CAPITAL ACCUMULATION AND STRUCTURAL TRANSFORMATION*

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Several scholars argue that high agricultural productivity can retard industrial development because it draws resources toward the comparative advantage sector, agriculture. However, agricultural productivity growth can increase savings and the supply of capital, generating an expansion of the capital-intensive sector, manufacturing. We highlight this mechanism in a simple model and test its predictions in the context of a large and exogenous increase in agricultural productivity due to the adoption of genetically engineered soy in Brazil. We find that agricultural productivity growth generated an increase in savings, but these were not reinvested locally. Instead, there were capital outflows from rural areas. Capital reallocated toward urban regions, where it was invested in the industrial and service sectors. The degree of financial integration affected the speed of structural transformation. Regions that were more financially integrated with soy-producing areas through bank branch networks experienced faster growth in nonagricultural lending. Within these regions, firms with preexisting relationships with banks receiving funds from the soy area experienced faster growth in borrowing and employment. *JEL* Codes: O14, O16, O41, F11.

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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. Economic historians have argued that in the first industrialized countries technical improvements in agriculture favored this process by increasing demand for manufactures or generating savings to finance industrial projects (Crafts 1985; Crouzet 1972). However, the experience of some low-income countries appears inconsistent with the idea that agricultural productivity growth leads to economic development.[1] The theoretical literature has proposed two sets of explanations. First, the positive effects of agricultural productivity on economic development might not take place in open economies where manufactures can be imported and savings can be exported (Matsuyama 1992). Second, market frictions might constrain factor reallocation (Banerjee and Newman 1993). The recent empirical literature has focused on understanding how these mechanisms shape the process of labor reallocation. However, there is scarce direct empirical evidence on the process of capital reallocation from the rural agricultural sector to the urban industrial sector.[2]

In this article we study the effects of productivity growth in agriculture on the allocation of capital across sectors and regions. To guide the empirical analysis we refer to the Heckscher-Ohlin model, which illustrates the classic effect of agricultural technical change on structural transformation in an open economy: larger agricultural productivity increases the demand for capital in agriculture, thus capital reallocates toward this sector (Findlay and Grubert 1959). This is the negative effect of agricultural

1. For example, Foster and Rosenzweig (2004, 2007) show that after the Green Revolution, regions in rural India with faster agricultural productivity growth experienced slower industrialization.

2. For evidence on labor reallocation across sectors see McCaig and Pavcnik (2013) and Bustos, Caprettini, and Ponticelli (2016); see also Herrendorf, Rogerson, and Valentinyi (2014) for a review of the macro literature. For labor reallocation across regions, see Moretti (2011), Michaels, Rauch, and Redding (2012), Munshi and Rosenzweig (2016), Bryan and Morten (2019), and Fajgelbaum and Redding (2014). For capital reallocation, see Banerjee and Munshi (2004), who document larger access to capital for entrepreneurs belonging to rich agricultural communities in the garment industry in Tirupur, India. See also the recent macroeconomic literature on financial frictions and development: Giné and Townsend (2004), Jeong and Townsend (2008), Moll (2014), Buera, Kaboski, and Shin (2015).

comparative advantage on industrialization highlighted in the development literature, and we refer to it as the capital demand effect. In this article, instead, we highlight that larger agricultural income generates savings, the supply of capital increases, and thus the capital-intensive sector, manufacturing, expands. This positive effect of agricultural productivity on industrialization has been overlooked by the theoretical literature and will be the main focus of our empirical analysis. We refer to it as the capital supply effect.

Our empirical analysis attempts to trace the causal effects of agricultural productivity growth on the allocation of capital across sectors and regions. This has proven challenging for the literature due to the limited availability of data on capital flows within countries. We overcome this difficulty by using detailed information on deposits and loans for each bank branch in Brazil. We match these data with confidential information on bank-firm credit relationships and social security records containing the employment histories for the universe of formal firms. Therefore, our final data set permits us to observe capital flows across both sectoral and spatial dimensions. We use these data to establish the causal effect of agricultural productivity growth on the direction of capital flows. For this purpose, we exploit a large and exogenous increase in agricultural productivity: the legalization of genetically engineered (GE) soy in Brazil. This new technology had heterogeneous effects on yields across areas with different soil and weather characteristics, which permits us to estimate the local effects of agricultural productivity growth. In addition, a second step in our empirical strategy relies on differences in the degree of financial integration across regions to trace capital flows across rural and urban areas.

First, we study the local effects of agricultural productivity growth. We find that municipalities subject to faster exogenous technical change indeed experienced faster adoption of GE soy and growth in agricultural profits.[3] We think of these municipalities directly affected by agricultural technical change as origin municipalities. Consistent with the model, we find that these municipalities experienced a larger increase in savings deposits in local bank branches. However, there was no increase

3. We use agricultural profits per hectare as a proxy for land rents because 93% of agricultural land is farmed by its owners. See Agricultural Census of Brazil, IBGE (2006), Table 1.1.1, 176.

in local bank lending. As a result, agricultural technical change generated capital outflows from origin municipalities. This finding suggests that the increase in the local demand for capital is smaller than the increase in local supply. Thus, banks must have reallocated savings toward other regions. Therefore, we propose a methodology to track the destination of those savings generated by agricultural productivity growth.

In a second step of the analysis, we need to trace the reallocation of capital across space. For this purpose, we exploit differences in the geographical structure of bank branch networks for 115 Brazilian banks. We think of these banks as intermediaries that reallocate savings from origin municipalities to destination municipalities where they have branches. First, we show that banks more exposed to the soy boom through their branch network indeed had a larger increase in aggregate deposits. Next we track the destination of those deposits generated by agricultural technical change. For this purpose, we assume that because of imperfections in the interbank market, banks are likely to fund part of their loans with their own deposits. This implies that we can construct exogenous credit supply shocks across destination municipalities using differences in the geographical structure of bank branch networks. We use this variation to assess whether destination municipalities more financially connected to origin municipalities experiencing agricultural productivity growth received larger capital inflows. We find that this is indeed the case. Interestingly, these funds went entirely to non-soy-producing regions and were channeled to nonagricultural activities.

To interpret our findings, we present a simple two-period multiregion Heckscher-Ohlin model. We assume that there are rural and urban regions where both agricultural and manufacturing activities take place. Rural areas face agricultural productivity growth, which reinforces their comparative advantage in agriculture. However, new agricultural technologies generate a temporary increase in land rents, which result in larger savings. If rural areas are in financial autarky, this increase in local capital supply generates a reduction in the autarky interest rate and an expansion of the capital-intensive sector, manufacturing. Instead, if rural regions are financially integrated with other regions, agricultural productivity growth generates further specialization in agriculture and capital outflows. Urban regions financially integrated to areas experiencing agricultural technical change receive capital inflows, which generates an expansion of the manufacturing sector.[4]

The findings discussed above are consistent with the capital supply mechanism emphasized by the model for the case in which rural and urban regions are financially integrated. Our empirical analysis permits us to quantify this effect by comparing the speed of capital reallocation across sectors in non-soy-producing municipalities with different degrees of financial integration with the soy boom area. Between 1996 and 2010, the share of nonagricultural lending increased from 75% to 84% in the average non-soy-producing municipality in Brazil. However, the speed of capital reallocation away from agriculture varied extensively across municipalities. Our estimates imply that one standard deviation in the degree of financial integration with soy-producing regions can explain 11% of a standard deviation in the increase of the nonagricultural lending share across non-soy-producing municipalities.

As mentioned, our findings are consistent with the capital supply mechanism emphasized by the model. However, to the extent that destination municipalities which are more connected to origin municipalities through bank branch networks are also more connected through the transportation or commercial networks, it is possible that our estimates are capturing the effects of agricultural technical change through other channels. For example, if technical change is labor saving, former agricultural workers might migrate toward cities and increase labor supply, the marginal product of capital, and capital demand. Similarly, cities could face larger product demand from richer farmers. As a result, our empirical strategy permits us to assess the effect of agricultural productivity on the allocation of capital across sectors and regions but cannot isolate whether this occurs through a labor supply, product demand, or capital supply channel. To make progress on this front we need to implement a firm-level empirical strategy that permits us to control for labor supply and product demand shocks in destination municipalities, as we describe below.

In a third step of the analysis, we trace the reallocation of capital toward firms located in destination municipalities. For

4. We assume that regions within the country are financially integrated but in financial autarky with respect to the rest of the world. This assumption is an extreme way to capture larger financial frictions across than within countries.

this purpose, we match administrative data on the credit and employment relationships for the universe of formal firms. We use these data to construct firm-level exogenous credit supply shocks using information on preexisting firm-bank relationships. We use these shocks to assess whether firms whose preexisting lenders are more connected to soy-producing regions through bank branch networks experienced larger increases in borrowing and employment growth. This empirical strategy permits us to isolate the capital supply channel by comparing firms borrowing from different banks but operating in the same municipality and sector, and thus subject to the same labor supply and product demand shocks. We find that firms with preexisting relationships with banks receiving deposits from the soy boom borrow more from those banks, and not from other banks with whom they also had relationships. Consistent with the aggregate results described above, we find that most of the new capital was allocated to nonagricultural firms: out of each 1 R$ of new loans from the soy-driven deposit increase, 1.3 cents were allocated to firms in agriculture, 50 cents to firms in manufacturing, 39.7 cents to firms in services, and 9 cents to other sectors. Finally, we study whether larger loans led to firm growth: we find that firms receiving credit from the soy boom also experience faster growth in employment and their wage bill.

Taken together, our empirical findings imply that agricultural productivity growth can lead to structural transformation in open economies through its impact on capital accumulation. We interpret these findings in light of a neoclassical model where agricultural productivity growth induces land owners to save, which increases the supply of capital. In addition, the new technology reinforces agricultural comparative advantage in rural areas. As a result, it is optimal to reallocate manufacturing activities and capital toward other areas. Consistent with this model, we observe capital outflows from soy-producing regions toward nonagricultural activities in non-soy-producing regions.

Finally, the empirical results highlight the importance of financial frictions. The presence of these frictions suggests that the allocation of capital across destination regions and firms might not be optimal. In Section VII we discuss how introducing credit constraints can modify the predictions of the model and the interpretation of the empirical results.

I.A. Related Literature

This article is related to a large literature characterizing the development process as one where agricultural workers migrate to cities to find employment in the industrial and service sectors. Understanding the forces behind this reallocation process is important, especially when labor productivity is lower in agriculture than in the rest of the economy (Gollin, Lagakos, and Waugh 2014). There is a rich recent empirical literature analyzing the determinants of the reallocation of labor both across sectors (Foster and Rosenzweig 2004, 2007; McCaig and Pavcnik 2013; Bustos, Caprettini, and Ponticelli 2016), and across regions (Moretti 2011; Michaels, Rauch, and Redding 2012; Munshi and Rosenzweig 2016; Fajgelbaum and Redding 2014; Bryan and Morten 2019). In contrast, our knowledge of the process of capital reallocation is extremely limited.[5]

The scarcity of empirical studies on the reallocation of capital is often due to the limited availability of data on the spatial dimension of capital movements.[6] In this article, we are able to track internal capital flows across regions in Brazil using detailed data on deposit and lending activity at branch level for all commercial banks operating in the country. These data permit us to obtain a measure of municipality-level capital flows by computing the difference between deposits and loans originated in the same location. To the best of our knowledge, this is the first data set that permits one to observe capital flows across regions within a country for the entire formal banking sector.

5. See Crafts (1985) and Crouzet (1972) for early studies on the role of agriculture as a source of capital for other sectors during the industrial revolution in England. See Gollin (2010) for references and a discussion of the role of agricultural productivity growth on industrialization in England. See also contemporaneous work by Marden (2016) studying the local effects of agricultural productivity growth in China, and Moll, Townsend, and Zhorin (2017), who propose a model of labor and capital flows between rural and urban regions and calibrate it using data on Thailand. Another contemporaneous related paper is Dinkelman, Kumchulesi, and Mariotti (2017), which studies the effect of capital injections from migrants' remittances on local labor markets in Malawi. The authors find that regions receiving the largest capital inflows from migrants experienced faster structural change. Dix-Carneiro and Kovak (2017) find that Brazilian regions more exposed to the 1990s trade liberalization experienced larger declines in employment and earnings and argue that capital reallocation away from these regions could explain this result.

6. For a detailed discussion of the literature which points out this limitation, see Foster and Rosenzweig (2007).

A second challenge we face is to sign the direction of capital flows: from the agricultural rural sector to the urban industrial sector. For this purpose we design a new empirical strategy that exploits differences in the geographical structure of bank branch networks to measure differences in the degree of financial integration across origin and destination municipalities. This strategy builds on the insights of the literature studying the effects of transportation networks on goods market integration, such as Donaldson (2018) and Donaldson and Hornbeck (2016).

