Capital Allocation Across Regions, Sectors and Firms

Evidence from a Commodity Boom in Brazil*

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PRELIMINARY AND INCOMPLETE

Abstract

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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.

JEL Classification: G21, Q16, E51

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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, small and medium-sized firms in the industrial and service sectors experienced faster growth in these areas.

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 5.4% larger increase in total bank deposits. On the other hand, we find no evidence of a positive effect of our exogenous measure of soy profitability on credit supplied by the same local branches. As a matter of fact, we find 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). 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, firms located in these municipalities experienced faster growth. The latter effect is driven by small and medium size firms, which suggests that the credit supply shock relaxed the borrowing constraint of smaller entrepreneurs.

To more precisely identify the effect of faster increase in bank deposits on bank credit supply and its real effects on firm growth, we are currently working with two new datasets.

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

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 a new version of the RAIS dataset (*Relação Anual de Informcações Sociais*) of the Brazilian Ministry of Labor, which provides detailed information on all formal workers and firms operating in Brazil. 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) investigate the direct effect on firm growth of the GE-soy-driven credit supply shock, and (ii) study 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. The results obtained using micro-data from the Credit Information System and RAIS are currently under approval of the Central Bank of Brazil and will be presented in the next iteration of this working paper.

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; 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

[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.

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 VI concludes.

II Genetically Engineered Soy

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

The main advantage of GE soy seeds relative to traditional soy seeds is that the former are herbicide resistant. This allows farmers to adopt a new set of techniques that lowers production costs, mostly due to lower labor requirements. First, GE soy seeds facilitates

[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.

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[6] with soy-producing farms, out of which 715 with farms declaring to use GE soy seeds[7]. 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)

[4]The cost-effectiveness of this technology explains why it spread so fast both in the US and in Brazil, even though experimental evidence in the U.S. reports no improvements in yield with respect to conventional soybeans (Fernandez-Cornejo and Caswell 2006)

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

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

[8]Note that, as discussed in detail in Section III, agricultural profits are only available aggregated across all agricultural activities in a given municipality.

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]

III Data

The main data sources are the ESTBAN dataset from the Central Bank of Brazil, the Agricultural Census and the PAM Survey from the National Statistical Institute, the RAIS dataset from the Ministry of Labor, and the Global Agro-Ecological Zones database from FAO.

The ESTBAN (*Estatística Bancária*) dataset is updated monthly by the Central Bank of Brazil and reports the main balance sheet items at branch level of universal banks with commercial bank capabilities and commercial banks operating in Brazil.[10] We use data from 1996 to 2013 and compute yearly averages of the variables of interest for each branch. The main variables of interest are total value of deposits and total value of loans originated by each branch. We observe four main categories of deposits: checking accounts of individuals, checking accounts of companies, 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 (*empréstimos*) 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 (*financiamentos*) which includes loans with a specific objective, such as export financing, or acquisition of vehicles.

In 2003, the ESTBAN dataset covered 142 commercial and universal banks operating in Brazil. Table II reports baseline information for the 10 largest banks by number of branches. Two of these banks are controlled by the Federal Government (*Banco do Brasil* and *Caixa Econômica Federal*), while the others are privately owned. There is large heterogeneity in terms of geographical diffusion across banks in our sample: seven of the 10 largest banks are present in all 27 Brazilian states, while 65 out of 142 banks in our sample are present only in one state.[11] Table II also reports an Herfindhal Index of

[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]ESTBAN is a confidential dataset of the Central Bank of Brazil. The collection and manipulation of individual bank agency data were conducted exclusively by the staff of the Central Bank of Brazil.

[11]Together, banks present only in one state represented 4.5% of all branches and 3.2% of deposits in

geographical concentration of branches across states. As shown, banks controlled by the Federal Government have a more even distribution of branches across geographical areas (lower HHI)[12] than private banks.

The Agricultural Census is released at intervals of 10 years by the *Instituto Brasileiro de Geografia e Estatística* (IBGE), the Brazilian National Statistical Institute. The empirical analysis focuses 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 online by the IBGE aggregated at municipality level. The agricultural variables of interest are the share of agricultural land planted with soy – out of which we can distinguish the area planted with GE vs traditional soy seeds –, the value of agricultural profits, the value of investments in agriculture and the value of external financing. The measures of profits, investments and external financing do not refer specifically to soy production but are aggregated across all agricultural activities. This is because the unit of observation in the census is the agricultural establishment, and establishments tend to perform several agricultural activities.

The PAM (*Produção Agrícola Municipal*) is a yearly survey covering information on production of the main temporary and permanent crops in Brazil, including soy. The survey is conducted at municipal level by the *Instituto Brasileiro de Geografia e Estatística* (IBGE) through interviews with government and private agricultural firms, local producers, technicians, and other experts involved in the production and commercialization of agricultural products. The main variables of interest at municipality level are: area farmed and total revenues accruing to producers for each crop covered in the survey.

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 IV and V.

Finally, we use data on employment from the RAIS dataset (*Relação Anual de Informcações Sociais*) of the Brazilian Ministry of Labor. RAIS provides information at individual level on all formal workers in Brazil, both in the private and the public sector. Employers are required by law to provide detailed worker information to the Ministry of

2003.

[12]An equal distribution of agencies across states would imply a HHI of approximately 0.0370.

Labor.[13] RAIS reports information on the sector, size and location of the firm for which each individual works for. This allows us to construct measures of employment by firm size in each municipality. We define employment in small, medium and large firms as the total number of workers that are active on December 31^{st} of each year and are employed by firms with less than 20 employees, with between 20 and 249, and with more than 250 employees respectively. We construct these measures for each municipality in Brazil for the years from 1998 to 2013. The fact that RAIS only records formal employment is not a limitation for our empirical analysis to the extent that firms that apply for loans in the banking sector have to be registered firms.

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

IV Empirics

In this section we provide empirical evidence on the effects of the adoption of GE soy seeds on the banking sector and firm growth. First, we investigate the local effects of this new technology. By "local" we mean the effects recorded within the boundaries of the municipalities where GE soy was adopted. In particular, we focus on agricultural profits, deposits in local bank branches, and loans originated by the same local branches. Second, we investigate to what extent local effects on bank deposits propagated to regions not directly affected by the new technology through bank branch networks. To this end, we first construct a measure of exposure to the GE-soy-driven deposit shock exploiting bank branch networks. Then, we study the effect of exposure on lending and firm growth.

In section IV.A we describe our identification strategy. Next, in section IV.B, we discuss the empirical results.

