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Modernization of production in the agricultural sector is a critical driver of economic development. However, it can generate conflictual claims on previously uncontested land. This paper shows that the expansion of commercial farming induced by a market-oriented reform and technological innovation increased land conflict since the mid-1990s in Brazil. We find mechanisms involving the decline of economic opportunities for the rural poor: the reduction of informally accessible land for traditional farmers, the loss of employment for rural workers and the rise in land inequality. Moreover, suggestive evidence indicates that agricultural modernization strengthened the landless movement's political incentive to engage in land disputes. *JEL* Codes: D74, J43, O13, P14, P16, Q15.

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Modernization of production in the agricultural sector is a critical driver of economic development. The shift from subsistence to commercial farming creates surpluses, stimulating growth. In turn, increased income can reduce conflict by raising the opportunity cost of violence (Collier and Hoeffler, 2004; Chassang and Padró i Miquel, 2009). However, the development of a modern agricultural sector could also generate conflictual claims on previously uncontested land. First, the expansion of the agricultural frontier into subsistence areas might lead to conflict with traditional farmers in the absence of a well-defined tenure system. Second, technological innovations in commercial areas, by substituting capital to labor, may reduce labor demand, therefore displacing rural workers. As a consequence, these groups could resort to the occupation of private land for subsistence purposes. Processes of agricultural modernization might therefore lead to contradictory results, both inducing high productivity gains while fostering conflict by depriving rural population from access to productive assets.

While conflicts over property rights as an obstacle to investments and growth have received much attention by economists, both in historical contexts (North, 1981; Mokyr, 1992; Acemoglu, Johnson, and Robinson, 2001; Hornbeck, 2010) and in developing countries (Besley, 1995; Alston, Libecap, and Mueller, 1999; Goldstein and Udry, 2008), how agricultural modernization might lead to tenure conflicts has been mainly confined to the historical literature on land enclosures (Neeson, 1996; Tilly, 2015). However, during the last three decades, developing countries experienced a strong expansion of commercial farming, leading to a 30% increase in cultivated land, a 70% rise in labor productivity, and a 24% decline in the share of employed labor.[1] How this process of agricultural modernization affects conflict is unclear. We contribute to this debate by estimating the effect of the expansion and intensification of capital-intensive agriculture on land conflict.[2]

We answer this question by studying the Brazilian soy sector. We focus on Brazil because, in 1995, the government introduced a market-oriented reform opening the country's economy to foreign investments and incentivizing agricultural production. We concentrate on soy for two reasons. First, since the production of soy is the most capital-intensive activity in Brazilian agriculture,[3] and given the invention of

[1]Data on the increase in land cultivated in developing countries are from the OECD-FAO Agricultural Outlook database. Measures of labor productivity and employment are from the World Bank's database (DataBank Microdata) and refer to the Least Developed Countries.

[2]Capital-intensive is defined compared to the average agricultural good in Brazil. Capital includes land and excludes labor among the factors of production.

[3]As shown in Table A.1, the production of soy in Brazil employed, on average, 28.6 workers per 1,000 hectares in 1996, a substantially lower number than for any other agricultural activity (IBGE,

the labor-saving genetically engineered (GE) soy seed in 1996 (Bustos, Caprettini, and Ponticelli, 2016), investments in the soy sector are likely to induce a substitution between capital and labor. Second, since the 1990s, soy has become one of the fastest expanding crops internationally, and therefore was likely the most reactive to the market reform: between 1990 and 2010, the share of global farmland devoted to soy has increased by more than 80%, while prices did not decline (Figures A.1 and A.2), pointing to a strong global demand for soy in the period.

Leading these global trends, Brazil experienced a sharp expansion of soybean production, which more than doubled in only ten years.[4] Along with this large increase in agricultural production, the country experienced a surge in land conflicts. Between 1988 and 2014, around 1.3 million families participated in more than 9,000 land occupations, while the yearly number of these occurrences increased fourfold since 1996 (Figure 1). The social cost of this phenomenon is reflected in the around 1,700 land dispute-related deaths in the same period.[5]

To establish the causal effect of agricultural modernization on land conflict, we rely on the timing of the market reform and the invention of GE soy, together with the exogeneity of local potential gains from investments in soybean production (soy potential gains). First, in 1995, the market reform increased the incentive to invest in Brazilian agriculture by abolishing the legal discrimination against Brazilian firms with foreign capital. Second, in 1996, the invention of GE soy further boosted the gains from investments in soy production. Given the international demand for soybean, these changes induced a sharp capital inflow in the soybean sector (Figure 2) and the expansion of soybean production. We then compute local potential gains from investments in soy production, exploiting variation in soil and weather characteristics at the municipal level. To measure these gains, we rely on Bustos, Caprettini, and Ponticelli (2016) and compute, for each municipality, the difference in the potential yields obtained under a regime of high- and low-tech inputs in soybean production. We capture local changes in the return from investments in soy production induced by the GE soy invention and the market reform using the interaction between a post-1995 indicator and soy potential gains.

To measure the relative contribution of the market reform and the GE soy inven-

1996).

[4]Brazil produced 46,195,843 tons of soy grains in 2006 (IBGE, 2006) and 21,588,199 in 1996 (IBGE, 1996). Although the Agricultural Census of 1995/1996 was conducted in both years, we always refer to 1996 for simplicity.

[5]Information is from the Pastoral Land Commission (*Comissão Pastoral da Terra*, CPT), presented in Section 2.

tion in explaining the effect on land occupations, we exploit differences in potential gains from investments in soy production due to the soil and climatic characteristics required for the cultivation of the two varieties of soybean seeds: while GE soy is suitable at high latitudes, with fertile land and moist climate, the local non-GE variety can also be grown at low latitudes, with poor soil and dry weather.

Our identification strategy relies on one key assumption: parallel trends in the number of land occupations after 1995 across municipalities with different soy potential gains in the absence of the agricultural modernization process spurred by the market reform and the GE soy invention. We take several steps to investigate the plausibility of this assumption. First, we find no differential trends in the number of land occupations across municipalities with different soy potential gains before 1996. Second, we control for the interaction between pre-treatment levels of several municipal characteristics and year fixed effects, allowing us to exclude that variables correlated with potential gains from soy production trigger the land occupations' onset after 1995. Third, we control for potential gains from investment in maize production interacted with the indicator of the post-1995 period. Because maize production involves a large number of workers per hectare (Table A.1), this control allows us to abstract from labor-intensive agricultural investments (Bustos, Caprettini, and Ponticelli, 2016), helping us to nail down the specific characteristics of soybean production that explain the estimated results.

To further test the robustness of our identification strategy, we proceed as follows. First, we show that the area planted with soy (soy area) is positively correlated with the number of land occupations and that areas where soybean did not expand do not show a relationship between soy potential gains and land occupations. In addition, we exploit the timing of the first year in which soy production is observed at the municipal level in a staggered difference-in-difference and confirm that, also in this specification, soy expansion predicts land occupations. Results are unchanged when focusing on geographic units larger than a municipality, when using alternative measures of land occupations, when including additional controls or when restricting the sample to rural municipalities. Last, we show that the effect on land occupations is not driven by the trade liberalization process of the 1990–1995 period (Dix-Carneiro and Kovak, 2017) or by changes in soy prices over time.

Our main results show that potential gains from soybean production induced an increase in land occupations starting from 1996. Around 60% of this effect is due to the market reform alone. Moreover, we find a reported increase in soybean-cultivated area starting in the following year, consistent with the hypothesis that land occupations are caused by conflicts between local peasants and prospective soybean producers. On average, an additional standard deviation in soy potential gains led to a 54% increase in the number of land occupations in the post-1995 period. These findings are supported by the anecdotal evidence discussed in Section C and are in line with the intensification of soy production occurring in municipalities with higher soy potential gains over the same period—an increase in mechanization, use of fertilizers and industrial use of the crop.

To understand why the expansion of capital-intensive agricultural production led to an escalation of land occupations, we explore three central hypotheses. First, we study whether the expansion of commercial farming in subsistence areas threatened traditional farmers' access to land. Our results indicate that soy potential gains induced an increase in censused farmland and a decline in pasture area. Since Brazilian pastures and areas outside the reach of the census are inhabited by local population relying on informal land access, this finding is evidence of a growth in land unavailable to traditional farmers. We also document an effect on indigenous occupations in indigenous land and forest areas. Because of the indigenous reliance on forestry and natural resources in indigenous land, these effects provide evidence of the decline of informally accessible land as a mechanism and reassure against the possibility that individuals move across municipalities in search of land to occupy.

Second, we explore the hypothesis that agricultural intensification led to land consolidation, thereby reducing employment opportunities. By decreasing the operating costs of agribusiness, the market reform may have facilitated access to credit and new technologies for large farms, raising the capital intensity of production and reducing the smaller labor-intensive farms' ability to survive. Consistent with this hypothesis, soy potential gains explains an increase in the number and size of the largest farms, a contraction of the smallest ones, and a specialization in soy production at the top of the size distribution. Overall, these economic transformations, coupled with the introduction of the labor-saving GE soy seed, led to a decline in the employment opportunities in the agricultural sector.

Third, in line with the hypothesis that targeting locations associated with expanding large farms is a viable political strategy for landless social movements, we find that the effect on land occupations is twice as strong in municipalities with higher shares of large estates. This result suggests that the political motives linked to the landless struggle against agribusiness played a role in pushing social movements to organize land occupations in areas where soy production was expanding. Finally, in Section F, we discuss why the increase in land value is unlikely to be a driver of land occupations.

This paper contributes to several strands of the literature. First, we relate to the extensive literature on the economic determinants of conflict. While this literature has mostly focused on transitory income shocks, such as weather or price changes affecting agricultural output (Miguel, Satyanath, and Sergenti, 2004; Hidalgo, Naidu, Nichter, and Richardson, 2010; Dube and Vargas, 2013; McGuirk and Burke, 2020), input (Berman, Couttenier, and Soubeyran, 2021) or lootable goods (Berman, Couttenier, Rohner, and Thoenig, 2017), this paper focuses on a structural aspect of economic development—the modernization of the agricultural sector through investments in capital-intensive farming. In this regard, we are close to the literature on the social unrest induced by agricultural mechanization in nineteenth-century England (Hobsbawm and Rudé, 1969; Caprettini and Voth, 2020). We add to these works by analyzing the ongoing process of agricultural modernization in developing countries and by pinning down the mechanisms through which positive income shocks lead to conflict.[6]

Second, our results contribute to the literature on the relationship between property rights and conflict. Most empirical work has shown that weakly enforced property rights induce conflict, notably Fetzer and Marden (2017) in the Brazilian Amazon and Mueller (2020) in the Brazilian indigenous land. Our results, instead, highlight the decline of informally accessible land as a motive for conflict. In this regard, our paper is close to the theoretical literature analyzing the social consequences of the decline in commonly owned, open, and informally accessible land, both in economics (Platteau, 1992; André and Platteau, 1998) and other social sciences (Hobsbawm, 1974; Scott, 1977).

Our study also contributes to the literature on the relationship between inequality and conflict. While several works indicate a positive relationship between inequality and conflict (Esteban and Ray, 2011), numerous scholars suggest otherwise. On the one hand, economic inequality is associated with a high value of appropriable assets and a large number of individuals with a low opportunity cost of rebellion, suggesting a positive connection with conflict. On the other hand, in context of extreme wealth inequality, the elite might be able to command resources to repress redistributive efforts (Olson, 1971; Acemoglu and Robinson, 2006), while the poor, in severe indigence, might be unable to challenge the *status quo* (Sen, 1997). Models based on contest success functions consistently find that equal access to resources

[6]Our findings are consistent with theoretical works linking the expansion of capital-intensive sectors to conflict (Dal Bó and Dal Bó, 2011).

leads to higher levels of conflict (Hirshleifer, 1991; Skaperdas, 1992; Grossman and Kim, 1995). The net effect of inequality on conflict is therefore ambiguous. In the context of Brazil, Hidalgo, Naidu, Nichter, and Richardson (2010) find a positive role of land inequality in explaining why transitory income shocks lead to land occupations. Albertus, Brambor, and Ceneviva (2018) argue that land inequality decreases conflict if landowners are able to organize their collective action, as in the case of sustained threat to property by the landless. Our paper shows that structural economic adjustments might affect tenure disputes by increasing land inequality.

Finally, this paper relates to the literature on the social consequences of agricultural modernization. The literature has shown the effect of new agricultural technologies on structural transformation (Bustos, Caprettini, and Ponticelli, 2016), the prevalence of large farms and employment loss (Deininger and Byerlee, 2012; Nolte and Ostermeier, 2017), and highlighted the negative distributional consequences of the rise of agribusiness on small farmers (Dhingra and Tenreyro, 2021). We relate to this literature and show that agricultural investments may lead to land conflict by displacing traditional farmers and rural workers.

The remainder of the paper is organized as follows. Section 1 describes the Brazilian context. Section 2 presents the data. Section 3 outlines the empirical strategy. Section 4 presents the main results. Section 5 discusses the potential channels driving our main results. Section 6 concludes.

1 Land Occupations and Agricultural Modernization

1.1 Brazilian Land Conflict

Brazil has one of the world's most unequal land distributions (FAO, 2010). In 2006, landholdings over 1,000 hectares accounted for 0.91% of the total and made up 45% of farmland, while landholdings less than 10 hectares represented 47% of the total, and occupied less than 2.3% of the agricultural area (IBGE, 2006).[7] This high level of land concentration has been in part inherited from the colonial period (Fausto and Fausto, 2014) and in part aggravated by the absence of a clear framework for land property regulation. The resulting lack of information on large estates and the common illegally declared private estates on public land, indigenous land, and conservation units (Reydon, Fernandes, and Telles, 2015) contributed to the rise of land concentration between 1960 and 2006 documented by the FAO (Gómez, 2014).

[7]Figure A.4 provides an overview of land inequality in Brazil in 1996 and 2006.

While the high level of land inequality has made land reform a critical issue in Brazilian politics, no systematic process of land redistribution has ever been put in place. This context saw the development of peasant movements advocating for land reform. Although operating at least since the 1950s, peasant movements intensified their activities starting in the late 1970s, in conjunction with the rise of national organizations pushing for land redistribution.[8] The development of political activity by the landless was encouraged by the Pastoral Land Commission (*Comissão Pastoral da Terra*, CPT), an organization within the Catholic church created in 1975, and the subsequent development of the Landless Rural Workers Movement (*Movimento dos Trabalhadores Rurais Sem Terra*, MST).

Against this backdrop, land occupations became the prominent tactic of the landless to advance land reform (Figure 1).[9] Through land occupations, landless peasants force the opening of a judicial case on a specific property, initiating a process that could eventually lead to obtaining a property title on the occupied land. The strategy relies on Brazil's Constitution, which institutes the "social function" of land, and sanctions that unproductive plots are susceptible to expropriation in exchange for monetary compensation (Morissawa, 2001).[10] Occupied land can result either in recognized settlements or in expulsion, possibly leading to violence. The decision is the result of the determinations of the National Institute for Colonization and Land Reform (*Instituto Nacional de Colonização e Reforma Agrária*, INCRA) and the judiciary. If the landowner of an occupied farm appeals to the local court to restore possession, the occupiers usually squat in an encampment of improvised tents for the entire duration of the trial (Hammond, 2009). When local judges rule in favor of the occupiers, INCRA negotiates the compensation with the landowner. However, occupiers are evicted in more than 95% of cases (Meszaros, 2000), often resulting in violence between farmers and military forces (Fernandes, 1997). Around 1,700 individuals have been killed in land-related disputes from 1988 to 2014 according to the CPT.

The groups involved in land occupations are heterogeneous. In several cases, in particular in remote regions close to the agricultural frontier, conflicts arise between peasants lacking property titles on the land (*posseiros*) and new alleged landowners

[8] The Peasant and Agricultural Workers Union of Brazil (ULTAB) was established in 1954.

[9] Although land occupations pervade Brazilian history, the military dictatorship established in 1964 silenced peasant movements for more than a decade. Only in 1979, in southern Brazil, did land occupations came back into the political arena (de Medeiros, 2015).

[10] The "social function" of rural property is sanctioned in Article 5, XXIII, of the Constitution. In Article 186, the Constitution specifies that the social function is fulfilled when a rural property meets four criteria, including "rational and adequate use" (authors' translation).

bearing proper or fraudulent titles on the land (Carter, 2015).[11] Less frequently—3.3% of the cases—land occupations are carried out by indigenous groups claiming rights on ancestral lands. Violent confrontations are frequent in these cases: "from 2003 to 2014 there were 390 Indians killed in Mato Grosso do Sul, mostly Kaiowa Guarani, fundamentally in conflict with ranchers and soybean plantations" (Turzi, 2016).[12] In addition to these groups, land occupations often involve individuals such as tenants, sharecroppers and rural workers who lose access to land because of economic adjustments. In total, 1.3 million families have been involved in land occupations between 1988 and 2014.

1.2 Market-Oriented Reform and Technological Innovation

During the last few decades, several developing countries registered significant increases in agricultural productivity and commercial farming. According to ILOSTAT, Latin American countries increased added value per agricultural worker by 75% and decreased the employment share in agriculture by 30% between 1991 and 2019. At the same time, the size of cultivated land increased by 74%.[13] The leading expanding crop was soybean, whose cultivated area grew twice as fast the overall global economy since the early 1990s (Goldsmith, 2008), doubling its share of global farmland in fifteen years (Panel A of Figure A.1). This rapid expansion occurred along a sharp increase in soybean imports by the top-ten world economies (Panel B of Figure A.1) and the growing use of processed grains as intermediate products in the food, feed, and bioenergy industries. However, despite the steep increase in production, international soy prices did not start to decline until 2010, indicating a strong global demand for the commodity in the 1990–2010 period.

Given the global trend in the soy sector, soybean became the leading expanding crop in the country when Brazil introduced a market reform that incentivized international investments in agriculture (Goldsmith and Hirsch, 2006). In 1995, Brazil opened its market to international investors through a constitutional reform that eliminated the distinction between Brazilian firms with national and foreign capital, facilitating the foreign purchase of domestic assets. In the same year, the government

[11] "Posseiros are peasants who occupy and cultivate plots of land but hold no property titles or legal agreements to farm this area usually lack land titles because they are unable to pay for and/or navigate through the bureaucratic process required to secure this document" (Carter, 2015).

[12] Anecdotal evidence on the struggle of the Guarani–Kaiowá is further discussed by Ioris (2020).

[13] Computation from OECD/FAO (2021) including the following agricultural commodities: cotton, maize, other coarse grains, other oilseeds, roots and tubers, raw sugar, rice, soybean, sugar, sugar beet, sugarcane, wheat.

sought to incentivize foreign investments in agriculture by exempting foreign capital destined to agricultural production from the payment of the Financial Operations Tax (*Imposto sobre Operações de Crédito, Câmbio e Seguros*, IOF).[14] Moreover, in 1996, the National Congress adopted the *Kandir Law* (Complementary Law N. 87), that eliminated the 13% value-added tax on primary exports (*Imposto sobre Circulação de Mercadorias e Serviços*, ICMS). Together, these reforms reduced the operation and export costs in the agricultural sector by opening the market to international agribusiness therefore facilitating access to commercial networks, and financial and technological products.