A third challenge is to isolate the capital supply channel from other effects of agricultural technical change that could spill over to connected regions. We overcome this difficulty by bringing the analysis to the firm level. This allows us to construct firm-level credit supply shocks by exploiting differences in the geographical structure of the branch network of their lenders. Our article is thus related to two strands of the literature studying the effect of exogenous credit supply shocks. First is the development literature studying the effects of exogenous credit shocks on firm growth (McKenzie and Woodruff 2008; De Mel, McKenzie, and Woodruff 2008; Cole 2009; Banerjee and Duflo 2014; Banerjee, Karlan, and Zinman 2015; Banerjee et al. 2015). Second is the finance literature studying the effects of bank liquidity shocks. This literature has established that bank credit supply changes can have important effects on lending to firms and employment (Chodorow-Reich 2014, Khwaja and Mian 2008) as well as on loans to individuals, such as mortgages (Gilje, Loutskina, and Strahan 2016). We contribute to this literature by proposing a methodology to trace the reallocation of capital from the rural agricultural sector to the urban industrial and service sectors.

Finally, let us note that this article is part of a broader research agenda in which we study the effect of agricultural productivity on development, exploiting the recent introduction of GE soy in Brazil. We organize our work around three channels through which productivity growth in agriculture can foster structural transformation: increasing demand for industrial goods and services, releasing labor, and generating savings. In Bustos, Caprettini, and Ponticelli (2016) we study the second channel: we find that the new technology was labor-saving and induced a reallocation of labor away from agriculture into the local industrial sector. We also show that agricultural productivity growth had a limited impact on migration, indicating that the reallocation of labor primarily occurred within the local labor market. In this article, we focus on the third channel: the effect of agricultural productivity growth on savings and the allocation of capital. Consistent with higher mobility of capital relative to labor, we find that capital reallocated both across sectors and across regions. In particular, capital reallocated from the rural regions where agricultural productivity increased into the urban regions financially connected to them. The fact that capital reallocated to regions not directly affected by soy technical change allows us to separately identify the savings channel from the labor channel discussed above.[7] We quantify their relative importance in Section VIII.

The rest of the article is organized as follows. We start by presenting a theoretical framework to illustrate the effects of agricultural technical change on structural transformation in open economies in Section II. Section III describes the data and our empirical strategies. In Sections IV, V, and VI we present the main empirical results on the local effects of soy technical change, the reallocation of capital toward destination municipalities, and the reallocation of capital toward destination firms, respectively. Finally, we discuss the evidence in light of models in which credit constraints can affect the direction of capital flows in Section VII.

II. Theoretical Framework

Here we present a simple two-period and two-sector neoclassical model to illustrate the effects of agricultural technical change on structural transformation in open economies. The model builds on Jones (1965)'s version of the Heckscher-Ohlin model and the dynamic extensions studied by Stiglitz (1970), Findlay (1970), and Ventura (1997). The model also relates to the literature studying capital flows in the context of the Heckscher-Ohlin model (Mundell 1957; Markusen 1983; Antràs and Caballero 2009). We start by discussing the effects of technical change in a country that is open to goods trade but in financial autarky. Next we split the country into two regions—Origin (o) and Destination (d)—which are open to international trade. We investigate the effects of agricultural technical change in one of the regions, the Origin, on the allocation

7. This is because destination regions are only affected by agricultural technical change through its effects on capital inflows. Note that in the case of origin regions, both the labor channel documented in Bustos, Caprettini, and Ponticelli (2016) and the capital channel studied in this article are at play, so that the net effect on capital allocation is ambiguous. We discuss this in Section V.

of capital across regions and sectors under two scenarios: financial autarky and financial integration. In what follows we describe the setup and discuss the implications of the model. The formal setup of the model and all derivations are included in Online Appendix A.

II.A. Setup

Consider a small open economy where individuals only live for two periods and display log preferences over consumption in periods 1 and 2. There is one final good that can be used for consumption and investment. This final good is nontraded but is produced using two traded intermediates: a manufacturing good and an agricultural good. In turn, production of the manufactured and the agricultural intermediate goods requires both capital (K) and land (T). The supply of land is fixed for both periods, but the supply of capital can vary in the second period because of capital accumulation. We assume that capital can be turned into consumption at the end of each period, thus its price in terms of period 1 consumption, the numeraire, is equal to 1. Instead, land can only be used for production, thus its price fluctuates to equilibrate asset markets. Factors of production are internationally immobile, but freely mobile across sectors. All markets are perfectly competitive and production functions in the final and intermediate goods sectors satisfy the neoclassical properties.

II.B. Equilibrium

The intratemporal equilibrium in this model follows the mechanics of the 2×2 Heckscher-Ohlin model. Provided that the small open economy produces both goods, free-entry conditions in goods markets imply that factor prices are uniquely pinned down by international goods prices and technology, regardless of local factor endowments (Samuelson 1949).[8] In turn, the production structure is determined by relative factor supplies, which are predetermined in the first period but are the result of capital accumulation in the second one. We obtain a solution for savings and the capital stock in the second period by considering

8. See Online Appendix A, where we state the zero-profit conditions in the agricultural and manufacturing sectors, which can be used to solve for factor prices as a function of goods prices and agricultural technology. This result requires the additional assumption that there are no factor intensity reversals and is the factor price insensitivity result by Samuelson (1949).

the intertemporal equilibrium conditions in asset markets. Finally, we use the factor market–clearing conditions in each period to solve for the allocation of factors across sectors, manufacturing and agricultural outputs. See Online Appendix A.B for a formal statement of the equilibrium conditions.

II.C. Comparative Statics: The Effects of Agricultural Technical Change

In this section we discuss the effects of an increase in agricultural productivity brought by the adoption of a new technology. That is, we compare the equilibrium level of sectoral outputs in two scenarios. The first scenario is a benchmark economy that is in a steady-state equilibrium with constant technology, international goods prices, and consumption. The second scenario is an economy that adopts the new agricultural technology in period 1 but expects a reduction in the profitability of the new technology in period 2.[9]

1. Factor Prices. If agriculture is land intensive, agricultural technical change increases the return to land and reduces the return to capital.[10] This is because agricultural productivity growth raises the profitability of agricultural production. As a result, land rents must increase to satisfy the zero-profit condition in the agricultural sector. However, because manufacturing also uses some land, the increase in land rents reduces its profitability and the return to capital falls. Note that this reduction is expected to be small to the extent that the land cost share in manufacturing production is small. The mechanics of these effects are similar to the Stolper-Samuelson effect of changes in commodity prices on factor prices. Finally, note that the increase in land rents is larger in the first period because the profitability of the new technology falls in the second period.

9. This can be the case, for example, if the economy is an early adopter of an agricultural technology and international prices are expected to fall when all countries adopt. Alternatively, technology adoption can generate a (partially) temporary increase in income when environmental regulation is expected to become stricter in the future.

10. Agriculture is land intensive if the land production cost share in agriculture is larger than in manufacturing. In Online Appendix A.C.2 we show that in this case, capital per unit of land is higher in manufacturing than in agriculture.

2. The Supply of Capital. Agricultural technical change increases the supply of capital in the second period as long as the aggregate land income share is large relative to the land cost share in manufacturing. This is because the increase in land rents generates a temporary increase in income, which has a positive effect on savings. This positive effect is proportional to the land share of aggregate income, thus we expect it to be large in land-abundant rural areas. Second, the reduction in the rental price of capital has a negative effect on savings. As mentioned already, the reduction in the rental price of capital is small because it is proportional to the land cost share in manufacturing, thus this negative effect is expected to be small.

3. The Allocation of Capital Across Sectors. An increase in agricultural productivity has two opposite effects on capital allocation across sectors. A capital demand effect generates a reallocation of capital toward agriculture, the comparative advantage sector.[11] A capital supply effect, instead, generates a reallocation of capital toward manufacturing, the capital-intensive sector. Therefore, the net effect of agricultural technical change depends on the relative strength of the capital demand and capital supply effects.

The capital demand effect takes place because agricultural technical change increases the profitability of the agricultural sector and thus generates a reallocation of factors toward it, increasing the relative supply of agricultural goods. The effect of technical change on the the relative supply of agriculture depends positively on the supply elasticity of substitution between commodities. This is because an increase in agricultural productivity has a similar effect on the profitability of agriculture as an increase in the relative price of agricultural goods. In turn, this supply elasticity depends on the elasticity of substitution between land and capital in production. If this elasticity is low, when agricultural productivity increases and more capital is drawn into the agricultural sector, decreasing returns set in quickly. Thus, the increase in capital demand is small.

In turn, the capital supply effect takes place when agricultural technical change increases savings and the relative supply

11. This effect has been emphasized by the theoretical literature linking larger agricultural productivity to deindustrialization (Corden and Neary 1982; Matsuyama 1992).

of capital, which leads to an increase in the relative supply of manufacturing, the capital-intensive sector. This is because, given factor prices, capital intensities are fixed within each sector. The only way to equilibrate factor markets is therefore to assign the new capital to the capital-intensive sector as in the Rybczynski theorem (Rybczynski 1955).[12] As a result, the growth in the relative supply of manufacturing due to the capital supply effect is proportional to the increase in capital supply. As mentioned, the increase in capital supply is increasing in the land income share relative to the land cost share in manufacturing.

In sum, the capital supply effect tends to dominate when the agricultural productivity shock is temporary, the income share of agriculture is large, the land cost share is low in manufacturing, and land and capital are not good substitutes in production (see condition (A16) in Online Appendix A.C.3). In what follows, we assume that this condition holds in the benchmark equilibrium.

II.D. Capital Flows across Regions

We can use the model developed above to think about the consequences of financial integration across regions within a country. To simplify the exposition, suppose that the country has two regions, Origin (o) and Destination (d), which are open to international trade. The model can be used to analyze the effects of agricultural technical change in the Origin on capital accumulation and structural transformation in both regions. We discuss first the results obtained when both regions are in financial autarky and later the results under financial integration.

1. Financial Autarky. If the origin region is open to international trade but in financial autarky, agricultural technical change generates a reallocation of capital toward the local manufacturing sector. Note that in this case, the benchmark equilibrium and the effects of technical change are identical to those described in Sections II.B and II.C. In particular, when

12. This prediction only applies when goods are traded. In a closed economy, the effect of an increase in the supply of capital on structural transformation depends on the demand elasticity of substitution between goods and services. When these are complements, an increase in the supply of capital would generate faster output growth in the capital intensive-sector, a reduction in its price and a reallocation of capital toward non-capital-intensive sectors, as emphasized by Acemoglu and Guerrieri (2008).

agricultural productivity grows, land rents increase and the rental price of capital falls to the financial autarky equilibrium level (r_K^a). In addition, the supply of capital increases more than capital demand in agriculture. As a result, the capital-intensive sector, manufacturing, expands. Finally, note that the destination region is not affected by technical change in the origin region. This is because the origin region is a small economy, thus agricultural technical change in this region does not affect world prices.

2. Financial Integration. In this section we consider the case in which the two regions are not only open to international trade but also open to capital flows. First, note that the small open economy assumption implies that if both regions were open to international capital flows, technical change in the origin would not have any effect on the destination region. Then, we assume that the two regions are financially integrated but in financial autarky with respect to the rest of the world. This assumption attempts to capture deeper financial integration within than across countries. In addition, we assume that in the benchmark steady-state equilibrium all countries and regions share the same technology. Thus, trade in goods leads to factor price equalization at r_K^* and r_T^* if both regions produce both goods. In this case, capital owners are indifferent between investing in any of the two regions. Therefore, we assume that in the financial-integration equilibrium there is a small cost ε for capital movements across regions so that the equalization of the rental rate of capital at r_K^* implies that capital flows are 0 in the benchmark equilibrium. In this case, the benchmark equilibrium is the same under financial autarky and financial integration, which simplifies the analysis.

3. Origin Region. Under financial integration, agricultural technical change in the origin region generates local deindustrialization and capital outflows. First, as in the autarky equilibrium, the increase in agricultural productivity raises land rents. However, the rental rate of capital stays above the autarky equilibrium level because of capital mobility ($r_K^* > r_K^a$). This has two implications. First, the increase in land rents makes manufacturing production unprofitable and the sector closes. Thus, local aggregate capital demand falls even if agriculture demands more capital. Second, the temporary increase in land rents generates savings and an increase in capital supply. Thus, there are capital outflows. More generally, in Online Appendix A.D we show that capital outflows are increasing in agricultural productivity growth if the capital supply effect is larger than the capital demand effect (see condition (A21) in Online Appendix A.D.2)).

4. Destination Region. Finally, we consider a destination region that does not experience technical change. In this region factor prices stay at the level r_K^* and r_T^* given by initial technology and international goods prices. As a result, capital leaving the origin region can flow into the destination region without affecting the rental rate of capital. Instead, the destination region absorbs this additional capital by expanding production of the capital-intensive sector, manufacturing. This is because the destination region faces a pure Rybczynski effect with no changes in technology. In sum, this region experiences structural transformation as capital reallocates toward the manufacturing sector.

III. Empirics

Our empirical work aims at tracing the reallocation of capital from the rural agricultural sector to the urban manufacturing sector. This reallocation process takes place across sectors and regions, thus our empirical strategy proceeds in two steps, which we summarize below.