IV.A Identification Strategy

In this section we detail our empirical strategy to identify exogenous increases in the supply of credit across regions in Brazil. This strategy proceeds in two steps. First, we use variation in the potential profitability of GE soy across areas in Brazil to identify its effect on local credit markets. For this purpose, we exploit the fact that the introduction of GE seeds had a differential impact on agricultural profits 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

[13] See Decree n. 76.900, December 23^{rd} 1975 (Brazil 1975). Failure to report can result in fines. In practice, workers and employers have strong incentives to provide complete RAIS records. 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*).

of this technology in Brazil (2003) as a source of variation across time. In a second step, 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. In what follows, we discuss each step in detail.

IV.A.1 Identification of 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. In addition, smuggling of GE soy seeds across the border with Argentina is reported since 2001.[14] Thus, in our empirical analysis we would ideally compare outcomes before and after the first use of GE seeds in Brazil. For agricultural variables, we compare outcomes across the last two Agricultural 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 bank outcomes sourced from ESTBAN, outcomes are observed yearly starting from 1996. In our baseline regression we compare outcomes before and after the official legalization of GE soy seeds in 2003.[15]

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

[14] 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).

[15] Using 2001 as the first year in which the new technology became available to Brazilian farmers does not affect our results. Tables available upor request.

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, 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 development across Brazilian municipalities. In Table III, upper panel, we compare municipalities with different $\Delta \log(A_{jt}^{soy})$ in terms of observable characteristics in the initial period. As shown, municipalities with higher increase in potential soy yield tend to display, on average, higher income per capita, lower share of rural population and lower population density. Because these differences are strongly significant, in what follows we control for differential trends across municipalities with heterogeneous initial characteristics – including the character-

istics of banks that have branches in those municipalities – in our baseline specification 1:

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

where: Municipality controls$_{j,1991}$ is the set of initial municipality characteristics presented in Table III and 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.A.2 Identification of Bank Network Effects

In this section, we detail how we use the structure of the bank branch network across Brazilian regions to identify bank and branch-level exogenous increases in the supply of credit. This permits to trace the flow of funds from soy producing (origin) municipalities to non-soy producing (destination) ones. To this end, we define our measure of municipality exposure to the increase in credit supply due to the increased profitability of soy production. This measure aims at capturing the extent to which banks in a given municipality are exposed to the soy driven increase in deposits through their branch network. We start by constructing a measure of exposure at bank level as follows:

$$
\begin{aligned}
\text{Bank Exposure}_{bt} &= \sum_j \omega_{bj,t=0} \times A_{jt}^{soy} \\
&= \sum_j \left(\frac{n_{bj}}{N_j} \right)_{t=0} \times A_{jt}^{soy} \qquad (4)
\end{aligned}
$$

where j indexes municipality, n_{bj} denotes the number of bank b's branches in municipality j and $N_j = \sum_b n_{bj}$ is the total number of bank branches in municipality j before the legalization of GE soy seeds ($t = 0$). Equation (4) assumes that each bank receives a share of the increase in deposits driven by GE soy profitability in municipality j that is proportional to its deposit 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 for the period before the legalization of GE seeds.

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.

Bank exposure 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 the source of variation in bank exposure, in Figure III 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.

Initial location of bank branches might be correlated with bank characteristics as well as municipality characteristics. That is why, 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. Additionally, in all our regressions we control for both bank characteristics and municipality characteristics as reported in equation 3.

Next, we define a measure of municipality exposure to GE-soy-driven deposit shock. We construct this measure only for municipalities that do not produce soy, thus are not directly affected by technical change. Municipality exposure captures the extent to which banks located in a given non-soy producing municipality are exposed to the GE-soy driven increase in credit supply. In order to construct this measure at municipality level, we proceed in two steps.

We start by assuming 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. Second, 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, as follows:

$$\text{Municipality Exposure}_{jbt} = \frac{n_{bj}}{N_b}\text{Bank Exposure}_{bt} \tag{5}$$

where j indexes municipalities, n_{bj} denotes the number of bank b's branches in municipality j and $N_b = \sum_j n_{bj}$ is the total number of branches of bank b.

Note that we do not assume that banks allocate funds across branches following the

rule behind equation (5). In practice, banks might allocate funds to respond optimally to credit demand, or can follow any other rule. We use our "neutral" assignment rule to construct an instrument which identifies the exogenous component in the actual increase in the supply of credit.

Finally, we define overall municipality exposure as the sum of its exposure to each bank who has branches in the municipality:

$$\begin{aligned}\text{Municipality Exposure}_{jt} &= \log \sum_b \text{Municipality Exposure}_{jbt} \\ &= \log \sum_b \frac{n_{bj}}{N_b} \text{Bank Exposure}_{bt} \\ &= \log \sum_b \frac{n_{bj}}{N_b} \sum_j \frac{n_{bj}}{N_j} \times (A_{jt}^{soy}) \end{aligned} \tag{6}$$

IV.B Empirical Results

In the following sections we report the results of our empirical analysis. We start by reporting estimates of the effect of potential soy profitability on GE soy adoption in section IV.B.1 and on agricultural profits, investment and external finance in section IV.B.2. Then, we study the effect of potential soy profitability on local bank deposits and bank credit in section IV.B.3. Finally, we study the effect of municipality exposure on bank credit and firm growth outside soy-producing regions in section IV.B.4.

IV.B.1 Local Effects: Soy Expansion and GE Soy Adoption

In this section we test the relationship between potential soy profitability at municipality level, and the actual expansion of soy area as well as the adoption of GE soy seeds by Brazilian farmers during the period under study.

We start by testing whether our measure of exogenous change in soy profitability predicts 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 IV report the results. The point estimates of the coefficients on $\log(A_{jt}^{soy})$ are positive, indicating that an increase in potential soy profitability predicts the expansion soy area as a share of agricultural area during the period under study. The estimated coefficient is equal to .015 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 1.7

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 IV reports the estimated coefficients. The point estimate of the coefficient on $\Delta \log(A_{jt}^{soy})$ is positive, indicating that an increase in potential soy profitability predicts the expansion in GE soy area as a share of agricultural area between 1996 and 2006. Estimates are precisely estimated and remain stable when including initial municipality characteristics, as shown in column 2. In column 4 we perform a falsification test by looking at whether our measure of potential soy profitability 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 potential soy profitability captures the benefits of adopting GE soy vis-à-vis traditional soy seeds.

