweig (2004, 2007), who study the effects of new agricultural technologies (high-yielding varieties of different crops) on manufacturing growth during the Green Revolution in India; Nunn and Qian (2011), who study the effect of agricultural productivity on urbanization; as well as Hornbeck and Keskin (2014), Rajan and Ramcharan (2011). Our work is also related to papers that have studied the effect of local commodity shocks on financial development. For example, Gilje (2011) uses variation in shale gas discoveries across US counties as a shock to local deposits, and document how this shock is associated with larger growth in the number of establishments operating in sectors that rely more on external finance.[2]

Our work attempts to contribute to the recent literature on the role of credit markets in developing countries. An important puzzle in this literature is that the growth in credit availability in developing countries during the last two decades has not always lead to access to finance to a broader set of the population. Instead, credit is often concentrated among the largest firms. Moreover, firms in developing countries continue to face barriers in accessing financial services. The theoretical literature has highlighted three main credit frictions that are consistent with these patterns, as discussed by Dabla-Norris et al. (2015). First, entrepreneurs in developing countries face several fixed transaction costs related to entering the formal sector and accessing bank credit. Second, moral hazard and limited liability lead to high collateral requirements for loans, which impose borrowing constraints on firms. Third, asymmetric information between banks and borrowers imposes monitoring costs which tend to be increasing in the level of leverage of firms, as a result, interest rate spreads (the difference between lending and deposit rates) tend to be much higher for poorer and younger entrepreneurs.

We expect to contribute to different strands of the literature. First, the literature on the role of factor misallocation on economic development (Banerjee and Duflo 2005, Hsieh and Klenow 2009, Caselli and Gennaioli 2013, Midrigan and Xu 2014). Second, the macroeconomic literature on financial frictions and economic development (Giné and Townsend 2004; Jeong and Townsend 2008, Buera et al. 2015, Moll 2014). This literature has laid out the theoretical mechanisms through which financial development can affect the allocation of capital and measured their importance using quantitative models. Our contribution is to provide for direct evidence of these mechanisms by observing the effect of actual exogenous credit shocks and following them using detailed micro-data. Third, the micro-economic literature on finance and development (McKenzie and Woodruff 2008;

[2]Similarly, Becker (2007) exploits variation in the presence of senior citizens across counties in the US to explain variation in local bank deposits, and shows that higher local deposits are correlated with local entrepreneurial activity. More recently, Drechsler et al. (2014) exploit monetary policy changes as a shock to local deposit supply. They show that, in response to Fed funds rate increases, banks operating in areas with less bank competition tend to increase deposit spread more, with a consequent outflow of capital from the banking system. In a follow-up paper Gilje et al. (2013) show that banks more exposed to deposits windfall in shale gas counties increase mortgage lending in non-shale gas counties where they have branches.

De Mel et al. 2008, Banerjee et al. 2001; Banerjee et al. 2013; Rosenzweig and Wolpin 1993). Part of this literature has directly observed the effects of exogenous credit shocks on firm growth and creation, but generally focused on micro-credit. In contrast, we focus our analysis on credit to firms of all sizes. Fourth, the literature on financial and real effects of bank liquidity shocks (Khwaja and Mian 2008, Amiti and Weinstein 2011, Schnabl 2012, Iyer et al. 2013). We contribute to this literature by using a different identification strategy. In particular, the exogenous shock to agricultural productivity used in this paper only affects soy producing regions and expands to non-producing regions through bank networks (we discuss other potential links in the empirical strategy section). Thus, in non-soy producing regions, it only affects credit supply and not credit demand. This allows us to study real effects of credit supply shock at firm level without relying exclusively on a sample of firms with multiple bank relationships.[3]

Finally, this paper builds on our earlier work. In Bustos, Caprettini and Ponticelli (2016) we study the effects of the adoption new agricultural technologies in Brazil on the reallocation of labor across sectors. Our identification strategy uses the differential effect of the new technology across geographical areas. We find that increases in local agricultural productivity lead to growth in the *local* manufacturing sector. We argue that this is because technical change in soy leads to a contraction in labor demand in agriculture, causing labor to reallocate towards the manufacturing sector. The current paper complements our earlier findings in that we find that the new technology leads to larger agricultural profits and increases in local bank deposits. However, we do not find an increase in local bank lending. As mentioned above, we interpret this finding as indicative that banks' internal capital markets are nationally integrated. This indicates that the profits generated by GE soy were not channeled to the local industrial sector through the formal banking sector. This finding suggests that local manufacturing expanded due to a larger local labor supply as we argue in our earlier work. This project differs in two dimensions. First, we focus on the spatial dimension of the reallocation process. Second, we study not only the allocation of labour but also the allocation of capital. To exploit the spatial dimension of the capital allocation problem, we design a new empirical strategy which exploits the geographical structure of bank branch networks to trace the reallocation of capital across regions.

The rest of the paper is organized as follows. In section II we provide background information on the introduction of genetically engineered soy seeds in Brazil and its impact on agricultural profitability. Section III describes the data used in the empirical analysis. In section IV we present the identification strategy and discuss the empirical results of the paper. Finally, section V concludes.

[3]The seminal work by Khwaja and Mian (2008) underlines the difficulty to obtain unbiased estimates of real effects of credit shocks at firm level using their methodology.

II Background on Genetically Engineered Soy in Brazil

In this section we describe the technological change introduced by genetically engineered (GE) soy in Brazilian agriculture and its impact on agricultural profitability.

The main difference between GE soy seeds and traditional soy seeds is that the former are genetically engineered to resist to the application of certain herbicides. The use of GE seeds allows farmers to adopt a new set of techniques that lowers production costs, mostly due to lower labor requirements for weed control. First, GE soy seeds facilitates the use of no-tillage planting techniques. The planting of traditional seeds is preceded by soil preparation in the form of tillage, the operation of removing the weeds in the seedbed that would otherwise crowd out the crop or compete with it for water and nutrients. In contrast, planting GE soy seeds requires no tillage, as the application of herbicide selectively eliminates all unwanted weeds without harming the crop. As a result, GE soy seeds can be applied directly on last season's crop residue, allowing farmers to save on production costs since less labor is required per unit of land to obtain the same output. Second, GE soybeans are resistant to a specific herbicide (glyphosate), which needs fewer applications: fields cultivated with GE soybeans require an average of 1.55 sprayer trips against 2.45 of conventional soybeans (Duffy and Smith 2001; Fernandez-Cornejo et al. 2002). Finally, no-tillage allows greater density of the crop on the field (Huggins and Reganold 2008).[4]

The first generation of GE soy seeds, the Roundup Ready variety, was commercially released in the U.S. in 1996 by the agricultural biotechnology firm Monsanto. In 1998, the Brazilian National Technical Commission on Biosecurity (CTNBio) authorized Monsanto to field-test GE soy for 5-years as a first step before commercialization in Brazil. In 2003, the Brazilian government legalized the use of GE soy seeds.[5]

The new technology experienced a fast pace of adoption in Brazil. The Agricultural Census of 2006 reports that, only three years after their legalization, 46.4% of Brazilian farmers producing soy were using GE seeds with the "objective of reducing production costs" (IBGE 2006, p.144). According to the Foreign Agricultural Service of the USDA, by the 2011-2012 harvesting season, GE soy seeds covered 85% of the area planted with soy in Brazil (USDA 2012). The Agricultural Census of 2006 reports 1355 municipalities with soy-producing farms, out of which 715 with farms declaring to use GE soy seeds.[6,7]

[4]Even though experimental evidence in the U.S. reports no improvements in yield of GE soy with respect to conventional soybeans (Fernandez-Cornejo and Caswell 2006), due to its cost-effectiveness this technology has spread both in the US and in Brazil.

[5]In 2003, Brazilian law 10.688 allowed the commercialization of GE soy for one harvesting season, requiring farmers to burn all unsold stocks after the harvest. This temporary measure was renewed in 2004. Finally, in 2005, law 11.105 – the New Bio-Safety Law – authorized production and commercialization of GE soy in its Roundup Ready variety (art. 35).

[6]We consider adopter a municipality with a positive amount of soy area cultivated with GE soy seeds in 2006

[7]Since borders of municipalities changed over time, the Brazilian Statistical Institute (IBGE) has

Census data show that, in non-GE-soy municipalities, the median increase in agricultural profits per hectare between 1996 and 2006 was by 4.5%, while in GE-soy municipalities, the median increase in the same period was 25.4%.[8]

Consistently with this increase in profitability in soy production, Bustos et al. (2016) show that the timing of adoption of GE soy seeds in Brazil coincides with a decrease in labor intensity of soy production, and a fast expansion in the area planted with soy. According to the last Agricultural Census, the area planted with soy increased from 9.2 to 15.6 million hectares between 1996 and 2006 (IBGE 2006, p.144). Similarly, Figure I shows that the area planted with soy has been growing since the 1980s, and experienced a sharp acceleration in the early 2000s.[9]

To gauge the magnitude of the soy boom and, in particular, the monetary value of soy production in Brazil relative to deposits in the banking sector, we can use data on revenues for soy producers from the Municipal Agricultural Production Survey.[10] Total soy revenues at national level were around 6 Bn BRL in 1996, at the beginning of the period under study. This constitutes around 3% of total deposits in Brazilian banks at the time. At the peak of the soy boom years, in the mid-2000s, total soy revenues at national level were 3 to 4 times higher at around 20 Bn BRL (all values are expressed in real terms, in 2000 BRL), or 5% of total deposits in Brazilian banks at the time.

III Data

The main data sources are: the Credit Information System of the Central Bank of Brazil for loan-level data, the Annual Social Information System of the Ministry of Labor for firm-level data, and the Municipal Bank Statistics for bank branch-level data. Additionally, we use data on agricultural outcomes from the Municipal Agricultural Production Survey and the Agricultural Census of the Brazilian Institute of Geography and Statistics, and data on potential soy yields from the Global Agro-Ecological Zones database of the Food and Agriculture Organization.

defined *Área Mínima Comparável* (AMC), smallest comparable areas, which are comparable over time and which we use as our unit of observation. In what follows, we use the term municipality for AMC. Brazil has, in total, 4260 AMCs.

[8] Note that agricultural profits are only available aggregated across all agricultural activities in a given municipality.

[9] Yearly data on area planted are from the CONAB survey. This is a survey of farmers and agronomists conducted by an agency of the Brazilian Ministry of Agriculture to monitor the annual harvests of major crops in Brazil. We use data from the CONAB survey purely to illustrate the timing of the evolution of aggregate agricultural outcomes during the period under study. In the empirical analysis, instead, we rely exclusively on data from the Agricultural Censuses which covers all farms in the country and it is representative at municipality level.

[10] The Agricultural Censuses do not report profits for producers by crop. See section III for a detailed description of these datasets.

III.A Banks, Firms, and Credit Relationships Data

The Credit Information System of the Central Bank of Brazil includes information on all credit relationships between firms and financial institutions operating in Brazil.[11] We use data from the Credit Information System covering the years from 1997 to 2010. Information on each loan is transmitted monthly by financial institutions to the Central Bank. The dataset reports a set of loan and borrower characteristics, including loan amount, type of loan and repayment performance.[12] In the current version of the paper, we focus on total outstanding loan amount.[13] The confidential version of the Credit Information System allows us to uniquely identify both the lender (bank) and the borrower (firm) in each credit relationship.

We matched data on bank-firm credit relationships with data on firm characteristics from the Annual Social Information System (RAIS) and on bank characteristics from the Municipal Bank Statistics (ESTBAN). RAIS is an employer-employee dataset that provides individual information on all formal workers in Brazil.[14] Using worker level data, we constructed the following set of variables for each firm: employment, wage bill, sector of operation and geographical location.[15] ESTBAN reports balance sheet information at branch level for all commercial banks operating in Brazil (around 150 banks per year in our data). The main variables of interest are total value of deposits and total value of loans originated by each branch.[16]

[11]The Credit Information System (CRC and SCR) as well as ESTBAN are confidential datasets of the Central Bank of Brazil. The collection and manipulation of individual loan-level data and bank-branch data were conducted exclusively by the staff of the Central Bank of Brazil.

[12]Unfortunately, data on interest rate is only available from 2004, with the introduction of SCR, the new version of the Credit Information System.