The relevance of this institutional discontinuity is reflected in the sharp increase in the FDI inflow in Brazil from 1996 relative to the previous period (Panel A of Figure A.5). This increase was particularly remarkable in the soy market where the share of international capital in the agro-industrial grain processing sector passed from 16% in 1995 to 57% in 2005, expanding total processing capacity by 21% from 1995 to 2000 (Wesz Jr., 2011).[15] After the market reform, the largest four international agribusiness companies increased their control of the sector by seven fold in only two years, from less than 6% in 1995 to more than 40% in 1997 (Panel B of Figure 2).[16] These companies affected the local environment in two ways, first, through direct land acquisition and production, and second, through increasing local demand for soybeans and providing new services and commercial networks.[17] These agribusinesses introduced into the market a new type of contract that bundled soy price guarantees, credit, and a technological package with seeds, inputs, and pesticides (Wesz Jr., 2011; Silva and Lapo, 2012; DePaula, 2017), shifting farmers' incentives to agricultural intensification and allowing cultivation in previously unproductive areas.

Together with the change in the market environment, the release in 1996 in the United States of a GE soy variety tolerant to glyphosate contributed to increase the gains from investments in soy production by reducing the crop labor requirement (Bustos, Caprettini, and Ponticelli, 2016; Duffy and Smith, 2001).[18] The lower labor

[14]This part of the reform was effectively put in place by the Central Bank of Brazil's Resolution N. 2148 of March 1995, known as *63 Caipira*, aimed at facilitating "the attraction of external resources to finance the cost, investment and commercialization of agricultural production" (authors' translation).

[15]Processing capacity is measured as the ability to process a given number of tons per day.

[16]The four largest companies are ADM, Bunge, Cargill, and Dreyfus, often referred to as ABCD from their initial letters.

[17]According to the ex-President of the INCRA, the constitutional reform led to the unbridled occupation of land by foreigners (Hackbart, 2008).

[18]Known as GTS 40-3-2, the new seeds were first commercially released in the United States in 1996 and authorized in Brazil in 2003 (Law N. 10.688). Although illegal in Brazil until 2003,

requirement is reflected in the decline from 28.6 to 17.2 workers per 1,000 hectares in the 1996–2006 period (Table A.1).

Since 1996, data show a sharp increase in the area cultivated with soybean and in the quantity of soy exports. First, Panel A of Figure 2 reveals that the expansion of the soy area in the 1988–2014 period accounted for almost the entire growth in land cultivated with crops in Brazil. Second, Panel B of Figure A.5 exhibits the increase in soybean exports' quantity since the mid-1990s. Moreover, Table A.1 shows that the land devoted to soybean cultivation nearly doubled between 1996 and 2006, jumping from 9.2 to 17.9 million hectares. This expansion accounted for around 85% of the growth in land for seasonal crops during the period.[19]

2 Data

Land Occupations. Information on the number of land occupations and occupying families from 1988 to 2014 for each Brazilian municipality is provided by *Dataluta (Banco de Dados da Luta pela Terra)* based on data published by various organizations.[20] The CPT, an institutional body of the National Conference of Bishops of Brazil, accounts for more than 75% of registered land occupations in the dataset.[21] The CPT defines land occupations as "collective actions of landless families who, through entry into rural properties, claim land that does not fulfill the social function" (Dataluta, 2018, authors' translation) and obtains data through primary and secondary sources.[22] The primary data are directly provided by agents of regional CPT offices or contained in official documents of social movements, churches, unions, and other organizations linked to land conflict, while secondary sources are collected

smuggling occurred since at least 2001 (USDA, 2001). With traditional soybean, unwanted weeds need to be removed either manually or through the application of less effective herbicides, in both cases increasing the labor necessary to prepare the field before planting. The glyphosate-resistant property of these new seeds is obtained through genetic-engineering techniques modifying the plant's DNA to include those of the herbicide-resistant bacteria *Agrobacterium sp. strain CP4* (Funke, Han, Healy-Fried, Fischer, and Schönbrunn, 2006).

[19]From 1996 to 2006, land cultivated with soy increased by 8.7 million hectares while land cultivated for all seasonal crops increased by 10.3 million. When accounting also for the 4.2 million hectares increase in permanent crops, then soy expansion accounted for 60% of the growth in crops' cultivation.

[20]*Dataluta* is a research project coordinated by the Land Reform Studies, Research and Projects Center (*Núcleo de Estudos, Pesquisas e Projetos de Reforma Agrária*, NERA) of the São Paulo State University (*Universidade Estadual Paulista*).

[21]Of the 9,278 registered events, 7,156 are provided by CPT.

[22]"Family is the set of persons linked by relatives' ties, domestic dependence or norms of cohabitation, living in the same home unit, or a single person who lives alone in one home unit" (IBGE, 2010, authors' translation).

from newspapers, political parties and governmental organizations.[23] We use information on social movements involved in land conflict to construct several measures of land occupations: number of total occupations (land occupations), log number of families involved in occupations, number of occupations performed by identified social movements (organized occupations), unidentified movements (spontaneous occupations), and occupations by indigenous groups (indigenous occupations).[24] Land occupations are computed per 10,000 km^2 using municipal satellite surface, and per 100,000 rural inhabitants, relying on population information in 1991.

Potential Yields. Data on potential yields in agricultural production are provided by FAO-GAEZ. Potential yields are measured as total production capacity in tons per hectare depending on soil and weather characteristics and an assumed technological level of inputs. Low-tech inputs refer to subsistence farming, labor-intensive techniques, traditional cultivars, and the absence of fertilizers or chemicals. Intermediate-tech inputs assume partly market-oriented farming, a mix of manual labor and mechanization, improved seed varieties, and partial use of fertilizers and chemicals. High-tech inputs stand for commercial farming, capital-intensive techniques, GE seed varieties, and optimal application of fertilizers and chemicals.[25]

We capture potential gains from agricultural modernization by computing the difference between potential yields under high- and low-tech inputs—potential gains. Bustos, Caprettini, and Ponticelli (2016) introduced this measure to study potential gains from the adoption of GE soybean seeds and a second season for harvesting maize. We compute the measure by taking the difference between soy potential yields under high- and low-tech inputs. We employ an identical procedure to quantify potential gains from investments in maize production. Maps of both measures are shown in Figure A.3. In addition, we compute the differences in potential yields under high- and intermediate-tech inputs, and intermediate- and low-tech inputs.

Agricultural Information. Data on cultivated area and rural workers are available in the 1995/1996—henceforth 1996—and 2006 Agricultural Censuses of IBGE, the Brazilian National Statistical Institute. Data are collected at the farm level via

[23]If information provided in secondary sources does not coincide with that from regional CPT offices, then the latter is registered. Also, if a property is occupied more than once in a given year, the CPT records one land occupation and the highest number of occupying families.

[24]The first registered land occupation by indigenous movements (*Movimentos Indígenas*) occurred in 2003.

[25]Further information on potential yields can be found in the GAEZ Model Documentation (IIASA/FAO, 2012).

interviews with producers and then aggregated at the municipal level. Total censused farmland was 353.6 million hectares in 1996 and 333.7 million hectares in 2006; land for unknown purposes amounted to 306.7 million hectares in 2006 (IBGE, 2006).[26] Our main Agricultural Census variables of interest are the share of municipal surface in farms, the shares of farmland used for seasonal crop production, pasture and natural forestry activities (*matas e florestas naturais*), GE and non-GE soy production, the number of workers in farms producing seasonal crops and those devoted to other agricultural activities. We also employ information on occupied farmland, the share of farmland and of workers in farms above 500 hectares, the share of farms above 500 hectares, the number and size of farms by farm size, and the use of chemical fertilizers in soy production and of tractors in agricultural production.[27] To measure the presence of agribusiness, we rely on the IBGE categorization of soy production destination: industry, intermediaries, cooperatives, and consumers. Municipal data on yearly planted area and crop production are provided by the Municipal Agriculture Production database (*Producão Agrícola Municipal*, PAM) of IBGE based on interviews with farms, firms, public administration agencies, and not-for-profit entities.

Information on soy prices, land cover, population and other characteristics used in this analysis is presented in Section B. Table A.3 reports summary statistics of our main variables.

3 Empirical Framework

To investigate the relationship between agricultural modernization and land occupations, we construct a panel of Brazilian municipalities observed from 1988 to 2014. We begin by exploring associations between changes in the soy area and the number of land occupations at the municipal level. However, there are several reasons this association cannot be interpreted as the effect of soy expansion on the number of land occupations. The most relevant one is that land conflict affects decisions related to agricultural production in Brazil (Alston, Libecap, and Mueller, 1999, Alston and Mueller, 2010 and Alston and Mueller, 2018). Landowners might, for instance, decide to cultivate soy in idle land to reduce the risk of expropriation following an escalation of land occupations.

[26] The total surface of Brazil's surface is 851 million hectares. In 2006, Brazilian land was subdivided into the following categories (in million of hectares): 333.7 in censused farmland, 125.6 in indigenous lands, 72 in conservation units, 2 in urbanized areas, 11.4 in water resources areas and 306.7 in land with unknown purposes (IBGE, 2006).

[27] Occupied land is defined as "property belonging to third parties, for which the producer paid nothing for its use" (IBGE, 2006, authors' translation).

To address these issues, we rely on two sources of plausibly exogenous variation in the incentive to invest in soy production in a difference-in-difference setting. First, we exploit the timing of the invention in the US of the GE soy seeds in 1996 together with the market-oriented reform that, in 1995, decreased the cost of foreign operations in the Brazilian economy by abolishing the legal distinction between Brazilian firms with national and foreign capital. As described in Section 1.2, the reform incentivized investments in soybean production by attracting foreign actors, leading to the expansion of international agribusiness (Panel B of Figure 2). These companies made investments in the soy sector more profitable to local producers by offering contracts that reduced uncertainty through bundled soy prices, providing access to credit, improved soy seeds, and technical support (DePaula, 2017). These contracts, together with a developed commercial network, facilitated the integration of local producers in the global market, incentivizing commercial farming.

Second, we build on Bustos, Caprettini, and Ponticelli (2016) and leverage the variation in the potential gains from investments in soybean production at the municipal level by computing the difference between soy potential yields under high- and low-tech inputs—soy potential gains. We construct this measure using data from FAO-GAEZ described in Section 2. Estimating the effect of soy potential gains, rather than actual investments or cultivated area, presents several advantages. First, because investments in soybean production might be a reaction to the local political environment, which in turn could also affect land occupations, estimates relying on potential gains allow us to avoid estimation bias due to reverse causality. Second, because land disputes might occur before or in the absence of actual production, soy potential gains more accurately captures the treatment of interest rather than the change in cultivated area. Finally, due to a large amount of Brazilian land with no census information (37%), soy potential gains captures the shift in the local incentive to invest in soy production in those areas since 1996. Relying on the interaction between an indicator for the post-1995 period and a measure of soy potential gains at the municipal level, our variable of interest captures the change in the incentive to invest in soybean production across municipalities since 1996.

Our baseline estimating equation is

$$y_{it} = \gamma_i + \delta_t + \beta \Delta \text{Soy}_i \times \text{Post}_t + \mathbf{X}_i^{1991} \delta_t + \varepsilon_{it}, \tag{1}$$

where i and t are indexes for municipalities and years respectively, y_{it} is the number of land occupations per km^2 or the soy area as the share of municipal surface, ΔSoy_i

is soy potential gains, Post_t is equal to 1 since 1996, γ_i is municipality fixed effects absorbing time-invariant municipal characteristics, δ_t is year fixed effects capturing year changes common to all municipalities, and $\mathbf{X}_i^{1991}$ is a vector of four municipal characteristics measured in 1991.[28] Our coefficient of interest is β, which we expect to be positive, capturing the increase in land occupations driven by the stronger incentive to produce soy. Results report standard errors robust to heteroskedasticity and clustered at the municipal level. Because our measures of potential gains are likely to be correlated across space and time, we also provide estimates allowing for a higher level of spatial correlations of the standard errors—microregions—and show results correcting standard errors for spatial and temporal dependence within several buffers using the procedure in Conley (1999).

In Section 5, we analyze the potential mechanisms behind our results using various sources of information. In several regressions, we rely on census information available only for 1996 and 2006 and therefore run a first-differenced version of equation (1).

3.1 Identifying Assumption and Threats to Identification

Our empirical strategy relies on one key assumption. We assume counterfactual parallel trends in land occupations across municipalities with different soy potential gains (ΔSoy) absent the change in the incentive to produce soy caused by the market reform and the invention of the GE soy seed. We take several steps to investigate the plausibility of the assumption. First, we inspect pre-treatment outcome trends across municipalities with different soy potential gains in the 1988–1995 period by estimating the following regression

$$y_{it} = \gamma_i + \delta_t + \sum_{t=1988, t\neq 1995}^{2014} \beta_t \mathbf{1}_{\text{Year = t}} \;\; \Delta\text{Soy}_i + \mathbf{X}_i^{1991}\delta_t + \varepsilon_{it} \qquad (2)$$

where i and t denote municipalities and years respectively, y_{it} refers to the number of land occupations per km^2 or the soy area as the share of municipal surface, $\mathbf{1}_{\text{Year = t}}$ is a set of year dummies omitting 1995 used as reference year, ΔSoy_i is soy potential gains, γ_i captures municipality fixed effects, δ_t absorbs year fixed effects, and $\mathbf{X}_i^{1991}$ measures four municipal characteristics in 1991. Figure 3 shows the absence of pre-trends in the expansion of the soy area in Brazil (Panel A), in the number of land occupations per 10,000 km^2 (Panel B), and in the incidence of land occupations (Panel C) in the three soy-producing regions—henceforth "soy regions."[29]

[28] Log income per capita, literacy rate, log population density and share of rural population.

[29] The three soy-producing regions are the South, South-East and Central-West, shown in Figure

Second, we estimate equation (1) controlling for the interaction between year fixed effects and pre-treatment levels of several municipal characteristics. This specification allows us to exclude that variables correlated with soil and climatic characteristics trigger the increase in land occupations since 1996. For example, different pre-treatment levels of income may explain diverging trends in land occupations due to economic reforms unrelated to agricultural modernization. Our baseline controls are income per capita, literacy rate, population density, and share of rural population, all measured in 1991. In Section D.4, we show that our results are robust to the inclusion of a larger set of controls observed before 1996: the share of farmland in farms above 500 hectares, the share of farms above 500 hectares, the share of workers in farms above 500 hectares, and natural areas as the municipal share.

Third, we show results controlling for the change in maize potential gains (ΔMaize $\times$ Post). This specification allows us to abstract from the expansion of the labor-intensive sector and the growth in labor demand due to the diffusion of a second season for harvesting maize (Figure A.8 and Bustos, Caprettini, and Ponticelli, 2016), which might bias downward our estimates of interest given the positive correlation between ΔSoy and ΔMaize (Figure A.3).

Fourth, we provide further evidence of the link between soybean production and land occupations leveraging the timing of the first year in which soy production is observed across municipalities—henceforth "soy adoption"—in a staggered difference-in-difference setting

$$\mathrm{y}_{it} = \gamma_i + \delta_t + \sum_{k=-9, k\neq 0}^{9} \beta_k L_{ik} + \mathbf{X}_i^{1991}\delta_t + \varepsilon_{it}, \tag{3}$$

where y_{it} is equal to 1 if the number of land occupations is higher than 0, γ_i are municipality fixed effects, δ_t are year fixed effects, L_{ik} are event study dummies equal to 1 when year t is k years since soy adoption.[30] The year soy cultivation is observed for the first time in the period of our study ($k = 0$) is omitted and used as reference. Panel B of Figure 3 plots the coefficients β_k. These estimates reassure against unobservables unrelated to agricultural modernization but correlated with soy potential gains that could affect land occupations since 1996. In Figure A.9, we present the same estimation for the largest Brazilian crops in terms of share of value in agriculture

A.7. These regions accounted for 8.8 million hectares of the soy area as of 1996, around 95% of the total (IBGE, 1996). For simplicity, we consider as South the sum of South and South-East.

[30] We consider as -9 if k is below -9 and as 9 if k is above 9. Results are similar when including the event study dummies for the entire time window.

and find no effect.[31]

Moreover, because soy prices might affect incentives to invest in soy production, we show results of equation (1) using the national trend in soy prices instead of the post-1995 indicator. Estimates discussed in Section 4.1 suggest that results are not driven by changes in soy prices, attesting to the link between agricultural modernization and land occupations. In the same spirit, we show that land occupations are unaffected when restricting the sample to municipalities or regions where soy area did not expand. Last, Panel B of Table A.12 shows that microregions more exposed to a reduction in tariffs between 1990–1995 (Dix-Carneiro and Kovak, 2017) did not invest more in soy production, ruling out potential confounders related to the abolition of tariffs.

3.1.1 Timing of the Effect

A final concern is related to anticipatory effects. Farmers in municipalities with high soy potential gains might have mobilized before the agricultural investments took place, obtaining access to land whose value was expected to increase in the near future. The comparison between Panels A and B (or C) of Figure 3 shows a difference of about one year in the timing of the soy expansion and the escalation in land occupations. While the year 1996 already displayed a substantially higher number (and incidence) of land occupations, the size of the soy area started to expand only in 1997. Although it is not implausible that farmers reacted to future investment plans, a more persuasive explanation might reflect the timing related to agricultural operations. In fact, while Panel A refers to the year when soy was harvested, the operations related to the preparation of the first harvest, including land acquisition, tillage, and sowing are likely to have started at least one year earlier. Section C.2 reports a case of soybean expansion suggesting the existence of this time lag between land acquisition and actual cultivation.

4 Results on Land Occupations and Soy Expansion

4.1 Main Results

Results shown in Table A.4 point to a positive association between the area cultivated with soy and land occupations. Doubling the soy area correlates with an increase in

[31] According to PAM, in 2019 soy was followed by sugar, maize, and coffee as the most valuable crops in Brazilian agriculture.

the number of land occupations per 10,000 km^2 of 0.1 (column 1). The direction and magnitude of this association is basically unaffected by the inclusion of control variables (column 2), the size of the area cultivated with maize (column 3) and the use of state-by-year fixed effects capturing time-varying changes at the state level (column 4).

Findings in Table 1 from equation (1) confirm these results, indicating a strong and positive effect of agricultural modernization on land occupations. One standard deviation increase in soy potential gains leads to an increase in the number of land occupations per 10,000 km^2 in the post-1995 period of 0.14 (column 1). When adding controls, the effect is stronger, inducing an increase in 0.2 land occupations per 10,000 km^2 (column 2). Columns 3–6 provide additional evidence on the relationship between agricultural modernization and land occupations. In columns 3 and 4, we show that the effect is driven by the two soy regions (South and Central-West). In column 5, soy potential gains (ΔSoy) does not predict land occupations in municipalities where the soy area did not expand between 1996 and 2006. Column 6 shows that estimates are not significant when the independent variable is given by the interaction between soy potential gains and the yearly price of soy. These two last findings reassure us about the role of agricultural modernization in affecting land occupations.

Results on the soy area shown in Panel B of Table 1 display a consistent pattern with the effect on land occupations. In fact, the latter is present only if ΔSoy $\times$ Post also explains soy expansion.[32] In Table A.5, we show that the sign and significance of the estimates are unchanged when using the incidence of land occupations instead of the number of land occupations per 10,000 km^2 (columns 1–6). Moreover, in column 7, the effect of soy potential gains is stronger when controlling for ΔMaize $\times$ Post, consistent with the hypothesis that the growth of the labor-intensive sector reduces land conflict. So, as not to bias downward our estimates of interest, we will control for ΔMaize $\times$ Post in the rest of our analysis.