IV.B.2 Local Effects: Soy Revenues, Agricultural Profits, Investment and Use of External Finance

In section IV.B.1 we showed that our exogenous measure of soy profitability is a good predictor of soy expansion and GE seeds adoption. In this section we investigate its effect on revenues for soy producers, agricultural profits, investment and external finance.

We start by testing whether our measure of exogenous change in soy profitability predict actual revenues from soy production. We estimate 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 V report the results. The point estimates of the coefficients on $\log(A_{jt}^{soy})$ are positive, indicating that an increase in potential soy profitability 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 test whether increases in our measure of exogenous change in soy profitability predict 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.

In column 3 of Table V 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 potential soy profitability 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 potential soy profitability corresponds to a 7.1% increase in agricultural profits between 1996 and 2006. These coefficients imply that for every R$10 of increase in profits around R$1.4 are reinvested in agricultural activities. Interestingly, the total value of external finance is unaffected by soy profitability.

IV.B.3 Local Effects: Bank Deposits and Credit

In sections IV.B.1 and IV.B.2 we showed that our exogenous measure of soy profitability is a good predictor of both the adoption of GE soy seeds and the change in agricultural profits. Additionally, we showed that only a fraction of the increase in agricultural profits was re-invested in agricultural activities. In what follows, we investigate what was the use of the remaining agricultural profits. In principle, they could have been channeled to consumption or to savings. In the second case, they could have been invested locally, nationally or internationally. Finally, investments could have taken the form of informal lending arrangements or could have been channeled through the banking sectors. To understand these issues, we investigate the effect of our exogenous measure of soy profitability on deposits in local bank branches and on loans originated by the same bank branches. We estimate equation (3) where y_j is the level 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 therefore available yearly from 1996 to 2013.

Table VI reports the results when the outcome variable is bank deposits. First, we study the effect of our exogenous measure of soy profitability on total bank deposits, which we define as the sum of demand deposits, saving deposits and term deposits. The estimates are reported in column 1 of Table VI. It indicates that municipalities with higher increase in soy profitability 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 5.4% larger increase in total bank deposits (3% of a standard deviation). Next, we study whether this effect varies for different types of bank deposits. Results are reported in columns 2 and 3 of Table VI for demand and saving accounts and for term deposits respectively. The estimated coefficients on $\log(A_{jt}^{soy})$ indicate that the effect of potential soy profitability on deposit is concentrated on demand and saving deposits. Demand deposits are unremunerated, while savings account 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. On the other hand, we find no effect on term deposits.

Table VII reports the results of estimating equation (3) when the outcome variable y_{jt} is value of loans originated by bank branches located in municipality j. We study the effect of our exogenous measure of soy profitability on agriculture loans, and the two categories of non-agriculture loans: general-purpose and specific-purpose loans. The estimates are reported in columns 1, 2 and 3 of Table VII. As shown, we find that soy profitability had a negative effect on loans to the agricultural sector. This is consistent with farmers financing new investment with retained profits rather than bank credit in areas with larger increase in potential soy profitability. The estimated coefficient on $\log(A_{jt}^{soy})$ is negative for general purpose loans and small in size and statistically not different from zero for specific purpose loans.

IV.B.4 Bank Network Effects: Bank Credit

In section IV.B.3 we showed that municipalities that are predicted to adopt GE soy experienced larger increases in agricultural profits and bank deposits in local branches during the period under study. At the same time, we find no evidence of a positive effect of our exogenous measure of soy profitability on 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.

In this section we explore whether larger increases in deposits in soy-producing areas of Brazil affect credit supply in non soy-producing areas through bank branch networks. To this end, we use the measure of municipality exposure described in section IV.A.2 and estimate the following version of equation 3:

$$\begin{aligned} y_{jt} &= \alpha_j + \alpha_t + \beta(\text{Municipality Exposure})_{jt} \\ &+ \sum_t \gamma_t(\text{Municipality controls}_{j,1991} \times d_t) \\ &+ \sum_t \delta_t(\text{Bank controls}_{j,1996} \times d_t) + \varepsilon_{jt} \end{aligned} \tag{7}$$

where Municipality Exposure$_{jt}$ is defined as in equation (6). As in equation (3), we add controls for municipality and bank initial characteristics interacted with time dummies.[16]

Table VIII reports the results obtained estimating equation 7 when the outcome variables y_{jt} are: rural loans, general purpose and specific purpose loans. We estimate this equation on the subsample of non-soy producing municipalities.[17] The estimated coeffi-

[16]Table III, lower panel, compares non-soy producing municipalities with different levels of exposure to the soy boom through their bank networks in terms of initial municipality characteristics.

[17]Non-soy municipalities are defined as municipalities with no area cultivated with soy in any of the

cients on municipality exposure are positive and precisely estimated, indicating that areas more exposed to the GE-soy-driven deposit shock through their bank networks experienced a larger increase in both agriculture and non-agriculture lending. To illustrate the magnitude of these coefficients, consider two non-soy producing municipalities that are one standard deviation apart in terms of exposure to the GE-soy-driven credit supply shock. The point estimates indicates that the municipality with a one standard deviation higher exposure experienced a 31% larger increase in agriculture loans (15.2% of a standard deviation), a 26.8% larger increase in general purpose loans (13.3% of a standard deviation) and a 23.8% larger increase in specific purpose loans (10.8% of a standard deviation).

IV.B.5 Bank Network Effects: Firm Growth

In section IV.B.4 we showed that bank branches in municipalities with higher exposure to the GE-soy driven deposit shock experienced higher increase in lending. We now test the effect of municipality exposure to the same shock on firm growth. To this end, we estimate equation (7) where the outcome variable y_{jt} is total employment (in logs) in municipality j at time t. Data on employment is sourced from the RAIS, and covers formal workers in all sectors over the years 1998 to 2013.[18] RAIS allows us to distinguish between workers employed in firms of different size. In addition to total number of workers, we construct total employment in small, medium and large firms.[19]

Table IX reports the results of our analysis. As in Table VIII, we restrict our sample to non-soy producing municipalities. Column 1 reports the results when the outcome is total employment. The estimated coefficient on municipality exposure is positive and significant, indicating that firms operating in areas that were more exposed to the GE-soy-driven deposit shock through their bank networks experienced a larger increase in employment. The point estimate indicates that firms located in municipalities with a one standard deviation higher exposure experienced a 13.4% larger increase in employment. In columns 2 to 4 we estimate the same equation when the outcomes are total employment in small, medium and large firms respectively. As shown, the effect of municipality exposure on firm growth is concentrated in small and medium sized firms. On the other hand, the point estimate on municipality exposure when the outcomes is employment in large firms is small and not statistically different from zero.