[13]Loan amount refers to the actual use of credit lines. In this sense, our definition of access to bank finance refers to the actual use and not to the potential available credit lines of firms.

[14]Employers are required by law to provide detailed worker information to the Ministry of Labor. See Decree n. 76.900, December 23^{rd} 1975 (Brazil 1975). Failure to report can result in fines. RAIS is used by the Brazilian Ministry of Labor to identify workers entitled to unemployment benefits (*Seguro Desemprego*) and federal wage supplement program (*Abono Salarial*).

[15]When a firm has multiple plants, we aggregate information on employment and wage bill across plants and assign to the firm the location of its headquarters. Whenever workers in the same firm declare to operate in different sectors, we assign the firm to the sector in which the highest share of its workers declare to operate.

[16]We observe three main categories of deposits: checking accounts, savings accounts and term deposits. As for loans, we observe three major categories: rural loans, which includes loans to the agricultural sector; general purpose loans to firms and individuals, which includes: current account overdrafts, personal loans, accounts receivable financing and special financing for micro-enterprises among others; and specific purpose loans which includes loans with a specific objective, such as export financing, or acquisition of vehicles. It is important to notice that ESTBAN data do not allow us to distinguish between loans to individuals vs firms. Also, we can not distinguish loans to different sectors with the exception of rural loans, which are loans directed to individuals or firms operating in the agricultural sector.

III.B Broad Stylized Facts

In this section, we present some broad stylized facts on credit market participation between 1997 and 2010 that can be uncovered using our data. One advantage of our dataset with respect to existing literature is that we observe both the universe of credit relationships and the universe of formal firms. That is, we observe both firms with access to credit and firms that do not have access to credit. This allows, for example, to study the evolution of credit market participation in Brazil.

Two caveats are in order for a correct interpretation of the stylized facts presented below. First, given the institutional nature of the two datasets and the characteristics of RAIS, our analysis focuses on formal firms with at least one employee.[17] Second, the Credit Information system has a reporting threshold above which financial institutions are required to transmit loan information to the Central Bank.[18] In the years 1997 to 2000, this threshold was set at 50,000 BRL (around 45,000 USD in 1997). Starting from 2001 and until the end of our dataset in 2010, the threshold was lowered to 5,000 BRL (around 2,200 USD in 2001).

Figure II shows the total number of formal firms (gray bars) and the share of formal firms with access to bank credit (blue line) by year in the period between 1997 and 2010. In this Figure, we define access to bank credit as an outstanding credit balance equal or above 50,000 1997 BRL. Our objective in choosing the higher threshold for this exercise is twofold: study credit market participation on the longest time period possible given our data, and capture the share of firms that start getting large loans (rather than, for example, an overdraft on their bank account). As shown, according to this definition, 7% of formal Brazilian firms (1.4 million in the initial year) had access to bank credit in 1997. This share increased to 14% by 2010, with most of the increase occurring in the second half of the 2000s. Figure III shows how the increase in credit access ratio has been largely heterogeneous across sectors, with manufacturing and services experiencing large increases, while the share of firms with access to bank credit in agriculture has been relatively constant in the period under study.[19] Finally, in Figure IV, we show the evolution of credit access ratio by firm size category. For this purpose, we use the firm size categories proposed by the Brazilian Institute of Geography and Statistics (IBGE). The IBGE defines micro firms those with between 1 and 9 workers, small firms those with between 10 and 49 workers, medium firms those with between 50 and 99 workers, and large firms those with 100 and more workers. The vast majority of Brazilian firms

[17]Self-employed are not required to report information to RAIS.

[18]To be more precise: the threshold applies to the total outstanding balance of a given client towards a given bank. Whenever the total outstanding balance goes above the threshold set by the Central Bank, the bank is required to transmit information on all credit operations of that client (potentially including loans whose amount is below the threshold).

[19]It should be noted, however, that our data covers only formal firms with at least one employee, and the agricultural sector in Brazil is still characterized by a higher degree of informality and self-employment than the manufacturing and services sectors.

registered in RAIS are micro firms (84.1% of firms in our data in 1997). For these firms, the 50,000 1997 BRL reporting threshold corresponds to 1.6 times their average wage bill, making the definition of access to bank credit particularly demanding. In the years between 1997 and 2010, however, the share of micro firms with access to bank credit has tripled, going from 3% in 1997 to 9% in 2010. Small firms, for which the 50,000 1997 BRL reporting threshold corresponds to 25% of their average wage bill, also experienced a significant increase in credit access ratio, that went from 18% in 1997 to 34% in 2010.

III.C Additional Datasets

Data on area cultivated with soy and value of soy production in each municipality is from the Municipal Agricultural Production Survey (PAM, *Produção Agrícola Municipal*). PAM is a yearly survey covering information on production of the main temporary and permanent crops in Brazil. The survey is conducted at municipal level by the Brazilian Institute of Geography and Statistics through interviews with government and private agricultural firms, local producers, technicians, and other experts involved in the production and commercialization of agricultural products. The PAM survey does not contain information on the type of seeds (GE vs non-GE) used by farmers.

We source data on agricultural land planted with GE and traditional soy seeds, the value of agricultural profits, investments in agriculture and external financing from the Agricultural Census. The Agricultural Census is released at intervals of 10 years by the Brazilian Institute of Geography and Statistics (IBGE). We focus on the last two rounds of the census which have been carried out in 1996 and in 2006. Data is collected through direct interviews with the managers of each agricultural establishment and is made available by the IBGE aggregated at municipality level. It is important to notice that the measures of profits, investments and external financing do not refer specifically to soy production but are aggregated across all agricultural activities.

Finally, to construct our measure of exogenous change in soy profitability we use estimates of potential soy yields across geographical areas of Brazil from the FAO-GAEZ database. These yields are calculated by incorporating local soil and weather characteristics into a model that predicts the maximum attainable yields for each crop in a given area. In addition, the database reports potential yields under different technologies or input combinations. Yields under the low technology are described as those obtained planting traditional seeds, no use of chemicals nor mechanization. Yields under the high technology are obtained using improved high yielding varieties, optimum application of fertilizers and herbicides and mechanization. Maps displaying the resulting measures of potential yields for soy under each technology are contained in Figures V and VI.

Table I reports summary statistics of the main variables of interest used in the empirical analysis.

IV Empirical Strategy

In this section, we attempt to trace the reallocation of capital from the rural agricultural sector to the urban industrial and service sectors. This reallocation process takes place both across sectors and space, thus our identification strategy proceeds in three steps. First, we attempt to establish the direction of causality, from agriculture towards other sectors. For this purpose, we exploit a large and exogenous increase in agricultural productivity: namely the legalization of genetically modified soy in Brazil. We use this variation to assess whether municipalities more affected by technical change experienced larger increases in agricultural profits and saving deposits in local bank branches. We think of these soy producing areas affected by technical change as *origin* municipalities. Second, we need to trace the reallocation of capital across space, from rural to urban areas. For this purpose, we exploit differences in the geographical structure of bank branch networks for 150 Brazilian Banks. We think of these banks as intermediaries that reallocate savings from soy producing (origin) municipalities to non-soy producing (*destination*) municipalities. We then use the bank branch network to construct exogenous credit supply shocks across different urban areas. Third, we trace the reallocation of capital across firms. For this purpose, we use administrative data on the credit and employment relationships for the universe of formal firms. We use this data to construct firm-level exogenous credit supply shocks using information on pre-existing firm-bank relationships.

We start by describing the identification of local effects of agricultural technical change in subsection IV.A. Next, we study the reallocation of capital through the bank branch network in subsection IV.B.

IV.A Local Effects

Let us first discuss the timing of legalization of GE soy seeds. GE soy seeds were commercially released in the U.S. in 1996, and legalized in Brazil in 2003. Given that the seeds were developed in the U.S., their date of approval for commercialization in the U.S., 1996, is arguably exogenous with respect to developments in the Brazilian economy. In contrast, the date of legalization, 2003, responded partly to pressure from Brazilian farmers. [20] Thus, in our empirical analysis we would ideally compare outcomes before and after the first use of GE seeds in Brazil. For agricultural variables sourced from the Agricultural Census, we compare outcomes across the last two Censuses, which were carried out in 2006 and 1996. Since the 1996 Census pre-dates both legalization and the first reports of smuggling, the timing can be considered exogenous. For variables on soy production sourced from PAM, and on bank outcomes sourced from ESTBAN, outcomes

[20] In addition, smuggling of GE soy seeds across the border with Argentina is reported since 2001. See the United States Department of Agriculture report: USDA 2001. On the smuggling of GE seeds across the Argentina-Brazil border, see also: Pelaez and Albergoni (2004), Benthien (2003) and Ortega et al. (2005).

are observed yearly starting from 1996. In our baseline regression we therefore compare outcomes before and after the official legalization of GE soy seeds in 2003.

Second, the adoption of GE soy seeds had a differential impact on potential yields depending on soil and weather characteristics. Thus, we exploit these exogenous differences in potential yields across geographical areas as our source of cross-sectional variation in the intensity of the treatment. To implement this strategy, we need an exogenous measure of potential yields for soy, which we obtain from the FAO-GAEZ database. These potential yields are estimated using an agricultural model that predicts yields for each crop given climate and soil conditions. As potential yields are a function of weather and soil characteristics, not of actual yields in Brazil, they can be used as a source of exogenous variation in agricultural productivity across geographical areas. Crucially for our analysis, the database reports potential yields under different technologies or input combinations. Yields under the low technology are described as those obtained using traditional seeds and no use of chemicals, while yields under the high technology are obtained using improved seeds, optimum application of fertilizers and herbicides and mechanization. Thus, the difference in yields between the high and low technology captures the effect of moving from traditional agriculture to a technology that uses improved seeds and optimum weed control, among other characteristics. We thus expect this increase in yields to be a good predictor of the profitability of adopting GE soy seeds.

Finally, notice that our analysis is conducted at municipality level. Therefore, even if Brazil is a major exporter of soy in global markets, individual Brazilian municipalities can be considered small open economies for which variations in the international price of soy are exogenous.

More formally, our baseline empirical strategy consists in estimating the following equation:

$$y_{jt} = \alpha_j + \alpha_t + \beta \log(A_{jt}^{soy}) + \varepsilon_{jt} \tag{1}$$

where y_{jt} is an outcome that varies across municipalities and time, the subscript j identifies municipalities, t identifies years, α_j are municipality fixed effects, α_t are time fixed effects and A_{jt}^{soy} is defined as follows:

$$A_{jt}^{soy} = \begin{cases} A_j^{soy,LOW} & \text{for } t < 2003 \\ A_j^{soy,HIGH} & \text{for } t \geq 2003 \end{cases}$$

where $A_j^{soy,LOW}$ is equal to the potential soy yield under low inputs and $A_j^{soy,HIGH}$ is equal to the potential soy yield under high inputs.

In the case of agricultural outcomes sourced from the Agricultural Census, our period of interest spans the ten years between the last two censuses which took place in 1996 and 2006. We thus estimate a first-difference version of equation (1):

$$\Delta y_j = \Delta\alpha + \beta\Delta\log(A_{jt}^{soy}) + \Delta\varepsilon_{jt} \tag{2}$$

where the outcome of interest, Δy_j is the change in outcome variables between the last two census years and:

$$\Delta\log(A_{jt}^{soy}) = \log(A_j^{soy,HIGH}) - \log(A_j^{soy,LOW})$$

A potential concern with our identification strategy is that, although the soil and weather characteristics that drive the variation in A_{jt}^{soy} across geographical areas are exogenous, they might be correlated with the initial levels of economic and financial development across Brazilian municipalities.

To mitigate this concern, in what follows we control for differential trends across municipalities with heterogeneous initial characteristics in our baseline specification 1:

$$\begin{aligned} y_{jt} &= \alpha_j + \alpha_t + \beta\log(A_{jt}^{soy}) \\ &+ \sum_t \gamma_t(\text{Municipality controls}_{j,1991} \times d_t) \\ &+ \sum_t \delta_t(\text{Bank controls}_{j,1996} \times d_t) + \varepsilon_{jt} \end{aligned} \tag{3}$$

where: Municipality controls$_{j,1991}$ is a set of initial municipality characteristics including: income per capita (in logs), share of rural population, population density (in logs) and literacy rate;Bank controls$_{j,1996}$ is a weighted average of observable characteristics of banks with branches in municipality j in the initial year (log value of assets, share of deposits over assets, and total number of bank branches) where the weights are calculated as the number of branches of bank b in municipality j over the total number of bank branches in municipality j. We interact both sets of controls with year dummies d_t.