First, we attempt to establish the direction of causality, from agriculture toward other sectors. For this purpose, we exploit a large and exogenous increase in agricultural productivity: the legalization of GE soy in Brazil. We use this variation to assess whether municipalities more affected by technical change in soy production experienced larger increases in land rents and savings, as predicted by the model. We think of these soy-producing areas affected by technical change as origin municipalities, which can be described as small economies open to international trade in agricultural and manufacturing goods but closed to international capital flows, as required by the model. Under these assumptions, our empirical strategy captures the general equilibrium effect of agricultural technical change on land rents and savings in origin municipalities. This is because free trade pins down goods and factor prices. As a result, technical change in a given origin municipality does not affect outcomes such as land rents or savings in other municipalities. Then, our empirical strategy can quantify the local effects of agricultural productivity growth by comparing the growth rate of outcomes of interest across municipalities facing different growth rates of exogenous agricultural technical change. This reduced-form empirical strategy mimics the comparative-statics exercise performed in the model developed in Online Appendix A, which describes the general equilibrium response of each endogenous variable to exogenous agricultural technical change under autarky and financial integration.[13] Section III.A describes the context, data, and empirical strategy we use to study the local effects of soy technical change on land rents and savings deposits.

Second, we trace the reallocation of capital across regions. For this purpose, we need to estimate the effects of agricultural technical change on the supply of capital in regions not affected by technical change but financially integrated to affected regions. The model predicts that a destination region financially integrated with an origin region facing larger agricultural technical change experiences larger capital inflows and faster reallocation of capital toward manufacturing. In contrast, a destination region that is not financially connected to the soy area is unaffected by technical change in other municipalities, because goods and factor prices are pinned down by international goods prices. In Online Appendix B we extend the model to derive a generalized version of this prediction for the case of many regions (municipalities) with different levels of financial integration. To measure the degree of financial integration across municipalities, we exploit differences in the geographical structure of the branch networks of Brazilian banks. We think of these banks as intermediaries that can potentially reallocate savings from soy-producing (origin) municipalities to non-soy-producing (destination) municipalities.[14] We link

13. For a closed-form solution of the model showing the response of each endogenous variable to exogenous technical change see Online Appendix A, Section A.C for the financial autarky case and Section A.D.2 for the case of financial integration across regions.

14. We extend the model by introducing banks and many regions in Online Appendix B. As our main objective is to use banks to measure the degree of financial integration across regions, we do not explicitly provide microfoundations of the role of banks. Instead, we extend our model in the simplest possible way by assuming that banks are providers of a technology that permits them to reallocate capital across regions where the same bank has branches, in the same way as transportation technology permits trade in goods across regions connected by a road. The role of banks as intermediaries between investors and firms has been justified on the grounds of imperfect information leading to moral hazard or adverse selection problems. Diamond (1984) develops a theory of financial intermediation where banks minimize monitoring costs because they avoid the

each destination municipality to all origin municipalities within the same bank branch network to construct exogenous credit supply shocks at the destination-municipality level. We use this variation to assess whether municipalities financially connected to soy-producing regions through bank branch networks experienced larger increases in aggregate bank lending and in the share of nonagricultural loans. Section III.B describes the data and the empirical strategy to study capital reallocation across regions.

One concern with our identification of aggregate capital flows across regions is that destination municipalities that are more financially connected to origin municipalities might also be more connected through migration or commercial networks. In that case, our estimates could be capturing the effects of agricultural technical change in origin municipalities on bank lending in destination municipalities through a labor supply or a product demand channel, rather than the capital supply mechanism emphasized by the model. Thus, we conduct our analysis at a more micro level and trace the reallocation of capital toward firms located in destination municipalities. For this purpose, we use administrative data on the credit and employment relationships for the universe of formal firms operating in Brazil. We use this data to construct firm-level exposure to capital inflows from origin municipalities using information on preexisting firm-bank relationships. We use this variation to assess whether firms whose preexisting lenders are more financially integrated to soy-producing regions through bank branch networks experienced larger increases in borrowing and employment than other firms operating in the same destination municipality.[15] Section III.C describes the data and the

duplication of effort or a free-rider problem occurring when each lender monitors directly. Holmström and Tirole (1997) propose a model of financial intermediation in which firms as well as intermediaries are capital constrained due to moral hazard. Firms that take on too much debt in relation to equity do not have a sufficient stake in the financial outcome and will therefore not maximize investor surplus. In this case, bank monitoring acts as a partial substitute for collateral. However, banks also face a moral hazard problem and must invest some of their capital in a project to be credible monitors. This makes the aggregate amount of intermediary capital one of the important constraints on aggregate investment. In this model, an increase in savings generates an expansion of bank credit and investment.

15. Note that this empirical strategy requires that firms that have a preexisting relationship with a bank are more likely to receive credit. In Online Appendix B we extend the theoretical model by assuming that each bank can only lend to a subset of firms already connected to it. These long-term firm-bank relationships can be the result of asymmetric information. For example, in the

empirical strategy used to study capital reallocation toward firms in destination municipalities.

The empirical results for the three steps in the empirical strategy are presented in Sections IV, V, and VI, respectively. We note that when interpreting our estimates, we do not take the model literally because some assumptions are quite extreme. First, the model considers the case in which regions are financially integrated within Brazil but in financial autarky with respect to the rest of the world. This assumption is an extreme way to capture larger financial frictions across countries than within countries. In practice, some savings likely leak abroad. Second, the model considers the case in which there is no interbank market. This assumption is also an extreme way to capture larger financial frictions across than within banks. In practice, some savings might leak through the interbank market to municipalities not directly served by banks operating in soy-producing regions. Note, however, that these deviations from the model's assumptions make us underestimate the effect of agricultural technical change on savings, capital flows, and structural transformation in Brazil.

III.A. *Local Effects of Soy Technical Change: Data and Empirical Strategy*

We start this section by providing background information on the technological change introduced by GE soy seeds in Brazilian agriculture. Then we present the data and the empirical strategy used to study the effects of technical change in soy production on local land rents and savings.

The main innovation introduced by GE soy seeds is that they are genetically modified to resist a specific herbicide (glyphosate). This allows farmers to adopt a new set of techniques that lowers production costs, mostly due to lower labor requirements for weed control. 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

model developed by Sharpe (1990) a bank that actually lends to a firm learns more about that borrower's characteristics than other banks. In this model, adverse selection makes it difficult for one bank to draw off another bank's good customers without attracting the less desirable ones as well. Alternatively, long-term bank-borrower relationships can reduce borrower moral hazard through the threat of future credit rationing as in Stiglitz and Weiss (1983).

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 allow farmers to save on production costs, increasing profitability.

Our empirical strategy to study the local effects of soy technical change builds on Bustos, Caprettini, and Ponticelli (2016). In particular, we implement a difference-in-differences strategy that exploits the legalization of GE soy seeds in Brazil as a source of time variation and differences in the increase of potential soy yields due to the new technology across regions as a source of cross-sectional variation. The first generation of GE soy seeds was commercially released in the United States in 1996, and these seeds were legalized by the Brazilian government only in 2003. Therefore, in our empirical analysis we use the year of GE soy legalization in Brazil (2003) as the source of time variation.[16] In terms of cross-sectional variation, we exploit the fact that the adoption of GE soy seeds had a differential effect on potential yields in areas with different soil and weather characteristics. We obtain a measure of potential soy yields in different Brazilian regions from the FAO-GAEZ database. These yields are calculated by incorporating local soil and weather characteristics into an agronomic model that predicts the maximum attainable yield for each crop in a given area. Because potential yields are a function of weather and soil characteristics, and not of actual yields in Brazil, they can be used as a source of exogenous variation in agricultural productivity across geographical areas (see Figure I). Crucially for our analysis, the FAO-GAEZ database reports potential yields under different technologies or input combinations. Yields under "low" agricultural technology are described as those obtained using traditional seeds and no use of chemicals, while yields

16. The new technology experienced a fast pace of adoption. 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, 144). The Foreign Agricultural Service of the USDA, reports that by the 2011–12 harvesting season, GE soy seeds covered 85% of the area planted with soy in Brazil (USDA 2012). The legalization of GE seeds coincided with a fast expansion in the area planted with soy in Brazil. According to the Agricultural Census, the area planted with soy increased from 9.2 to 15.6 million hectares between 1996 and 2006. As shown in Figure I, soy area had been growing since the 1980s, but experienced a sharp acceleration in the early 2000s.

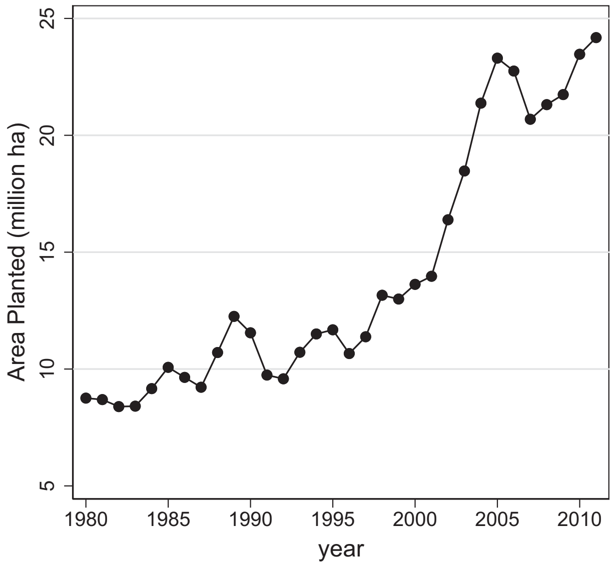

FIGURE I

Evolution of Area Planted with Soy in Brazil

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 farmers on the ground, agronomists, and financial agents in the main cities of the country.

under "high" agricultural technology are obtained using improved seeds, optimum application of fertilizers and herbicides, and mechanization. Figure II shows maps of Brazil displaying the measures of potential yields for soy under each technology. 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 expect this increase in potential yields to be a good predictor of the profitability of adopting GE soy seeds.

To test the model predictions on the effect of agricultural technical change on land rents and local capital supply, we estimate the following specification:

$$y_{jt} = \alpha_j + \alpha_t + \beta \log(A^{soy}_{jt}) + \varepsilon_{jt}, \quad (1)$$

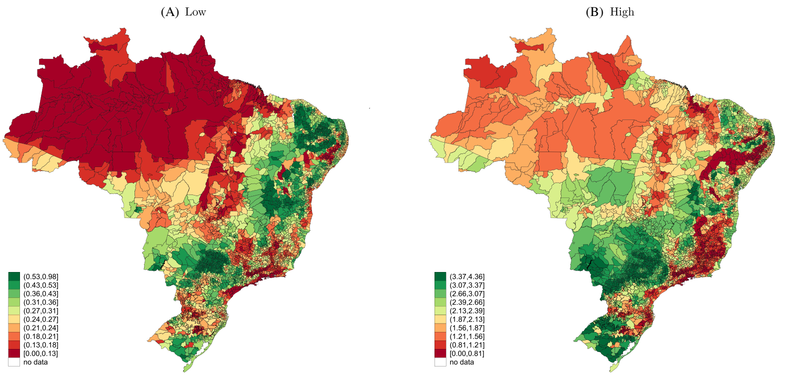

FIGURE II

Potential Soy Yield under Low and High Agricultural Technology

Data source is FAO-GAEZ. Units are tons per hectare.

where y_{jt} is an outcome that varies across municipalities (j) and time (t).[17] A_{jt}^{soy} is our measure of agricultural technical change in soy, defined as follows:

$$A_{jt}^{soy} = \begin{cases} A_j^{soy,LOW} & \text{for } t < 2003 \\ A_j^{soy,HIGH} & \text{for } t \geqslant 2003, \end{cases} \tag{2}$$

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 as reported in the FAO-GAEZ dataset. The timing of the change in potential soy yield from low to high inputs corresponds to the legalization of GE soy seeds in Brazil. In Online Appendix B we show how we derive this estimating equation from the model.

In our analysis of local effects of soy technical change, the main outcomes of interest are local land rents and savings. As a proxy of land rents we use agricultural profits per hectare as reported in the Agricultural Census of Brazil. Although the Agricultural Census includes farmers' expenses for the leasing of land into agricultural costs, 93% of agricultural land—and 76% of agricultural establishments—are farmed by the actual owners of the

17. Since borders of municipalities changed over time, in this article we use AMCs (minimum comparable areas) as our unit of observation. AMCs are defined by the Brazilian Statistical Institute as the smallest areas that are comparable over time. In what follows, we use the term *municipalities* to refer to AMCs.

land.[18] Therefore, the vast majority of land rents are included in agricultural profits.[19] As a proxy for local savings, we use deposits in local bank branches. The data on deposits are sourced from the Central Bank of Brazil ESTBAN data set, which reports balance sheet information at branch level for all commercial banks operating in the country. We use deposits and loans data at local level to construct a measure of capital outflow for each municipality, which is equal to $\frac{(\text{deposits}-\text{loans})}{assets}$. Table I reports summary statistics of the main variables of interest used in the empirical analysis.

Our difference-in-differences empirical strategy attempts to isolate the contribution of technical change in soy production to the increase in land rents and savings during the period under study. One potential concern with this strategy is that although the soil and weather characteristics that drive the variation in A_{jt}^{soy} across geographical areas are plausibly exogenous, they might be correlated with the initial levels of economic and financial development across Brazilian municipalities.[20] To address this concern, we add a set of baseline municipality-level controls interacted with year fixed effects to flexibly capture differential trends across municipalities with different initial characteristics during the period under study. In particular, we control for the initial share of rural population in all specifications. In addition, we control for income per capita, population density, and the literacy rate.