To lend credibility to the causal interpretation of our baseline regressions, we scrutinize pre-trends plotting coefficients from equation (2) in Figure 3. We find that soy potential gains (ΔSoy) predicts a sizable and persistent expansion of the soy area starting from 1997 with respect to 1995 (Panel A). In Panels B–C, we focus on soy regions that displayed positive and significant estimates on the number and incidence of land occupations in Tables 1 and A.5. The two figures corroborate our causal

[32]We consider as missing the observations on soy area with no information. A large amount of observations is missing outside soy regions, and this explains the low number of observations in column 10. Results are robust to substituting the missing information with the zero value.

interpretation of the estimates. Moreover, a comparison between Panels A and B (or C) reveals the close dynamics of the increase in the incentive to invest in soy on soy cultivation and land occupations, both in the case of the number (Panel B) and the incidence (Panel C). On the contrary, when focusing on regions outside the three main soy-producing areas, soy potential gains does not explain any change in the soy area or in the number of land occupations (Figure A.10), consistent with estimates in columns 4 and 10 of Table 1.

When comparing the timing of the effect on the soy area and land occupations, three features are worth noting. First, the timing of soy expansion and escalation of land occupations closely followed the trend in FDI inflow in the Brazilian economy (Panel A of Figure A.5). Second, as discussed in Section 3.1.1, except for the years around 1995, the effect on land occupations mimicked the one on soy cultivation with a year lag. This is consistent with the escalation of land occupations being driven by the expansion of soy. Third, the effect of GE soy diffusion on land occupations and soy cultivation is visible since 2002.

Finally, in Panel D of Figure 3, we show the relationship between soy adoption and the incidence of land occupations, plotting coefficients from equation (3). We find an increase in the probability of land occupations in the period after soy cultivation made its first appearance in the PAM municipal dataset. Overall, findings discussed in this section suggest that the market reform and the invention of the new GE soy seed accelerated the modernization process of the Brazilian agricultural sector, leading to both the expansion of soy cultivation and an escalation of land occupations.

4.2 Disentangling the Market Reform and GE Soy Effects

Table 1 captures the additive effect of both the market reform and the GE soy invention. Consistently, soy potential gains leads to an expansion of the non-GE soy area (column 1 of Table 2). To disentangle the effect of the market reform from the GE soy technical innovation, we rely on variation in climatic and soil conditions at the municipal level, and the timing of the GE seed diffusion in Brazil.

GE seeds were legally introduced in 2003 but smuggled since 2001 (USDA, 2001). While GE soy is more productive than non-GE soy, it is suitable for planting at high latitudes, with moist climates and fertile land. Conversely, the Brazilian non-GE soy variety can be grown at low latitudes with dry climates and scarcely fertile soil.[33]

[33] By fertile land, we mean a high presence of nutrients (nitrogen) and low acidity (high pH). While GE soy was developed to maximize yields in temperate and moist zones with seasonal changes in sunlight and high-quality land (DePaula, 2017), non-GE varieties were progressively made available

Given these seeds' characteristics, potential gains from technological adoption while growing GE soy are positive only in high-quality land and moist climate; instead, those obtained while growing non-GE soy are positive irrespective of soil and climatic conditions.

We obtain measures of potential gains from technological adoption for soy production relying on information from FAO-GAEZ. According to this database, the difference in soy yields between high- and intermediate-tech (ΔSoy^{H-I}) is a positive function of soil quality and moisture levels, while the one between intermediate- and low-tech (ΔSoy^{I-L}) is higher in poor quality land and dry climate. Consistently, ΔSoy^{H-I} predicts lower temperature and soil acidity, and higher latitude, water presence, precipitation and land fertility, while the opposite is true for ΔSoy^{I-L} (Table A.2, and Tables 2 and 4 in DePaula, 2017). In addition, we show that, while ΔSoy^{H-I} predicts both GE and non-GE soy expansion, ΔSoy^{I-L} explains the latter only. Thus, by running equation (1) using ΔSoy^{H-I} and ΔSoy^{I-L}, we isolate the effect of the market reform from the one due to the GE soy invention.

Table 2 shows the results. First, soy potential gains (ΔSoy) predicts a 61% increase in the non-GE soy area from 1996 to 2006 (column 1).[34] Second, while both ΔSoy^{H-I} and ΔSoy^{I-L} explain the non-GE soy expansion (column 2), only the former led to the growth of the GE soy area (column 3). Third, when using the full sample, ΔSoy^{H-I} explains an expansion almost three times higher than ΔSoy^{I-L} (column 4). However, if we restrict the analysis to the 1988–2000 period, when GE soy was still unavailable in Brazil, the soy expansion due to ΔSoy^{H-I} was only 1.7 times higher than the expansion due to ΔSoy^{I-L} (column 5).

These results suggest that, while ΔSoy^{H-I} captures the additive effect of both the market reform and the GE soy invention, ΔSoy^{I-L} shows the effect of the market reform only. Consistently, we find that land occupations increase in both types of land but the effect is around 60% higher in high ΔSoy^{H-I} municipalities where the use of both types of soybean seeds expanded (column 6) and 35% higher when only the use of the non-GE variety grew (column 7). Dividing the coefficient for ΔSoy^{I-L} $\times$ Post by the one for ΔSoy^{H-I} $\times$ Post in column 6, we calculate that around 60%

by Brazilian authorities since at least the 1980s in an effort to expand soy production at low latitudes. The research center of the Brazilian Ministry of Agriculture (*Empresa Brasileira de Pesquisa Agropecuária*, EMBRAPA) was the leading actor in the invention of this "tropical soybean". Further reference to the development of the tropical soy variety in Brazil and the role of biological nitrogen fixation (BNF) technology to achieve it can be found in Alves, Boddey, and Urquiaga (2003).

[34] In columns 3–4 of Table 6, Bustos, Caprettini, and Ponticelli (2016) find that soy potential gains (ΔSoy) does not explain changes in non-GE soy area from 1996 to 2006. Our result is different because we control for ΔMaize.

of the effect on land occupations is driven by the market reform alone.

Finally, we run a robustness check exploring the heterogeneous effects of soy potential gains (ΔSoy) across latitudes. Table A.6 shows that, while ΔSoy leads to the non-GE soy expansion in the North and to the GE one in the South, its positive effect on land occupations is identical across latitudes. Taken together, our findings indicate that both the market reform and the GE soy invention induced land occupations in Brazil in the period of our study.

4.3 Soy Destination and Input Use

We expect that the market reform led to an increase in the capital intensity of soy production by attracting foreign investments. Moreover, given that the market reform attracted foreign agribusiness in the soy processing industry, the latter should have captured a higher share of the Brazilian soy output. This section provides evidence corroborating this hypothesis. We study the use of chemical fertilizers and tractors as measures of the capital intensity of the soy sector.[35] Moreover, we study changes in the destination of soy output using restricted census information at the municipal level. The most relevant destinations in terms of relative shares are "cooperatives," "intermediaries," and "industry," with the production destined for the industry experiencing the largest growth between 1996 and 2006. These destinations accounted for respectively 37%, 30%, and 30% of soy production in 1996 and 35%, 13%, and 44% in 2006.

In Table A.7, we analyze the change in destination of soy production between 1996 and 2006. Because of data limitations, we can only explore the extensive margins.[36] Column 1 shows that a one standard deviation increase in soy potential gains (ΔSoy) raised the probability of industrial destination by 4.4 percentage points. We find no significant results for intermediaries or cooperatives (columns 2–3), while the probability that a municipality produced soybean directly destined for consumers declined by 2.9 percentage points (column 4). In addition, the incidence of the use of chemical fertilizers increased by 4.5 percentage points (column 5), while the number of tractors per hectare of soy area increased by 17 units for each standard deviation higher ΔSoy

[35] Information on chemical fertilizers is for soy production only. Due to data limitations, tractors refer to the whole agricultural sector.

[36] In fact, due to privacy and security concerns, the census does not report information on the number of operating firms in municipalities where the market is highly concentrated, namely with less than three firms (IBGE, 2006). Both in 1996 and 2006, the share of municipalities where the market concentration was considered too high for the data to be reported was 30% for industry and 36% for intermediaries.

(column 6). These results are consistent with an effect of the market reform and the invention of the new GE soy technology on the modernization of the soybean sector through the rise of agribusiness activities.

4.4 Robustness

In Section D, we show that our main results are not driven by the expansion of alternative crops, geographic spillovers, and the administrative splitting of municipalities—redistricting. Moreover, our inference is robust when accounting for spatial correlation of unobservables. Last, we provide further robustness checks including the use of alternative measures of land occupations, when restricting our sample to rural municipalities, and when including additional control variables.

5 Mechanisms

We propose several potential mechanisms to explain the link between agricultural modernization and land conflict. First, the higher potential gains from investments in soybean production in areas not cultivated commercially may threaten traditional farmers' access to land. In turn, this can induce excluded groups to resort to land occupations for subsistence purposes. This mechanism is particularly relevant when land for commercial production is acquired through fraudulent expansion on public land or indigenous territories where most traditional communities are settled. Second, we explore the hypothesis that expanding soybean production leads to a loss of employment opportunities by consolidating land in large and capital-intensive farms, thus decreasing the opportunity cost of land occupations. Third, we investigate the role of political organizations involved in landless movements. Because these organizations engage in land occupations to advance land reform, we explore the strategic role that soybean expansion may represent for these political groups. Finally, we discuss the increase in land value as a potential mechanism.

5.1 Decline of Informally Accessible Land

Our first hypothesis is that the increased gains from investments in soybean production threaten traditional farmers' access to land. In Brazil, examples of traditional communities relying on informal access to land are abundant (Eidt and Udry, 2019).[37]

[37] For instance, see communities of *Fundo de Pasto*, *Geraizeiros*, *Quilombolas*, *Vazanteiros* and indigenous people who share collective tenure on natural assets (Eidt and Udry, 2019).

Aspiring and expanding soybean producers claim land titles in various ways, cutting off the land groups informally living on these estates. Excluded groups are hence reported to resort to land occupations either on estates they were already cultivating or on marginal estates that fulfill requirements for land reform. Although difficult to quantify, the importance of this process is reflected in the extent of the land market's lack of regulation (Carter, 2015). A representative case is Executive Order 558/99 of the INCRA, the National Institute for Colonization and Land Reform, which required all purported owners of real state property larger than 10,000 hectares to formally prove their ownership. According to data from the INCRA presented by Reydon (2006), about 47% of these alleged property owners did not answer, leading them to be categorized as suspected illegal land occupiers. We explore this hypothesis in two ways, first, by studying changes in land use and accessibility, and second, by focusing on groups of occupiers whose livelihood is strongly associated with informally accessible land.

Table A.8 uses census data to study the effect on farmland allocation. A one standard deviation increase in soy potential gains leads to a rise in farmland as share of municipal surface of around 4 percentage points, an increase of 5.4%. We also document a 10% increase in the area cultivated with seasonal crops, 66% of which is due to soy expansion. In addition, pasture area shrinks by 7% as a consequence of the soy expansion. Due to the weak legal institutions that characterize large shares of non-farming and pasture areas in Brazil, results in Table A.8 point to the decline in informally accessible land as a driver of land occupations.

5.1.1 Reduction in Forestry

Given the biodiversity that characterizes the Brazilian environment, the effect of soy potential gains (ΔSoy) on the decline in informally accessible land is likely to vary depending on the biomes. As shown in Table 1, the effect on soy expansion and land occupations is driven by South and Central-West regions. Therefore, focusing on these two regions, we explore the effect of soy potential gains on areas dedicated to natural forestry activities (*matas e florestas naturais*) and pasture area in Table A.9. While the reduction in pasture area is present in both regions and similar in magnitude (column 2), agricultural modernization leads to a shrinkage of farmland for forestry activities only in the Central-West (column 3).

5.1.2 Deforestation: Satellite Data Analysis

In Table 3, we complement information from the census with satellite data. While census data offer a more precise categorization of land types, satellite data have the advantage of providing yearly information. We analyze three outcome variables: the shares of municipal surface devoted to agricultural and pasture land respectively, and the deforested area (*desmatamento*) as the share of municipal surface in the Legal Amazon.[38] Column 1 shows a 2 percentage points increase in the share of agricultural area for each standard deviation higher soy potential gains (ΔSoy) after 1995. Yearly data confirm the decline in pasture area, which shrank by almost 1 percentage point as a share of municipal surface (column 2).[39] These results are also shown in Figure A.11, which presents yearly estimates of the effect of ΔSoy on the share of agricultural and pasture land.

In column 3, we present results on deforestation in the Legal Amazon using information from PRODES, available yearly from 2000 to 2014. We find that each standard deviation increase in soy potential gains (ΔSoy) leads to the doubling of the deforested area as a share of municipal surface in the 2000–2014 period. This finding confirms the decline in farmland for forestry activities in the Central-West region registered in the census (column 3 of Table A.9). However, when relying on information from MapBiomas, we find no evidence of deforestation.[40] The literature on the relationship between soybean expansion and deforestation has not found definitive results. While Dias, Rocha, and Soares (2019) document no effect of GE soy adoption on deforestation, other scholars argue that a large proportion of soy expansion occurred on previously cleared land (Lambin et al., 2018).[41] In addition, other research suggests that cattle ranchers are pushed from pasture to forest areas due to the soy expansion and that, therefore, soy indirectly contributes to deforestation (Barona, Ramankutty, Hyman, and Coomes, 2010).

5.1.3 Indigenous Occupations

Finally, we focus on indigenous occupations by relying on information by *Dataluta* on actions performed by the political organizations fighting for the conservation of indigenous land.[42] Because of the strong reliance of indigenous peoples on access

[38] The Legal Amazon comprises the nine states of the Amazon basin.

[39] The result on pasture area using satellite data is consistent with Dias, Rocha, and Soares, 2019.

[40] Result not shown.

[41] The authors argue that between 2006 and 2013, about 40% and 20% of soy expansion in, respectively, the *Mapitoba* and *Cerrado* regions occurred through deforestation.

[42] We code as indigenous the land occupations performed by *Movimentos Indígenas*.

to open land and forestry activities, these groups represent a pertinent example of stakeholders in agricultural modernization.[43] We explore the effect of soy potential gains (ΔSoy) on indigenous occupations by the presence of indigenous land and by the share of natural forest formation measured in the pre-treatment period.

This analysis serves three main purposes. First, when focusing on indigenous actions on indigenous land, we identify occupations of local groups, reducing the likelihood that the effect is driven by individuals moving in search of land to occupy. Second, because of the indigenous people's reliance on the natural environment for their livelihoods (Tresierra, 2017), an effect of soybean expansion on indigenous occupations provides evidence of the decline of informally accessible land as a mechanism. Last, since the Constitution specifies that the usufruct right of indigenous people to indigenous land forbids their sale or lease,[44] this analysis reinforces the interpretation that land occupations are driven by commercial farming expanding into subsistence areas inhabited by peasants with inadequately protected tenure, rather than by the increased value of land.

In the case of indigenous land, while formally preserved by Brazilian law, poor enforcement of land regulation led to several invasions of indigenous territories by commercial farmers (Delgado, 2015; Damasceno, Chiavari, and Lopes, 2017).[45] In support of our estimates, several cases provide evidence of the relationship between soybean expansion and indigenous occupations. For example, disputes between the Guarani-Kaiowás and soybean agribusiness in the southern part of Mato Grosso do Sul have been active since the 1990s. Ioris (2020) reports the presence of 250 camps, while Turzi (2016) indicates that 390 Guarani-Kaiowás were killed in conflicts with soybean producers and ranchers between 2003 and 2014. Results in column 4 of Table 3 indicate that the effect of soy potential gains on indigenous occupations is sixteen times higher in municipalities with indigenous land. Moreover, municipalities in the top half of the 1991 distribution of natural forest experience an effect twice as large as those in the bottom half (column 5).

Overall, findings in Table 3 suggest that soybean expanded to the detriment of

[43] Indigenous groups include 820,000 people, 71% of whom live in rural areas (IBGE, 2010). These groups are entitled by the Constitution to 117 million hectares of land, constituting 13.8% of the national territory (ISA, 2021). Article 231 of the Constitution indeed states that the state recognizes "to indigenous peoples their social organization, customs, languages, beliefs and traditions, and the ancestral rights to the lands that they traditionally occupy" (authors' translation).

[44] The Article 231 of the Constitution states that indigenous land are destined to "permanent possession" an that they are "inalienable and unattributable, and the rights over them imprescriptible" (authors' translation).

[45] The 2004 cases in the states of Mato Grosso and Roraima—particularly in the *Raposa Terra do Sol* reserve—illustrate the long history of precarious protection for native people's lands in Brazil.

pasture areas and by converting forests into commercial farmland. Because of the importance of accessible pasture and forest areas for the livelihood of traditional farmers, the reduction of these two environments, along with the effect on indigenous occupations, point to the decline of informally accessible land as an important channel through which agricultural modernization induces land occupations.

5.2 Land Consolidation and Employment Opportunities

While Section 5.1 clarifies how the expansion of commercial farming in subsistence areas contributed to the escalation in land occupations, this channel does not account for changes within commercial farmland. This section argues that one mechanism through which the intensification of soybean production may induce an increase in land occupations is land consolidation and the consequent decline of employment opportunities.

The market reform could lead to land consolidation by decreasing the operating costs of large international agribusinesses (Panel B of Figure 2). In turn, the rise of agribusiness, by facilitating access to credit and new technologies, raises the capital intensity of production. As part of the consequences of this process, along with the increase in productivity, small producers tend to see a decrease in income (Dhingra and Tenreyro, 2021), affecting their ability to stay in the market. Because large farms are better placed to capture the gains from investments in soybean through mechanization and technology adoption, smallholders might sell their land to larger farms, inducing land consolidation. This process, coupled with the fact that, in Brazil, large soy farms are more capital-intensive than smaller ones (Table A.11), may thus lead to a decline in employment opportunities in the agricultural sector, stimulating land occupations. The invention of the labor-saving GE soy seed, by reducing the labor intensity of production (Bustos, Caprettini, and Ponticelli, 2016), may have further contributed to decrease employment opportunities in the agricultural sector.

In Figure A.12 and Table A.10, we show the effect of soy potential gains (ΔSoy) on land consolidation. We find that the number of small and medium farms in seasonal crop production decreased, with the smallest group leading the decline—24% (Panel A)—while the number of large farms above 1,000 hectares increased—4% (Panel B). Moreover, Table A.10 shows that the average size of farms in seasonal crop production displays a consistent pattern, with the smallest farms shrinking—9% (column 10)—and the largest ones expanding—26% (column 18). While we find no soybean expansion among small soy farms (columns 19–23), except for a 30% increase among those between 5 and 10 hectares (column 20), large farms lead the pattern (columns 24–27). The larger the farm, the larger the soybean expansion, spanning from a 49% increase for farms between 100 and 200 hectares (column 24) to a 108% growth for those above 1,000 hectares (column 27). Thus, Table A.10 indicates that soybean expansion occurred at the expenses of small farmers.