IV.B Reallocation through Bank Branch Network

In this section, we describe how we trace the reallocation of capital across space. In particular, we explain how we use the structure of the bank branch network across Brazilian regions to trace the flow of funds from soy producing (origin) municipalities to non-soy producing (destination) ones.

First, in subsection IV.C, we study the intensive margin, or the effects of larger credit supply on firms with prior access to credit. Our empirical strategy for the intensive margin involves two steps. In the first step we estimate the exposure of each bank to the soy boom. For this purpose, we estimate the increase in deposits in each bank branch due to the local increase in agricultural productivity. Next, we aggregate predicted deposits across all branches of each bank. In the second step, we construct firm-level exogenous increases in the supply of credit and study their effects on firm growth.

Second, in subsection IV.D we study the extensive margin, or credit market participation. For this purpose, we construct exogenous credit supply increases for each *destination* municipality using differences in the geographical structure of bank branch networks.

IV.C Intensive Margin

IV.C.1 Step I: Estimation of bank exposure to soy boom

Before describing the estimation strategy, let us just illustrate the sources of variation in bank exposure. GE soy-driven growth in deposits is a function of the geographical location of the branches of each bank before the legalization of GE soy seeds, as well as the increase in potential soy yields across these locations. To better illustrate this source of variation in bank exposure, in Figure IX we show the geographical location of the branches of two Brazilian banks with different levels of exposure to GE soy adoption. The Figure reports, for each bank, both the location of bank branches across municipalities (red dots) and the increase in soy revenues in each municipality during the period under study (darker green indicates a larger increase). As shown, the branch network of bank A extends into areas that experienced large increase in soy revenues following the legalization of GE soy seeds. On the contrary, the branch network of bank B mostly encompasses regions with no soy production. A potential concern with this strategy is that the initial location of bank branches might have been instrumental to finance the adoption of GE soy. Thus, to construct bank exposure, we do not use the actual increase in soy revenues but our exogenous measure of potential increase in soy profitability, which only depends on soil and weather characteristics.

Estimation

The first step in our empirical strategy estimates the increase in liquidity of each bank due to the soy boom. For this purpose, we estimate the increase in deposits in each bank branch due to the local increase in agricultural productivity as follows:

$$log(deposits)_{bot} = \alpha_b + \alpha_o + \alpha_t + \beta log(A_{ot}^{soy}) + \varepsilon_{bot} \tag{4}$$

where b indexes banks, o origin municipalities and t time. In turn, α_b, α_o and α_t are bank, origin municipality and time fixed effects. A_{ot}^{soy} are the FAO-GAEZ potential yields of soy in municipality o at time t, our measure of agricultural technical change.

The dataset we use to obtain a measure of $(deposits)_{bot}$ contains information on the deposits on each branch of each bank in a given year. Thus, if a bank has more than one branch in a given municipality we aggregate the deposits of all branches of the same bank in a given year to obtain $(deposits)_{bot}$. Our ideal unit of observation would be a parcel of land served by a number of branches of the same bank. However we can only match bank branches to municipalities. Thus, we weight observations by:

$$\omega_{bo,t=0} = \frac{n_{bo,t=0}}{N_{o,t=0}} T_{o,t=0}$$

where T_o is total agricultural land in municipality o, N_o is the total number of branches in municipality o and n_{bo} is the total number of branches of bank b in municipality o. The weights $\omega_{bo,t=0}$ implicitly assume that each bank receives a share of the increase in deposits driven by GE soy profitability in municipality o that is proportional to its market share in that municipality, which we measure as its number of branches relative to the total number of branches in the municipality. Note that we compute this market share using bank location in 1996, before the legalization of GE seeds in Brazil. This ensures that we do not capture the opening of new branches in areas with faster deposit growth due to the new technology. This new openings are more likely to occur by banks which face larger demand for funds. Thus, focusing on the pre-existing network ensures that we only capture an exogenous increase in the supply of funds.

Aggregation

Next, we aggregate deposits collected in all branches of each bank. If we assume that ε_{bot} is normally distributed with variance σ_ε^2, then we can use our estimates of equation (4) to construct the predicted level of deposits in each branch, as follows:

$$(\widehat{deposits})_{bot} = \exp\left[\widehat{\alpha}_b + \widehat{\alpha}_o + \widehat{\alpha}_t + \widehat{\beta} log(A_{ot}^{soy})\right] \exp(0.5\widehat{\sigma}_\varepsilon^2)$$

Then, we can obtain the predicted total deposits in each bank by summing over the set of all municipalities where bank b has branches at $t = 0$, which we define as O_b :

$$\widehat{Deposits}_{bt} = \sum_{o \in O_b} \widehat{deposits}_{bot}$$

Next, we take logs and obtain:

$$\log \widehat{Deposits}_{bt} = \widehat{\sigma}_\varepsilon^2/2 + \widehat{\alpha}_t + \widehat{\alpha}_b + \log \sum_{o \in O_b} e^{\widehat{\alpha}_o} (A_{ot}^{soy})^{\widehat{\beta}} \tag{5}$$

Finally, to illustrate the properties of this measure, let us take first differences between the period before (t-1) and the period after (t) legalization of GE soy:

$$\log \widehat{Deposits}_{bt} - \log \widehat{Deposits}_{bt-1} = (\widehat{\alpha}_t - \widehat{\alpha}_{t-1}) + \log \sum_{o \in O_b} e^{\widehat{\alpha}_o} (A_{ot}^{soy})^{\widehat{\beta}} - \log \sum_{o \in O_b} e^{\widehat{\alpha}_o} (A_{ot-1}^{soy})^{\widehat{\beta}}$$

This measure of the change in predicted deposits aims at capturing the extent to which banks are exposed to the soy-driven increase in deposits through their branch network. Indeed, differences in the initial structure of the bank branch network O_b can lead to differential effects of technical change in soy across banks. This relationship is displayed in the top left panel of Figure VII which contains a scatter plot of the change in predicted deposits and the aggregate actual change in soy area in municipalities where the bank has branches. Indeed, banks with larger increase in predicted deposits have more branches in municipalities where the area planted with soy expanded. Note that an advantage of this specification is that the change in predicted deposits is not correlated with permanent bank characteristics as reflected in the bank fixed effects which are differenced-out. To assess the extent to which permanent differences across banks are captured by the fixed effects we construct a set of scatter plots displaying the relationship between the change in predicted deposits and baseline bank characteristics such as its size measured as its level of assets and number of branches and its leverage ratio measured as deposits over assets. Figure VII shows that none of these bank characteristics are correlated with the predicted increase in deposits.

IV.C.2 Step II

In this section we explain how we use the predicted increase in deposits in each branch due to the local increase in agricultural productivity to construct exogenous increases in credit supply. In particular, we study the effects of larger credit supply on firms with prior access to credit. For this purpose, we construct firm-level credit supply increases using pre-existing firm-bank relationships.

To construct firm-level credit supply shocks, we assume that loans of firm i from bank b are described as follows:

$$loans_{ibt} = I_{ib,t=0} r_{bt}^{\lambda} u_{bit}$$

where $I_{ib,t=0}$ is an indicator variable taking the value of one when there is a bank-firm relationship at time zero. This variable captures the idea that informational frictions imply that banks are more likely to lend to firms with whom they have prior relationships. In turn, r_{bt} is the interest rate, which varies across banks due to internal capital markets: we assume that it is cheaper to finance loans with deposits than other sources such as the interbank market.

To proceed with estimation, we first condition on the sample with $I_{ib,t=0} > 0$ and take logs to obtain:

$$\log(loans_{ibt}) = \delta_i + \delta_t + \delta_b + \lambda \log r_{bt} + \varepsilon_{bit} \quad (6)$$

note that because we condition on $I_{ib,t=0} > 0$ all potential bank-firm relationships with

$I_{ib,t=0} = 0$ are dropped. Thus, our estimates on this sample of firms only capture the "intensive margin." In the next sub-section we describe our empirical strategy to study the extensive margin, or credit market participation.

Second, we assume that differences in interest rates across banks are partly determined by deposits due to internal capital markets:

$$\log r_{bt} = \rho_t + \rho_b + \mu \log Deposits_{bt} + \upsilon_{bt}$$

Third, we substitute the equation above on equation 6 to obtain our main estimating equation:

$$\log(loans_{ibt}) = \delta_i + \delta_t + \delta_b + \lambda\mu \log Deposits_{bt} + e_{bit} \quad (7)$$

The equation above shows that exogenous increases in deposits can generate larger loans if $\lambda\mu > 0$: firms borrow more when the interest rate falls and banks increase their lending when they receive more deposits due to frictions in the interbank market. To identify $\lambda\mu$ we use the exogenous increases in deposits constructed in Step I ($\widehat{Deposits}_{bt}$) and substitute them in our structural equation of interest (7). Thus, we estimate:

$$\log(loans_{ibt}) = \delta_i + \delta_t + \delta_b + \beta \log \widehat{Deposits}_{bt} + \varepsilon_{bit} \quad (8)$$

This estimation strategy allows to identify the parameter $\beta = \lambda\mu$ under the assumption that the soy driven credit supply change at the bank-level is uncorrelated with credit demand changes at the firm-level. In order to assess whether the setup described above is likely to satisfy this identification assumption, it is useful to substitute the first stage equation (5) in the equation above, to obtain:

$$\log(loans_{ibt}) = \gamma_i + \gamma_t + \gamma_b + \beta \log \sum_{j \in J_b} e^{\widehat{\alpha}_o} (A_{ot}^{soy})^{\widehat{\beta}} + \varepsilon_{bit}$$

where $\gamma_i = \lambda\mu\widehat{\sigma}_{\varepsilon}^2/2 + \delta_i$; $\gamma_t = \delta_t + \lambda\mu\widehat{\alpha}_t$; $\gamma_b = \delta_b + \lambda\mu\widehat{\alpha}_b$.

This equation implies that constant bank characteristics which make aggregate bank-deposits larger as reflected in $\widehat{\alpha}_b$ are absorbed in the bank-fixed effects γ_b. In addition, note that invariant destination municipality characteristics which make loans larger for all firms are captured by firm-fixed effects. However, note that $\widehat{\alpha}_o$, which reflect source municipality characteristics making deposits larger for all banks with local branches can not be extracted from the summation over all bank branches (J_b) as they are interacted with the time-variant agricultural productivity term. This implies that they can not be absorbed by firm-fixed effects. This could challenge our identification assumption if the bank branch network J_b connects municipalities with similar unobserved characteristics and these are on similar trends. This implies we need to address a set of concerns discussed below.

Our identification assumption could be not satisfied in the following cases. First, if firms credit demand grows because they face larger demand from richer soy farmers or face larger labor supply from former agricultural workers. To address this concern, we restrict our sample to firms operating in non-soy producing regions. Second, if firms supply or buy inputs for soy production. To address this concern, we exclude firms operating in sectors directly linked to soy using the IO Matrix. A broader related concern is that different industries might be on differential growth trends due to other changes in the world economy such as increased trade with China. To address this concern, we include interactions of industry and time dummies in our specification. A third concern is that the bank branch network connects municipalities that are also better connected through the transportation network. Thus, even if they do not produce soy they might be affected by in-migration or demand linkages. To address this concern, we estimate a specification where we control for an interaction of municipality and time dummies which absorb all the municipality-level variation across time. An additional source of heterogeneity is that firms of different size might be on differential growth trends. Thus, we include an interaction of firm size and time dummies. We then estimate the following specification:

$$\log(loans_{idsbt}) = \delta_i + \delta_b + \delta_{dt} + \delta_{st} + \delta_{size,t} + \beta \log \widehat{Deposits}_{bt} + \varepsilon_{bit} \tag{9}$$

where the subindex d denotes the destination municipality, that is the municipality where the firm is located. In turn, δ_{dt} are destination municipality interacted with time fixed effects, and δ_{st} are industry interacted with time fixed effects. Finally, $\delta_{size,t}$ are firm-size interacted with time fixed effects.