III.B. Capital Reallocation towards Destination Municipalities: Data and Empirical Strategy

In the second step of our identification strategy, we trace the reallocation of capital across regions. In this section, we explain how we use the structure of the bank branch network to trace the flow of funds from origin municipalities—soy-producing regions experiencing an increase in savings and capital outflows—to destination municipalities—regions not affected by soy technical change but financially integrated with origin municipalities.

18. See Agricultural Census of Brazil, IBGE (2006), Table 1.1.1, 176.

19. It is important to note that the measures of profits and investments as reported in the census refer to all agricultural activities, not only to soy.

20. See Table 5 in Bustos, Caprettini, and Ponticelli (2016) for a comparison of baseline characteristics across municipalities with different potential increases in soy yields.

TABLE I
SUMMARY STATISTICS

Variable	Mean	Std. dev.	N
Independent variables			
$\Delta log(A_{jt}^{soy})$	1.917	0.466	3,020
$log(A_{jt}^{soy})$	– 0.285	1.136	44,406
Municipality Exposure	– 0.041	0.242	44,406
Bank Exposure	0.069	0.198	1,052
Outcome variables at municipality level			
$\Delta \frac{GESoyArea}{AgriArea}$	0.015	0.064	3,020
ΔAgri profits per ha (pct points)	0.319	1.867	3,020
ΔAgri investment per ha (pct points)	0.475	1.042	3,020
ΔAgri productivity	0.504	0.695	3,020
log(deposits)	15.693	1.809	44,406
log(loans)	15.458	2.112	44,406
$\frac{\text{(deposits}-\text{loans)}}{\text{assets}}$	0.811	1.977	44,406
$\frac{\text{Nonagricultural loans}}{\text{total loans}}$	0.690	0.275	44,406
Bank credit participation	0.056	0.058	26,897
Outcome variables at loan level			
log(loan)			
All sectors	10.378	1.759	4,806,825
All sectors—multilender firms	10.677	1.829	2,821,990
Agriculture	11.426	2.064	36,148
Manufacturing	10.924	1.926	1,094,139
Services	10.195	1.652	3,450,876
Other	10.417	1.863	198,879
Outcome variables at firm level			
log employment			
All sectors	1.987	1.447	2,992,981
Agriculture	2.659	1.651	18,282
Manufacturing	2.594	1.450	587,290
Services	1.776	1.364	2,220,615
Other	2.703	1.664	130,732
log wage bill			
All sectors	8.278	1.692	2,992,981
Agriculture	8.952	1.856	18,282
Manufacturing	8.988	1.710	587,290
Services	8.036	1.593	2,220,615
Other	9.067	1.981	130,732

Notes. All variables are winsorized at 1% in each tail.

In the model presented in Section II, we consider the case of two regions: one origin and one destination. In the data, on the other hand, there are many regions (municipalities) and we can only observe capital flows that are intermediated through

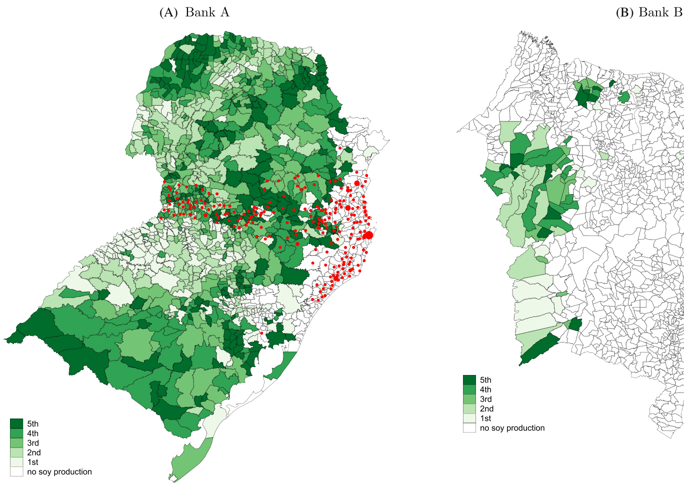

FIGURE III

Bank Networks and Increase in Soy Revenues

Red dots indicate bank presence in a given municipality, dot size captures number of bank branches in a given municipality. Green areas are soy-producing municipalities: darker green indicates larger percentage increase in soy revenues between the years before and after GE soy legalization (color version available online). Data sources are ESTBAN for bank branch location and the Municipal Agricultural Production survey (PAM) for revenues from soy production.

banks. To test the model's predictions, therefore, we adapt them to our empirical context. Online Appendix B extends the two-region model presented in Online Appendix A to the case of many regions financially integrated through banks. The objective of this exercise is to derive an empirical measure of destination municipality exposure to the GE soy–driven increase in deposits. This measure exploits differences in the geographical structure of bank branch networks to capture differences in financial integration across origin and destination municipalities. Destination municipality exposure is higher for municipalities served by banks that have branches in origin municipalities facing larger growth in potential soy yields.

Before describing how we construct the measure of municipality exposure in more detail, we illustrate the intuition behind it with an example. In Figure III we show the geographical location of the branches of two Brazilian banks with different levels of exposure to the soy boom. The figure reports, for each bank, the location of bank branches across municipalities (red dots) and the increase in area farmed with soy in each municipality during the period under study (where darker green indicates a larger increase; color version of figure available online). As shown, the branch network of bank A extends into areas that experienced a large increase in soy farming following the legalization of GE soy seeds. On the contrary, the branch network of bank B mostly encompasses regions with no soy production.[21] Therefore, non-soy-producing municipalities served by bank A are more exposed to a potential GE soy-driven increase in deposits than those served by bank B.

The first step in the construction of the measure of municipality exposure is to estimate the increase in national deposits of each bank due to technical change in soy production. For each bank b, national deposits can be obtained by aggregating deposits collected in all municipalities where the bank has branches:

$$Deposits_{bt} = \sum_{o \in O_{bt}} deposits_{bot}, \tag{3}$$

where $Deposits_{bt}$ are national deposits of bank b, $deposits_{bot}$ are local deposits of bank b in origin municipality o, and O_{bt} is the set of all origin municipalities where bank b has branches at time t. Note that this equation implies that the growth rate of national deposits for a bank is a weighted average of the growth rate of deposits in each of the municipalities where the bank has branches. In turn, in Online Appendix B.A we show that the growth rate of deposits in each origin municipality is a function of local agricultural productivity growth. This implies that the growth rate of national deposits for each bank is a weighted average of the growth rate of agricultural productivity in each of the origin municipalities where the bank has branches (see equation (A28)). In Online Appendix B.B we use this insight to obtain the following empirical specification linking aggregate deposits for each bank b

21. 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 area but our exogenous measure of potential increase in soy profitability, which only depends on soil and weather characteristics.

to the vector of potential soy yields in all municipalities:

$$\log Deposits_{bt} = \gamma_b + \gamma_t + \beta \underbrace{\left[\sum_{o \in O_b} \omega_{bo} \lambda_{TAo} \left(\log A_{ot}^{soy} \right) \right]}_{BankExposure_{bt}} + \eta_{bt}, \quad (4)$$

where γ_b and γ_t are bank and time fixed effects and η_{bt} is an error term capturing classical measurement error and other bank-level shocks to deposit growth not explicitly included in the model. We define the summation in brackets as our measure of bank exposure. The elements inside the summation are the empirical mapping of the model equation describing the growth in savings in the origin municipality as a function of local agricultural productivity growth (see equation (A26) in Online Appendix B). Note that this equation implies that deposit growth is faster in municipalities facing larger agricultural productivity growth, especially if the land income share is large. We measure agricultural productivity growth using the FAO-GAEZ potential yields of soy A_{ot}^{soy}. In turn, our proxy for the land income share is λ_{TAo}, the share of land employed by the agricultural sector in the initial year of our sample, which we source from the 1996 Agricultural Census. The weights ω_{bo} are the share of national deposits of bank b coming from origin municipality o in the initial period.[22]

Finally, we construct a measure of predicted capital flows to destination municipalities. In principle, banks could lend the funds raised through deposits in the national or in the international interbank market, in which case it would be hard for us to trace where the money goes. However, to the extent that there are frictions in the interbank market, banks are more likely to finance their loans with their own deposits. Thus, we can trace intranational capital flows by exploiting differences in the geographical structure of bank branch networks. Recall that, in the model, capital inflows do not generate changes in the return to capital in destination municipalities because free trade in goods implies that factor prices are pinned down by international goods

22. Focusing on the initial period ensures that we do not capture the opening of new branches in areas with faster deposit growth due to the new technology. These new openings are more likely to occur by banks that face larger demand for funds. Thus, focusing on the preexisting network ensures that we only capture an exogenous increase in the supply of funds.

prices. Thus, in our extension of the model to many municipalities, banks are indifferent between allocating capital across any destination municipality because these will absorb capital by expanding manufacturing output at a constant interest rate. Then, we can make the simple assumption that each bank responds to the growth in deposits by increasing the supply of funds proportionally in all destination municipalities where it has branches. Using this assumption, in Online Appendix B.A we show that the growth of credit in each destination municipality can be written as a weighted average of the growth rate of national deposits in each bank present in that destination municipality, which in turn is a weighted average of agricultural productivity growth in each origin municipality where the bank has branches.[23] The empirical counterpart of this measure of destination municipality exposure can be written as follows:

$$\text{(5)} \qquad \textit{Municipality Exposure}_{dt} = \sum_{b \in B_d} w_{bd} \textit{Bank Exposure}_{bt},$$

where weights w_{bd} capture the lending market share of bank b in destination municipality d and are constructed as the value of loans issued by branches of bank b in municipality d divided by the total value of loans issued by branches of all banks operating in municipality d (whose set we indicate with B_d) in the baseline year 1996. The weighting should capture the total exposure of destination municipality d to funds coming from origin municipalities through bank networks. Note that to link origin and destination municipalities, we assume that banks' 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 municipalities where a bank has branches. Figure IV shows the geographical distribution of our measure of municipality exposure. We present this measure separately for soy-producing regions, non-soy-producing regions, and all municipalities in Brazil.

The definition of municipality exposure in equation (5) captures the capital flow from origin municipalities exposed to soy technical change to a given destination municipality. The model predicts that destination municipalities more financially integrated with origin municipalities facing larger agricultural

23. See equation (A30) in Online Appendix B.A.

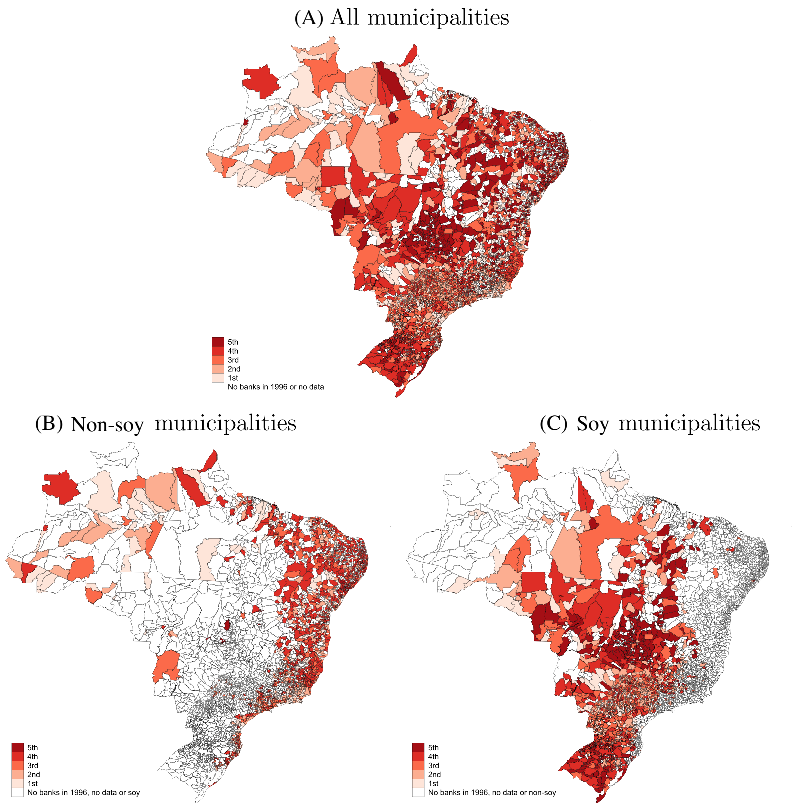

FIGURE IV

Destination Municipality Exposure

The maps show the geographical distribution of destination municipality exposure across Brazil. Destination municipality exposure is defined as in equation (5). Soy municipalities are those with positive soy production at any point in time between 1996 and 2010 according to the Municipal Agricultural Production survey (PAM).

technical change experience a larger increase in capital supply and faster reallocation of capital toward manufacturing. We test these predictions by estimating the following equation:

$$\log(loans_{dt}) = \alpha_d + \alpha_t + \mu Municipality\ Exposure_{dt} + \varepsilon_{dt}, \tag{6}$$

where $loans_{dt}$ are total loans originated by bank branches located in destination municipality d at time t, as observed in ESTBAN. Online Appendix B.B shows how to derive the equation as the empirical counterpart of equation (A30) in the model, which links changes in capital supply in the destination region to capital outflows from the origin region. In turn, capital outflows are a function of soy technical change and the land income share in origin regions.