Since small farms were at the top of the labor intensity distribution in 1996 (Table A.11), land consolidation had to reduce employment opportunities. Estimates in Panel A of Table A.12 show that each standard deviation increase in soy potential gains (ΔSoy) leads to a decrease of 152 workers in the production of seasonal crops, a drop of 11% (column 1). Although these changes were partly compensated by an increase in the number of workers in other agricultural activities, this coefficient is less precisely estimated and accounts for less than 50% of the employment loss in seasonal crop production (column 2). Consistently, soy potential gains (ΔSoy) induces an overall decline in the labor intensity of the agricultural sector of about one worker per 100 hectares at the municipal level (column 3), a similar estimate to the one found in Bustos, Caprettini, and Ponticelli (2016) for minimum comparable areas (*Áreas Mínimas Comparaveis*, AMCs).

To corroborate the importance of the decline in employment opportunities as a driver of land occupations, we analyze the mitigating effect of industrial labor demand in Section E.

5.3 Political Organizations and Strategic Behavior

Because the main objective of land occupations is to pressure the Brazilian government to redistribute land, there is an advantage in media attention that could shift the public opinion in favor of the land struggle. Targeting locations associated with large agribusiness and estates—latifundia—can represent both a goal in itself and a viable political strategy for the political movements fighting for land reform. These motives behind land occupations are made explicit by members of political movements involved in land occupations: "The agribusiness displaces peasants from their land, destroys the land, it fills it with its big machines and poison, pays little the few numbers of workers it employs, and for what? To sell soy and sugar to other countries."[46]

Higher political return from actions targeting areas exposed to agricultural modernization could represent a complementary mechanism through which soy expansion

[46] MST article quoted in Silvério (2012).

increases land occupations. Under this hypothesis, agricultural modernization leads to land occupations in two ways. The first way is by affecting peasants' economic incentives, as argued in Sections 5.1 and 5.2. The second way is by creating political incentives for landless social movements, which increases the return from local land occupations. We first investigate the effect of soy potential gains (ΔSoy), distinguishing between land occupations organized by identified social movements and those that are not. Second, we examine the heterogeneous effect of agricultural modernization as a function of the share of farmland in latifundia.[47] This analysis allows us to investigate the relationship between economic and political incentives as drivers of land occupations.

We divide land occupations into two groups: those claimed by a recognized political group (organized) and identified by *Dataluta* and those that did not involve any political organization or whose political organization was not identified (spontaneous). Figure 4 shows the timing of the effect of soy potential gains (ΔSoy) depending on the involvement of political organizations. Starting from 1996, ΔSoy affected both organized and spontaneous land occupations. However, after 2002, spontaneous occupations disappear from the sample (Figure A.13), indicating the increasingly important role of political organization over time (Ondetti, 2008; Carter, 2015).

To understand the role of political motives, we explore the heterogeneous effect by the presence of latifundia focusing on the period until 2002, where both spontaneous and organized occupations occurred. Column 1 of Table 4 shows that, on average, land occupations targeted around twice as many municipalities where the share of latifundia was higher. This effect is driven by organized occupations (columns 2–3), while the effect of agricultural modernization is not increasing in the share of latifundia in the case of spontaneous occupations (columns 4–5). These results indicate that, on average, both economic and political channels are in place, while strategic motives are important only for organized occupations.

6 Conclusion

This paper shows that higher potential gains from investments in soybean production led to an increase in land occupations in Brazil since the concurrent introduction of the new labor-saving GE soy seed and a market-oriented reform opening the country to foreign producers since the mid-1990s. In particular, we find that the expansion

[47] Given the IBGE (2006) official definition of family farms (up to 440 hectares of land), we use the closest available category in the census (500 hectares) to determine the threshold size defining latifundia.

of soybean caused a decline in informally accessible land and an increase in land inequality, increasing the number of farmers with no access to land. As a consequence, poor farmers resorted to land appropriation for subsistence purposes. We identify three main forces affecting land conflict.

First, although difficult to document, our findings suggest that part of the effect is due to the expansion of private estates into public and indigenous land characterized by weakly defined and enforced customary rights, leading to the dispossession of groups living and producing on the land. Second, market dynamics mainly operating through the expansion of agribusiness led to a decline in employment opportunities in the agricultural sector by forcing smallholders facing higher trade barriers to sell off their plots to larger and capital-intensive farms. Third, we find suggestive evidence that agricultural modernization strengthened the political incentive of the landless movement to engage in land disputes.

Although the uneven implications of processes of economic development are well known, they typically highlight the labor market consequences of technological innovation in the industrial sector (Acemoglu and Restrepo, 2020), while systematic analysis of agribusiness-led growth is remarkably thin (Dhingra and Tenreyro, 2021). Our work sheds light on this particular aspect of economic development and discusses how agricultural modernization leads to land conflict. These results must be evaluated in light of the sharp rise in agricultural investments and cultivated land in developing countries in the last three decades and the political destabilization of rural areas that this process may entail (De Janvry, Gordillo, Sadoulet, and Platteau, 2001).

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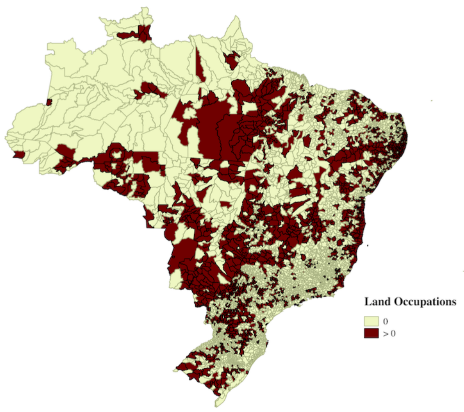
7 Figures

FIGURE 1: Land Occupations, 1988–2014

A. Trend

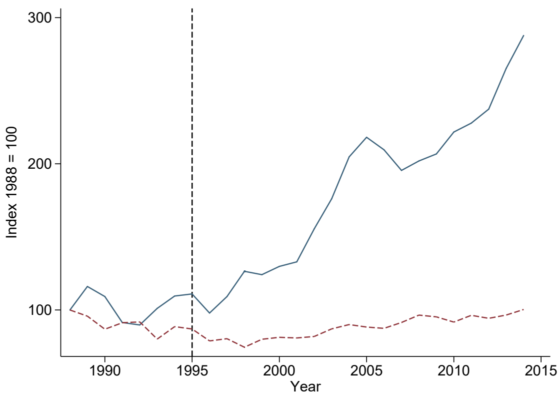
B. Geographic distribution



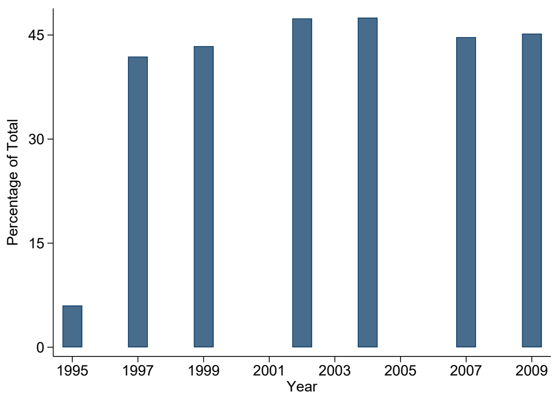
Notes: Panel A: number of land occupations from 1988 to 2014. Panel B: municipalities with at least one land occupation from 1988 to 2014. Source: *Dataluta*.

FIGURE 2: Growth of Soy Area and FDI in Soy Sector

A. Expansion of Soy and Other Crops Areas

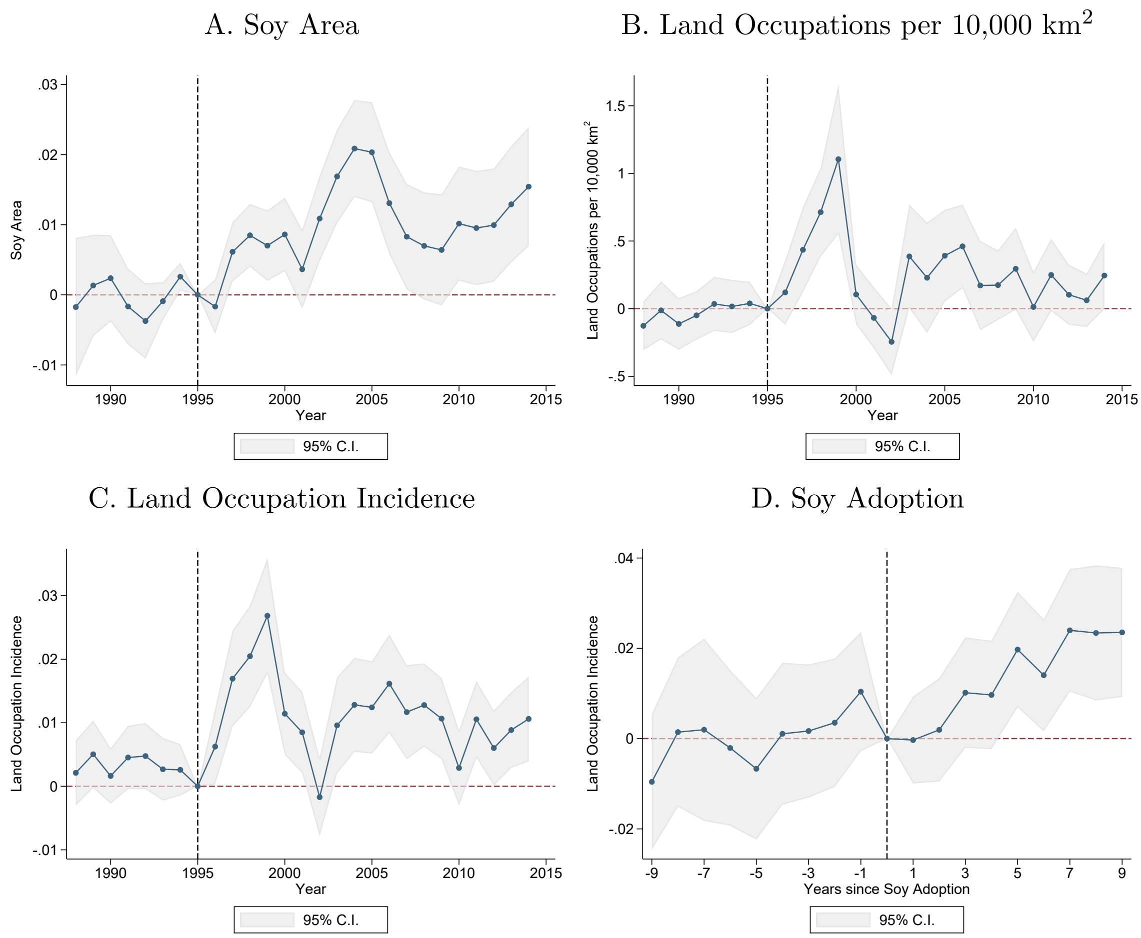


B. FDI in Soy Processing Capacity



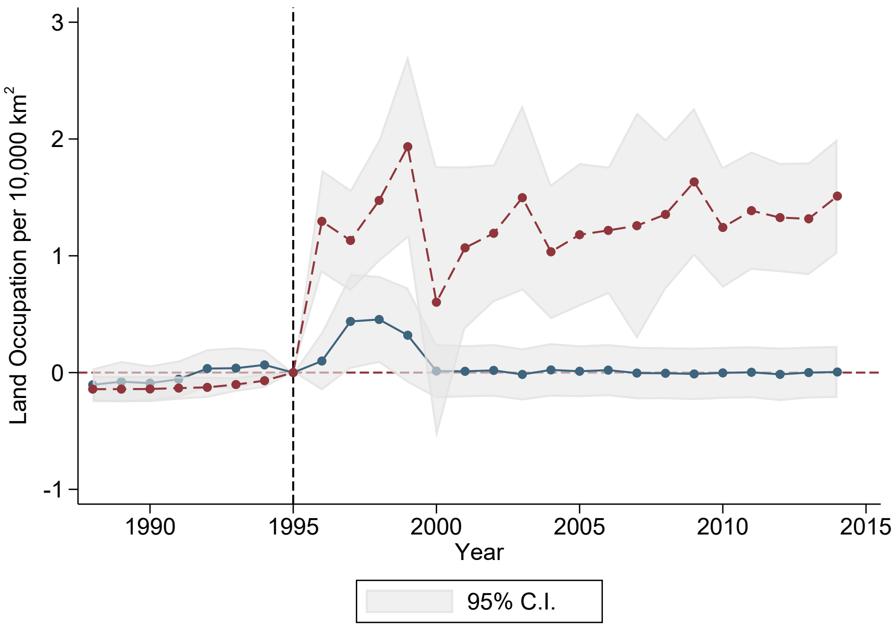
Notes: Panel A: trend in area cultivated with soy (continuous blue) and all other crops (dashed red) from 1988 to 2014 normalized to 100 in 1988. Panel B: soy processing capacity by largest four foreign firms as share of total from 1995 to 2009 for available years. Sources: areas: PAM; capacity: Wesz Jr. (2011).

FIGURE 3: Timing of Effect on Land Occupations and Soy Area



Notes: Panel A: estimates of equation (2); dependent variable is soy area as municipal share. Panel B: estimates of equation (2) for soy regions; dependent variable is number of land occupations per 10,000 km^2. Panel C: estimates of equation (2) for soy regions; dependent variable is equal to 1 if number of land occupations is higher than 0. Panel D: estimates of equation (3); dependent variable is equal to 1 if number of land occupations is higher than 0. Soy regions: South, South-East and Central-West (Figure A.7). Sources: soy area: PAM; land occupations: *Dataluta*.

FIGURE 4: Effect on Land Occupations by Political Organizations



Notes: Estimates of equation (2) controlling also for ΔMaize × Post; dependent variable is number of land occupations per 10,000 km^2 by identified (dashed red) and unidentified (continuous blue) political organizations. Source: *Dataluta*.

8 Tables

TABLE 1: Effect on Land Occupations

Panel A						
	Land Occupations					
	(1)	(2)	(3)	(4)	(5)	(6)
ΔSoy × Post	0.144**	0.202**	0.287***	-0.101	0.139	
	(0.065)	(0.087)	(0.057)	(0.227)	(0.106)	
ΔSoy × Soy Price						0.102
						(0.153)
Observations	150066	119448	71388	48060	97011	119448
Mean DV	0.265	0.317	0.258	0.405	0.274	0.317
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Soy Regions	No Soy Regions	No Expansion	Full
Adjusted R^2	0.098	0.108	0.107	0.110	0.107	0.108
Panel B						
	Soy Area					
	(7)	(8)	(9)	(10)	(11)	(12)
ΔSoy × Post	0.015***	0.010***	0.009**	0.012	-0.004	
	(0.003)	(0.004)	(0.004)	(0.011)	(0.007)	
ΔSoy × Soy Price						0.006
						(0.004)
Observations	42501	34977	32865	2112	14836	34977
Mean DV	0.135	0.133	0.137	0.013	0.127	0.133
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Soy Regions	No Soy Regions	No Expansion	Full
Adjusted R^2	0.886	0.887	0.887	0.730	0.911	0.887

Notes: Panel A: dependent variable is number of land occupations per 10,000 km^2. Panel B: dependent variable is soy area as municipal share. Columns 1–5 and 7–11: estimates of equation (1) are restricted to municipalities in soy regions (columns 3 and 9), restricted to municipalities in all other regions (columns 4 and 10) and restricted to municipalities where soy area did not expand from 1996 to 2006 (columns 5 and 11). Columns 6 and 12: estimates of equation (1) using Soy Price instead of Post. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Soy Price: national trend in real price of soy in 2010 US dollars normalized from 0 to 1. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density and share of rural population in 1991 times year FE. Standard errors clustered at municipal level in parentheses. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: land occupations: *Dataluta*; soy area: PAM; soy prices: World Bank Commodity Price.

TABLE 2: Effects on Land Occupations due to Market Reform and GE soy invention

	Non-GE Soy Area Farmland Share		GE Soy Area Farmland Share	Any Soy Area Municipal Share		Land Occupations	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔSoy	0.017***						
	(0.003)						
ΔSoy^{H-I}		0.007**	0.014***				
		(0.003)	(0.001)				
ΔSoy^{I-L}		0.019***	-0.024***				
		(0.002)	(0.002)				
$\Delta\text{Soy}^{H-I} \times$ Post				0.033***	0.019***	1.130***	1.786***
				(0.005)	(0.003)	(0.258)	(0.456)
$\Delta\text{Soy}^{I-L} \times$ Post				0.012***	0.011***	0.697***	1.312***
				(0.004)	(0.003)	(0.126)	(0.300)
Observations	4418	4418	4420	34977	15020	119448	57512
Mean DV	0.028	0.028	0.000	0.133	0.134	0.317	0.317
Municipality FE	.	.	.	Yes	Yes	Yes	Yes
Year FE	.	.	.	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample	1996, 2006	1996, 2006	1996, 2006	Full	1988-2000	Full	1988-2000
Adjusted R^2	0.042	0.057	0.247	0.889	0.916	0.109	0.129

Notes: Columns 1–3: estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. Columns 4–7: estimates of equation (1). Columns 2–3 and 4–7 use ΔSoy^{H-I} and ΔSoy^{I-L} instead of ΔSoy. Columns 1–2: dependent variable is non-GE soy area as farmland share. Column 3: dependent variable is GE soy area as farmland share. Columns 4–5: dependent variable is soy area as municipal share. Columns 6–7: dependent variable is number of land occupations per 10,000 km^2. Columns 5 and 7: sample is from 1988 to 2000. ΔSoy: difference in soy potential yields under high- and low-tech inputs. ΔSoy^{H-I}: difference in soy potential yields under high- and intermediate-tech inputs. ΔSoy^{I-L}: difference in soy potential yields under intermediate- and low-tech inputs. Post: indicator of post-1995 period. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density and share of rural population in 1991 (times year FE in columns 4–7), and ΔMaize (times Post in columns 4–7). ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors (columns 1–3) clustered at municipal level (columns 4–7) in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: soy area: IBGE (1996), IBGE (2006) and PAM; land occupations: *Dataluta*.

TABLE 3: Effect on Agriculture, Pasture and Deforested Areas, and Indigenous Occupations

	Agriculture Area Municipal Share	Pasture Area Municipal Share	Deforested Area Municipal Share	Indigenous Occupations	
	(1)	(2)	(3)	(4)	(5)
ΔSoy × Post	0.020***	-0.008***		0.001*	0.001*
	(0.002)	(0.002)		(0.001)	(0.001)
ΔSoy			0.002***		
			(0.000)		
ΔSoy × Post × Indigenous				0.016***	
				(0.004)	
ΔSoy × Post × Forest					0.001**
					(0.001)
Observations	119448	119448	7290	119448	119448
Mean DV	0.200	0.336	0.002	0.000	0.000
Municipality FE	Yes	Yes	.	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	2000-2014	Full	Full
Adjusted R^2	0.962	0.959	0.439	0.075	0.069

Notes: Column 1: estimates of equation (1); dependent variable is agricultural area as municipal share. Column 2: estimates of equation (1); dependent variable is pasture area as municipal share. Column 3: estimates of $y_{it} = \delta_t + \beta \Delta \text{Soy}_i + \mathbf{X}_i^{1991} + \varepsilon_{it}$; dependent variable is deforested area as municipal share in the Legal Amazon from 2000 to 2014. Column 4: estimates of equation (1) adding ΔSoy × Post × Indigenous and Indigenous × Post (not shown); dependent variable is equal to 1 if number of indigenous land occupations is higher than 0. Column 5: estimates of equation (1) adding ΔSoy × Post × Forest and Forest × Post (not shown); dependent variable is equal to 1 if number of indigenous land occupations is higher than 0. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Indigenous: identifier of municipalities with at least 1 hectare of indigenous land; Forest: identifier of municipalities over the median level of forest formation. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 (times year FE in columns 1–2 and 4–5) and ΔMaize (times Post in columns 1–2 and 4–5). ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors (column 3) clustered at municipal level (columns 1–2 and 4–5) in parentheses. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: areas: IBGE (1996) and IBGE (2006); deforestation: PRODES; land occupations: *Dataluta*.