We are interested in assessing the real effects of this additional borrowing. In particular, we want to understand the extent to which firms use additional credit to substitute potentially more expensive loans from other banks or they use it to finance growth enhancing investments. These investments can take the form of expanding the use of capital, labor or other inputs. Because we only observe labor and the wage bill, we focus our analysis on these two inputs. However, we think that to the extent that there is some complementarity between production inputs, we expect that any investment leading to expansion of the firm is likely to be reflected in larger employment and wage bill. Thus, we analyze real effects through the following specification:

$$\log(y_{idsbt}) = \delta_i + \delta_b + \delta_{dt} + \delta_{st} + \delta_{size,t} + \beta \log \widehat{Deposits}_{bt} + \varepsilon_{bit} \tag{10}$$

where y_{idsbt} denotes an outcome such as aggregate borrowing from all banks, the wage bill and employment in firm i, located in destination municipality d, operating in industry s at time t, and whose main lender in the initial period of the sample was bank b. Note that this specification only takes into account the increase in predicted deposits of the main lender of the firm, even if some firms borrow from more than one bank.[21] Since the main lender is defined in the initial period and it is time invariant for each firm, the main lender fixed effects δ_b are absorbed by firm fixed effects δ_i.

IV.D Extensive Margin

In section IV.C we propose an identification strategy to study the effects of larger credit supply on firms with prior access to credit. In this section, we propose an identification strategy to study the effect of a credit supply increase on all firms, including those with no prior access to finance. For this purpose, we bring the analysis at municipality level and construct a measure of potential credit supply increases for each *destination* municipality using differences in the geographical structure of bank branch networks. We call this measure: destination municipality exposure.

We define our measure of destination municipality exposure as follows:

$$\text{Municipality Exposure}_{dt} = \log \underbrace{\sum_{b} \frac{n_{bd}}{N_b}}_{\text{destination}} \underbrace{\sum_{o \in O_b} \frac{n_{bo,t=0}}{N_{o,t=0}} T_{o,t=0} A_{ot}^{soy}}_{\text{origin}} \tag{11}$$

Equation 11 aims at capturing to what extent destination municipality d is exposed to the soy boom in origin municipalities through the bank branch network. In particular, the second summation captures the exposure to the soy boom of bank b, where $\frac{n_{bo,t=0}}{N_{o,t=0}}$ is the deposit market share of bank b in municipality o in the initial year, and $T_{o,t=0}A_{ot}^{soy}$ is the potential increase in soy yield (expressed in tons per hectare) in municipality o multiplied by initial agricultural land (in hectares) in the same municipality.

The first summation, instead, captures the total exposure of destination municipality d to funds coming from origin municipalities through bank networks. Notice that, in order to link origin and destination municipalities, we assume that bank's internal capital markets are perfectly integrated. This implies that deposits captured in a given municipality are first centralized at the bank level and later distributed across bank branches. To keep exogeneity of the credit supply shock, we use a neutral assignment rule for these funds across branches. That is, each bank divides these funds equally across all its branches. As a result, a municipality's share of the increase in credit supply of bank b is given by the share of bank b's branches located in the municipality: $\frac{n_{bd}}{N_b}$. In this expression, d indexes *destination* municipalities, n_{bd} denotes the number of bank b 's branches in municipality d and N_b is the total number of branches of bank b. Note that we do not assume that banks allocate funds across branches following this rule. In practice, banks might allocate funds to respond optimally to credit demand, or can follow any other rule. We use our "neutral"

[21] An alternative would be to aggregate the predicted increase in deposits for all banks operating with firm i.

assignment rule to construct an instrument which identifies the exogenous component in the actual increase in the supply of credit.

As in section IV.C, where we were studying the intensive margin, we construct the measure of destination municipality exposure only for non-soy producing municipalities, thus are not directly affected by technical change.

IV.E Empirical Results

In this section we describe the results of our empirical analysis. We start by reporting the estimates of the effect of soy technical change on *local* agricultural and banking sector outcomes in sections IV.E.1 and IV.E.2. Our unit of observation in this first part of the empirical analysis is the municipality. We use changes in potential soy profitability at municipality level to assess whether municipalities that are potentially more affected by the adoption of GE soy seeds experienced larger increases in soy revenues and deposits in local bank branches. Then, in sections IV.E.3 and IV.E.4, we trace the reallocation of capital from *origin* to *destination* municipalities using bank branch networks as described in our empirical strategy (section IV).

IV.E.1 Local Effects: Agricultural Outcomes

We start by testing the relationship between our measure of soy technical change at municipality level, and the actual expansion of soy area as well as the adoption of GE soy seeds by Brazilian farmers.

First, we study whether our measure of soy technical change predicts the actual expansion of soy area as a fraction of agricultural area. To this end, we estimate equation (3) where the outcome of interest, y_{jt} is the area cultivated with soy in municipality j at time t from the PAM Survey divided by the total initial agricultural area (as observed in the Agricultural Census of 1996). Columns 1 and 2 of Table II report the results. The point estimates of the coefficients on $\log(A_{jt}^{soy})$ are positive, indicating that an increase in soy technical change predicts the expansion soy area as a share of agricultural area during the period under study. The estimated coefficient is equal to .014 when including controls, as shown in column 2. The magnitude of the estimated coefficients implies that a one standard deviation difference in $\log(A_{jt}^{soy})$ implies a 1.6 percentage points higher increase in the share of soy area over agricultural area during the period under study.

Next, we test whether increases in our measure of exogenous change in soy profitability predicts actual adoption of the new technology. To this end, we estimate equation (2) where the outcome of interest, Δy_j is the change in the share of agricultural land devoted to GE soy between 1996 and 2006. Note that because this share was zero everywhere in 1996, the change in the share of agricultural land corresponds to its level in 2006. Column 3 of Table II reports the estimated coefficients. The point estimate of the coefficient on

$\Delta \log(A_{jt}^{soy})$ indicates that an increase in soy technical change predicts the expansion in GE soy area as a share of agricultural area between 1996 and 2006. In column 4 we perform a falsification test by looking at whether our measure of soy technical change explains the expansion in the area planted with non-GE soy. In this case, the estimated coefficient on $\Delta \log(A_{jt}^{soy})$ is negative and significant. This finding supports our interpretation that the measure of soy technical change captures the benefits of adopting GE soy vis-à-vis traditional soy seeds.

We then investigate the effect of our measure of soy technical change on revenues for soy producers, agricultural profits, investment and use external finance.

We start by estimating equation (3) where the outcome of interest, y_{jt} is the monetary value of revenues from soy production in municipality j at time t from the PAM Survey. Columns 1 and 2 of Table III report the results. The point estimates of the coefficients on $\log(A_{jt}^{soy})$ are positive, indicating that an increase in soy technical change predicts an increase in revenues from soy production during the period under study. The estimated coefficient remains stable and statistically significant when including controls, as shown in column 2. The magnitude indicates that a one standard deviation difference in $\log(A_{jt}^{soy})$ implies a 23% higher increase in revenues from soy production.

Next, we focus on three additional agricultural outcomes: agricultural profits, investment and use of external finance. These outcomes are sourced from the Agricultural Census of 1996 and 2006. Therefore, we estimate equation (2), where Δy_j is the change in agricultural outcomes between 1996 and 2006. As described in section III, these outcomes refer to all agricultural activities and not specifically to soy production.

In column 3 of Table III the outcome variable is the change in agricultural profits. The point estimate on $\Delta \log(A_{jt}^{soy})$ indicates that municipalities with a larger increase in our measure of exogenous change in soy profitability experienced a larger increase in agricultural profits. In particular, a one standard deviation increase in soy technical change corresponds to a 21.6% increase in agricultural profits between 1996 and 2006. Next, we estimate the same equation using as outcomes the change in agricultural investment and external finance. The estimated coefficient on $\Delta \log(A_{jt}^{soy})$ when the outcome is agricultural investment is positive and significant. The magnitude indicates that a one standard deviation increase in soy technical change corresponds to a 7.1% increase in agricultural investments between 1996 and 2006. The total value of external finance — which covers all sources of external finance including commercial banks, suppliers of inputs and machineries as well as family and friends — is unaffected by potential soy profitability. One potential explanation, other than measurement error, is that additional investments required to adopt GE soy seeds were financed mostly out of retained earnings.

IV.E.2 Local Effects: Banking Sector Outcomes

In the previous sections we showed that our measure of soy technical change is a good predictor of the adoption of GE soy seeds, the expansion of soy area and the increase of revenues for soy producers. Additionally, we showed evidence that municipalities with higher potential increase in soy profitability, experienced larger increase in agricultural profits. In what follows, we investigate what was the use of agricultural profits. In principle, they could have been reinvested in agriculture (we showed evidence suggesting that they partly are), channeled to consumption or to savings. If saved, they could have taken the form of informal lending arrangements or could have been channeled through the banking sector. Finally, they could have been lent locally, nationally or internationally. To understand these issues, we investigate the effect of our measure of soy technical change on deposits in local bank branches and on loans originated by the same bank branches. We estimate equation (3) where y_j is the log of the total value of bank deposits or bank loans originated by bank branches located in municipality j. Data on bank outcomes is sourced from the ESTBAN dataset and it is described in section III.

Columns 1 and 2 of Table IV report the results when the outcome variable is total bank deposits, which we define as the sum of deposits in checking accounts (demand deposits), deposits in saving accounts (saving deposits) and term deposits. The estimates indicate that municipalities with higher increase in soy technical change experienced a larger increase in total bank deposits during the period under study. The magnitude of the effect is economically significant: the estimated coefficient in column (2) indicates that a municipality with a one standard deviation higher potential soy profitability experienced a 4.2% larger increase in total bank deposits.[22] We can use the estimates obtained in Table III and IV to back out the elasticity of bank deposits to revenues from soy production. The implied elasticity can be computed by dividing the estimated coefficient on soy technical change when the outcome is total deposits (0.037) by the estimated coefficient on the same variable when the outcome is revenues from soy production (0.167). Our estimates indicate that a 1% increase in revenues for soy farmers is associated with a 0.22% increase in total bank deposits at municipality level.

Finally, columns 3 and 4 of Table IV report the results of estimating equation (3) when the outcome variable is the total value of lending originated by bank branches located in municipality j. Lending includes loans to individuals and firms, which we cannot separate in ESTBAN. As shown, the estimated effect of soy technical change on total bank lending at municipality level is negative and not statistically different from zero. This suggests

[22]In additional tables not reported here we studied whether this effect varies for different types of bank deposits. We find that the effect of potential soy profitability on deposit is concentrated on demand and saving deposits. Demand deposits are unremunerated, while saving accounts are remunerated at a rate that is lower than the interbank rate (around half). As such, these deposits constitute a cheap source of financing for Brazilian banks and are the most common way of saving, especially in rural areas of Brazil. On the other hand, we find no effect on term deposits.

that municipalities that experienced larger increase in potential soy profitability are net "exporters" of capital in their bank branch network.

Additional Results: Timing of the Effect on Agricultural and Banking Sector Outcomes In this section we investigate whether our exogenous measure of soy technical change captures the right timing of the introduction of GE soy seeds.

When we estimate equation (3) as described in section IV we implicitly assume that soy production experienced technical change in 2003. This is because the measure of potential soy yield (A^{soy}_{jt}) is assumed to change from its level under low inputs to its level under high inputs in correspondence with the legalization of GE soy seeds in Brazil. Since outcomes are available at yearly level, we can investigate whether the measure of soy technical change captures the right timing of the introduction of GE soy seeds by running the following equation:

$$y_{jt} = \alpha_j + \alpha_t + \sum_t \beta_t(\Delta \log(A^{soy}_j) \times d_t) + \varepsilon_{jt} \tag{12}$$

where d_t is a time dummy and $\Delta \log A^{soy}_j$ is a time invariant measure of the change in potential yield when soy production switches from low to high inputs:

$$\Delta \log A^{soy}_j = \log(A^{soy,HIGH}_j) - \log(A^{soy,LOW}_j)$$

In Figure VIII we plot the estimated β_t coefficients along with their 95% confidence intervals when the outcome variables are: soy area as a share of agricultural area (left graph) and total bank deposits (right graph).[23] The timing of the effect of ΔA^{soy}_j on both outcomes is broadly consistent with the timing of the legalization of GE soy seeds. However, as shown, the estimated β_t coefficients are positive and statistically different from zero starting from 2002. This indicates that the positive effect of soy technical change on the expansion of soy area and total bank deposits started before the official legalization of GE soy seeds in 2003. One potential explanation is the presence of smuggling of GE soy seeds from Argentina detected before 2003 (USDA 2001).