Finally, let us note that during the second half of the 2000s, Brazil experienced a fast increase in nonagricultural bank lending, documented in Online Appendix Figure C8. Our empirical strategy attempts to isolate the contribution of technical change in soy production to the reallocation of capital towards nonagricultural activities during this period. One potential concern with this strategy is that destination municipality exposure is correlated with other contemporaneous shocks that might have contributed to the increase in the share of nonagricultural lending during this period. For example, other forces that might have contributed to the aggregate increase in the share of nonagricultural lending during the 2000s are the introduction of institutional reforms increasing creditors' protection (Assunçao, Benmelech, and Silva 2013; Ponticelli and Alencar 2016), favorable international commodity prices, or the increase in trade with China (Costa, Garred, and Pessoa 2016). To address this concern, in the next section we present an empirical strategy that exploits variation in exposure to capital accumulation from soy technical change across firms operating within the same destination municipality. This specification fully absorbs any macroeconomic forces that differentially affected Brazilian destination municipalities during the period under study.

III.C. Capital Reallocation toward Destination Firms: Data and Empirical Strategy

A potential concern with the identification strategy described in Section III.B is that destination municipalities that are more financially connected to origin municipalities might also be more connected through migration or commercial networks. In that case, our estimates could be capturing the effects of agricultural technical change in origin municipalities on bank lending in destination municipalities through a labor supply or a demand channel, rather than the capital supply mechanism described in the model. To make progress on this front, we conduct our analysis at a more micro level and trace the reallocation of capital toward firms located in destination municipalities.

In particular, we construct a measure of firm-level exposure to capital inflows from origin municipalities using information on preexisting firm-bank relationships. To construct this measure we match administrative data on the credit and employment relationships for the universe of formal firms operating in Brazil. Data on credit relationships between firms and financial institutions is sourced from the Credit Information System of the Central Bank of Brazil for 1997 to 2010.[24] The confidential version of the Credit Information System uniquely identifies the lender (bank) and the borrower (firm) in each credit relationship. This allows us to match data on bank-firm credit relationships with data on firm characteristics from the Annual Social Information System (RAIS). RAIS is an employer-employee data set that provides individual information on all formal workers in Brazil.[25] Using worker-level data, we constructed the following set of variables at the firm level: employment, wage bill, sector of operation, and geographical location.[26] One advantage of our data set is that we observe the universe of credit relationships and the universe of

24. The Credit Information System and ESTBAN are confidential data sets 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. The data set reports a set of loan and borrower characteristics, including loan amount, type of loan, and repayment performance. We focus on total outstanding loan amount, which 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. Unfortunately, data on interest rates are only available from 2004, after GE soy legalization.

25. Employers are required by law to provide detailed worker information to the Ministry of Labor. See Decree no. 76.900, December 23^{rd}, 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). For firms with 10 or more employees, RAIS covers, on average, 76.2% of firms with a juridical person fiscal code that are present in the Brazilian Business Registry (CEMPRE) during the period under study. It is important to note that our data on bank-firm relationships exclusively covers the formal sector, as firms need to have a tax identifier (CNPJ) to apply for a loan and need to make contributions to the social security system to be registered in the employer-employee data sets (RAIS).

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

formal firms.[27] That is, we observe firms with access to credit and firms that do not have access to credit. This allows us, for example, to study the evolution of credit market participation in Brazil. Online Appendix C.A presents a set of stylized facts on credit market participation between 1997 and 2010 that can be uncovered using our database. In particular, we show the different evolution in credit market participation among Brazilian firms of different sizes and operating in different sectors during the period under study.

We use our matched data set to construct firm-level exposure to credit supply shocks using information on preexisting firm-bank relationships. This allows us to assess whether firms whose preexisting lenders are more financially integrated to origin municipalities through bank branch networks experienced larger increases in borrowing and employment growth. This empirical strategy permits us to compare firms operating in the same destination municipality and sector but initially borrowing from different banks. Thus, it allows us to control for labor supply and product demand shocks in destination municipalities and to isolate the capital supply channel. More formally, we estimate the following equation:

$$\log(loans_{ibdst}) = \nu_i + \nu_b + \nu_{dt} + \nu_{st} + \mu Bank\ Exposure_{bt} + \varepsilon_{ibdst}. \tag{7}$$

This equation relates borrowing of firm i from bank b to the measure of bank exposure presented in equation (4). The subscript d indexes the destination municipality where the firm is located, and s the industry in which the firm operates.[28] Online Appendix B.B shows how to derive the equation above as the empirical counterpart of equation (A31) in the model, which links changes in loans from a given bank b to firm i in the destination region to capital outflows from origin regions in which the bank has branches. In turn, capital outflows are a function of soy technical change and the land income share in origin municipalities.

Firms' credit demand could grow because local firms face larger demand from richer soy farmers or larger labor supply

27. See also Bottero, Lenzu, and Mezzanotti (forthcoming) for a study that uses similar data sets for Italy.

28. Sector fixed effects are two-digit sectors according to the Brazilian CNAE 1.0 classification. Firms in our sample are present in 56 two-digit CNAE 1.0 sectors.

from former agricultural workers. A second and related concern is that different industries might be on differential growth trends because of other changes in the world economy, such as increased trade with China, or could be indirectly affected by GE soy legalization because they supply or buy inputs from the soy sector. To address these concerns, we include in equation (7) destination municipality fixed effects interacted with time fixed effects (ν_{dt}), and industry fixed effects interacted with time fixed effects (ν_{st}). Thus, this specification allows us to mitigate the concerns that our estimates could be capturing the effects of agricultural technical change in origin municipalities on bank lending in destination municipalities through a labor supply or a demand channel, rather than the capital supply mechanism described in the model.[29]

In addition to studying the effect of capital reallocation on firm borrowing, we are interested in assessing its real effects. In particular, we want to understand the extent to which firms use additional credit to finance growth-enhancing investments. These investments can take the form of expanding the use of capital, labor, or other inputs. Because in the RAIS data set we observe labor and the wage bill, we focus our analysis on these two inputs. However, 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 more employment and a larger wage bill. Thus, we analyze real effects through the following firm-level specification:

$$\log(L_{idst}) = \nu_i + \nu_{dt} + \nu_{st} + \lambda \textit{Firm Exposure}_{it} + \varepsilon_{idst}, \qquad (8)$$

where:

$$\textit{Firm Exposure}_{it} = \sum_{b \in B} \pi_{ib,t=0} \ \textit{Bank Exposure}_{bt.}$$

The variable L_{idst} denotes employment in firm i, located in destination municipality d, operating in industry s at time t. Our measure of firm exposure is defined as a weighted average of bank exposure of all lenders with which firm i had a credit relationship

29. All our results are robust to restricting our sample to firms operating in non-soy-producing municipalities (that is, municipalities that do not produce soy at any point during the period under study) and firms not operating in sectors directly linked to soy production through input-output linkages. These results are available from the authors on request.

in the pre GE-soy legalization period, which corresponds to 2001 and 2002 in the Credit Registry Data. The weights $\pi_{ib,\,t=0}$ correspond to the share of borrowing of firm i from bank b in 2001 and 2002 as a share of total borrowing of firm i in the same years. We use preexisting bank relationships to minimize the concern that endogenous formation of firm-bank relationships—which could result from a bank's exposure to the soy boom—might affect our results.[30]

IV. Local Effects of Soy Technical Change

We start by estimating the effect of local agricultural technical change on local land rents. In both the autarky and financial integration equilibrium, the model predicts that municipalities experiencing faster technical change should experience faster growth in land rents. As a proxy for land rents, we use agricultural profits sourced from the Agricultural Census. Because the Agricultural Census is released at intervals of 10 years, we focus on the last two waves (1996 and 2006) and estimate the following first-difference version of equation (1):

$$\Delta y_j = \Delta\alpha + \beta\Delta\log(A_j^{soy}) + \Delta\varepsilon_j. \tag{9}$$

where Δy_j is the decadal change in outcome variables between 1996 and 2006 and $\Delta\log(A_j^{soy}) = \log(A_j^{soy,HIGH}) - \log(A_j^{soy,LOW})$.

Table II, columns (1) and (2) show the results of estimating equation (9) when the outcome is agricultural profits per hectare.[31] The point estimate on $\Delta\log(A_{jt}^{soy})$ indicates that municipalities with a one standard deviation larger increase in soy technical change experienced a 10.7% larger increase in agricultural profits per hectare between 1996 and 2006. In

30. Note that this implies that we use the exposure of the pre-2003 lenders for all years in which a firm is present in our sample, no matter whether the firm is borrowing from those lenders in the years after GE soy legalization. Since the set of lenders used to construct this measure is defined in the initial period and is constant for each firm, the bank fixed effects ν_b are effectively absorbed by firm fixed effects ν_i in this specification.

31. Using a similar identification strategy, Bustos, Caprettini, and Ponticelli (2016) show that municipalities more exposed to soy technical change experienced higher adoption of GE soy seeds and higher agricultural productivity growth in the period between 1996 and 2006. We replicate these results for the sample of municipalities studied in this article in Table C1 of the Online Appendix.

TABLE II
SOY TECHNICAL CHANGE AND AGRICULTURAL CENSUS OUTCOMES AGRICULTURAL PROFITS, AND INVESTMENT PER HECTARE

Outcome	Δ Profits per ha (%)		Δ Investment per ha (%)	
	(1)	(2)	(3)	(4)
$\Delta \log A^{soy}$	0.259***	0.229***	0.181***	0.214***
	[0.071]	[0.079]	[0.044]	[0.048]
rural pop$_{t=1991}$	y	y	y	y
AMC controls$_{t=1991}$		y		y
Observations	3,020	3,020	3,020	3,020
R-squared	0.004	0.014	0.014	0.018

Notes. The outcomes in this table are sourced from the Agricultural Censuses of 1996 and 2006. We thus estimate a first-differenced version of equation (1): $\Delta y_j = \Delta\alpha + \beta \Delta \log(A_j^{soy}) + \Delta\varepsilon_j$, where the outcome of interest, Δy_j is the change in outcome variables between the last two census years and $\Delta \log(A_j^{soy}) = \log(A_j^{soy,HIGH}) - \log(A_j^{soy,LOW})$. Robust standard errors are reported in brackets. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. The variable rural pop is the share of the rural adult population in an AMC according to the 1991 population census. AMC controls include: income per capita (in logs), population density (in logs), and the literacy rate, all observed in 1991 (source: population census). AMC stands for minimum comparable area (*Área Mínima Comparável*).

principle, extra agricultural profits could have been reinvested in agriculture, channeled into consumption, or into savings. We start by studying the effect of soy technical change on agricultural investment in columns (3) and (4). The estimated coefficient on $\Delta \log(A_{jt}^{soy})$ is positive and significant, indicating that the municipalities more exposed to soy technical change experienced larger increases in investment in agriculture. The magnitude of the estimated coefficient in column (4) is similar to the effect on agricultural profits per hectare. However, agricultural profits per hectare are three times larger than investment per hectare in the 1996 Agricultural Census baseline. Thus, taken together, these coefficients imply that for every R$10 increase in profits per hectare due to soy technical change, only around R$3.45 are reinvested in agricultural activities. Then, we observe that agricultural productivity growth generates an increase in capital demand in agriculture as predicted by the model. However, growth in agricultural profits is larger than investment, so there is a surplus that could be used to increase consumption or savings to finance investment in other sectors or regions.

Next we estimate the effect of local agricultural technical change on local savings. In both the autarky and financial-integration equilibrium, the model predicts that municipalities experiencing faster technical change should experience faster growth in capital supply. To test this prediction, we estimate equation (1) where the outcome variable is the log of the total value of bank deposits in bank branches located in municipality j.[32] We define bank deposits as the sum of deposits in checking accounts, savings accounts, and term deposits as reported by the ESTBAN dataset of the Central Bank of Brazil. Results are reported in Table III, columns (1) and (2). The estimates indicate that municipalities with a larger increase in soy technical change experienced a larger increase in local bank deposits during the period under study. The magnitude of the estimated coefficient in column (2) indicates that a municipality with a one standard deviation higher increase in soy technical change experienced a 3.3% larger increase in bank deposits in local branches.[33]

We also investigate the timing of the effect of soy technical change on bank deposits, in particular whether it is consistent with the legalization of GE soy seeds in 2003. To this end, we estimate a version of equation (1) in which we allow the effect of $\Delta \log(A_j^{soy})$ to vary over time. Figure V plots the time-varying estimated coefficients on $\Delta \log(A_j^{soy})$ and 90% confidence intervals when the outcome variable is the log of deposits in local bank branches. As shown, the timing of the effect is consistent with the timing of the legalization of GE soy seeds. There are no preexisting trends in the years 1996 to 2001—the magnitude of the point estimates is close to 0 and not statistically significant—and there are positive effects of soy technical change on local deposits afterward.[34] We find, however, that the effect starts in 2002, one

32. Note that when estimating equation (1) we focus on the average effects of soy technical change on deposits. That is, we do not take into account the heterogeneous effects predicted by the model depending on the land income share in each municipality. This is to keep these results directly comparable with those on agricultural outcomes presented in Table II. We will take into account differences in land income shares across municipalities when computing our measure of bank exposure in the next step.