TABLE 4: Effect by Presence of Latifundia and Political Organization

	Land Occupations	Organized Occupations		Spontaneous Occupations	
	(1)	(2)	(3)	(4)	(5)
ΔSoy $\times$ Post	1.057***	0.951***	0.913***	0.106	0.573***
	(0.271)	(0.244)	(0.310)	(0.088)	(0.189)
ΔSoy $\times$ Post $\times$ Latifundium	0.986***	1.006***	0.713**	-0.020	0.192
	(0.307)	(0.278)	(0.345)	(0.102)	(0.192)
Observations	119367	119367	66315	119367	66315
Mean DV	0.317	0.046	0.046	0.272	0.272
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	1988-2002	Full	1988-2002
Adjusted R^2	0.109	0.098	0.086	0.057	0.091

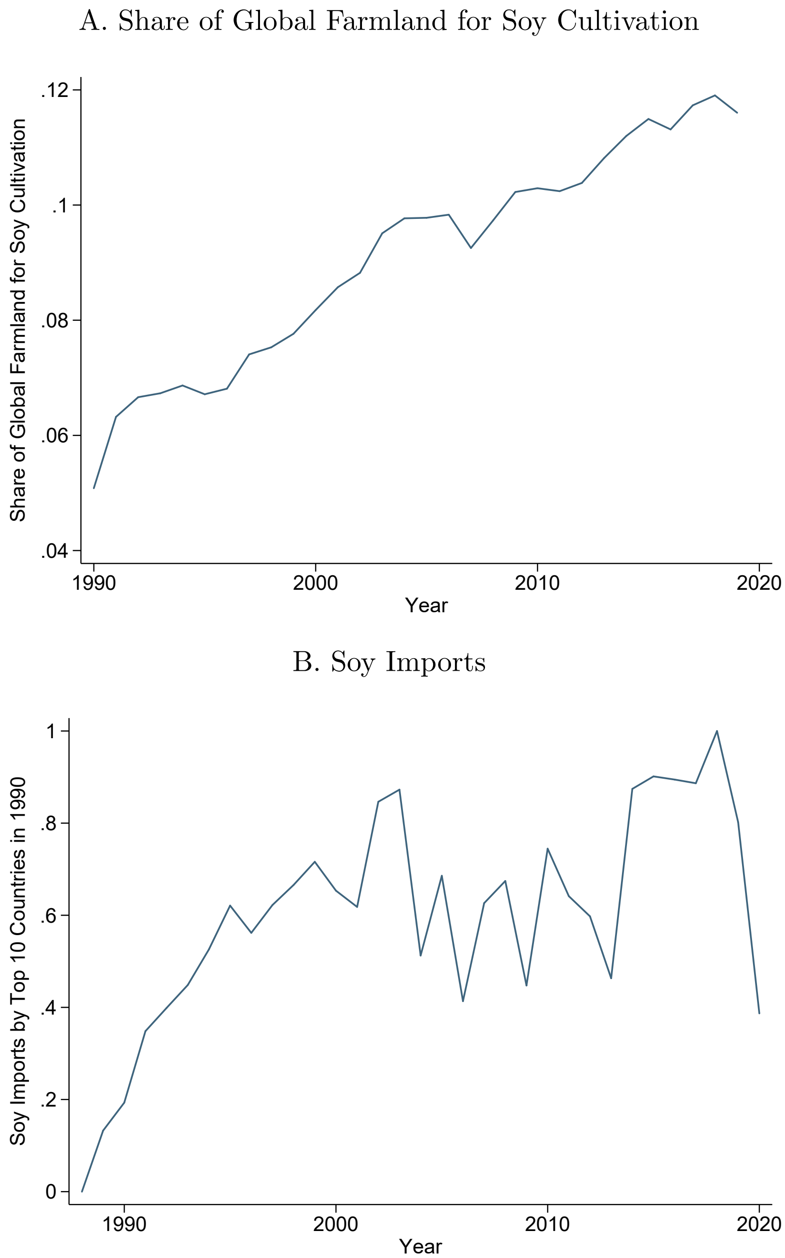
Notes: Estimates of equation (1) adding ΔSoy $\times$ Post $\times$ Latifundium and Latifundium $\times$ Post (not shown). Column 1: dependent variable is number of land occupations per 10,000 km^2. Columns 2–3: dependent variable is number of land occupations by identified political organizations per 10,000 km^2. Columns 4–5: dependent variable is number of land occupations by unidentified political organizations per 10,000 km^2. Columns 3 and 5: sample is from 1988 to 2002. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Latifundium: area in farms above 500 hectares as farmland share in 1996. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 times year FE and ΔMaize times Post. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Standard errors clustered at the municipal level in parentheses. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Source: land occupations: *Dataluta*

Appendix
For Online Publication

A Additional Figures and Tables

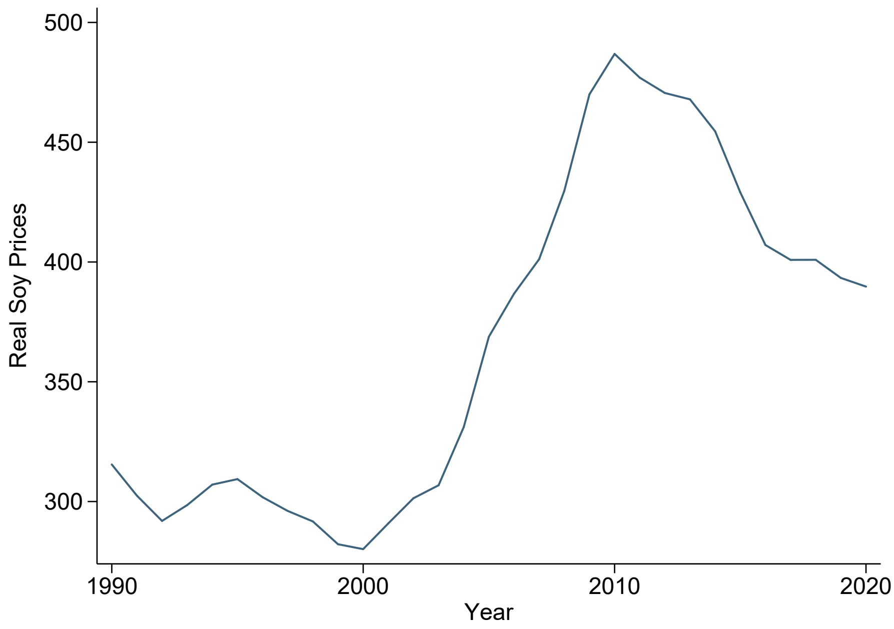
A.1 Figures

FIGURE A.1: Global Soy Trends



Notes: Panel A: area cultivated with soy as global farmland share computed as the sum of areas for cotton, maize, other coarse grains, other oilseeds, roots and tubers, raw sugar, rice, soybean, sugar, sugar beet, sugarcane and wheat. Panel B: soy imports by the ten largest economies in 1990 normalized from 0 to 1: Canada, France, Germany, Iran, Italy, Japan, Russian Federation, Spain, USA, UK. Sources: farmland: OECD-FAO Agricultural Outlook; imports: UN Comtrade.

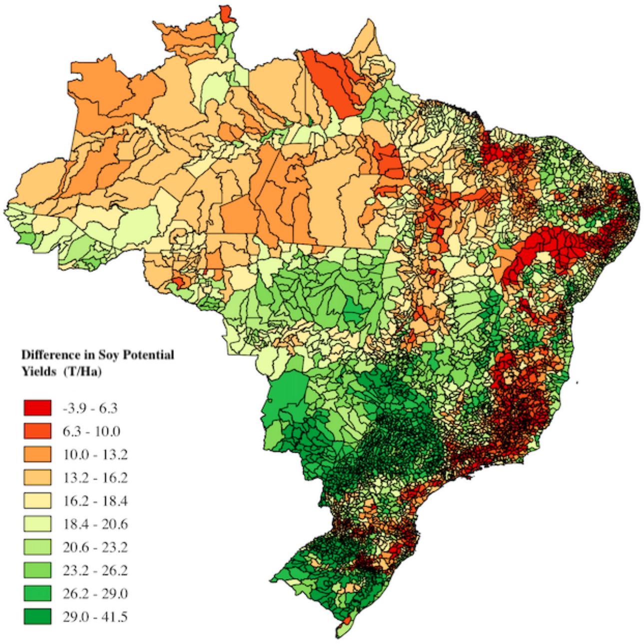
FIGURE A.2: Soy Prices



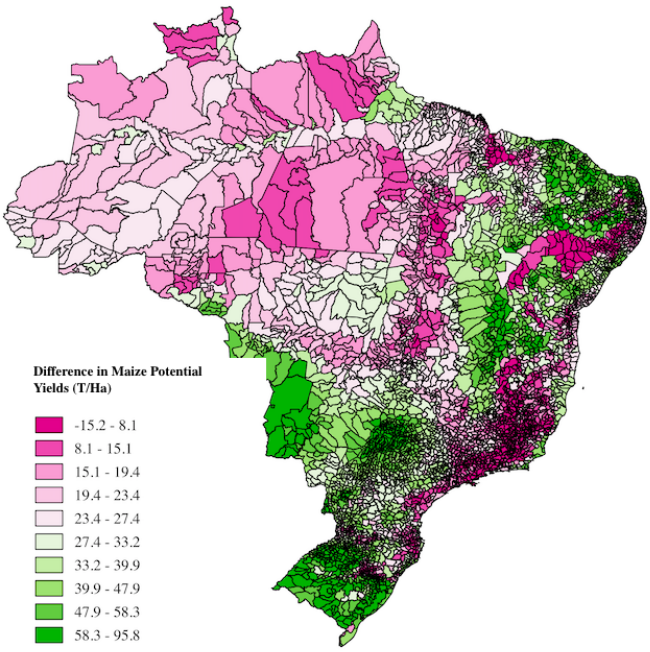
Notes: Real soy prices are in 2010 US dollars. Source: World Bank Commodity Price.

FIGURE A.3: Soy and Maize Potential Gains

A. Soy Potential Gains

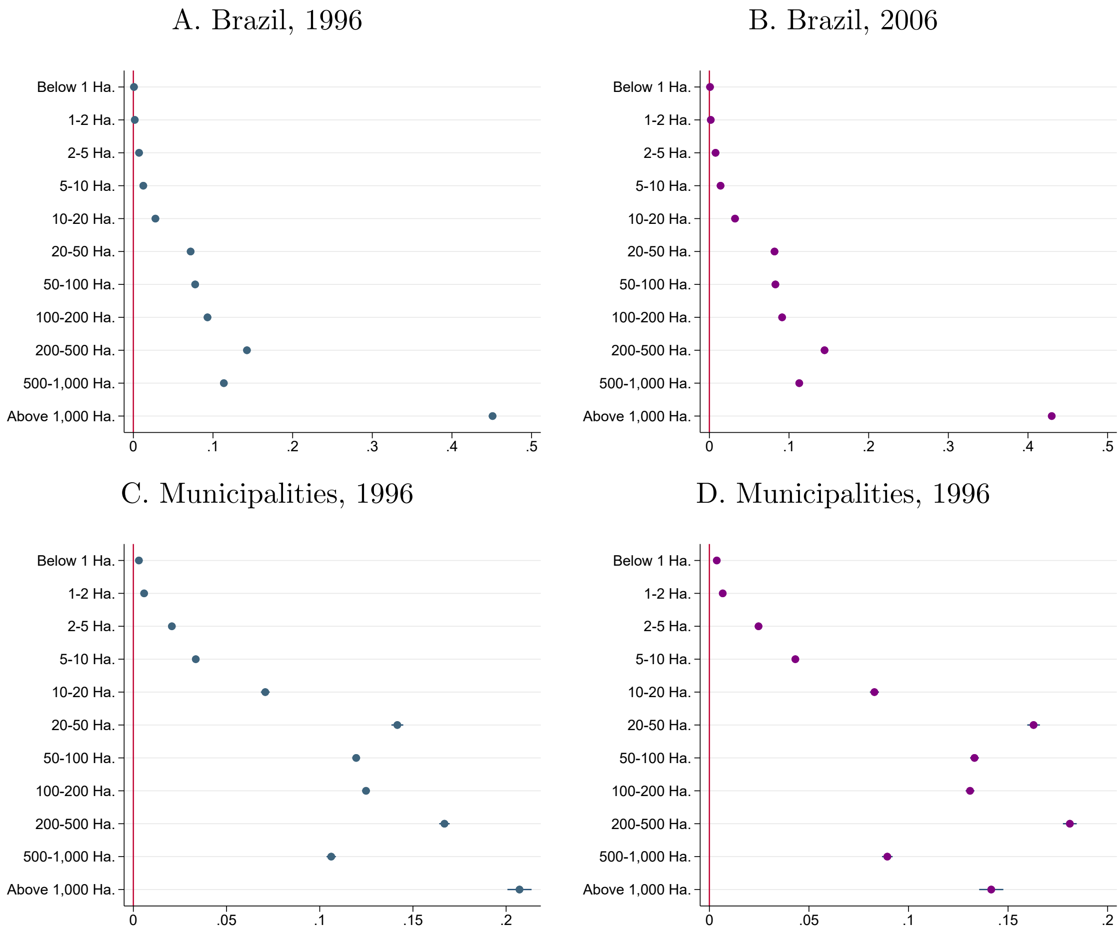


B. Maize Potential Gains



Notes: Panel A: difference in soy potential yields in tons per hectare under high- and low-tech inputs at the municipal level. Panel B: difference in maize potential yields in tons per hectare under high- and low-tech inputs at the municipal level. Source: FAO-GAEZ.

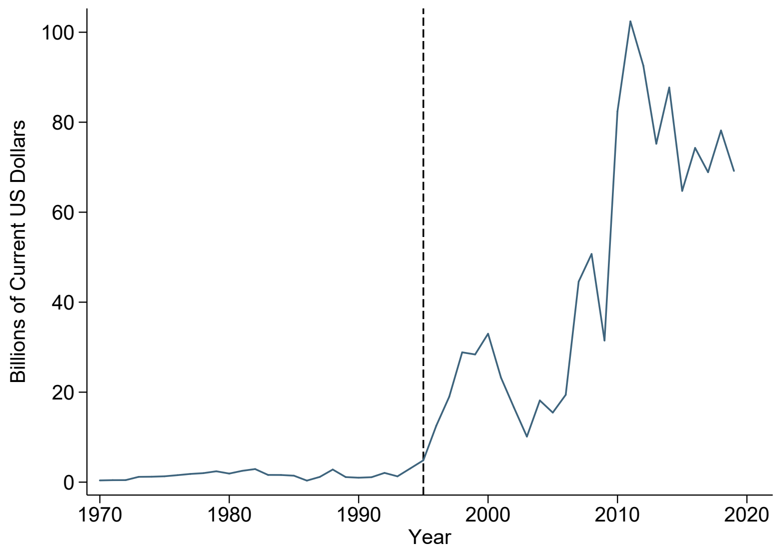
FIGURE A.4: Farmland Share by Farm Size, 1996 and 2006



Notes: Farmland share by farm size in Brazil (Panels A-B) and municipalities (Panels C-D) in 1996 and 2006. Sources: IBGE (1996) and IBGE (2006).

FIGURE A.5: Growth in FDI and Soy Exports after 1995

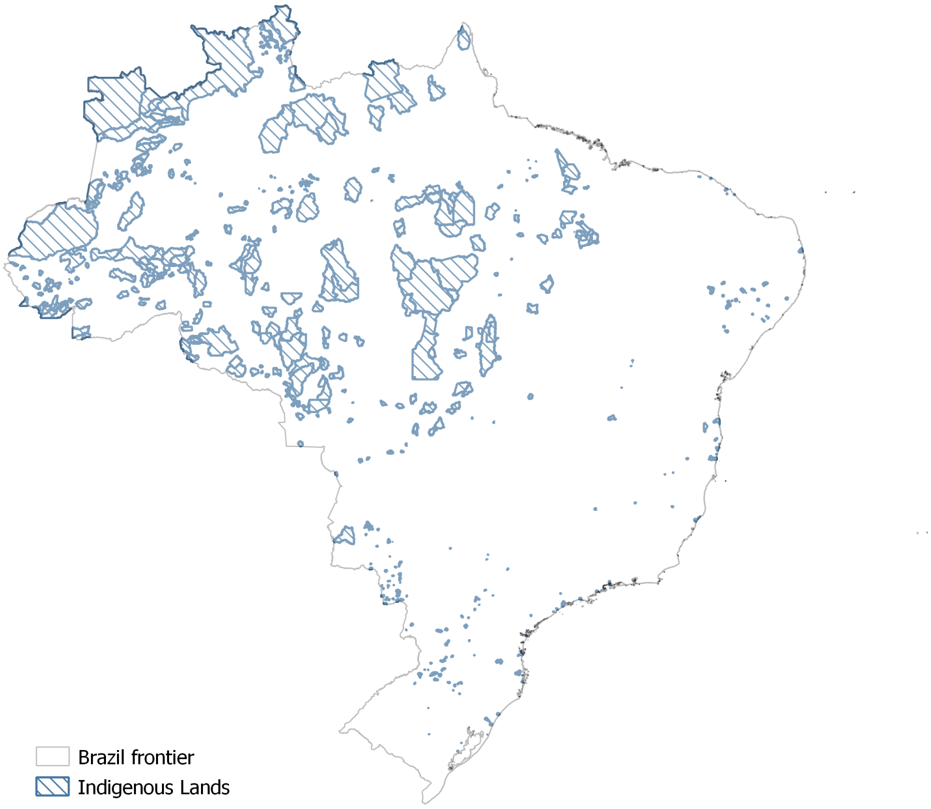
A. FDI Net Inflow, Billions of Current US$



B. Brazilian Soy Exports

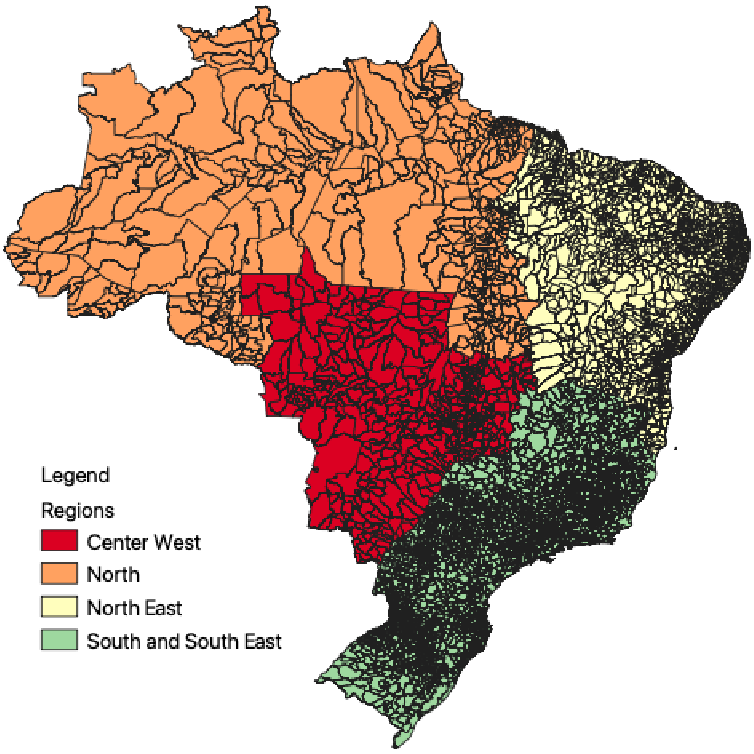
Notes: Panel A: FDI net inflow in billions of current US dollars. Panel B: exports of raw soy and soy crushed grains in millions of tons. Sources: FDI: World Development Indicators; exports: UN Comtrade.