IV.E.3 Reallocation Through Bank Branch Network: Intensive Margin

In this section we explore whether larger increases in bank deposits due to soy technical change affected credit supply in non soy-producing areas through bank branch networks. As explained in section IV, this paper aims at tracing the reallocation of capital from rural agricultural areas to urban industrial and services areas. In this process of reallocation, we think of soy producing areas that are more affected by technical change as *origin*

[23] All these regressions include municipality and bank controls interacted with time fixed effects.

municipalities, and of non-soy producing areas as *destination* municipalities. Origin and destination municipalities are connected through the branch networks of Brazilian banks.

We start by constructing a measure of bank exposure to the soy boom for each bank. To this end, we estimate the increase in deposits in each bank branch due to the local increase in potential soy productivity as described in equation (5). Differently from the previous sections IV.E.1 and IV.E.2, our unit of observation for this specification is a bank branch. Table V reports the estimated coefficients. As shown, bank branches located in areas more affected by soy technical change experienced a larger increase in bank deposits. The point estimates remain precisely estimated and of similar size after controlling for municipality and bank characteristics interacted with year fixed effects (see column 3). Finally, we aggregate predicted deposits collected in all branches of each bank to construct a measure of bank exposure to the soy boom that varies for each bank and year: $\log \widehat{Deposits}_{bt}$.[24]

We then study the effect of the soy-driven increase in deposits of each bank — or "bank exposure to the soy boom" — on a set of firm level outcomes as described in equation (8). For each firm, we focus on the bank exposure of its main lender, i.e. the bank from which a firm borrows the larger share of its outstanding loan balance. On average, firms in our sample borrow 87% of their outstanding loan balance from their main lender, and the median firm (in terms of share of main lender in total outstanding loan balance) borrows 100% from one single bank. To minimize the concern that the endogenous formation of firm-bank relationships (which could depend from a bank exposure to the soy boom) might affect our results we proceed as follows. First, we define the main lender of each firm using exclusively data from the years before the legalization of GE soy in Brazil, which occurred in 2003.[25] Second, we assign the main lender exposure to all years in which a firm is present in our sample, no matter whether the firm is borrowing or not from its main lender in the years after GE soy legalization.

In terms of firm-level outcomes, we focus on four main variables: loans from main lender, defined as the log of the monetary value of firm borrowing from its main lender; loans from all lenders, defined as the log of the monetary value of firm borrowing from all banks; employment, defined as the log of the yearly average number of workers; and wage bill, defined as the log of the monetary value of the wage bill. The first two outcomes are sourced from the Credit Information System of the Central Bank of Brazil, while the second two outcomes — which we use as proxies for firm size — are sourced from RAIS. Notice that, to construct our measure of bank loans for each firm, we use all loans above

[24]This aggregation is described in section IV.C.1. The estimated coefficients used to construct predicted deposits at branch level are those from column 1 of Table V.

[25]Results are unchanged if we define main lender using exclusively year 2001.

the 5,000 BRL threshold. At the expense of restricting our analysis to a shorter time period (2001 to 2010), this threshold allows us to minimize the sample selection we face when using the 50,000 BRL threshold. Finally, the sample is restricted to firms operating in non-soy producing municipalities and in sectors that are not directly linked to soy production through IO linkages.

Average Effects

Table VI shows the results of estimating equation (10), described in section IV and reported below for convenience:

$$\log(y_{idsbt}) = \delta_i + \delta_t + \delta_{dt} + \delta_{st} + \delta_{size,t} + \beta \log \widehat{Deposits}_{bt} + \varepsilon_{bit}$$

The coefficient of interest in this specification is β, which captures the effect of main lender exposure on firm-level outcomes. We interpret main lender exposure as an exogenous credit supply shock at firm level.

Table VI reports the estimated β under two specifications for each outcome. In the first specification, we regress a firm-level outcome in logs ($\log(y_{idsbt})$) on firm and time fixed effects, the main lender exposure, and an interaction of firm size quartiles with time fixed effects. In the second and most conservative specification, we also introduce interactions of municipality and sector fixed effects with time fixed effects.

We find positive and large effects of main lender exposure on firm borrowing. In terms of economic magnitude, the estimated coefficient in column (4) indicates that a firm whose main lender has a 1 standard deviation higher increase in deposits due to the soy boom experienced a 2 standard deviation higher increase in total loans. We also find positive real effects on firm size. Firms whose main lender has a larger exposure to the soy boom experienced larger growth in employment (column 6) and wage bill (column 8). In what follows, let us focus our attention on the estimated coefficients on main lender exposure when the outcome is firm wage bill, which are larger, stable across specifications and precisely estimated. In terms of economic magnitude, the estimated coefficient in column (8) indicates that a firm whose main lender has a 1 standard deviation higher increase in deposits due to the soy boom experienced a 0.3 standard deviation higher increase in its wage bill. We can use the estimates obtained in columns (4) and (8) to back out the elasticity of firm size to bank loans. The implied elasticity can be computed by dividing the estimated coefficient on main lender exposure when the outcome is firm wage bill (0.179) by the estimated coefficient on the same variable when the outcome is bank loans from all lenders (1.449). This elasticity indicates that a 1% increase in total bank loans is associated with a 0.12% increase in firm size as measured by its wage bill.

In Table VII we report the results of estimating equation (8) by sector of operation of each firm. The four sectors we focus on are: agriculture, manufacturing, services and other sectors.[26] As shown, the effects of main lender exposure to the soy boom on firm borrowing are positive, precisely estimated and similar in size across all sectors. On the contrary, real effects are heterogeneous across sectors. In particular, the estimates suggest that, for a similar increase in borrowing due to their main lender exposure, manufacturing firms experience a significantly higher increase in size with respect to firms operating in services and other sectors. More specifically, the elasticity of firm size to bank loans is twice as large for firms operating in manufacturing with respect to firms operating in any other sector: it is equal to 0.25 for manufacturing, 0.12 for agriculture and other sectors, 0.1 for services.

Heterogeneous Effects

In Table VIII we report the results of estimating a version of equation (8) in which we interact main lender exposure with firm size quartile dummies. As shown in columns 1 and 2, the estimated coefficients on these interactions are of similar size when the outcomes are bank loans from main lender and bank loans from all lenders. When the outcomes are employment and wage bill, instead, point estimates on the interactions suggest that the effect of main lender exposure on firm size might be larger for small firms than for large firms. The coefficients are monotonically decreasing with size but not statistically different from each other. Finally, in Table IX, we replicate the analysis of Table VIII splitting the sample by sector of operation of each firm. Even within sector we find effects of similar magnitude across firm quartiles. Again, while the effect of main lender exposure on borrowing is similar across sectors, real effects are larger for manufacturing firms with respect to firms operating in agriculture, services and other sectors even within each firm size quartile.

IV.E.4 Reallocation Through Bank Branch Network: Extensive Margin

In this section we study the effect of municipality exposure to the soy boom through the bank branch network on firm access to bank credit. To this end, we estimate the following equation:

$$I_{dt} = \alpha_d + \alpha_t + \beta \text{Municipality exposure}_{dt} + \varepsilon_{dt} \qquad (13)$$

Where the measure of municipality exposure is defined as in section IV and the outcome variable I_{dt} is the share of firms with access to bank credit in destination municipality

[26] Services include: construction, commerce, lodging and restaurants, transport, housing services, domestic workers and other personal services. We exclude banks and other firms in the financial sector. Other sectors include: public administration, education, health, international organizations, extraction, and public utilities.

d and year t. We define access to bank credit using the 50,000 1997 BRL threshold in the Credit Information System. Under this definition, a firm is considered as having access to bank credit if its outstanding loan balance with a bank in a given year is greater or equal to 50,000 1997 BRL. As explained in subsection III.B, the rationale of using this higher threshold when studying access to bank finance is to capture access to large term loans rather than, for example, short term finance in the form of current account overdrafts. As in the previous sections, we focus exclusively on non-soy producing municipalities, and we exclude from our measure of I_{dt} firms that operate in sectors linked to soy production through IO linkages.

Table X reports the results of estimating equation (13). We find that municipalities with larger exposure to the soy boom through the bank network experience larger increase in firm access to bank credit. The magnitude of the estimated coefficient reported in column (1) implies that a municipality with a 1 standard deviation larger exposure to the soy boom experienced a 2 percentage points larger increase in the share of firms with access to bank credit (36% of a standard deviation in I_{dt}). In columns (2), (3), (4) and (5) we report the results of estimating equation (13) when the outcome variable is the share of firms with access to bank credit operating in, respectively: agriculture, manufacturing, services and other sectors. We find positive and significant effects on access to bank credit for firms operating in manufacturing and services, while the effect is not precisely estimated for firms operating in agriculture and other sectors. In terms of magnitude, the estimated coefficients reported in columns (3) and (4) imply that a municipality with a 1 standard deviation larger exposure to the soy boom experienced a 2.7 percentage points larger increase in the share of manufacturing firms with access to bank credit, and a 1.5 percentage points larger increase in the share of services firms with access to bank credit. Finally, in column (6) to (9), we report the results of estimating equation (13) when the outcome variable is the share of firms with access to bank credit in different firm size categories: micro, small, medium size and large firms, all defined as in section III. Here we find positive and significant effects for micro and small firms, while the estimates are not statistically different from zero for medium size and large firms.

V Concluding Remarks

In this paper we study the effect of new agricultural technologies on reallocation of capital across regions, sectors and firms. The empirical analysis is focused on the widespread adoption of genetically engineered (GE) soy in Brazil. This technology allows farmers to obtain the same yield with lower production costs, thus increasing agricultural profits.

We find that municipalities that are predicted to experience a larger increase in soy profitability after the legalization of GE soy seeds are more likely to adopt this new technology and experience a larger increase in agricultural profits. At local level, we find a positive effect of GE soy adoption on deposits in local bank branches but no significant change in loans originated by the same bank branches. Instead, capital was reallocated towards other regions through bank branch networks. This increase in credit supply affected firms' credit access through the extensive and intensive margin. First, regions with more bank branches receiving funds from soy areas experienced an increase in credit market participation of small and medium sized firms. In addition, banks experiencing faster deposit growth in soy areas increased their lending to firms with whom they had preexisting relationships. In turn, these firms grew faster in terms of employment and wage bill. Our estimates imply that the elasticity of firm growth to credit is largest in the manufacturing sector. These findings suggest that agricultural productivity growth can lead to structural transformation through a financial channel.