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years under study.

[18]As discussed above, even though a substantial fraction of Brazilian firms operate in the informal economy, firms that apply for loans at commercial banks tend to be registered.

[19]Small firms are those with less than 25 workers employed on December 31^{st} of each year. Medium firms have between 25 and 249 workers, while large firms have 250 or more workers.

V Additional Results and Robustness

In this section we show additional results and robustness tests for the main results presented in section IV.B. First, we investigate whether our exogenous measure of soy profitability captures the right timing of the introduction of GE soy seeds. Second, we test the robustness of our results to the exclusion of the two major government controlled banks from our sample, and to the use of bank conglomerates instead of individual banks as unit of observation.

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 technological component of our exogenous measure of soy profitability (A_{jt}^{soy}) 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 bank outcomes are available at yearly level, we can investigate whether our exogenous measure of soy profitability captures the right timing of the introduction of GE soy seeds by running the following equation:[20]

$$\begin{aligned} y_{jt} &= \alpha_j + \alpha_t + \sum_t \beta_t(\Delta \log(A_j^{soy}) \times d_t) \\ &+ \sum_t \gamma_t(\text{Municipality controls}_{j,1991} \times d_t) \\ &+ \sum_t \delta_t(\text{Bank controls}_{j,1996} \times d_t) + \varepsilon_{jt} \end{aligned} \tag{8}$$

where $\Delta \log A_j^{soy}$ is a time invariant measure of the change in potential yield when soy production switches from low to high inputs. More formally:

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

In Figure II 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). The timing of the effect of ΔA_j^{soy} on both outcomes is broadly consistent with capturing the effect 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 potential soy profitability 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 that, prior to legalization, smuggling of GE soy seeds from Argentina was detected since 2001 according to the Foreign Agricultural Service of the United States Department of Agriculture (USDA 2001).

Next, we test the robustness of our main results on bank deposits and credit to the

[20] The same test cannot be performed for agricultural outcomes, which we only observe in correspondence of the Agricultural Census.

exclusion of the two major government controlled banks in our sample: Banco do Brasil and Caixa Econômica Federal. One potential concern is that these banks might follow different lending policies than private commercial banks. Table A1 replicates the results presented in Tables VI, VII and VIII in the paper when excluding government controlled banks from our sample. As shown, all the main results are robust to this test in the sense that (i) municipalities with higher increase in soy profitability experienced a larger increase in total bank deposits, (ii) the same municipalities experienced no increase in total bank credit at local level (if anything, lending decreased) (iii) non-soy producing municipalities that are more exposed to the GE-soy-driven deposit shock through their bank networks experienced a larger increase in lending.[21]

Finally, we test to what extent our main results depend on the use of bank conglomerates instead of individual banks as units of observation. So far, we considered each individual bank that we observe in the pre-soy boom period as a separate branch network during the whole period under study. This is because banks with a network of branches in rural areas more exposed to the soy boom might be the target of mergers and acquisitions by banks with better investment opportunities and in search of cheap source of financing, making the branch network endogenous to the soy shock. In Table A2 we show that the results presented in Table VIII are similar to those obtained taking into account these M&A activity and using the bank branch network of bank conglomerates.

VI Concluding Remarks

In this paper we study the effect of new agricultural technologies on reallocation of capital across sectors. 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. We then explore whether larger increases in bank deposits in soy-producing areas of Brazil affect credit supply in non soy-producing areas through bank branch networks. We find that regions of Brazil that were more exposed to the GE-soy-driven deposit shock through bank branch networks experienced a larger increase in bank lending and larger firm growth, where the latter effect is concentrated in small and medium size firms.

[21] In an additional test not reported in this draft we also show that all our main results are robust to excluding capital cities from our sample.

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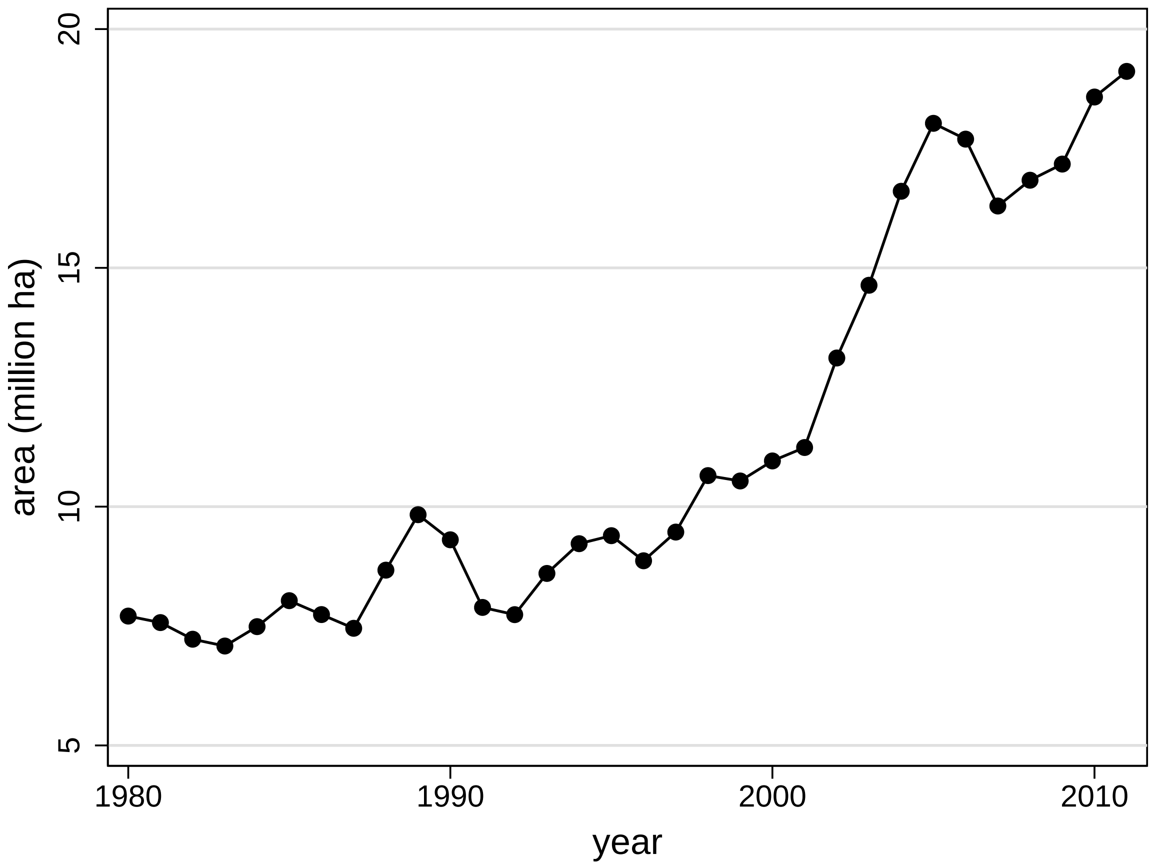
Figures and Tables