33. In additional results reported in Table C2 of Online Appendix C, we decompose the effect of soy technical change on deposits into three different types: checking, savings, and term deposits accounts. One potential concern is that areas more affected by the soy boom experienced an increase in the use of formal banking due to the higher amount of transactions linked to growing soy production rather than an increase in actual savings. As shown in Table C2, the growth in deposits triggered by soy technical change was concentrated in savings deposits.

34. These results also imply that our estimates do not capture a delayed response to the trade liberalization that occurred at the beginning of the previous decade in areas with different initial agricultural intensity, as studied by

TABLE III

LOCAL EFFECTS OF SOY TECHNICAL CHANGE: DEPOSITS, LOANS, AND CAPITAL OUTFLOWS

Outcome	log (deposits)		log (loans)		$\frac{deposits-loans}{assets}$	
	(1)	(2)	(3)	(4)	(5)	(6)
$\log A^{soy}$	0.060***	0.070***	−0.077***	−0.061**	0.305***	0.297***
	[0.016]	[0.016]	[0.029]	[0.029]	[0.062]	[0.065]
AMC FE	y	y	y	y	y	y
Year FE	y	y	y	y	y	y
Rural $\text{pop}_{t=1991}$ × year FE	y	y	y	y	y	y
AMC $\text{controls}_{t=1991}$ × year FE		y		y		y
Observations	44,406	44,406	44,406	44,406	44,406	44,406
R-squared	0.975	0.976	0.951	0.951	0.711	0.713
N clusters	3,145	3,145	3,145	3,145	3,145	3,145

Notes. Standard errors clustered at the AMC level are reported in brackets. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. The variable rural pop is the share of the rural adult population in an AMC according to the 1991 population census. AMC controls include: income per capita (in logs), population density (in logs), and the literacy rate, all observed in 1991 (source: population census).

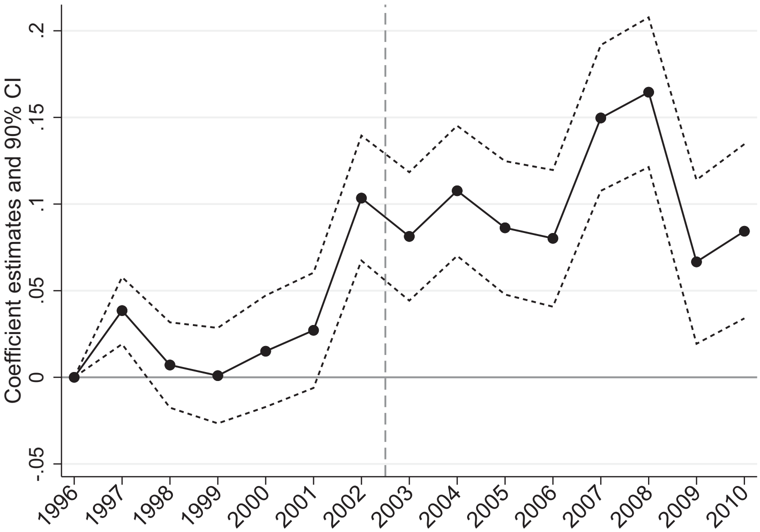

FIGURE V

Timing of the Effect of Soy Technical Change on Deposits

The graph reports the time-varying estimated coefficients β_t, along with their 90% confidence intervals from the following equation:

$$\log deposits_{jt} = \alpha_t + \alpha_j + \sum_{t=1996}^{2010} \beta_t \Delta \log \left(A_j^{soy}\right) + \varepsilon_{jt}.$$

where

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

The excluded year is 1996. The estimated coefficients are net of AMC controls interacted with time fixed effects as in Table III, column (4). AMC controls include share of rural adult population, income per capita (in logs), population density (in logs), and the literacy rate, all observed in 1991 (source: population census). Standard errors are clustered at the AMC level.

year before the official legalization of GE soy seeds. This is consistent with the timing of the expansion in the area planted with

Dix-Carneiro and Kovak (2017). In particular, Dix-Carneiro and Kovak (2017) find long-run negative effects of tariff cuts on formal employment and earnings and show that tariff cuts were smaller in the agricultural sector relative to other sectors. By showing that soy technical change has no effect on bank deposits until the early 2000s, Figure V addresses the concern that the long-lived dynamics of the trade liberalization of the early 1990s has a confounding effect on our results.

soy documented in Figure I. This figure documents a break in the trend of the expansion of the area planted with soy starting in 2002, which might respond to the contraband of soy seeds from Argentina (USDA 2003).

Next we estimate equation (1) when the outcome variable is the total value of loans originated by bank branches located in municipality j.[35] The results are reported in Table III, columns (3) and (4) and show that municipalities with higher increase in soy technical change experienced a decrease in bank loans originated by local branches. Taken together, the results reported in columns (2) and (4) suggest that municipalities with a larger increase in soy technical change experienced an increase in deposits and a decrease in loans, thus becoming net exporters of capital. Indeed, the model predicts that municipalities with faster agricultural productivity growth experience capital outflows if the capital supply effect is larger than the capital demand effect and they are financially integrated with other regions. To test the model prediction more formally, in Table III, columns (5) and (6) we estimate equation (1) when the outcome variable is capital outflow, defined as total value of deposits minus total value of loans originated by bank branches located in municipality j, divided by total assets of the same branches. As shown, we find a positive and precisely estimated coefficient on $\log(A_j^{soy})$, which indicates that municipalities with a higher increase in soy technical change experienced a larger net increase in capital outflows through the formal banking sector during the period under study.[36]

35. Note that the total value of loans includes loans to both individuals and firms, which we cannot separate in ESTBAN. We observe three major categories of bank loans: 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 microenterprises, among others; and specific-purpose loans, which includes loans with a specific objective, such as export financing, or acquisition of vehicles. The ESTBAN data do not allow us to distinguish between loans to individuals and loans to firms. Also, we cannot distinguish loans to different sectors with the exception of rural loans, which are loans directed to individuals or firms operating in the agricultural sector.

36. Note that if the land endowment was not fixed, higher land rents would give rise to incentives to expand the supply of land. This could increase the demand for capital in agriculture, resulting in capital inflows in the soy-producing municipalities. We test this prediction in Online Appendix Table C3. First, in column (1), we show that municipalities with a one standard deviation larger increase in soy technical change were 6 percentage points more likely to experience an expansion

V. Capital Reallocation toward Destination Municipalities

The results presented in Section IV show that adopting new agricultural technologies in soy production generates more profits than investments in the agricultural sector, as well as capital outflows from origin municipalities. This suggests that the capital supply effect dominates the capital demand effect. In this case, our theoretical framework predicts that destination municipalities financially integrated with origin municipalities facing larger agricultural technical change should experience both larger capital inflows and faster reallocation of capital toward manufacturing.

In this section we test these predictions. We focus on two main outcome variables: the total level of bank lending and the share of bank lending to nonagricultural sectors in destination municipalities. These two outcomes capture, respectively, capital inflows and capital reallocation toward manufacturing in the model. Table IV reports the results of estimating equation (6) with these two outcomes. We find that municipalities served by banks that were more exposed to the soy-driven deposit growth through their branch network experienced a larger increase in bank lending. Recall from the discussion in Section III.B that our measure of municipality exposure is a (weighted) average of the exposure of the banks operating in that municipality. Our estimates then imply that a destination municipality with a one standard deviation higher increase in exposure is a municipality whose banks experienced, on average, a 4 percentage points faster annual growth in national deposits due to soy technical change in the post-GE soy legalization period (2003–2010).[37] The magnitude of the estimated coefficient reported in Table IV,

in agricultural land (the average probability is 36%). Next, in columns (2) and (3) we separately estimate the effect of soy technical change on capital outflows for municipalities that experienced an increase in land endowment (Frontier) and for those that did not (Non-Frontier). Soy technical change has a positive effect on capital outflows in both samples, with point estimates being smaller in Frontier municipalities, as predicted by the model.

37. To obtain this number we multiply a standard deviation in the increase in municipality exposure (0.18) by our estimate of the effect of bank exposure on deposit growth at the bank level—that is, the coefficient β in equation (4), which we estimate in Table V to be 1.75—and then divide this product by the number of years in the post-GE soy legalization period for which data are available (2003–2010). Note also that one standard deviation in the annual growth rate of bank deposits across Brazilian municipalities in the post-GE soy legalization period was 23.1%.

TABLE IV
CAPITAL REALLOCATION ACROSS MUNICIPALITIES: LENDING AND NONAGRICULTURAL LENDING SHARE

Outcome	log(loans)			$\frac{\text{Nonagricultural loans}}{\text{Total loans}}$		
	All	Soy region	Non-soy region	All	Soy region	Non-soy region
	(1)	(2)	(3)	(4)	(5)	(6)
MunicipalityExposure$_{dt}$	0.283***	0.054	0.580***	0.090***	0.046*	0.139***
	[0.090]	[0.124]	[0.131]	[0.016]	[0.024]	[0.023]
AMC FE	y	y	y	y	y	y
Year FE	y	y	y	y	y	y
Rural pop$_{t=1991}$ × year FE	y	y	y	y	y	y
AMC controls$_{t=1991}$ × year FE	y	y	y	y	y	y
Observations	44,406	22,550	21,856	44,406	22,550	21,856
R-squared	0.952	0.949	0.953	0.843	0.846	0.779
N clusters	3,145	1,565	1,580	3,145	1,565	1,580

Notes. Standard errors clustered at the AMC level are reported in brackets. Significance levels: *** $p < .01$, **$p < .05$, * $p < .1$. The variable rural pop is the share of the rural adult population in an AMC according to the 1991 population census. AMC controls include: income per capita (in logs), population density (in logs), and the literacy rate, all observed in 1991 (source: population census).

column (1) indicates that a municipality whose banks had a 4 percentage points faster annual growth in deposits due to soy technical change experienced a 0.7 percentage points faster annual growth in bank lending in the post-GE soy legalization period.[38]

If banks were to operate in financial autarky and could only invest in loans, these should grow at the same rate as deposits. However, banks can lend to individuals and firms abroad or invest funds in assets other than loans. Thus, we expect deposits and loans not to grow at the same rate. In addition, the existence of an interbank market implies that some of the capital outflow from origin regions might flow to destination regions that are not directly connected via bank branches. Thus, the coefficients presented in Table IV are likely to underestimate the true effect of soy technical change on capital inflows in destination municipalities.

Next, in Table IV, columns (2) and (3), we split the sample into soy-producing and non-soy-producing municipalities.[39] Each of these groups accounts for around half of the observations used in column (1). The estimated coefficient in the soy-producing sample is positive but small (0.054) and not statistically significant, whereas the estimated coefficient on the non-soy-producing sample is 10 times larger (0.580) and strongly significant. These results indicate a reallocation of capital toward non-soy-producing regions, as predicted by the model when the capital supply effect is larger than the capital demand effect in soy-producing regions.

We then study whether this increase in lending has been directed toward agricultural or nonagricultural sectors. Because rural loans are observable in the ESTBAN data set, we use as the outcome variable the share of bank loans to sectors other than

38. To obtain this number, we multiply one standard deviation in the increase in municipality exposure (0.18) by the estimated coefficient in Table IV, column (1), and then divide this product by the number of years in the post-GE soy legalization period for which data are available (2003–2010). Note that taken together, our estimates imply that a destination municipality connected to a set of origin municipalities experiencing a (weighted average) 1% increase in bank deposits due to agricultural technical change will face a 0.16% increase in loans. As shown in Online Appendix B.B.3, this elasticity of 0.16 can be obtained by dividing the coefficient μ in equation (6) by the coefficient β in equation (4). Empirically, this elasticity can be obtained by dividing the estimated coefficient in Table IV, column (1) by the estimated coefficient in Table V, column (4). Table V studies the relationship between national deposits of bank b and the increase in aggregate deposits for the same bank that is predicted by our measure of bank exposure.