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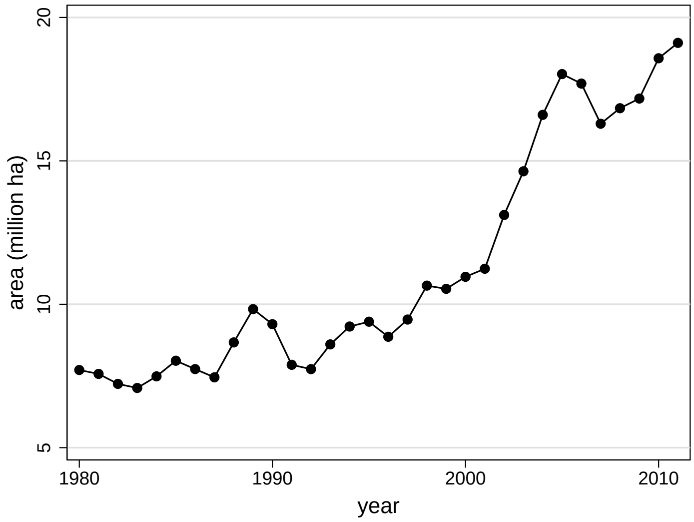
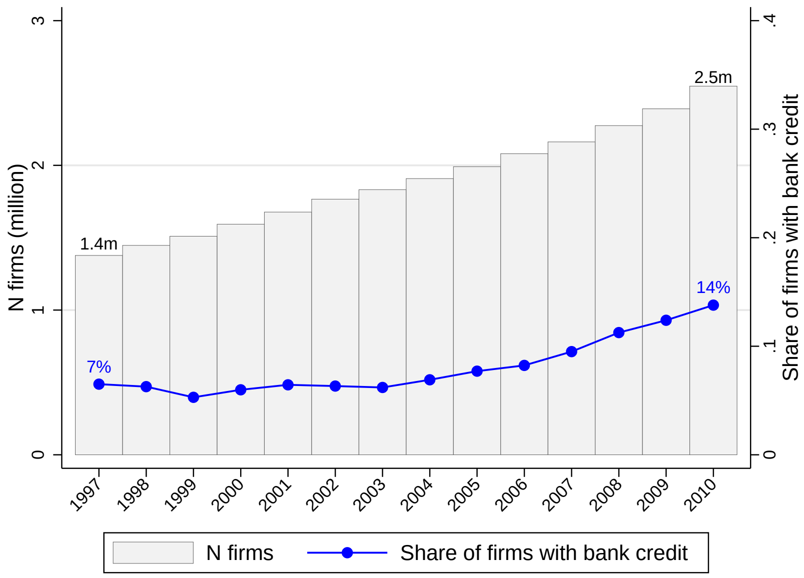
Figures and Tables

Figure I: Evolution of Area Planted with Soy in Brazil



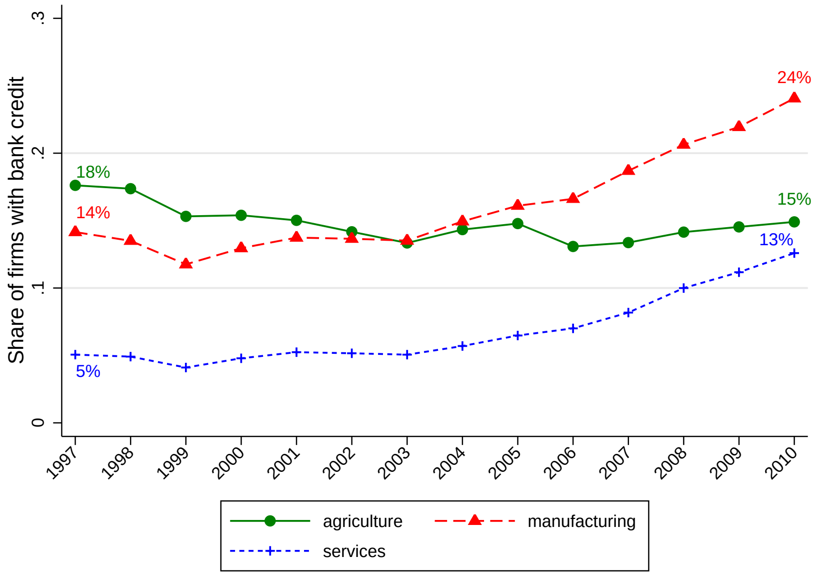
Notes: Data source is CONAB, Companhia Nacional de Abastecimento, which is an agency within the Brazilian Ministry of Agriculture. CONAB carries out monthly surveys to monitor the evolution of the harvest of all major crops in Brazil: the surveys are representative at state level and are constructed by interviewing on the ground farmers, agronomists and financial agents in the main cities of the country. All data can be downloaded at: `http://www.conab.gov.br/conteudos.php?a=1252&t=`.

Figure II: Share of Firms with Bank Credit Brazil: 1997-2010



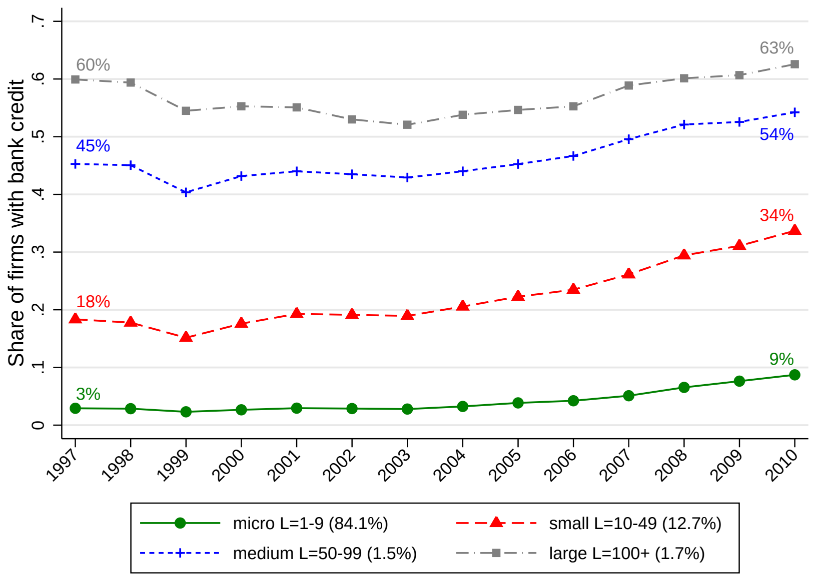
Notes: Sources are the Credit Information System of the Central Bank of Brazil and RAIS, authors' calculation from micro-data. Access to bank credit is defined as an outstanding credit balance of at least 50,000 1997 BRL.

Figure III: Share of Firms with Bank Credit: by Sector
Brazil: 1997-2010



Notes: Sources are the Credit Information System of the Central Bank of Brazil and RAIS, authors' calculation from micro-data. Access to bank credit is defined as an outstanding credit balance of at least 50,000 1997 BRL. Services include: construction, commerce, lodging and restaurants, transport, housing services, domestic workers.

Figure IV: Share of Firms with Bank Credit: by Firm Size
Brazil: 1997-2010



Notes: Sources are the Credit Information System of the Central Bank of Brazil and RAIS, authors' calculation from micro-data. Access to bank credit is defined as an outstanding credit balance of at least 50,000 1997 BRL. Numbers in parenthesis are the percentage of firms in each size category in 1997.

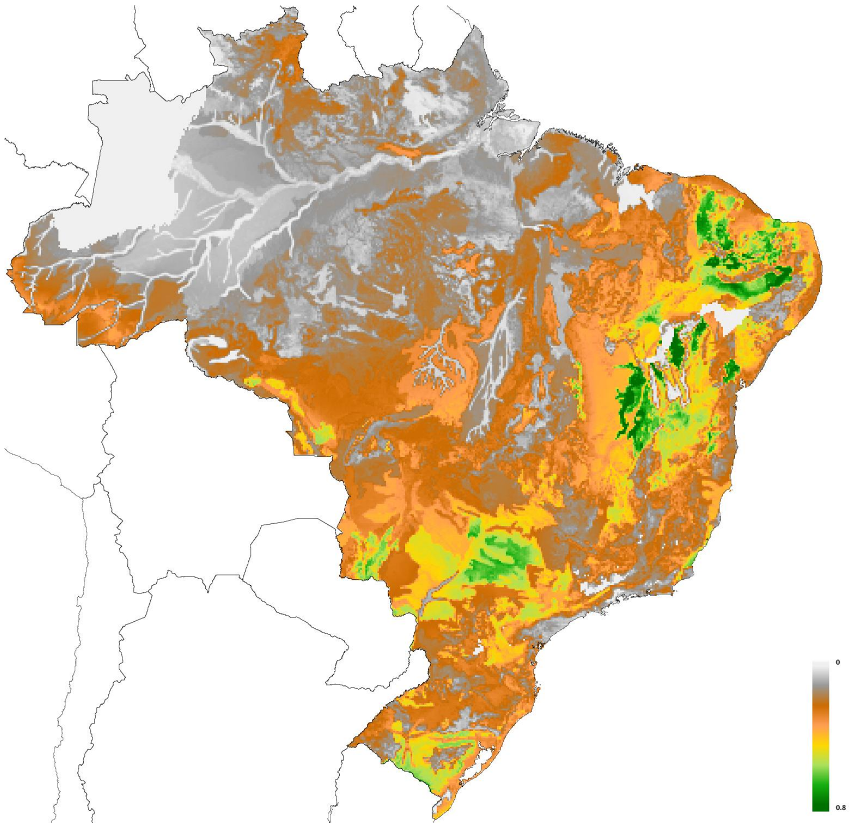


Figure V: **Potential soy yield under low agricultural technology**

Notes: Data from FAO-GAEZ.

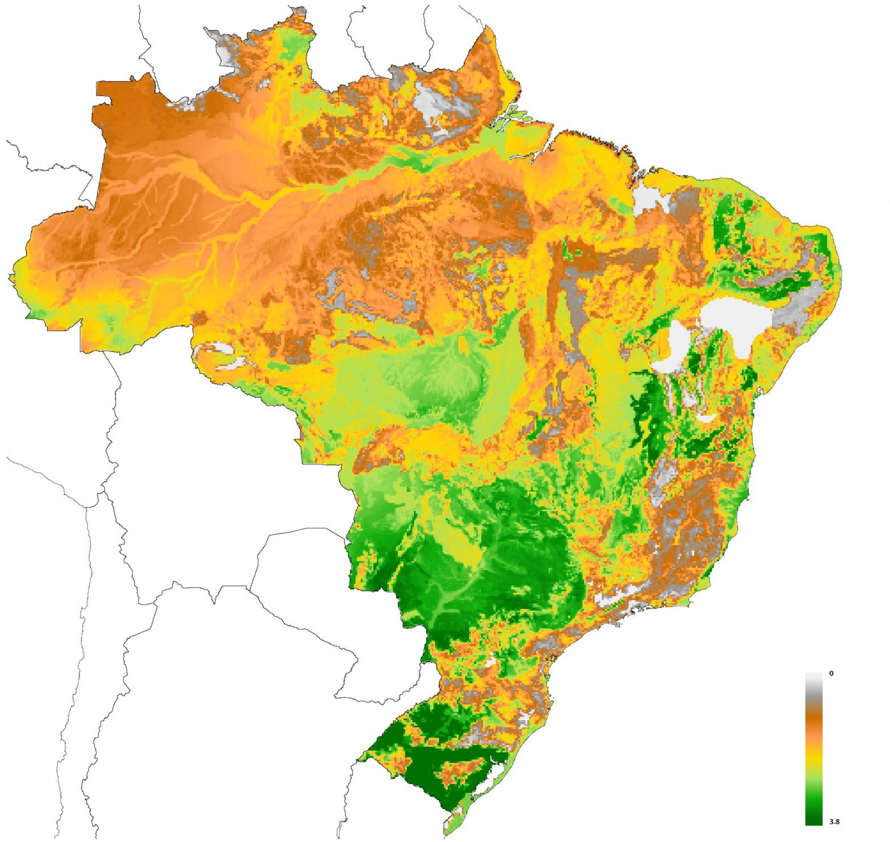


Figure VI: **Potential soy yield under high agricultural technology**

Notes: Data from FAO-GAEZ.