Figure I: Evolution of Area Planted with Soy in Brazil

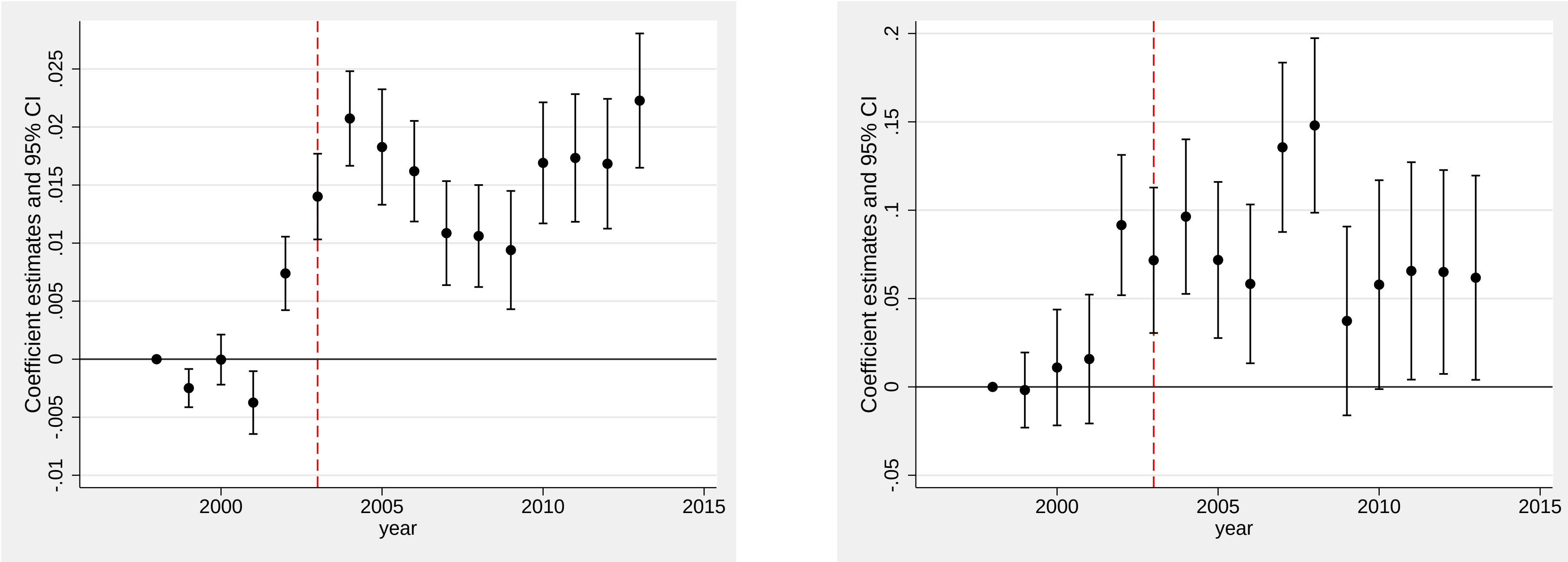


Notes: Data source is CONAB, Companhia Nacional de Abastecimento, which is an agency within the Brazilian Ministry of Agriculture. CONAB carries out monthly surveys to monitor the evolution of the harvest of all major crops in Brazil: the surveys are representative at state level and are constructed 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: Increase in Potential Soy Yield and Timing of Soy Expansion and Bank Deposits