39. Non-soy-producing municipalities are those with no agricultural area farmed with soy at any point in time between 1996 and 2010.

agriculture. As shown in column (4) we find that municipalities that are more financially integrated with soy-producing regions experienced a larger increase in nonagricultural lending as a share of total lending: 1.7 percentage points for a one standard deviation difference in the increase in municipality exposure. This effect is present in both soy-producing and non-soy-producing regions, although largely concentrated in the latter, as shown in columns (5) and (6).[40]

The findings discussed above are consistent with the capital supply mechanism emphasized by the model: agricultural technical change can increase savings in soy-producing regions and lead to capital outflows towards non-soy-producing regions where capital reallocates toward the capital-intensive sector, manufacturing. Our empirical analysis permits us to quantify this effect by comparing the speed of capital reallocation across sectors in non-soy-producing municipalities with different degrees of financial integration with the soy boom area. During the period under study (1996–2010), the share of nonagricultural lending increased from 74.6% to 83.5% in the average non-soy-producing municipality. However, the degree of capital reallocation away from agriculture

40. The estimates reported in Table IV are representative for the average Brazilian municipality and not the aggregate Brazilian economy. To obtain estimates of the elasticity of capital reallocation to soy-driven deposit growth that are representative of a municipality with similar characteristics as the aggregate economy we weight observations by aggregate bank lending in the initial period. These estimates are reported in Online Appendix Table C4, columns (5) and (6). As shown, the point estimate of the effect of soy technical change on nonagricultural lending is similar in magnitude when weighting by initial bank lending (it increases only marginally from 0.090 to 0.111). This is consistent with the effects presented in Table IV being driven by urban municipalities, which represent the majority of bank lending in Brazil as a whole. In the same Online Appendix Table C4 we also show that the main results on the effect of soy technical change on agricultural profits per hectare and on capital outflows are robust to weighting municipalities by their relative importance in terms of the relevant aggregate quantities. Note that in the case of origin regions, the mechanism emphasized in Bustos, Caprettini, and Ponticelli (2016) and the mechanism emphasized in this article are at play. First, the labor-saving new technology generates a reallocation of labor toward manufacturing, increasing the demand for capital in this sector. Second, agricultural productivity growth reinforces the comparative advantage in agriculture, inducing capital to reallocate toward this sector. As a result, the net effect on capital allocation across sectors in origin municipalities is ambiguous. The findings in Table IV are consistent with these two opposing effects being at play in origin regions. In particular, we find some evidence of capital reallocation toward nonagricultural sectors in soy-producing regions, but these effects are small compared with those observed in financially connected non-soy-producing regions, which only experience the capital supply effect.

varied extensively across municipalities. One standard deviation in the change in the share of nonagricultural lending across non-soy-municipalities is 24 percentage points. Our estimates imply that the differences in the degree of financial integration with the soy boom area can explain 11% of the observed differences in the increase in the nonagricultural lending share across non-soy-producing municipalities.[41]

Overall, the results presented in Table IV are consistent with the predictions of the model and indicate that new agricultural technologies can generate structural transformation in regions not directly affected by such technologies. Two caveats with this specification are in order. First, this specification does not allow us to distinguish the direct effect of capital reallocation from the labor supply or product demand channels of agricultural productivity growth. For example, destination municipalities served by more exposed banks might also be better connected to soy-producing regions through transportation or migrant networks. Therefore, in Section VI, we use an identification strategy that aims at identifying the capital supply channel separately from other channels using loan-level and firm-level data. Second, the ESTBAN data set used to construct the agricultural and nonagricultural lending shares used as outcomes in this section includes lending to both firms and individuals. This has the advantage of capturing loans to farmers who take personal loans to invest in their farm, but the disadvantage of also including mortgages and other personal consumption loans. Therefore, in Section VI, we use loan-level data to more precisely identify credit flows to firms in different sectors.

VI. Capital Reallocation toward Destination Firms

In this section we bring the analysis to the firm level and study how increases in bank deposits due to soy technical change affected capital supply to firms in destination municipalities. We proceed as follows. First, we document that our measure of bank exposure predicts aggregate deposit growth at the bank level. Then we study whether firms that are more financially integrated with origin municipalities through their preexisting banking relationships experienced larger growth in borrowing and employment.

41. That is, one standard deviation in our measure of municipality exposure explains 11% of a standard deviation in the increase in the nonagricultural lending share across non-soy-producing municipalities.

TABLE V
BANK DEPOSITS AND BANK EXPOSURE

Outcome	log deposits			
	(1)	(2)	(3)	(4)
Bank Exposure$_{bt}$	1.427**	1.664***	1.580**	1.750**
	[0.587]	[0.562]	[0.761]	[0.688]
Log assets$_{b,\,t=0}$ $\times t$		−0.012		−0.010
		[0.010]		[0.012]
$\frac{\text{Deposits}}{\text{Assets}_{b,t=0}} \times t$			−0.085	−0.068
			[0.140]	[0.151]
Bank FE	y	y	y	y
Year FE	y	y	y	y
Observations	1,052	1,052	1,052	1,052
R-squared	0.913	0.913	0.913	0.913
N clusters	121	121	121	121

Notes. Standard errors clustered at the bank level are reported in brackets. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Regressions are weighted by total bank assets in 1996. Bank controls are observed in 1996 (source: ESTBAN) and interacted with linear time trends.

VI.A. Bank Exposure and Aggregate Deposits

We start by testing the relationship between aggregate deposits of bank b and the increase in aggregate deposits for the same bank that is predicted by our measure of bank exposure. Table V reports the results of estimating equation (4) when the outcome variable is aggregate deposits of bank b, and bank-year observations are weighted by initial bank size (assets). Aggregate deposits for each bank are obtained summing branch-level deposits. The point estimate on *Bank Exposure* is positive and significant, which indicates that banks that are more exposed to soy technical change through their branch network experienced a higher increase in aggregate deposits. The magnitude of the estimated coefficient reported in column (1) is 1.43. It indicates that a 1% increase in aggregate deposits of bank b predicted by the change in the vector of potential soy yields corresponds to a 1.43% increase in actual national deposits of the same bank. In other words, changes in our measure of predicted deposits are associated with changes in actual deposits of similar magnitude.[42]

42. We think that one reason our estimate of β is larger than one is that our measure of bank exposure is a first-order approximation to changes in aggregate deposits holding the bank branch network constant. Thus, changes in the bank branch network are in the error term. It is very likely that the soy boom might

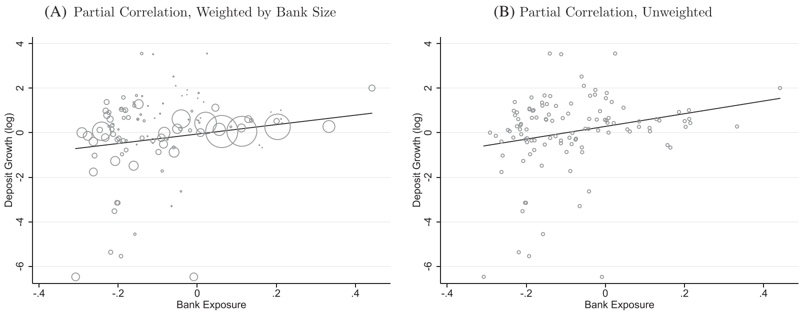

FIGURE VI

Bank Deposits and Bank Exposure

The graphs show the partial correlations between changes in bank exposure and changes in log deposits at the bank level. Changes are computed after averaging bank exposure and log deposits for each bank before (2001–2002) and after (2003–2010) the legalization of GE soy seeds. Bank exposure and log deposits are averaged after partialing out year fixed effects, as well as the log of bank assets and deposit-to-asset ratio (both observed in 1996) interacted with linear time trends. This is therefore equivalent to a first-differenced version of equation (4). The results of estimating equation (4) in levels are reported in Table V, column (4). In these graphs we focus on bank exposure values (after partialing out fixed effects and bank controls) between −0.5 and +0.5. This is for a more transparent visualization of the data and has negligible effects on the slope of the regression. The estimated slope using the same 121 banks as in Table V is 1.81 (t-stat = 2.25), whereas if we focus on bank exposure values between −0.5 and +0.5 (N = 114), the estimated slope is 2.12 (t-stat = 2.44). Panel B reports the unweighted version of Panel A.

Columns (2) to (4) show that this effect is not driven by differential growth trends across banks with different initial characteristics. Finally, in Figure VI, Panels A and B, we report partial correlations between changes in bank exposure and changes in the log of aggregate deposits at the bank level, weighting and without weighting by initial bank size, respectively.[43] As shown, our estimates are not driven by extreme observations or weighting by bank size.

have led banks to open new branches, which capture deposits. Thus, our measure of bank exposure might underestimate the effect of the soy shock on aggregate deposits.

43. This is equivalent to a first-differenced version of equation (4) obtained after partialing out year fixed effects and bank initial characteristics interacted with linear time trends and then averaging bank exposure and log deposits for each bank in the years before (2001–2002) and after (2003–2010) the legalization of GE soy seeds.

TABLE VI
THE EFFECT OF BANK EXPOSURE ON LOANS

Outcome	log loan			
			Multilender	
	(1)	(2)	(3)	(4)
Bank Exposure$_{bt}$	0.257**	0.290***	0.280**	0.228**
	[0.124]	[0.108]	[0.108]	[0.095]
Fixed effects				
Firm	y	y	y	y
Year	y	y	y	y
Bank	y	y	y	y
AMC × year		y	y	y
Sector × year		y	y	y
Firm × year				y
Observations	4,806,825	4,806,825	2,821,990	2,821,990
R-squared	0.549	0.554	0.536	0.664
N clusters	115	115	115	115

Notes. Standard errors clustered at the bank level are reported in brackets. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sector dummies correspond to the 87 two-digit sectors according to the Brazilian CNAE 2.0 classification.

VI.B. Bank-Firm Level Specification

We study the effect of bank exposure on firm borrowing from that same bank.[44] Table VI shows the results of estimating equation (7) when the outcome variable is the log of the monetary value of the outstanding loan balance of firm i from bank b. We start by estimating a specification with firm, bank, and time fixed effects. The estimated coefficient on the variable *Bank Exposure* is positive, indicating that firms with preexisting relationships with more exposed banks experienced a larger increase in borrowing from those banks. In column (2) we add municipality and sector fixed effects, both interacted with time fixed effects. Note that we find similar point estimates when controlling for municipality-time and industry-time fixed effects, which should capture any labor supply or product demand shocks

44. To minimize sample selection, we focus our analysis at the firm-level on the period 2001–2010, that is, the years after the reporting threshold of the Credit Registry was lowered to 5,000 BRL. As shown in Figure C4 of the Online Appendix, in 2001 only around 7% of Brazilian firms had access to finance when using the 50,000 BRL reporting threshold. In the same year, 31% of Brazilian firms had access to finance under the 5,000 BRL reporting threshold.

affecting firms that operate in the same destination municipality or industry. This suggests that the increase in firm borrowing is driven by the capital supply effect of agricultural technical change and not labor supply or product demand shocks.

We can quantify the effect of the soy-driven increase in bank deposits on firm borrowing as follows. The estimated coefficient in column (2) indicates that firms with a preexisting relationship with a bank experiencing a 4 percentage points faster deposit growth due to soy technical change experienced a 0.7 percentage points faster annual growth in borrowing in the post–GE soy legalization period. Note that the magnitude of this effect is similar to the one documented in Table IV using municipality-level data. This suggests that our municipality-level measure of total bank lending captures lending to firms well, and that our effects are driven by the intensive rather than the extensive margin of bank lending.

In column (4) we augment equation (7) with firm fixed effects interacted with time fixed effects. This specification fully captures firm-specific demand shocks, and only exploits variation across banking relationships of the same firm to identify the coefficient on bank exposure (Khwaja and Mian 2008). As a consequence, it can only be estimated using firms with multiple lending relationships in both the pre– and the post–GE soy legalization period. The estimated coefficient is positive, which implies that firms connected to banks with larger exposure to the soy boom increased their borrowing from those banks but not from other banks with whom they also had a relationship. The magnitude of the estimated coefficient is similar to that obtained without firm-time fixed effects on the same sample of firms. This indicates that the effect of bank exposure on firm borrowing is driven by credit supply forces rather than unobservable firm-specific demand shocks correlated with lender exposure.

Next we study the effect of bank exposure on loans by sector of operation of the borrowing firm. To this end, we estimate equation (7) separately for borrowers operating in agriculture, manufacturing, services, and other sectors.[45] Table VII reports

45. 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.

TABLE VII
THE EFFECT OF BANK EXPOSURE ON LOANS BY SECTOR

Outcome	log loan			
	Agriculture (1)	Manufacturing (2)	Services (3)	Other (4)
Bank Exposure$_{bt}$	0.204	0.304**	0.282***	0.226
	[0.168]	[0.153]	[0.099]	[0.170]
Fixed effects				
Firm	y	y	y	y
Year	y	y	y	y
Bank	y	y	y	y
AMC × year	y	y	y	y
Sector × year	y	y	y	y
Observations	36,148	1,094,139	3,450,876	198,879
R-squared	0.678	0.584	0.526	0.589
N clusters	86	114	115	99

Notes. Standard errors clustered at the bank level are reported in brackets. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sector dummies correspond to the 87 two-digit sectors according to the Brazilian CNAE 2.0 classification.

the results. We find positive coefficients for firms in all sectors. The effects are precisely estimated for firms in manufacturing and services, but are not statistically significant for agriculture and other sectors. The magnitude of the estimated coefficients is largest in the manufacturing sector (0.304) and smallest in the agricultural sector (0.204). Taking into account differences in average loan size and the number of loans across sectors in the pre–GE soy legalization period, these estimates indicate that out of 1 R$ of new loans in destination municipalities from the soy-driven deposit shock, 1.3 cents were allocated to firms in agriculture, 50 cents to firms in manufacturing, 39.7 cents to firms in services and 9 cents to firms in other sectors.[46]

46. This quantification is obtained as follows. First, we multiply the estimated coefficient on bank exposure by the average loan size in 2001 and 2002 in each sector. This gives us the estimated increase in loan size for the average loan in each sector, in response to a unit increase in exposure of the main lender of the borrower. Second, we multiply this estimate by the average number of loans to firms operating in each sector in the years 2001 and 2002. This multiplication gives us an estimate of the total increase in the value of loans of firms in each sector in response to a unit increase in exposure of their lenders. Finally, we use these estimates of total increase in loan value in each sector to compute the allocation across sectors of 1 R$ of new loans from the soy-driven deposit shock.