Figure VII: Predicted Increase in Deposits and Initial Bank Characteristics

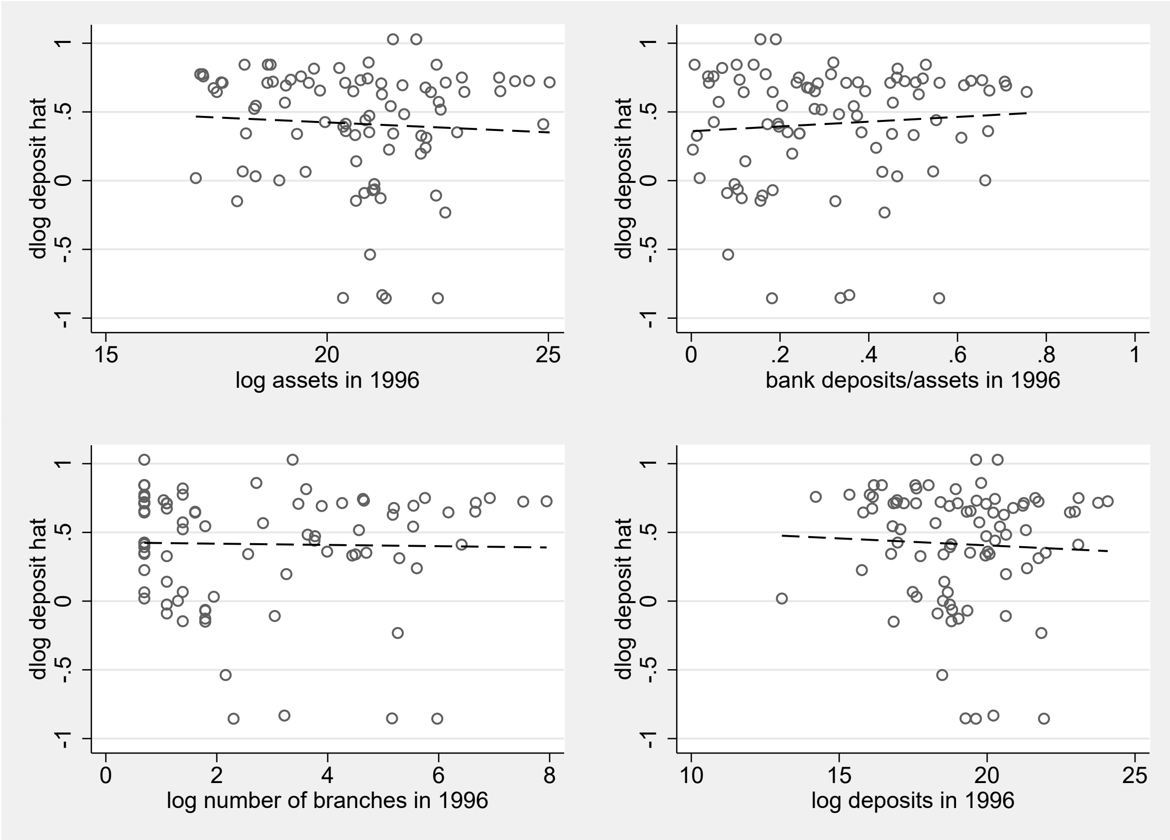
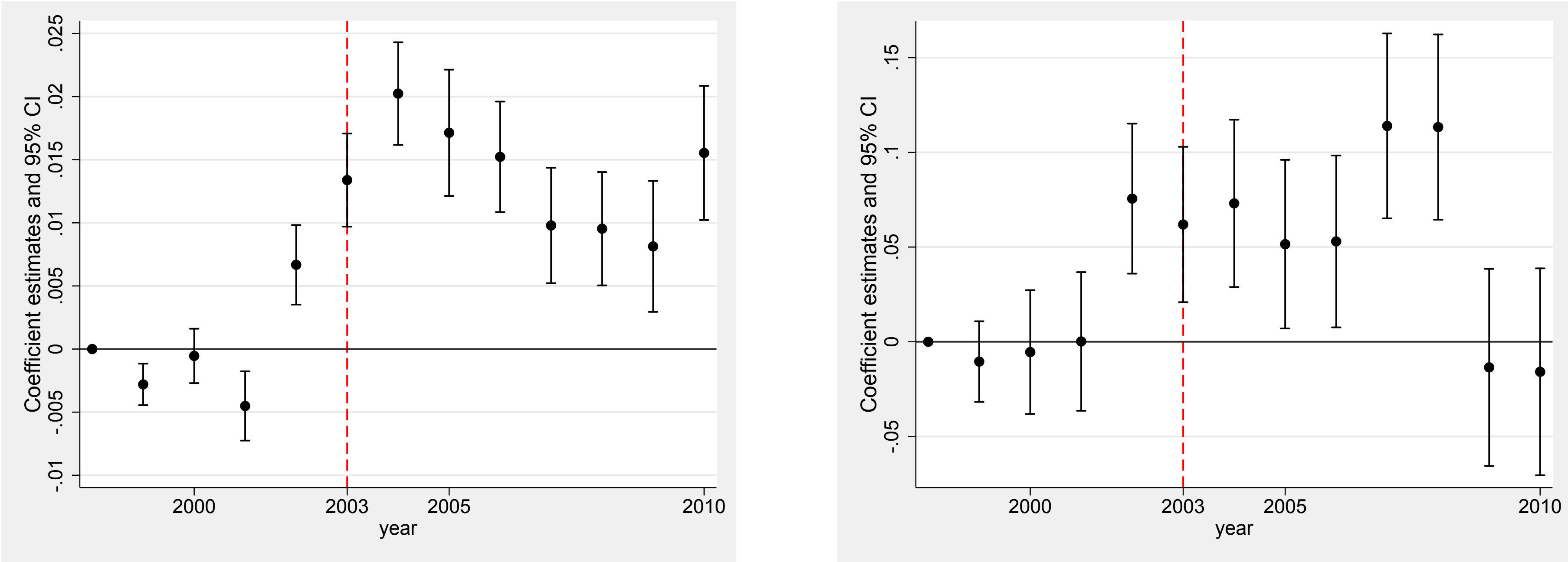


Figure VIII: Increase in Potential Soy Yield and Timing of Soy Expansion and Bank Deposits

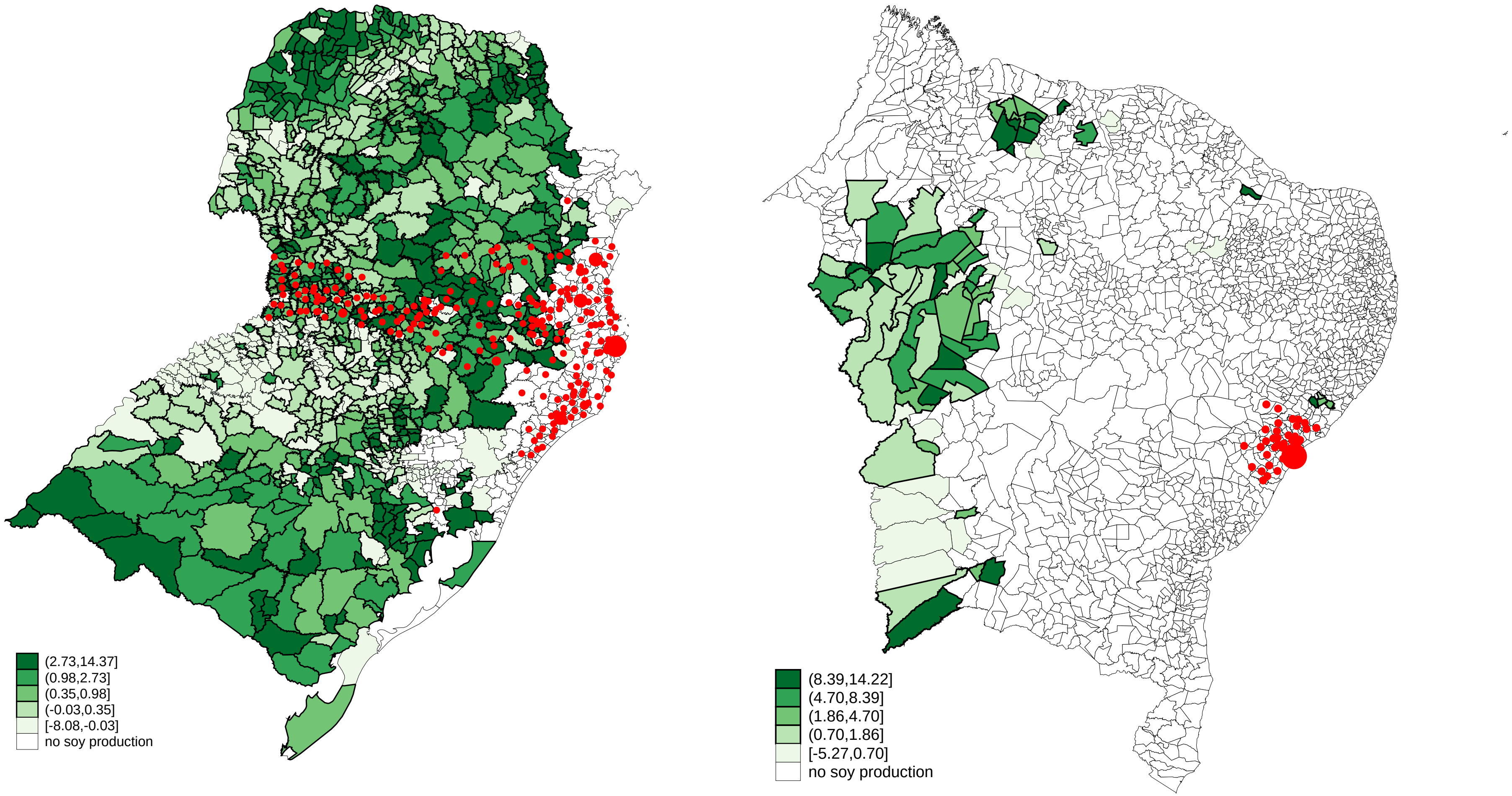
(a) Soy Expansion (b) Bank Deposits



Notes: Data from Central Bank of Brazil and PAM (IBGE).

FIGURE IX: BANK NETWORKS AND INCREASE IN SOY REVENUES

(a) Bank A (b) Bank B



Notes: Data from Central Bank of Brazil and PAM (IBGE).

Table I: Summary Statistics

variable name	mean	p50	sd	N
independent variables:				
$log(A_{jt}^{soy})$	-0.288	-0.417	1.135	44,524
$\Delta log(\widehat{A_{jt}^{soy}})$	1.945	1.919	0.459	3,749
log $\widehat{\text{deposits}}_{bt}$ (main lender exposure)	21.325	22.282	2.597	1,547,783
destination municipality exposure	10.638	10.712	1.350	22,273
outcome variables at municipality level				
Δ GE Soy Area/Agri Area	0.013	0.000	0.059	3,749
ΔProfits (pct points)	-0.288	-0.095	6.111	3,749
Δ log Investment	0.158	0.146	0.868	3,749
Δ log Ext Fin	1.113	1.041	1.369	3,749
Soy Area/Agri Area	0.052	0.000	0.136	44,524
log(1 + revenues from soy production	5.106	0.000	6.961	44,524
log(total deposits)	15.689	15.582	1.814	44,524
log(total loans)	15.456	15.637	2.112	44,524
I_{dt}: share of firms with access to bank credit	0.054	0.045	0.055	23,660
outcome variables at bank branch level				
log(total deposits)	14.943	15.009	1.387	118,548
outcome variables at firm level:				
log loan - main lender	10.318	10.310	1.661	1,547,783
log loan - all lenders	10.790	10.757	1.814	1,547,783
log employment	2.013	1.922	1.435	1,547,783
log wage bill	8.306	8.190	1.681	1,547,783

Notes: See section III for detailed description of each variable and data sources.

Table II: Soy Technical Change and Agricultural Outcomes
Soy Expansion, GE Soy Adoption

Dependent variables:	$\frac{\text{Soy Area}}{\text{Agricultural Area}}$		$\Delta \frac{\text{GE Soy Area}}{\text{Agricultural Area}}$	$\Delta \frac{\text{Non-GE Soy Area}}{\text{Agricultural Area}}$
	(1)	(2)	(3)	(4)
$\log(A_{jt}^{soy})$	0.014	0.014		
	[0.002]***	[0.002]***		
$\Delta \log(A_{j}^{soy})$			0.028	-0.014
			[0.002]***	[0.002]***
fixed effects:				
municipality	yes	yes		
year	yes	yes		
municipality controls × year	yes	yes		
bank controls × year		yes		
municipality controls			yes	yes
Observations	44,524	44,524	3,749	3,749
R-squared	0.959	0.960	0.136	0.037
N clusters	3177	3177		
Data source dep.var. :	PAM 1996-2010	PAM 1996-2010	Agricultural Census 1996 and 2006	

Notes: Standard errors clustered at municipality level are reported in brackets in columns 1 and 2. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Municipality controls include: share of rural adult population, income per capita (in logs), population density (in logs), literacy rate, all observed in 1991 (source: Population Census). Bank controls capture average characteristics of banks operating in a given municipality, including: bank size in terms of assets (in logs) and number of branches (in logs), and importance of deposits as a share of bank financing (deposits/assets). Bank characteristics are weighted by share of branches of each bank in each municipality, all observed in 1996 (source: ESTBAN).