(a) Soy Expansion

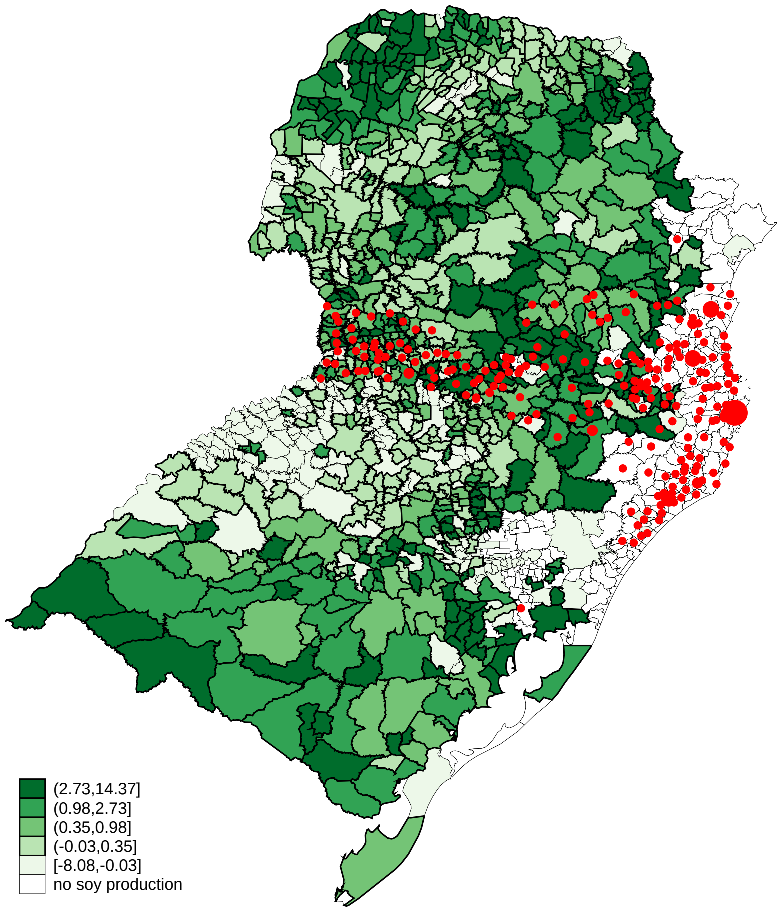
(b) Bank Deposits



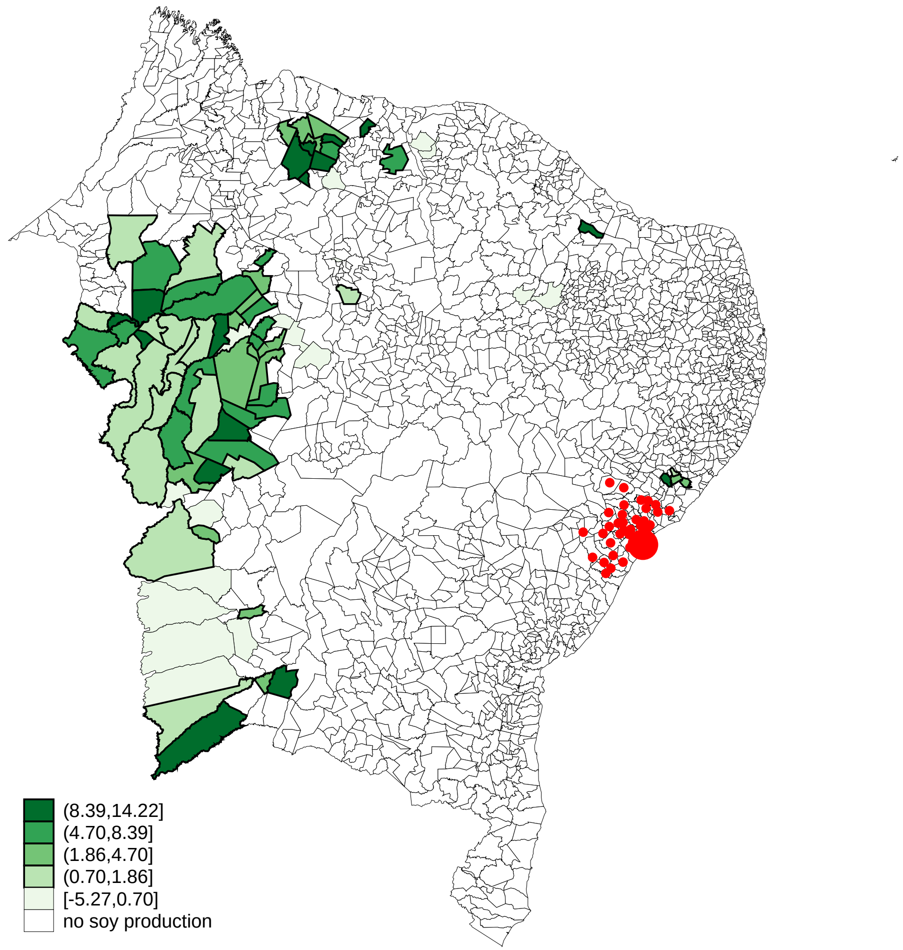
Notes: Data from Central Bank of Brazil and PAM (IBGE).

Figure III: Bank Networks and Increase in Soy Revenues

(a) Bank A



(b) Bank B



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

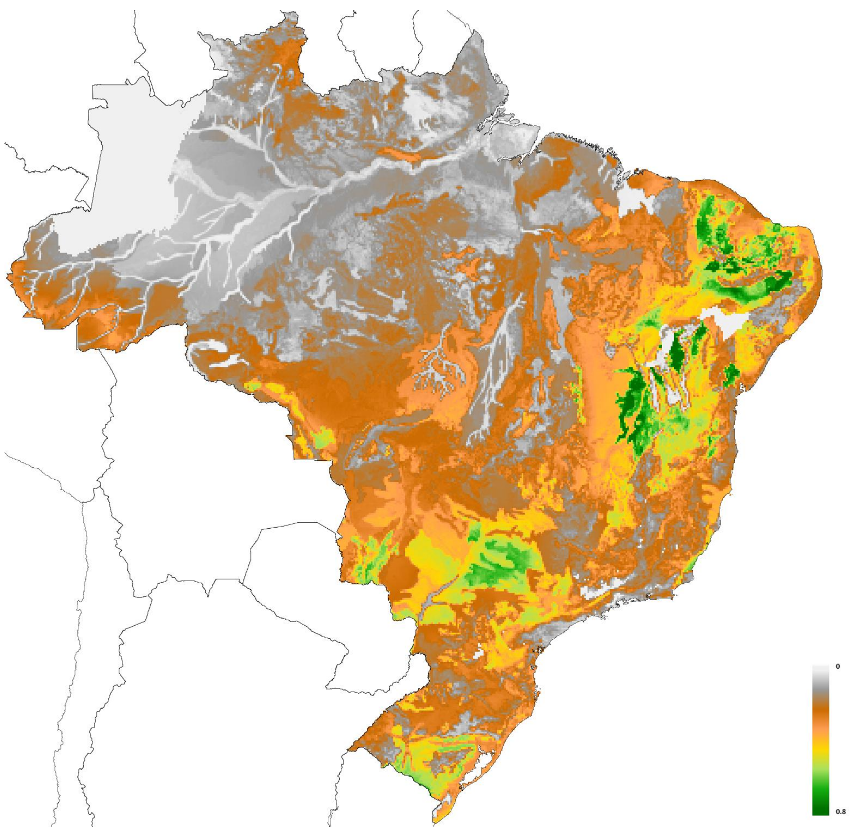


FIGURE IV: **Potential soy yield under low agricultural technology**

Notes: Data from FAO-GAEZ.