FIGURE A.6: Indigenous Lands



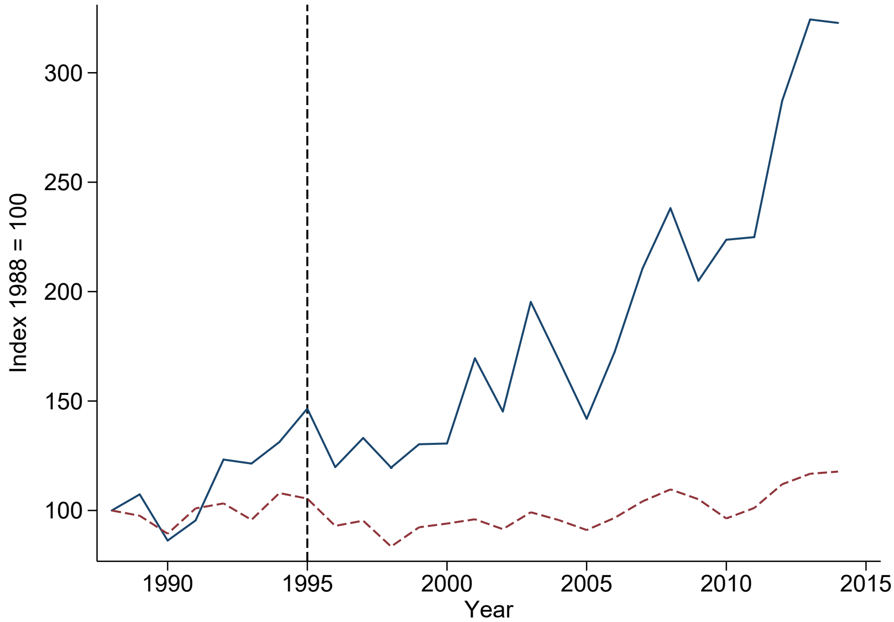
Notes: Geographic distribution of indigenous land. Source: ISA.

FIGURE A.7: Brazilian Census Regions



Notes: The five Brazilian census regions. The South and the South-East regions are shown with the same color. Source: IBGE.

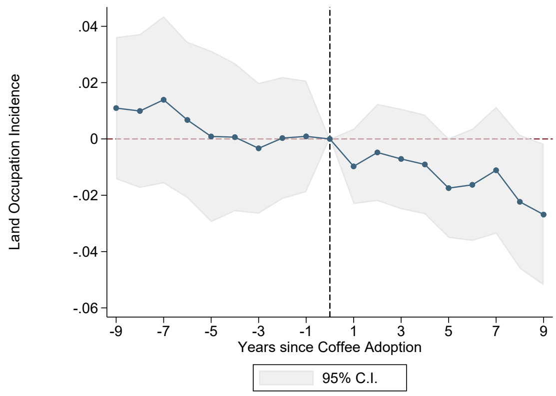
FIGURE A.8: Expansion of Maize Production, 1988–2014



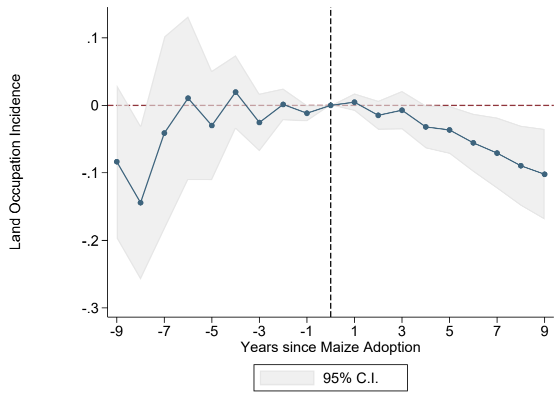
Notes: Trend in area cultivated with maize (dashed red) and in maize produced quantity (continuous blue) from 1988 to 2014 normalized to 100 in 1988. Source: PAM.

FIGURE A.9: Adoption of Alternative Crops

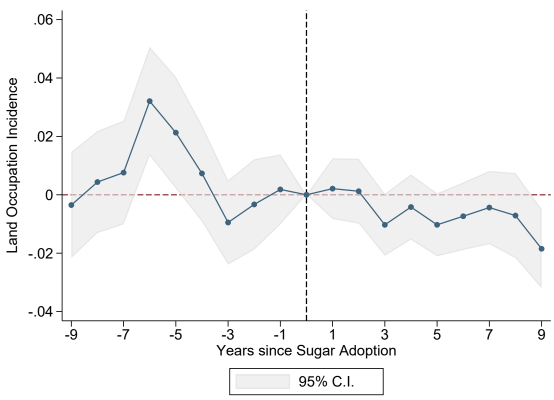
A. Coffee Adoption



B. Maize Adoption



C. Sugar Adoption

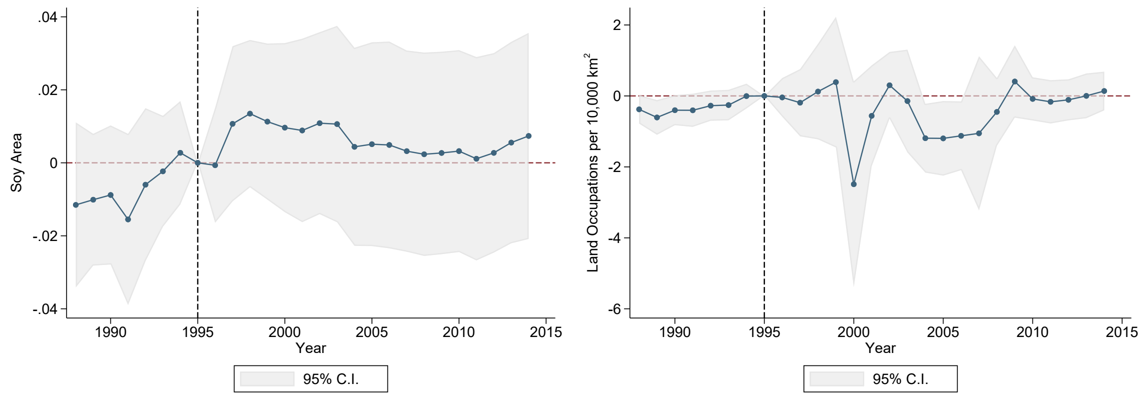


Notes: Estimates of equation (3) for areas cultivated with coffee (Panel A), maize (Panel B) and sugar (Panel C). Sources: areas: PAM; land occupations: *Dataluta*.

FIGURE A.10: Soy Potential Gains Outside Soy Regions

A. Soy Area

B. Land Occupations per 10,000 km^2

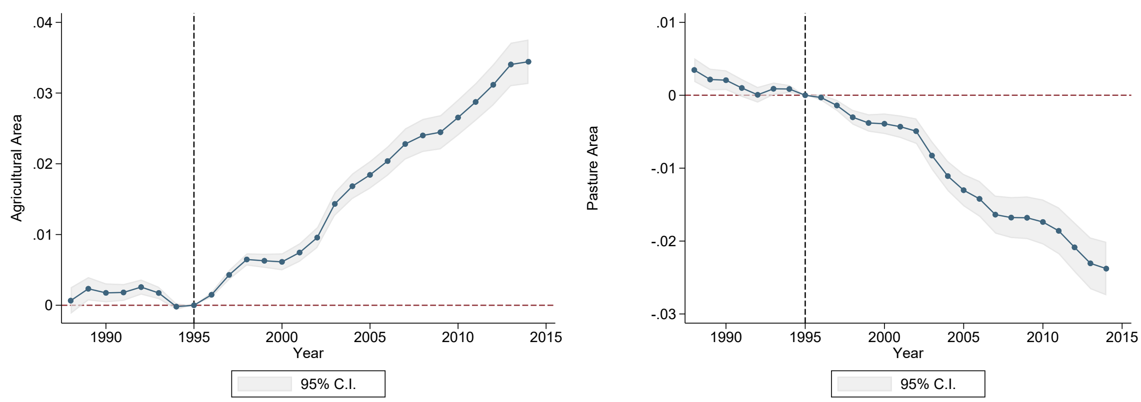


Notes: Estimates of equation (2) restricted to municipalities outside soy regions. Panel A: dependent variable is soy area as municipal share. Panel A: dependent variable is number of land occupations per 10,000 km^2. Soy regions: South, South-East and Central-West (Figure A.7). Sources: soy area: PAM; land occupations: *Dataluta*.

FIGURE A.11: Effect on Agriculture and Pasture Areas

A. Agricultural Area

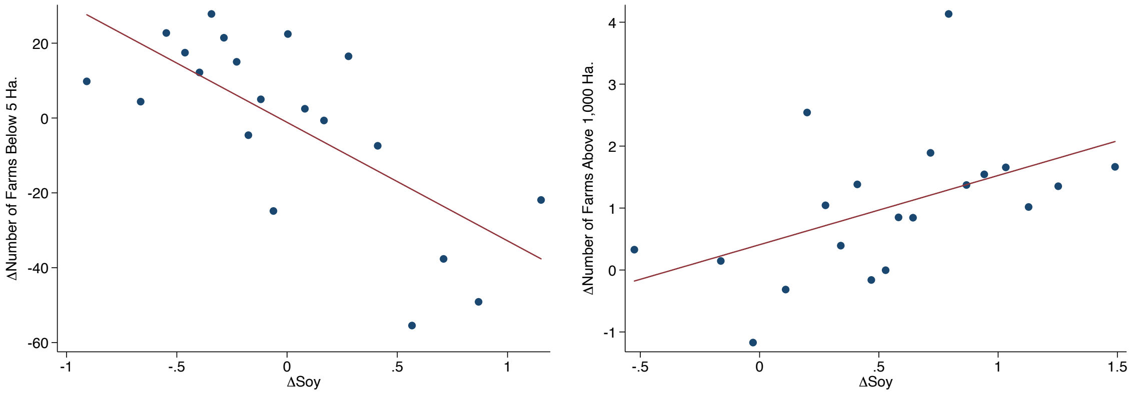
B. Pasture Area



Notes: Estimates of equation (2). Panel A: dependent variable is agricultural area as municipal share. Panel B: dependent variable is pasture area as municipal share. Agricultural area: sum of area for mosaic of crops, mosaic of agriculture and pasture, soy and sugarcane (MapBiomas, 2020 and footnote 48). Source: MapBiomas.

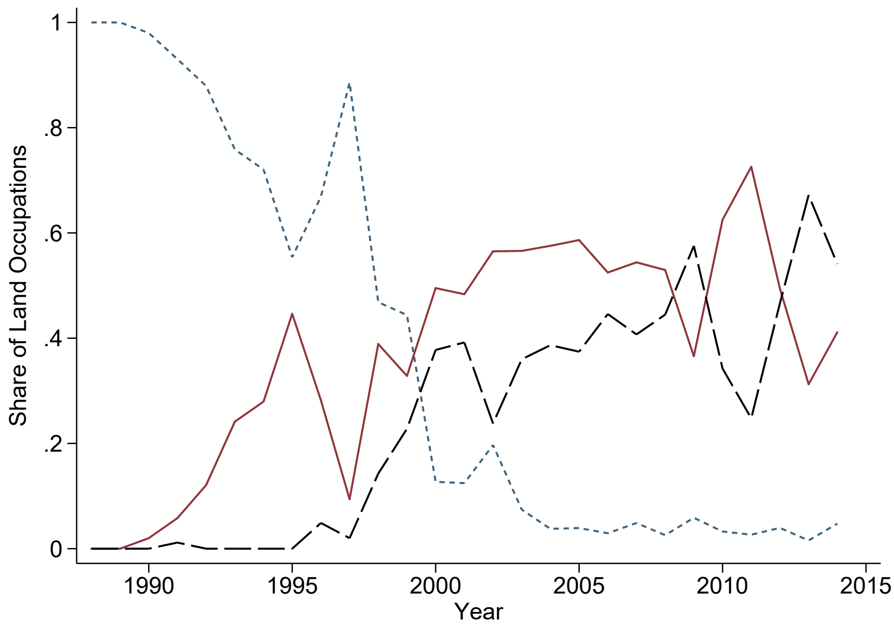
FIGURE A.12: Effect on Land Consolidation

A. Effect on the Number of Small Farms B. Effect on the Number of Large Farms



Notes: Binscatter where dependent variable is difference between values in 2006 and 1996 in number of farms in seasonal crop production below 5 hectares (Panel A) and above 1,000 hectares (Panel B). ΔSoy: difference in soy potential yields under high- and low-tech inputs. Controls: log income per capita, literacy rate, log population density, share of rural population and ΔMaize. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Sources: farms' number by size: IBGE (1996) and IBGE (2006).

FIGURE A.13: Trends in Land Occupations by Political Organizations



Notes: Trends in the share of land occupations by identified political organizations from 1988 to 2014. Continuous red: MST. Long-dashed black: other organizations. Short-dashed blue: no identified organization. Source: *Dataluta*.

A.2 Tables

TABLE A.1: Land Use and Labor Intensity by Farming Activity

	Land Use		Workers	
	1995	2006	1995	2006
	(1)	(2)	(3)	(4)
Permanent crops	7.5	11.7	127.2	126.7
Seasonal crops	34.3	44.6	110.8	83.7
Soy	9.2	17.9	28.6	17.2
Non-GE soy	9.2	13.7	28.6	NA
GE soy	NA	4.2	NA	NA
Maize	10.4	11.6	94.1	NA
Pasturing	177.7	168.4	25.9	30.6
Forestry	110.7	91.7	34.4	42.6

Notes: Data are for Brazil. Land use: total amount of farmland in millions of hectares. Workers: number of workers per 1,000 hectares. Soy and Maize: subset of Seasonal Crops. Non-GE soy and GE soy: subset of Soy. The sum of Permanent crops, Seasonal crops, Pasturing and Forestry constituted 93% of total censused farmland in 1996 and 95% in 2006. Total censused farmland was 353.6 and 333.7 millions of hectares in 1996 and 2006 respectively. Unusable land or land for other uses not reported. Sources: IBGE (1996) and IBGE (2006).

TABLE A.2: Geographical Correlates of Soy Potential Gains

	Latitude	Longitude	South	Center-West	Water Presence
	(1)	(2)	(3)	(4)	(5)
ΔSoy^{H-I}	2.685***	3.250***	0.104***	0.033***	0.007***
	(0.097)	(0.063)	(0.006)	(0.003)	(0.001)
ΔSoy^{I-L}	-1.207***	-1.638***	-0.064***	0.017***	-0.003***
	(0.111)	(0.084)	(0.007)	(0.003)	(0.001)
Observations	5558	5558	5558	5558	5557
Mean DV	16.464	46.238	0.513	0.084	0.014
Adjusted R^2	0.093	0.231	0.040	0.023	0.024

Notes: Estimates of $y_i = \delta + \beta_1 \Delta\text{Soy}_i^{H-I} + \beta_2 \Delta\text{Soy}_i^{I-L} + \mathbf{X}_i^{1991} + \varepsilon_i$. Column 1: dependent variable is latitude (absolute value). Column 2: dependent variable is longitude (absolute value). Column 3: dependent variable is equal to 1 if municipality is in South region. Column 4: dependent variable is equal to 1 if municipality is in Central-West region. Column 5: dependent variable is river, lakes and ocean area as municipal share. ΔSoy^{H-I}: difference in soy potential yields under high- and intermediate-tech inputs. ΔSoy^{I-L}: difference in soy potential yields under intermediate- and low-tech inputs. South: indicator of municipality in South or South-East; Central-West: indicator of municipality in Central-West (Figure A.7). Mean DV: average dependent variable. Robust standard errors in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: latitude, longitude and regions: IBGE; water presence: MapBiomas.

TABLE A.3: Summary Statistics

	From 1988 to 2014		
	Mean	SD	Observations
Source: Dataluta			
Land occupations per 10,000 km^2	1.153	12.900	150066
Organized occupations per 10,000 km^2	0.878	11.349	150066
Spontaneous occupations per 10,000 km^2	0.275	4.904	150066
Indigenous occupations per 10,000 km^2	0.029	1.753	150066
Source: PAM			
Soy area, municipal share	0.138	0.194	42501
Source: MapBiomas			
Agricultural area, municipal share	0.212	0.233	150066
	Cross-section		
	Mean	SD	Observations
Source: FAO-GAEZ			
Difference in soy potential yields, High - Low	1813.681	852.805	5559
Difference in soy potential yields, High - Int	1266.743	690.722	5559
Difference in soy potential yields, Int - Low	546.937	312.287	5559
Source: ISA			
Indigenous municipality	0.096	0.294	5559
	1991		
	Mean	SD	Observations
Source: Population Census			
Log income per capita	5.074	0.577	4424
Literacy rate	0.707	0.167	4424
Log population density per km^2	2.938	1.304	4424
Rural population share	0.467	0.228	4424

	1996		1996–2006		
	Mean	SD	Mean	SD	Observations
Source: Agricultural Census					
Farmland area, municipal share	0.736	0.310	-0.093	0.332	4420
Pasture area, farmland share	0.467	0.236	-0.033	0.134	4418
Forestry area, farmland share	0.166	0.149	0.025	0.108	4226
Non-GE soy area, farmland share	0.028	0.100	0.001	0.091	4418
GE soy area, farmland share	0.000	0.000	0.016	0.076	4420

Notes: Data are for municipalities. PAM: Municipal Agriculture Production database. FAO-GAEZ: FAO Global Agro-Ecological Zones database. ISA: Socioenvironmental Institute data on indigenous land. Population Census: IBGE (1991). Agricultural Census: IBGE (1996) and IBGE (2006).