To sum up, we showed that firms that were more financially integrated with origin municipalities through their preexisting banking relationships experienced a larger increase in borrowing from those banks. Second, capital flowing from origin to destination municipalities due to soy technical change was mostly allocated to firms operating in the nonagricultural sectors (manufacturing and services). These findings are obtained exploiting variation across firms within destination municipalities, and support the interpretation of the municipality-level results presented in Section V as resulting from the capital supply channel.[47]

VI.C. Firm-Level Specification: Real Effects

Finally, we study the effect of firm exposure to soy technical change through preexisting bank relationships on firm growth. To this end, we estimate equation (8). We focus on two main outcome variables: employment, defined as the log of the yearly average number of workers; and the wage bill, defined as the log of the monetary value of the firm's total wage bill.

The results are reported in Table VIII. We find that the increase in credit had positive real effects. Firms whose preexisting lenders had a larger exposure to the soy-driven deposit increase experienced a larger growth in employment and their wage bill.[48] Next we estimate the same equation by sector of operation of each firm. Table IX reports the results. As shown, the average effects of firm exposure on firm size are positive and similar in size in

47. By construction, equation (7) focuses on firms with preexisting banking relationships. In Online Appendix Table C5 we study the effect of capital accumulation on credit market participation (extensive margin) using the municipality-level exposure measure described in equation (5). Overall, we find positive but small effects of municipality exposure on the share of firms with access to credit. These effects are concentrated in micro and small firms (under 10 employees) operating in non-soy-producing municipalities.

48. In contrast with the loan estimates discussed in Section VI.B, we find that our estimated real effects decrease in magnitude when we control for municipality and sector-level shocks. To the extent that labor and capital are complements in production, labor supply and local demand shocks should affect firm borrowing and employment similarly. One potential explanation for this difference is that firms receiving a product demand shock can expand in terms of employment but cannot borrow more, due to credit constraints. In other words, while changes in credit supply significantly affect firm borrowing, changes in credit demand (driven by, for example, an increase in local product demand) might not translate into more bank credit as seamlessly.

TABLE VIII

THE EFFECT OF FIRM EXPOSURE ON FIRM-LEVEL OUTCOMES: EMPLOYMENT, AND THE WAGE BILL

Outcome	log employment		log wage bill	
	(1)	(2)	(3)	(4)
Firm Exposure$_{it}$	0.269***	0.159***	0.417***	0.214***
	[0.047]	[0.043]	[0.057]	[0.046]
Fixed effects				
Firm	y	y	y	y
Year	y	y	y	y
AMC × year		y		y
Sector × year		y		y
Observations	2,992,981	2,992,981	2,992,981	2,992,981
R-squared	0.878	0.882	0.898	0.902
N clusters	115	115	115	115

Notes. Standard errors clustered at the main-lender level are reported in brackets. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sector dummies correspond to the 87 two-digit sectors according to the Brazilian CNAE 2.0 classification.

agriculture, manufacturing, and services, although they are small and not statistically significant for firms operating in other sectors. These estimates, along with differences in the average firm size and number of firms in each sector, can be used to compute the allocation of extra workers across sectors for a given increase in firm exposure. Our estimated coefficients indicate that out of 100 additional workers in destination municipalities due to the soy-driven deposit shock, 1.9 were employed in agriculture, 39.9 in manufacturing, 54 in services and 4.2 in other sectors. To sum up, our results indicate that reallocation of capital from origin to destination municipalities had real effects on employment, and these effects were concentrated in the manufacturing and services sectors.

VII. THE ROLE OF CREDIT FRICTIONS

Our empirical results highlight the importance of credit frictions. In particular, if there were no frictions in the interbank market, regions served by banks with branches in the soy-producing area would not face larger increases in credit supply. Similarly, if there were no frictions in firm-bank borrowing, firms

TABLE IX
THE EFFECT OF FIRM EXPOSURE ON FIRM-LEVEL OUTCOMES, BY SECTOR EMPLOYMENT AND THE WAGE BILL

Outcome	log employment (1)	log wage bill (2)
Agriculture	0.163	0.230**
	[0.105]	[0.111]
Observations	18,282	18,282
R-squared	0.927	0.937
N clusters	70	70
Manufacturing	0.212***	0.322***
	[0.052]	[0.056]
Observations	587,290	587,290
R-squared	0.888	0.911
N clusters	111	111
Services	0.152***	0.191***
	[0.042]	[0.043]
Observations	2,220,615	2,220,615
R-squared	0.870	0.891
N clusters	112	112
Other	0.023	0.095
	[0.056]	[0.070]
Observations	130,732	130,732
R-squared	0.941	0.949
N clusters	85	85
Fixed effects in all specifications		
Firm	y	y
Year	y	y
AMC × year	y	y
Sector × year	y	y

Notes. Independent variable: *Firm Exposure*$_{it}$. Standard errors clustered at the main-lender level are reported in brackets. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. AMC stands for Minimum Comparable Area (*Área Mínima Comparável*). Sector dummies correspond to the 87 two-digit sectors according to the Brazilian CNAE 2.0 classification.

with preexisting relationships with more exposed banks would not face a larger increase in credit than other firms operating in the same municipality and sector.[49] The presence of these frictions

49. Several empirical papers in the banking literature have provided evidence consistent with the existence of financial frictions in the interbank market. In particular, these studies have documented a positive correlation between loan growth and liquidity shocks from deposit growth (Gilje, Loutskina, and Strahan 2016; Gilje 2017) or monetary policy (Kashyap and Stein 2000). Similarly, a large empirical literature in corporate finance has documented the stickiness in bank-firm relationships—which is consistent with the existence of financial frictions

suggests that the allocation of capital across sectors, regions, and firms might not be optimal. As a result, the direction of capital flows might be driven by credit constraints and not by the capital supply effect emphasized in our model. In this section we discuss how the presence of credit frictions can modify the predictions of the model and the interpretation of the empirical results.

First, in the presence of credit constraints, the allocation of capital across sectors, regions, and firms might not be optimal. Note that this is not the case within the context of our model. In particular, consider the extension of the model presented in Online Appendix B.A where we incorporate interbank market frictions by assuming that each bank can reallocate capital only across regions where it has branches.[50] The predictions of the model are not affected by the inclusion of this type of credit friction because the return to capital is equalized across regions thanks to free trade in goods. Thus, banks are indifferent between allocating capital across any destination municipality, which will absorb capital flows by expanding manufacturing output at constant interest rates. Similarly, introducing constraints in firm-bank borrowing in our model is inconsequential because firms are homogeneous and face constant returns to scale, thus the size of firms is indeterminate. This implies that in the context of our model, credit frictions can help us empirically identify the capital supply effect but do not imply capital misallocation. However, in models with trade costs, increasing returns, or firm heterogeneity, credit constraints imply that the allocation of capital across sectors, regions, and firms might not be optimal, as we discuss below.

In our model, agricultural productivity growth generates capital outflows from rural areas because it reduces the autarky

from asymmetric information—using credit registry data from both developed and developing countries, including the United States (Chodorow-Reich 2014), Italy (Bottero, Lenzu, and Mezzanotti forthcoming), Portugal (Iyer et al. 2013), China (Cong et al. 2019), and Pakistan (Khwaja and Mian 2008). Finally, note that our empirical results also highlight the importance of international capital market imperfections. See Gourinchas and Rey (2014) for a review of the relationship between changes in domestic savings and investment.

50. See Online Appendix B.A. The role of banks as intermediaries between depositors and firms has been justified due to their advantage in monitoring firms in the context of asymmetric information (Diamond 1984; Holmström and Tirole 1997). Because our main objective is to use banks to measure the degree of financial integration across regions, we do not explicitly provide microfoundations of the role of banks here.

interest rate, thus capital optimally flows toward the urban manufacturing sector. However, the international finance literature has shown that the presence of credit constraints can reverse the direction of capital flows relative to the prediction of neoclassical models. In particular, Gertler and Rogoff (1990) showed that when borrowing requires the use of wealth as collateral, autarky interest rates might be lower in capital-scarce regions than in capital-abundant ones, even if the marginal product of capital is higher. To the extent that financial markets are less developed in rural than in urban regions, this mechanism might explain why we observe capital outflows from rural areas.

Let us consider the setup in Song, Storesletten, and Zilibotti (2011), to assess to what extent the alternative mechanism discussed above can explain our results. In particular, suppose that the new technology can only be adopted by rural entrepreneurs who do not have access to credit. When the technology arrives, rural entrepreneurs adopt it and use the profits to reinvest and rent land from land owners. Land owners cannot invest, thus they save their rents in local banks, which do not lend money locally because entrepreneurs with high returns are credit constrained. As a result, local banks lend to the manufacturing sector, which is concentrated in urban areas with less credit frictions. In this case, the direction of capital flows is reversed by credit constraints and the allocation of capital across regions and sectors is not optimal. We think this alternative explanation does not fit the data studied in this article for two reasons. First, 93% of Brazilian agricultural land was farmed by their owners in 2006 (see discussion of Agricultural Census in Section III.A). This implies that rural producers who adopt GE soy are the beneficiaries of the increase in land rents. Thus, there is no separation between those who can save and those who can invest in the new technology, as required by the international finance models discussed above. Second, soy technical change increases agricultural profits per hectare three times more than it increases investment per hectare (see Table II). This suggests that rural producers who adopt GE soy are not credit constrained, because if they were they would reinvest a larger share of their profits. Then, the evidence appears inconsistent with the idea that capital outflows from the rural agricultural sector to the urban industrial sector were the result of credit constraints in agriculture.

The evidence discussed here suggests that the reallocation of capital away from agriculture into manufacturing and from soy-producing to non-soy-producing municipalities was an optimal response to agricultural technical change because it generated an increase in the supply of savings larger than the induced demand for capital in agriculture. However, this does not imply that the allocation of capital across destination municipalities or manufacturing firms is optimal. In particular, it is possible that municipalities connected to the soy-producing area through bank branch networks had a lower marginal product of capital than nonconnected municipalities. Similarly, it is possible that firms connected to banks with branches in the soy-producing area were less productive than other firms operating in the same sector and municipality. The simplest way to measure the extent of misallocation is to estimate the marginal product of capital, using the exogenous credit supply shocks we construct in our empirical strategy. This requires data on outputs, whereas we only observe labor inputs in the social security data. Thus, we leave this interesting question for future work.

VIII. Concluding Remarks

The literature on structural transformation has underlined three main channels through which productivity growth in agriculture can foster structural transformation: increasing demand for industrial goods and services, releasing labor, and generating savings that are reinvested in industrial projects. In Bustos, Caprettini, and Ponticelli (2016), we exploit the recent introduction of GE soy in Brazil to document that when new agricultural technologies are labor-saving, they can induce a reallocation of labor from agriculture to manufacturing. We also document that this effect primarily occurred within the local labor market. This article contributes to this broad research agenda by providing evidence on the capital channel of structural transformation.

Taken together, the evidence presented in the two papers indicates that both the labor and the capital channels had a significant impact on structural transformation in Brazil. We think it is important to discuss the relative importance of these two effects for the aggregate economy. This can be done by estimating a simple specification similar to equation (12) in Bustos, Caprettini, and Ponticelli (2016), where the outcome variable is the decadal change in manufacturing employment share at the municipality level between 2000 and 2010. We regress this outcome on our measure of local labor-saving agricultural technical change (which captures the labor channel) and on our measure of municipality exposure to the soy-driven deposit shock (which captures the capital channel).[51] Because we are interested in estimating these effects for a municipality with characteristics similar to the aggregate Brazilian economy, we weight observations by the share of aggregate employment. We find point estimates that are positive, of similar magnitude, and statistically significant for both channels of structural transformation. To quantify the relative importance of the labor and capital channels we multiply the two estimated coefficients by the (weighted) average of the respective explanatory variables. Our estimates imply that a municipality with the same characteristics as the Brazilian aggregate economy and with average exposure to the GE-soy-driven growth in agricultural productivity experienced a 2 percentage points larger increase in the manufacturing employment share between 2000 and 2010. We find that approximately 80% of this increase is driven by the labor channel and 20% is driven by the capital channel of structural transformation. The magnitude of the capital channel is likely to be a lower bound of the true effect because it does not take into account the capital reallocation occurring through the interbank market.

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Supplementary Material

An Online Appendix for this article can be found at *The Quarterly Journal of Economics* online. Data and code replicating tables and figures in this article can be found in Bustos, Garber, and Ponticelli (2020), in the Harvard Dataverse, doi:10.7910/DVN/AIKECP.

51. The measure of local labor-saving technical change is ΔA_j^{soy} used in Bustos, Caprettini, and Ponticelli (2016), while the measure of municipality exposure to the soy-driven deposit shock is reported in equation (5) in this article. This specification also includes all municipality controls included in equation (12) in Bustos, Caprettini, and Ponticelli (2016), which are technical change in maize production, share of rural population, log income per capita, log population density, and the literacy rate, all observed at the municipality level and sourced from the 1991 population census.

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