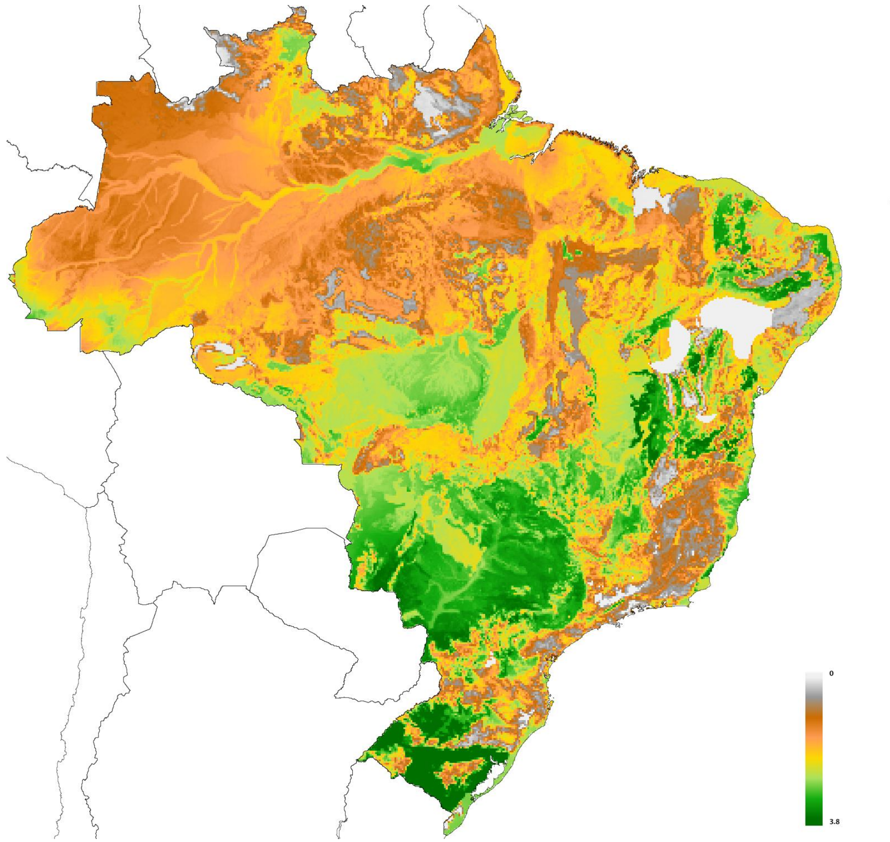


FIGURE V: **Potential soy yield under high agricultural technology**

Notes: Data from FAO-GAEZ.

Table I: Summary Statistics

Variable Name	mean	st.dev.	N
Agricultural outcomes (changes 2006-1996):			
Δ GE Soy Area Share	0.013	0.059	3,749
Δ Non-GE Soy Area Share	-0.002	0.053	3,749
Δ Profits (%)	-0.288	6.111	3,794
Δ Log Investment	0.158	0.868	3,794
Δ Log External Finance	1.113	1.369	3,794
Banking sector outcomes:			
Log Demand Deposits	13.554	0.983	56,594
Log Saving Deposits	15.806	0.709	54,575
Log Term Deposits	14.745	1.398	51,364
Log Rural Loans	13.189	1.509	46,773
Log General Purpose Loans	15.414	0.919	56,633
Log Specific Purpose Loans	13.447	1.182	48,895
Firm outcomes:			
Log Number of Workers - All Firms	6.882	1.874	26741
Small Firms	6.430	1.569	26741
Medium Firms	6.014	2.125	26741
Large Firms	5.510	3.237	26741
Potential Soy Profitability and Municipality Exposure:			
$\Delta \log(A_{soy})$	1.451	0.459	3,794
$\log(A_{soy})$	5.567	1.289	56,764
Municipality Exposure	4.630	1.184	28,321

Notes: Sources are the Agricultural Censuses of 1996 and 2006 (agricultural outcomes); the ESTBAN dataset, years 1996 to 2013 (banking sector outcomes); the RAIS, years 1998 to 2013 (firm outcomes); the FAO-GAEZ dataset and IMF Primary Commodity Prices database (potential soy profitability)

Table II: Bank Characteristics
10 Largest Banks by Number of Branches in 2003

Bank Name	N Branches	Branch Share	Deposit Share	N States Present	HHI	Control
Banco Do Brasil	3,291	17.8%	18.6%	27	0.08	Federal Goverment
Banco Bradesco	2,823	15.3%	10.9%	27	0.17	Private
Banco Itaú	1,713	9.3%	4.7%	27	0.19	Private
Caixa Economica Federal	1,598	8.7%	17.6%	27	0.11	Federal Goverment
HSBC Bank Brasil S.A. - Banco Multiplo	942	5.1%	3.2%	27	0.16	Private
Unibanco	904	4.9%	5.3%	24	0.23	Private
Banco Sudameris Brasil S.A.	888	4.8%	4.3%	25	0.31	Private
Banco Alvorada S.A.	880	4.8%	2.0%	27	0.17	Private
Banco Abn Amro Real S.A.	793	4.3%	4.0%	27	0.20	Private
Banespa*	598	3.2%	2.3%	17	0.87	Private

Notes: Source is the ESTBAN dataset, data refers to year 2003. * Belonging to the Santander Group.

Table III: Comparing Municipalities

	$\Delta \log A_j^{soy}$ below median (1)	above median (2)	difference (3)	level of significance (4)
Log Income per capita	4.557	4.820	0.263	***
Share rural population	0.468	0.355	-0.114	***
Literacy rate	0.730	0.786	0.056	
Log Population Density	3.316	3.304	-0.012	***

	ΔMunicipality Exposure below median (1)	above median (2)	difference (3)	level of significance (4)
Log Income per capita	4.556	4.488	-0.068	**
Share rural population	0.437	0.400	-0.036	***
Literacy rate	0.730	0.681	-0.049	***
Log Population Density	3.623	3.959	0.337	***

Notes: Average values of observable characteristics of municipalities that rank below and above the median of $\Delta \log A^{soy}$ and ΔMunicipality Exposure. $\Delta \log(A_{jt}^{soy})$ is computed as $\log(A_j^{soy,HIGH}) - \log(A_j^{soy,LOW})$. Municipality exposure is computed as the average (across years) municipality exposure in the years from 2003 onwards minus the average (across years) municipality exposure in the years before 2003. Municipality exposure is defined as in equation (5) in the paper. Initial municipality characteristics refer to year 1991 (source: Population Census). Column (3) reports the difference between columns (2) and (1), along with the standard error and significance level of the difference. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table IV: Potential Soy Profitability and Agricultural Outcomes
Soy Expansion and Adoption of GE seeds

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)
$\log(A_{jt}^{soy})$	0.016	0.015		
	[0.002]***	[0.002]***		
$\Delta\log(A_{j}^{soy})$			0.028	-0.014
			[0.002]***	[0.002]***
Municipality controls $_{j,1991} \times t$	Y	Y		
Bank Controls $_{j,1996} \times t$		Y		
Municipality controls $_{j,1991}$			Y	Y
Year fixed effects	Y	Y		
AMC fixed effects	Y	Y		
Observations	53,203	53,203	3,749	3,749
Adjusted R-squared	0.952	0.952	0.136	0.037
N clusters (AMC)	3177	3177	3,749	3,749
Data source dep.var. :	PAM 1996-2013	PAM 1996-2013	Agricultural Census 1996 and 2006	

Notes: Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table V: Potential Soy Profitability and Agricultural Outcomes
Soy Revenues, Agricultural Profits, Investment and Use of External Finance