TABLE A.4: Land Occupations and Soy Area, Correlation

	Land Occupations			
	(1)	(2)	(3)	(4)
Ln Soy Area	0.098*	0.110**	0.122**	0.117**
	(0.051)	(0.056)	(0.057)	(0.059)
Ln Maize Area			-0.083	-0.078
			(0.065)	(0.077)
Observations	42501	34977	34880	34845
Mean DV	0.307	0.306	0.306	0.306
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
State-by-Year FE	No	No	No	Yes
Controls	No	Yes	Yes	Yes
Adjusted R^2	0.120	0.126	0.122	0.124

Notes: Dependent variable is number of land occupations per 10,000 km^2. Column 1: estimates of $y_{it} = \gamma_i + \delta_t + \beta \text{Ln Soy Area}_{it} + \varepsilon_{it}$. Column 2: estimates of $y_{it} = \gamma_i + \delta_t + \beta \text{Ln Soy Area}_{it} + \mathbf{X}_{i,1991} + \varepsilon_{it}$. Column 3: estimates of $y_{it} = \gamma_i + \delta_t + \beta_1 \text{Ln Soy Area}_{it} + \beta_2 \text{Ln Maize Area}_{it} + \mathbf{X}_{i,1991} + \varepsilon_{it}$. Column 4: estimates of $y_{it} = \gamma_i + \delta_t + \beta_1 \text{Ln Soy Area}_{it} + \beta_2 \text{Ln Maize Area}_{it} + \mathbf{X}_{i,1991} + \varepsilon_{it}$ where δ_t are state-by-year fixed effects. Ln Soy Area: log of hectares cultivated with soy (inverse hyperbolic sine transformation). Ln Maize Area: log of hectares cultivated with maize (inverse hyperbolic sine transformation). Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density and share of rural population in 1991 times year FE. Standard errors clustered at municipal level in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: areas: PAM; land occupations: *Dataluta*.

TABLE A.5: Effect on Land Occupations, Robustness

	Land Occupation Incidence						Land Occupations per 10,000 Km^2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln Soy Area	0.003**						
	(0.001)						
ΔSoy × Post		0.005***	-0.010***		-0.000	0.008**	1.500***
		(0.001)	(0.003)		(0.002)	(0.003)	(0.290)
ΔSoy × Post × South			0.015***				
			(0.004)				
ΔSoy × Post × Center-West			0.056***				
			(0.011)				
ΔSoy × Soy Price				0.001			
				(0.002)			
ΔMaize × Post						-0.006*	-1.479***
						(0.003)	(0.272)
Observations	42501	150093	119448	119448	97011	119448	119448
Mean DV	0.019	0.012	0.014	0.014	0.012	0.014	0.317
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Full	Full	No Expansion	Full	Full
Adjusted R^2	0.174	0.161	0.169	0.168	0.167	0.168	0.108

Notes: Columns 1–6: dependent variable is equal to 1 if number of land occupations is higher than 0. Column 7: dependent variable is number of land occupations per 10,000 km^2. Column 1: estimates of $y_{it} = \gamma_i + \delta_t + \beta \text{Ln Soy Area}_{it} + \varepsilon_{it}$; Column 2: estimates of equation (1) with no controls. Column 3: estimates of equation (1) adding ΔSoy × Post × South, ΔSoy × Post × Central-West, South × Post and Central-West × Post (last two not shown). Column 4: estimates of equation (1) using Soy Price instead of Post. Column 5: estimates of equation (1) restricted to municipalities where soy area did not expand from 1996 to 2006. Columns 6–7: estimates of equation (1) adding ΔMaize × Post. ΔSoy: difference in soy potential yields under high- and low-tech inputs. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. South: indicator of municipality in South or South-East regions; Central-West: indicator of municipality in Central-West region (Figure A.7). Soy Price: national trend in real price of soy in 2010 US dollars normalized from 0 to 1. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density and share of rural population in 1991 times year FE. Standard errors clustered at municipal level in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Source: land occupations: *Dataluta*.

TABLE A.6: Effect on Soy Expansion and Land Occupations by Latitude

	Non-GE Soy Area Farmland Share	GE Soy Area Farmland Share	Land Occupations
	(1)	(2)	(3)
ΔSoy	0.046***	-0.051***	
	(0.004)	(0.005)	
ΔSoy × Latitude	-0.051***	0.092***	
	(0.008)	(0.009)	
ΔSoy × Post			1.494***
			(0.466)
ΔSoy × Post × Latitude			0.012
			(0.393)
Observations	4418	4420	119448
Mean DV	0.028	0.028	0.317
Municipality FE	.	.	Yes
Year FE	.	.	Yes
Controls	Yes	Yes	Yes
Sample	1996, 2006	1996, 2006	Full
Adjusted R^2	0.057	0.247	0.108

Notes: Columns 1–2: estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. Column 3: estimates of equation (1) adding ΔSoy × Post × Latitude and Latitude × Post (not shown). Column 1: dependent variable is non-GE soy area as farmland share. Column 2: dependent variable is GE soy area as farmland share. Column 3: dependent variable is number of land occupations per 10,000 km^2. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Latitude: absolute value normalized from 0 to 1. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density and share of rural population in 1991 (times year FE in column 3), and ΔMaize (times Post in column 3). ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors (columns 1–2) clustered at municipal level (columns 3) in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: soy area: IBGE (1996) and IBGE (2006); land occupations: *Dataluta*.

TABLE A.7: Effect on Soy Destination and Input Use

	Destination				Inputs	
	Industry	Intermediaries	Cooperatives	Consumers	Fertilizers	Tractors
	(1)	(2)	(3)	(4)	(5)	(6)
ΔSoy	0.044***	-0.011	0.007	-0.029***	0.045***	17.276***
	(0.010)	(0.011)	(0.009)	(0.009)	(0.010)	(6.406)
Observations	4424	4424	4424	4424	4424	912
Mean DV	0.181	0.247	0.171	0.090	0.278	9.059
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.029	0.006	0.016	0.003	0.023	0.029

Notes: Estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta \Delta \text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. Column 1: dependent variable is an indicator of soy sold to industry. Column 2: dependent variable is an indicator of soy sold to intermediaries. Column 3: dependent variable is an indicator of soy sold to cooperatives. Column 4: dependent variable is an indicator of soy sold to consumers. Column 5: dependent variable is an indicator of soy cultivated with chemical fertilizers. Column 5: dependent variable is number of tractors in agricultural production per hectare of soy. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 and ΔMaize. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors in parentheses. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: IBGE (1996) and IBGE (2006).

TABLE A.8: Effect on Farmland Allocation

Panel A			
	Farmland Area Municipal Share	Seasonal Crops Area Farmland Share	Soy Area Seasonal Crops Share
	(1)	(2)	(3)
ΔSoy	0.039***	0.022***	0.046***
	(0.014)	(0.003)	(0.006)
Observations	4418	4418	4409
Mean DV	0.738	0.199	0.066
Controls	Yes	Yes	Yes
Adjusted R^2	0.008	0.074	0.062
Panel B			
	Pasture Area Farmland Share	Soy Area Municipal Share	Soy Area Farmland Share
	(4)	(5)	(6)
ΔSoy	-0.032***	0.015***	0.018***
	(0.004)	(0.003)	(0.003)
Observations	4418	4424	4418
Mean DV	0.467	0.025	0.028
Controls	Yes	Yes	Yes
Adjusted R^2	0.088	0.036	0.056

Notes: Estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. Column 1: dependent variable is farmland area as municipal share. Column 2: dependent variable is seasonal crops area as farmland share. Column 3: dependent variable is soy area as seasonal crops area share. Column 4: dependent variable is pasture area as farmland share. Column 5: dependent variable is soy area as municipal share. Column 6: dependent variable is soy area as farmland share. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 and ΔMaize. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: areas: IBGE (1996) and IBGE (2006).

TABLE A.9: Effect on Soy, Pasture, and Forestry Areas by Region

	Soy Area Farmland Share	Pasture Area Farmland Share	Forestry Area Farmland Share
	(1)	(2)	(3)
ΔSoy	0.002	-0.021***	0.005
	(0.002)	(0.006)	(0.005)
ΔSoy × South	0.018***	-0.014***	0.001
	(0.002)	(0.005)	(0.004)
ΔSoy × Central-West	0.044***	-0.018*	-0.026***
	(0.005)	(0.010)	(0.008)
Observations	4418	4418	4226
Mean DV	0.028	0.467	0.167
Controls	Yes	Yes	Yes
Adjusted R^2	0.068	0.116	0.033

Notes: Estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta_1 \Delta \text{Soy}_i + \beta_2 \Delta \text{Soy}_i \times \text{South} + \beta_3 \Delta \text{Soy}_i \times \text{Central-West} + \text{South} + \text{Central-West} + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. Estimates for South and Central-West are not shown. Column 1: dependent variable is soy area as farmland share. Column 2: dependent variable is pasture area as farmland share. Column 3: dependent variable is forestry area as farmland share. ΔSoy: difference in soy potential yields under high- and low-tech inputs. South: indicator of municipality in South or South-East regions; Central-West: indicator of municipality in Central-West region (Figure A.7). Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 and ΔMaize. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors in parentheses. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: areas: IBGE (1996) and IBGE (2006).

TABLE A.10: Effect on Land Consolidation

Panel A: Number of Farms by Size in Hectares									
	0–5	5–10	10–20	20–50	50–100	100–200	200–500	500–1,000	≥ 1,000
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔSoy	-31.658***	-0.428	-5.471***	-10.291***	-3.778***	-0.268	0.158	0.392	1.117***
	(6.880)	(1.520)	(1.294)	(1.826)	(0.897)	(0.503)	(0.360)	(0.298)	(0.339)
Observations	4424	3828	3958	4062	3781	3255	2666	1404	1058
Mean DV	134.298	150.112	162.740	183.627	57.000	62.349	48.069	25.549	29.560
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.012	0.012	0.026	0.020	0.012	0.008	0.007	0.015	0.017
Panel B: Log Size of Farms by Size in Hectares									
	0–5	5–10	10–20	20–50	50–100	100–200	200–500	500–1,000	≥ 1,000
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
ΔSoy	-0.091***	0.000	0.001	0.008**	0.001	0.008*	0.010	0.011	0.260***
	(0.019)	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)	(0.008)	(0.011)	(0.077)
Observations	3321	3470	3621	3733	3160	2429	1874	742	433
Mean DV	2.509	7.152	14.044	31.112	68.302	135.034	299.562	679.233	2861.493
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.065	-0.000	0.003	0.002	0.000	-0.000	0.001	0.000	0.042
Panel C: Soy Area in Farms by Size in Hectares									
	0–5	5–10	10–20	20–50	50–100	100–200	200–500	500–1,000	≥ 1,000
	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
ΔSoy	1.467	11.591**	4.554	-1.628	-3.484	93.623**	227.904***	287.893***	748.068***
	(6.042)	(5.218)	(10.715)	(14.426)	(9.650)	(42.825)	(46.831)	(73.494)	(186.770)
Observations	4424	4400	4400	4400	4400	4400	4400	4400	4400
Mean DV	9.201	29.066	101.011	207.452	167.292	190.981	323.756	285.416	688.700
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	-0.000	0.003	-0.001	0.005	0.014	0.008	0.024	0.018	0.032

Notes: Estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996 and refers to farms in seasonal crops production: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Mean DV: average pre-treatment dependent variable (in absolute value in Panel B). Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 and ΔMaize. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: farms' number, size and soy area by size: IBGE (1996) and IBGE (2006).

TABLE A.11: Labor Intensity by Size of Farm in 1996

Hectares	Mean Labor Intensity	SD	Observations
Below 5	1.340	1.372	4869
5–10	0.459	0.349	4861
10–20	0.249	0.109	4912
20–50	0.125	0.087	4920
50–100	0.067	0.054	4910
100–200	0.043	0.055	4817
200–500	0.027	0.031	4661
500–1,000	0.019	0.034	4069
Above 1,000	0.014	0.034	3430

Notes: Labor Intensity: number of workers in agricultural production per hectare of farmland in 1996 in relative category of farm size. Source: IBGE (1996).

TABLE A.12: Effect on Employment Opportunities

Panel A			
	Workers Seasonal Crops	Workers Other Activities	Workers per 100 Hectares
	(1)	(2)	(3)
ΔSoy	-151.800***	73.716*	-1.042**
	(37.978)	(38.315)	(0.500)
Observations	4373	4373	4418
Mean DV	1456.837	2394.583	12.534
Controls	Yes	Yes	Yes
Sample	1996, 2006	1996, 2006	1996, 2006
Adjusted R^2	0.022	0.019	0.004
Panel B			
	Soy Area Municipal Share	Land Occupation Incidence	Land Occupations per 10,000 Km^2
	(4)	(5)	(6)
ΔSoy × Post	0.022***	0.015	1.571**
	(0.004)	(0.027)	(0.725)
ΔSoy × Post × RTR	-0.018***	0.070	0.122
	(0.007)	(0.044)	(0.701)
Observations	12204	12204	12204
Mean DV	0.018	0.098	0.345
Microregion FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Sample	Microregions	Microregions	Microregions
Adjusted R^2	0.941	0.319	0.269

Notes: Panel A: estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. Panel B: estimates of equation (1) adding ΔSoy × Post × RTR and RTR × Post (not shown). Column 1: dependent variable is number of rural workers in production of seasonal crops. Column 2: dependent variable is number of rural workers in agricultural activities other than production of seasonal crops. Column 3: dependent variable is number of rural workers per 100 hectares of farmland. Column 4: dependent variable is soy area as municipal share. Column 5: dependent variable is equal to 1 if number of land occupations is higher than 0. Column 6: dependent variable is number of land occupations per 10,000 km^2. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. RTR: regional tariff reduction (footnote 50). Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 (times year FE in Panel B) and ΔMaize (times Post in Panel B). ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors (Panel A) clustered at the microregion level (Panel B) in parentheses. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: workers: IBGE (1996) and IBGE (2006); soy area: PAM; land occupations: *Dataluta*.

B Other Data Sources

Information on soy prices in 2010 real US dollars is from the World Bank Commodity Price database. We complement information on agricultural production using satellite data aggregated at the municipal level. This data allow us to keep track of changes in land cover and use in areas unregistered by the census. We use two sources. First, we employ data from MapBiomas version 5.0 to compute variables per unit of municipal area, such as number of land occupations per 10,000 km^2 and shares of municipal area with soy, agriculture, pasture, water presence, and natural zones.[48] Second, we use information from the Project on the Satellite Monitoring of Deforestation in the Legal Amazon (*Projeto de Monitoramento do Desmatamento na Amazônia Legal por Satélite*, PRODES) on deforested area as the share of municipal surface from 2000 to 2014 in the region.[49]

To attribute the "indigenous" status to municipalities, we use information from the Socioenvironmental Institute (*Instituto Socioambiental*, ISA) and consider as indigenous the 533 municipalities—around 9.5% of the total—with at least one hectare of indigenous land (Figure A.6).

Information on population characteristics comes from the 1991 Population Census of IBGE. For each municipality, we construct the population density as the log number of people divided by the satellite area in 1991, the literacy rate as the number of literate people over total population, and the share of rural population as the number of people living in rural areas over total population. To compute income per capita, we use information on average household income per capita and aggregate it at the municipal level using individual households weights. All demographic variables refer exclusively to people who are at least ten years old.

We compute the "regional tariff reduction" variable (RTR) measuring exposure to tariff reduction for each microregion, a larger unit of observation than the municipality, from 1990 to 1995 as in Kovak (2013), based on data from Kume, Piani, and de Souza (2015), IBGE (1991), and the 1990 National Accounts data from IBGE.[50] Last, we use information on municipal latitude, longitude, borders, minimum com-

[48] We measure agricultural area as the sum of land in the following categories: *temporary crops* and *mosaic of agriculture and pasture*, the former being subdivided in soybean, sugarcane, and *mosaic of crops*. Mosaic is defined as the area where satellites do not distinguish between the referred categories. Water presence is computed based on rivers, lakes and ocean cover. Total satellite area is subdivided in natural and anthropic zones, the former being defined as the sum of areas for forest, savanna and grassland formation, wetlands, salt flats, rocky outcrops, other non-forest formation, mangroves, beaches and dunes, rivers, lakes and ocean (MapBiomas, 2020).

[49] The Legal Amazon comprises the nine states of the Amazon basin.

[50] The variable is computed as $\text{RTR}_r = -\sum_i \beta_{ri}\ d\ ln(1+\tau_i)$, where r is microregion, τ_i tariff rate

parable areas (*Áreas Mínimas Comparaveis*, AMCs), microregions, and regions from IBGE. To perform the analysis at the microregion level in Panel B of Table A.12 and Section D.2, we create microregion variables using the same procedure as for municipal-level observations.

C Anecdotal Evidence

C.1 The case of the Triângulo Mineiro

The region called *Triângulo Mineiro* represents the typical area where the intensification of soybean production led to land occupations. By focusing on this specific region, we can verify whether our main results hold at the local level and gain a more precise understanding of the dynamics involved in the relationship between soybean production and land occupations. The region in the west of Minas Gerais, with around 90,000 km^2 and 65 municipalities, witnessed a dramatic expansion of the agro-industrial complex since the mid-1990s. In 1997, one of the most prominent international players in the industry (Cargill) presented a plan to double its soy processing capacity (Cleps Jr, 1998).

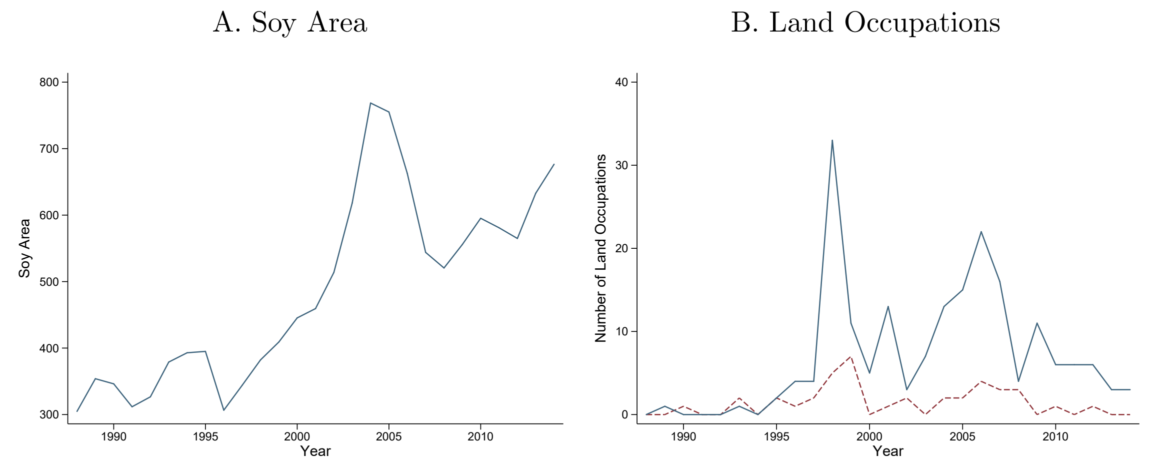
Between 1996 and 2004, the region registered a 150% increase in the area devoted to soybean cultivation, growing from around 307,000 to 769,000 hectares (Panel A of Figure C.14). Local commentator Rozetti de Carvalho (2007) describes the significant increase in the number of landless peasants forced to rural exodus because of the reduced access to land and employment opportunities, while the multiplication of social movements fighting for land redistribution led to a three fold increase in land occupations in the 1996–2004 period. Rural workers participating in land occupations describe the link between agribusiness and the land issue as follows: "The agribusiness affects life in the countryside and in the city as it only produces on a large scale with high-tech machinery, thus bringing about unemployment in the countryside, and making the phenomenon of rural exodus reappear."[51] Consistently, we find that, in the 35 municipalities where soy expanded from 1996 to 2006, the number of land occupations increased more than in the 30 municipalities where soy did not expand after 1995 (Panel B of Figure C.14). This differential increase is visible since 1996

in industry i, d long difference from 1990 to 1995 and β_{ri} equal to $\frac{\lambda_{ri}\frac{1}{\gamma_i}}{\sum_j \lambda_{ri}\frac{1}{\gamma_j}}$, with γ_i being the cost share of nonlabor factors and λ_{ri} the share of regional labor initially allocated to tradable industry i. See Kovak (2013) and Dix-Carneiro and Kovak (2017) for further reference.