Table III: Soy Technical Change and Agricultural Outcomes
Revenues from Soy Production, Agricultural Profits, Investment and Use of External Finance

Dependent variables:	log (1+ revenues from soy production)		Δ Profits (pct)	Δ log Inv	Δ log Ext Fin
	(1)	(2)	(3)	(4)	(5)
$\log(A^{soy}_{jt})$	0.183	0.167			
	[0.087]**	[0.086]*			
$\Delta \log(A^{soy}_{j})$			0.470	0.154	-0.082
			[0.234]**	[0.036]***	[0.058]
fixed effects:					
municipality	yes	yes			
year	yes	yes			
municipality controls × year	yes	yes			
bank controls × year		yes			
municipality controls			yes	yes	yes
Observations	44,524	44,524	3,794	3,794	3,794
R-squared	0.959	0.960	0.001	0.018	0.042
N clusters	3177	3177			
Data source dep.var. :	PAM 1996-2010	PAM 1996-2010	Agricultural Census 1996 and 2006		

Notes: Standard errors clustered at municipality level are reported in brackets in columns 1 and 2. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Municipality controls include: share of rural adult population, income per capita (in logs), population density (in logs), literacy rate, all observed in 1991 (source: Population Census). Bank controls capture average characteristics of banks operating in a given municipality, including: bank size in terms of assets (in logs) and number of branches (in logs), and importance of deposits as a share of bank financing (deposits/assets). Bank characteristics are weighted by share of branches of each bank in each municipality, all observed in 1996 (source: ESTBAN).

Table IV: Soy Technical Change and Local Banking Sector Outcomes
Total Deposits and Total Lending

Outcomes:	log(total deposits)		log(total loans)	
	(1)	(2)	(3)	(4)
log A_{soy}	0.053	0.037	-0.057	-0.041
	[0.015]***	[0.014]***	[0.028]**	[0.026]
fixed effects:				
municipality	yes	yes	yes	yes
year	yes	yes	yes	yes
municipality controls × year		yes		yes
bank controls × year		yes		yes
Observations	44,524	44,524	44,524	44,524
R-squared	0.975	0.977	0.951	0.953
N clusters	3177	3177	3177	3177

Notes: Outcomes are total monetary value (in 2000 BRL) at municipality/year level, in logs, winsorized at 1% in each tail. Standard errors clustered at municipality level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Municipality controls include: share of rural adult population, income per capita (in logs), population density (in logs), literacy rate, all observed in 1991 (source: Population Census). Bank controls capture average characteristics of banks operating in a given municipality, including: bank size in terms of assets (in logs) and number of branches (in logs), and importance of deposits as a share of bank financing (deposits/assets). Bank characteristics are weighted by share of branches of each bank in each municipality, all observed in 1996 (source: ESTBAN).

Table V: Soy Technical Change and Deposits in Bank Branches
Total Deposits

outcomes	log(total deposits)		
	(1)	(2)	(3)
log A_{soy}	0.159	0.110	0.118
	[0.025]***	[0.025]***	[0.025]***
fixed effects:			
municipality	yes	yes	yes
bank	yes	yes	yes
year	yes	yes	yes
municipality controls × year		yes	yes
bank controls × year			yes
Observations	118,548	118,548	118,548
R-squared	0.886	0.889	0.892
N clusters	3176	3176	3176

Notes: Outcomes are total monetary value (in 2000 BRL) at municipality/bank/year level, in logs, winsorized at 1% in each tail. Standard errors clustered at municipality level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Municipality controls include: share of rural adult population, income per capita (in logs), population density (in logs), literacy rate, all observed in 1991 (source: Population Census). Bank controls include: bank size in terms of assets (in logs) and number of branches (in logs), and importance of deposits as a share of bank financing (deposits/assets), all observed in 1996 (source: ESTBAN).

Table VI: The Effect of Bank Exposure on Firm-level Outcomes
Loans, Employment, Wage Bill

	log loan main lender		log loan all lenders		log employment		log wage bill	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log \widehat{\text{deposit}}$	2.567	2.623	1.417	1.449	0.036	0.086	0.114	0.179
	[0.758]***	[0.739]***	[0.612]**	[0.515]***	[0.051]	[0.046]*	[0.109]	[0.061]***
fixed effects:								
firm	yes	yes	yes	yes	yes	yes	yes	yes
year	yes	yes	yes	yes	yes	yes	yes	yes
size quartile × year	yes	yes	yes	yes	yes	yes	yes	yes
municipality × year		yes		yes		yes		yes
sector × year		yes		yes		yes		yes
Observations	1,551,393	1,547,783	1,551,393	1,547,783	1,551,393	1,547,783	1,551,393	1,547,783
R-squared	0.670	0.676	0.752	0.757	0.950	0.951	0.954	0.955
N clusters	115	115	115	115	115	115	115	115

Notes: Outcomes winsorized at 1% in each tail. Standard errors clustered at bank level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Size quartiles are computed using firm employment. Sectors are 2-digit sectors according to the Brazilian CNAE classification.

Table VII: The Effect of Bank Exposure on Firm-level Outcomes - by Sector
Loans, Employment, Wage Bill

Independent variable in all panels is: $\log \widehat{\text{deposit}}$
Firm-level outcomes reported in bold in each row

	agriculture		manufacturing		services		other	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A								
log loan - main lender	3.378	2.718	2.487	2.458	2.505	2.572	3.556	3.441
	[1.079]***	[1.495]*	[0.779]***	[0.780]***	[0.771]***	[0.754]***	[1.081]***	[0.990]***
Panel B								
log loan - all lenders	2.972	2.637	1.591	1.611	1.293	1.336	2.157	1.834
	[1.174]**	[1.044]**	[0.536]***	[0.508]***	[0.614]**	[0.526]**	[1.018]**	[0.845]**
Panel C								
log employment	0.141	0.259	0.163	0.227	0.003	0.060	0.144	0.191
	[0.140]	[0.234]	[0.062]***	[0.063]***	[0.055]	[0.049]	[0.194]	[0.191]
Panel D								
log wage bill	0.187	0.311	0.336	0.396	0.067	0.129	0.152	0.224
	[0.221]	[0.412]	[0.116]***	[0.090]***	[0.116]	[0.064]**	[0.239]	[0.182]
fixed effects:								
firm	yes	yes	yes	yes	yes	yes	yes	yes
year	yes	yes	yes	yes	yes	yes	yes	yes
size quartile × year	yes	yes	yes	yes	yes	yes	yes	yes
municipality × year		yes		yes		yes		yes
sector × year		yes		yes		yes		yes
Observations	8,226	5,406	271,678	268,762	1,185,531	1,181,795	77,235	74,182
R-squared	0.959	0.976	0.961	0.963	0.947	0.949	0.973	0.975
N clusters	58	53	102	101	111	111	76	76

Notes: Outcomes winsorized at 1% in each tail. Standard errors clustered at bank level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Size quartiles are computed using firm employment. Sectors are 2-digit sectors according to the Brazilian CNAE classification.

Table VIII: The Effect of Bank Exposure on Firm-level Outcomes - by Firm Size Quartiles
Loans, Employment, Wage Bill

	log loan main lender	log loan all lenders	log employment	log wage bill
	(1)	(2)	(3)	(4)
log $\widehat{\text{deposit}} \times Q1$	2.610	1.462	0.111	0.201
	[0.737]***	[0.514]***	[0.047]**	[0.061]***
log $\widehat{\text{deposit}} \times Q2$	2.614	1.458	0.100	0.190
	[0.738]***	[0.514]***	[0.045]**	[0.061]***
log $\widehat{\text{deposit}} \times Q3$	2.620	1.453	0.094	0.184
	[0.739]***	[0.514]***	[0.045]**	[0.060]***
log $\widehat{\text{deposit}} \times Q4$	2.627	1.445	0.081	0.175
	[0.739]***	[0.515]***	[0.044]*	[0.060]***
fixed effects:				
firm	yes	yes	yes	yes
year	yes	yes	yes	yes
size quartile × year	yes	yes	yes	yes
municipality × year	yes	yes	yes	yes
sector × year	yes	yes	yes	yes
Observations	1,547,783	1,547,783	1,547,783	1,547,783
R-squared	0.676	0.757	0.951	0.955
N clusters (lenders)	115	115	115	115

Notes: Outcomes winsorized at 1% in each tail. Standard errors clustered at bank level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Size quartiles are computed using firm employment. Sectors are 2-digit sectors according to the Brazilian CNAE classification.

Table IX: The Effect of Bank Exposure on Firm-level Outcomes - by Sector and Size Quartile
Loans, Employment, Wage Bill

	agriculture (1)	manufacturing (2)	services (3)	other (4)	agriculture (1)	manufacturing (2)	services (3)	other (4)
	outcome: **log loan - main lender**				outcome: **log employment**			
$\log \widehat{\text{deposit}} \times Q1$	2.720	2.450	2.562	3.425	0.260	0.239	0.091	0.199
	[1.481]*	[0.780]***	[0.753]***	[0.988]***	[0.231]	[0.062]***	[0.048]*	[0.189]
$\log \widehat{\text{deposit}} \times Q2$	2.717	2.455	2.566	3.440	0.275	0.227	0.080	0.188
	[1.475]*	[0.782]***	[0.754]***	[0.992]***	[0.232]	[0.060]***	[0.047]*	[0.189]
$\log \widehat{\text{deposit}} \times Q3$	2.790	2.464	2.570	3.448	0.259	0.220	0.073	0.186
	[1.486]*	[0.786]***	[0.755]***	[0.991]***	[0.237]	[0.060]***	[0.046]	[0.188]
$\log \widehat{\text{deposit}} \times Q4$	2.717	2.472	2.573	3.493	0.251	0.211	0.059	0.173
	[1.489]*	[0.784]***	[0.754]***	[0.995]***	[0.234]	[0.059]***	[0.045]	[0.186]
	outcome: **log loan - all lenders**				outcome: **log wage bill**			
$\log \widehat{\text{deposit}} \times Q1$	2.633	1.615	1.358	1.826	0.313	0.405	0.159	0.231
	[1.039]**	[0.506]***	[0.525]**	[0.843]**	[0.407]	[0.089]***	[0.063]**	[0.180]
$\log \widehat{\text{deposit}} \times Q2$	2.628	1.613	1.352	1.832	0.317	0.395	0.147	0.218
	[1.041]**	[0.507]***	[0.524]**	[0.845]**	[0.407]	[0.089]***	[0.062]**	[0.180]
$\log \widehat{\text{deposit}} \times Q3$	2.726	1.610	1.345	1.838	0.290	0.391	0.141	0.219
	[1.044]**	[0.510]***	[0.524]**	[0.845]**	[0.409]	[0.088]***	[0.062]**	[0.179]
$\log \widehat{\text{deposit}} \times Q4$	2.672	1.605	1.335	1.856	0.295	0.387	0.128	0.217
	[1.039]**	[0.510]***	[0.525]**	[0.848]**	[0.408]	[0.087]***	[0.061]**	[0.177]
fixed effects:								
firm	yes	yes	yes	yes	yes	yes	yes	yes
year	yes	yes	yes	yes	yes	yes	yes	yes
size quartile × year	yes	yes	yes	yes	yes	yes	yes	yes
municipality × year	yes	yes	yes	yes	yes	yes	yes	yes
sector × year	yes	yes	yes	yes	yes	yes	yes	yes
Observations	5,406	268,762	1,181,795	74,182	5,406	268,762	1,181,795	74,182
R-squared	0.976	0.959	0.945	0.974	0.976	0.959	0.945	0.974
N clusters	53	101	111	76	53	101	111	76

Notes: Outcomes winsorized at 1% in each tail. Standard errors clustered at bank level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Size quartiles are computed using firm employment. Sectors are 2-digit sectors according to the Brazilian CNAE classification.

Table X: Propagation to Non-Soy Producing Regions: Access to Bank Credit
Overall, by Sector and Firm Size Category

		sector				firm size category			
	all firms	agriculture	manufacturing	services	other	micro	small	medium	large
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
destination municipality exposure	0.015	0.011	0.020	0.011	0.003	0.017	0.029	0.041	-0.008
	[0.005]***	[0.018]	[0.011]*	[0.004]**	[0.009]	[0.005]***	[0.014]**	[0.033]	[0.020]
fixed effects:									
municipality	yes	yes	yes	yes	yes	yes	yes	yes	yes
year	yes	yes	yes	yes	yes	yes	yes	yes	yes
municipality controls x year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	23,660	14,559	18,803	23,447	23,440	23,550	20,470	12,543	22,040
R-squared	0.501	0.446	0.513	0.482	0.278	0.394	0.433	0.487	0.573
N clusters	1696	1458	1574	1695	1696	1696	1664	1404	1694

Notes: Outcomes winsorized at 1% in each tail. Standard errors clustered at municipality level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.