Dependent variables:	log revenues from soy production		Δ Profits (%)	Δ log Inv	Δ log Ext Fin
	(1)	(2)	(3)	(4)	(5)
$\log(A^{soy}_{jt})$	0.211	0.206			
	[0.089]**	[0.089]**			
$\Delta \log(A^{soy}_{j})$			0.470	0.154	-0.082
			[0.234]**	[0.036]***	[0.058]
Municipality controls $_{j,1991} \times t$	Y	Y			
Bank Controls $_{j,1996} \times t$		Y			
Municipality controls $_{j,1991}$			Y	Y	Y
Year fixed effects	Y	Y			
AMC fixed effects	Y	Y			
Observations	53,203	53,203	3,794	3,794	3,794
Adjusted R-squared	0.881	0.881	0.001	0.018	0.042
N clusters (AMC)	3177	3177	3,794	3,794	3,794
Data source dep.var. :	PAM 1996-2013	PAM 1996-2013	Agricultural Census 1996 and 2006		

Notes: Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table VI: Potential Soy Profitability and Bank Deposits
Demand and Saving Accounts, Term Deposits

Dependent variables:	log private deposits		
	all	demand and saving deposits	term deposits
	(1)	(2)	(3)
$\log(A^{soy})$	0.048	0.041	-0.003
	[0.016]***	[0.014]***	[0.036]
Municipality controls $_{j,1991} \times t$	Y	Y	Y
Bank Controls $_{j,1996} \times t$	Y	Y	Y
Year fixed effects	Y	Y	Y
AMC fixed effects	Y	Y	Y
Observations	53,203	53,203	48,126
Adjusted R-squared	0.971	0.972	0.892
N clusters (AMC)	3177	3177	3037
Data source dep.var. :	ESTBAN 1996-2013		

Notes: Outcomes are total monetary value (in 2000 BRL) at AMC/year level, in logs, winsorized at 1% in each tail. Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table VII: Potential Soy Profitability and Bank Loans
Agriculture and Non-Agriculture Loans

	log agriculture loans	non-agriculture loans	
Dependent variables:		log general purpose loans	log special purpose loans
	(1)	(2)	(3)
$\log(A^{soy})$	-0.150	-0.052	-0.019
	[0.050]***	[0.026]**	[0.046]
Municipality controls $_{1991} \times t$	Y	Y	Y
Bank Controls $_{j,1996} \times t$	Y	Y	Y
Year fixed effects	Y	Y	Y
AMC fixed effects	Y	Y	Y
Observations	46,300	53,201	45,833
Adjusted R-squared	0.845	0.948	0.869
N clusters (AMC)	2958	3177	2965
Data source dep.var. :		ESTBAN 1996-2013	

Notes: Outcomes are total monetary value (in 2000 BRL) at AMC/year level, in logs, winsorized at 1% in each tail. Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table VIII: Propagation to Non-Soy Producing Regions
Agriculture and Non-Agriculture Loans

Dependent variables:	log agriculture loans	non-agriculture loans: log general purpose loans	non-agriculture loans: log special purpose loans
	(1)	(2)	(3)
Municipality exposure $_{jt}$	0.326	0.282	0.250
	[0.146]**	[0.057]***	[0.109]**
Municipality controls $_{1991} \times t$	Y	Y	Y
Bank Controls $_{j,1996} \times t$	Y	Y	Y
Year fixed effects	Y	Y	Y
AMC fixed effects	Y	Y	Y
Observations	21,967	25,268	21,334
Adjusted R-squared	0.791	0.965	0.875
N clusters (AMC)	1394	1609	1358
Data source dep.var. :		ESTBAN 1996-2013	

Notes: Outcomes are total monetary value (in 2000 BRL) at AMC/year level, in logs, winsorized at 1% in each tail. Regressions only include AMC with no soy production in the years under study according to the PAM Survey. Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table IX: Propagation to Non-Soy Producing Regions
Fim Gowth: All Firms and Effect by Firm Size (Small, Medium and Large firms)

Dependent variables:	log L All firms	log L Small firms ($L < 20$)	log L Medium firms ($20 < L < 249$)	log L Large firms ($L \geq 250$)
	(1)	(2)	(3)	(4)
Municipality exposure$_{jt}$	0.141	0.109	0.234	0.017
	[0.041]***	[0.029]***	[0.098]**	[0.172]
Municipality controls $_{j,1991} \times t$	Y	Y	Y	Y
Bank controls $_{j,1996} \times t$	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
Municipality fixed effects	Y	Y	Y	Y
Observations	26,741	26,741	26,741	26,741
Adjusted R-squared	0.978	0.984	0.848	0.827
N clusters	1714	1714	1714	1714
Data source dep.var. :	RAIS 1998-2013			

Notes: Regressions only include AMC with no soy production in 1996. Outcomes are winsorized at 1% in each tail. Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Appendix

Table A1 Robustness to Excluding Government Controlled Banks

Dependent variables	log total deposits	log agriculture loans	non-agriculture loans		log agriculture loans	non-agriculture loans	
			log general purpose loans	log special purpose loans		log general purpose loans	log special purpose loans
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\log(A^{soy})$	0.122	-0.211	-0.124	-0.182			
	[0.024]***	[0.089]**	[0.040]***	[0.083]**			
Municipality Exposure $_{jt}$					0.850	0.351	-0.128
					[0.161]***	[0.067]***	[0.123]
Municipality controls $_{1991} \times t$	Y	Y	Y	Y	Y	Y	Y
Bank Controls $_{j,1996} \times t$	Y	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y	Y
AMC fixed effects	Y	Y	Y	Y	Y	Y	Y
Observations	48,206	33,522	48,171	33,022	14,780	20,635	13,827
Adjusted R-squared	0.936	0.757	0.899	0.819	0.757	0.936	0.844
N clusters (AMC)	3185	2557	3182	2482	1171	1521	1150

Notes: Outcomes are total monetary value (in 2000 BRL) at AMC/year level, in logs, winsorized at 1% in each tail. Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Robustness to Using Bank Conglomerates

Dependent variables	log agriculture loans	non-agriculture loans	
		log general purpose loans	log special purpose loans
	(1)	(2)	(3)
Municipality Exposure $_{jt}$	0.411	0.278	0.121
	[0.133]***	[0.039]***	[0.095]
Municipality controls $_{1991} \times t$	Y	Y	Y
Bank Controls $_{j,1996} \times t$	Y	Y	Y
Year fixed effects	Y	Y	Y
AMC fixed effects	Y	Y	Y
Observations	25,016	31,019	26,237
Adjusted R-squared	0.783	0.952	0.870
N clusters (AMC)	1655	1934	1722

Notes: Outcomes are total monetary value (in 2000 BRL) at AMC/year level, in logs, winsorized at 1% in each tail. Standard errors clustered at AMC level are reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.