[51] A participant in a land occupation in the Triângulo Mineiro, quoted in Silvério (2012). Interview taken in 2010.

and is in line with the timing in our baseline analysis (Panel B-C of Figure 3).

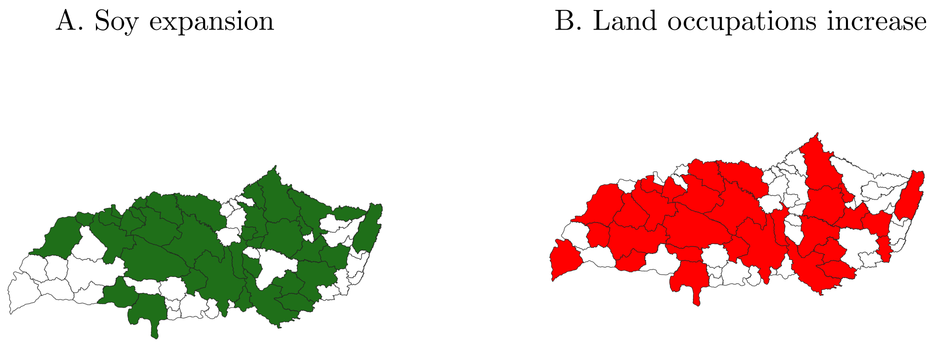
FIGURE C.14: Timing of Soy Expansion and Effect on Land Occupations



Notes: Panel A: trend in area cultivated with soy in thousands of hectares from 1988 to 2014. Panel B: number of land occupations in municipalities where soy area expanded from 1996 to 2006 (continuous blue) versus those in which it did not (dashed red). Sources: soy area: IBGE (1996), IBGE (2006) and PAM; land occupations: *Dataluta*.

In Figure C.15, we show the local dynamics of soybean expansion and escalation of land occupations in the 1988–2014 period.

FIGURE C.15: Soy Area and Land Occupations, 1996 and 2006



Notes: Panel A: municipalities where soy expanded from 1996 to 2006 in green. Panel B: municipalities where the average number of land occupations was higher in the 1996–2006 than in the 1988–1995 period in red. Sources: soy area: IBGE (1996) and IBGE (2006); land occupations: *Dataluta*.

C.2 The Agricultural Frontier in Santarém

Steward (2007) provides a detailed analysis of soybean expansion since 1996 in Santarém, a municipality in the state of Pará. In 1995, the governor of Pará financed a program—Agricultural Engineering and Consulting—to study Santarém and neighboring municipalities' potential for commercial farming. In 1996–1997, the first soy pilot projects were implemented. New farmers established in the area, followed by agribusiness entrepreneurs, mainly soy buyers, technicians and inputs suppliers. Notably, the international agribusiness company Cargill initiated the "Northern Exit Project" to seek Northern export routes for soy, and established office in Santarém.

According to Steward (2007), these events were contextual to a first wave of small farmers' displacement. In 2003, Cargill finalized the construction of a port along the banks of the Amazon river in Santarém. By that year, approximately 200 agro-industrial farms were already operating in the Santarém region. Unions and NGOs reported large number of small farmers' displacement to surrounding forest areas and to Santarém city. In July 2003, the Rural Workers Union (*Sindicato dos Trabalhadores Rurais*) and the Pastoral Land Commission launched a campaign to stop the production of soy and asked local farmers not to sell their land to soybean producers.

Available anecdotal evidence suggests that the soybean expansion brought conflict in the region. According to van Solinge and Kuijpers (2013), "representatives of civil society who were interviewed in Santarém claimed that much of the land on which soy is cultivated in the Santarém area was not actually bought but grabbed. They argue that soy farmers around Santarém grab publicly owned land from those who do not want to leave." Events often escalated in violence involving treats and killings of members of local communities (Schlesinger and Noronha, 2006).

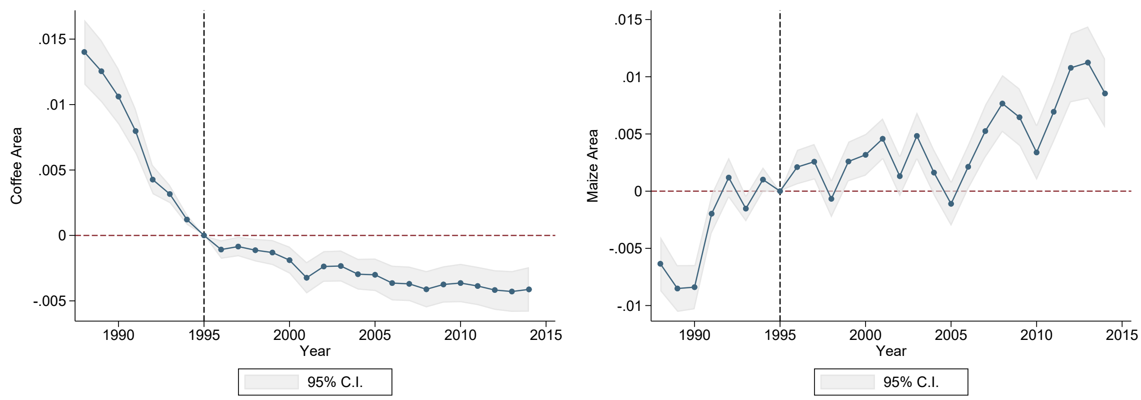
D Robustness

D.1 Alternative Crops

Although the expansion of soy production was the main feature of the Brazilian agricultural modernization process, the higher incentive to invest in Brazilian agriculture since the mid-1990s might have led to the growth of other crops' cultivated area, possibly affecting land occupations. Although not undermining our identification strategy, the additive effect of soy and other crops' expansions would prevent us from isolating the specific channels that relate agricultural modernization to land occupations. Therefore, we investigate and rule out the growth of the cultivated area for other crops driven by soy potential gains after 1995. Figure D.16 shows estimates of equation (2) where the outcome variable is the land used for coffee, maize, and sugar production. These findings suggest that soy potential gains induced the expansion of soy cultivation but did not affect the production of other crops in the post- versus pre-1995 period.

FIGURE D.16: Expansion of Alternative Crops

A. Coffee Area B. Maize Area



C. Sugar Area

Notes: Estimates of equation (2) for areas cultivated with coffee (Panel A), maize (Panel B) and sugar (Panel C). Sources: areas: PAM; land occupations: *Dataluta*.

D.2 Geographic Spillovers, Spatial Correlation, and Redistricting

To alleviate concerns related to geographic spillovers and the administrative splitting of municipalities—redistricting—during the period of our study (Dahis and Szerman, 2020), we estimate equation (1) at the microregion level, a larger unit of analysis. Since the redistricting process may have attributed split municipalities to different microregions, we also show results at the AMC level.[52] Columns 1–2 and 5–6 of Table D.13 show that our main effects are stronger in microregions than municipalities or AMCs. When focusing on soy cultivation, we find that a one standard deviation increase in soy potential gains (ΔSoy) at the AMC level leads to 1.5 percentage points higher soy area, from a pre-treatment mean of 9.7, which is a 15% increase (column 1). In contrast, the increase is 51% for microregions (column 5). A similar geographic pattern is also apparent for land occupations: here, the effect is almost twice as high in microregions (column 6) than AMCs (column 2), indicating that soy potential gains might have induced land occupations in neighboring municipalities.

[52] We count 4,267 AMCs and 558 microregions in our dataset.

TABLE D.13: Geographic Spillovers, Spatial Correlations, and Redistricting

Panel A	Soy Area AMC Share	Land Occupations	Pasture Area Farmland Share	Workers Seasonal Crops
	(1)	(2)	(3)	(4)
ΔSoy × Post	0.015***	0.808***		
	(0.002)	(0.151)		
ΔSoy			-0.032***	-160.095***
			(0.004)	(41.150)
Observations	35798	113643	4203	4159
Mean DV	0.097	0.304	0.474	1626.063
AMC FE	Yes	Yes	.	.
Year FE	Yes	Yes	.	.
Controls	Yes	Yes	Yes	Yes
Sample	Full	Full	1996, 2006	1996, 2006
Adjusted R^2	0.915	0.110	0.092	0.017
Panel B	Soy Area Microregion Share	Land Occupations	Pasture Area Farmland Share	Workers Seasonal Crops
	(5)	(6)	(7)	(8)
ΔSoy × Post	0.023***	1.528***		
	(0.004)	(0.458)		
ΔSoy			-0.036***	-1369.012***
			(0.007)	(497.896)
Observations	8775	15012	556	556
Mean DV	0.045	0.317	0.438	12189.588
Microregion FE	Yes	Yes	.	.
Year FE	Yes	Yes	.	.
Controls	Yes	Yes	Yes	Yes
Sample	Full	Full	1996, 2006	1996, 2006
Adjusted R^2	0.950	0.271	0.190	0.066

Notes: Panel A: estimates at AMC level. Panel B: estimates at microregion level. Columns 1 and 5: estimates of equation (1); dependent variable is soy area as share of geographical unit. Columns 2 and 6: estimates of equation (1); dependent variable is number of land occupations per 10,000 km^2. Columns 3 and 7: estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$; dependent variable is pasture area as farmland share. Columns 4 and 8: estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$; dependent variable is number of rural workers in production of seasonal crops. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 (times year FE in columns 1–2 and 5–6) and ΔMaize (times Post in columns 1–2 and 5–6). ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors (columns 3–4 and 7–8) clustered at AMC (columns 1–2) and microregion (columns 5–6) levels in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: areas and workers: IBGE (1996), IBGE (2006) and PAM; land occupations: *Dataluta*.

Finally, because soy potential gains are correlated across municipalities (Panel A of Figure A.3), we correct standard errors in Table D.14 using the Conley HAC method, yielding similar results to the baseline regression.

TABLE D.14: Spatial Correlation, Conley HAC Standard Errors

	Land Occupations			
	(1)	(2)	(3)	(4)
ΔSoy × Post	0.810**	0.810**	0.810**	0.810**
	(0.189)	(0.205)	(0.190)	(0.182)
Observations	150039	150039	150039	150039
Mean DV	0.265	0.265	0.265	0.265
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Distance Cutoff	500 Km	1,000 Km	5,000 Km	10,000 Km
Years Lag	5	10	15	15
Adjusted R^2	0.0004	0.0004	0.0004	0.0004

Notes: Estimates of equation (1) correcting standard errors for spatial and temporal dependence within several buffers using the procedure in Conley (1999). Dependent variable is number of land occupations per 10,000 km^2. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density and share of rural population in 1991, (times year FE in columns 1–3) and ΔMaize (times Post in columns 1–3). ΔMaize: difference in maize potential yields under high- and low-tech inputs. Standard errors in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Source: land occupations: *Dataluta*.

D.3 Alternative Measures of Land Occupations

Table D.15 shows that our main results are robust to the use of alternative outcome measures. In Panel A, we find that soy potential gains (ΔSoy) leads to a higher number of land occupations (column 1), occupying families (column 2), land occupations per capita (column 3), and share of occupied farmland (column 4) in the post-1995 period.

TABLE D.15: Alternative Outcome Measures

	Ln Number Land Occupations	Ln Number Occupying Families	Land Occupations per 100,000 rural inhabitants	Occupied Area Farmland Share
	(1)	(2)	(3)	(4)
ΔSoy × Post	0.012***	0.038**	0.868**	
	(0.004)	(0.017)	(0.351)	
ΔSoy				0.007***
				(0.002)
Observations	119448	119285	119448	4171
Mean DV	0.016	0.077	0.521	0.040
Municipality FE	Yes	Yes	Yes	.
Year FE	Yes	Yes	Yes	.
Controls	Yes	Yes	Yes	Yes
Sample	Full	Full	Full	1996, 2006
Adjusted R^2	0.194	0.176	0.152	0.013

Notes: Columns 1–3: estimates of equation (1). Column 1: dependent variable is log number of land occupations (inverse hyperbolic sine transformation). Column 2: dependent variable is log number of occupying families (inverse hyperbolic sine transformation). Column 3: dependent variable is number of land occupations per 100,000 rural inhabitants measured in 1991. Column 4: estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta\Delta\text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 times year FE and ΔMaize times Post. ΔMaize: difference in maize potential yields under high- and low-tech inputs. Robust standard errors (column 4) clustered at municipal level (columns 1–3) in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: land occupations: *Dataluta*; rural inhabitants: IBGE (1991); areas: IBGE (1996) and IBGE (2006).

D.4 Rural Municipalities and Additional Controls

Table D.16 provides evidence that our baseline findings are robust to restricting the sample to rural municipalities and to the inclusion of additional controls measuring land inequality and the presence of landless peasants. Previous research has in fact shown that these variables are important determinants of land occupations in the Brazilian context (Hidalgo, Naidu, Nichter, and Richardson, 2010).[53] We construct three proxies of land inequality and landless presence using information in IBGE (1996): share of farmland in farms above 500 hectares, share of farms above 500 hectares, and share of workers in farms above 500 hectares. Accounting for the interaction between these variables and year fixed effects reduces the concern that we are capturing the effect of the struggle of the landless since the political events in the 1990s in municipalities with high land inequality, large farms, or organized hired labor. In addition, we control for yearly trends in the share of municipal surface

[53] We focus only on municipalities with at least 50% rural population and with a urban population below 100,000 inhabitants in 1991, thus excluding large metropolitan areas.

in natural zones in 1991 to account for environmental degradation and worsening climatic conditions in natural areas—both potential drivers of land occupations.

TABLE D.16: Rural Municipalities and Additional Controls

	Soy Area Municipal Share	Land Occupations	Pasture Area Farmland Share	Workers Seasonal Crops
	(1)	(2)	(3)	(4)
ΔSoy × Post	0.058***	1.135**		
	(0.013)	(0.515)		
ΔSoy			-0.020***	-507.021***
			(0.007)	(88.219)
Observations	13102	56160	2080	2075
Mean DV	0.169	0.250	0.426	2018.566
Municipality FE	Yes	Yes	.	.
Year FE	Yes	Yes	.	.
Controls	Yes	Yes	Yes	Yes
Additional Controls	Yes	Yes	Yes	Yes
Rural	Yes	Yes	Yes	Yes
Sample	Full	Full	1996, 2006	1996, 2006
Adjusted R^2	0.871	0.087	0.078	0.035

Notes: Columns 1–2: estimates of equation (1). Columns 3–4: estimates of first-differenced version of equation (1) where dependent variable is difference between values in 2006 and 1996: $\Delta y_i = \Delta\delta + \beta_\Delta \text{Soy}_i + \mathbf{X}_i^{1991} + \Delta\varepsilon_i$. Column 1: dependent variable is soy area as municipal share. Column 2: dependent variable is number of land occupations per 10,000 km^2. Column 3: dependent variable is pasture area as farmland share. Column 4: dependent variable is number of rural workers in production of seasonal crops. ΔSoy: difference in soy potential yields under high- and low-tech inputs. Post: indicator of post-1995 period. Mean DV: average pre-treatment dependent variable. Controls: log income per capita, literacy rate, log population density, share of rural population in 1991 (times year FE in columns 1–2) and ΔMaize (times Post in columns 1–2). ΔMaize: difference in maize potential yields under high- and low-tech inputs. Additional controls: share of farmland in farms above 500 hectares, share of farms above 500 hectares and share of workers in farms above 500 hectares in 1996, and natural zones as municipal share in 1991 (times year FE in columns 1–2). Rural: more than 50% rural population and urban population below 100,000 inhabitants in 1991. Robust standard errors (columns 3–4) clustered at municipal level (columns 1–2) in parenthesis. Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$. Sources: areas and workers: IBGE (1996), IBGE (2006) and PAM; land occupations: *Dataluta*.

E Industrial Labor Demand

Panel B of Table A.12 focuses on the role of the industrial labor demand in mitigating the effect on land occupations. Both the qualitative literature (Schlesinger and Noronha, 2006) and the available quantitative evidence (Bustos, Caprettini, and Ponticelli, 2016) indicate that rural workers moved to the closest city in search of employment opportunities as a consequence of agricultural modernization. Therefore, industrial employment availability can mitigate the effect of agricultural modernization on land conflict by reabsorbing excess labor from rural areas. We test the hypothesis by exploiting the heterogeneous labor market conditions induced by the regional variation in tariff reduction between 1990 and 1995, relying on its measurement by Kovak (2013). Using this measure, Dix-Carneiro and Kovak (2017) show that a microregion facing a 10-percentage-point larger tariff reduction experienced a 35-percentage-point higher decline in formal industrial employment.

We find evidence that industrial labor demand plays a role in mitigating the effect of agricultural modernization. While the effect on soy expansion is largely weaker in microregions with higher tariff reduction (column 4), in this same area, the effect on land occupations is either stronger, when measured as incidence (column 5), or similar when in levels (column 6).[54] When focusing on land occupations per 10,000 km^2, the effect is similar in magnitude across microregions with different exposures to tariff reduction (column 6). These facts, coupled with the weaker soy expansion found in areas exposed to higher tariff reduction, point to the role of urban labor demand in mitigating soy-induced land occupations.

F Rapacity Effect

An additional potential explanation of the effect of agricultural modernization on land occupations could be given by the rapacity effect—an increase in the asset value leading to stronger incentives for its appropriation. Although we can not test this hypothesis because of lack of systematic information on land prices, results in previous sections suggest that an increased land value is unlikely to explain the effect of agricultural modernization on land occupations.

First, Table 1 shows no relationship between soy prices and land occupations, indicating that if the rapacity channel is in place, occupiers are driven by the expected increase in the value of land. Second, although anecdotal evidence suggests that land value increased in municipalities with larger soybean investments, the regulation of settlements established within the framework of the Brazilian land reform program forbids market transactions involving plots of land redistributed as a consequence of land occupations for at least ten years.[55] In addition, results on land occupations

[54] Several hypotheses might explain why the effect on soy expansion is weaker in microregions with higher tariff reductions. For example, this result is consistent with complementarity between industrial activities and soybean production at the microregion level.

[55] Established by Article 189 of the Constitution and regulated by penal (Article 171 of *Código Penal, Decreto Lei* 2.848/40) and administrative (*Lei 8.629/93*) laws.

occurring on indigenous land provides further evidence against this channel.

If land occupations are not driven by changes in land value or soy prices, they might be fueled by the higher gains from investing in soy production itself. This last perspective is the least likely given the lack of access to credit, equipment and capital that characterizes the rural poor. Last, if the change in the value of land is the channel relating investments in agricultural production to land occupations, then it is difficult to interpret the negative coefficients found for the modernization of the labor-intensive sector (maize, columns 6–7 of Table A.5 and Panel B of Figure A.9). These results, together with extensive anecdotal evidence (Ondetti, 2008; Carter, 2015), indicate that land occupations are performed by poor peasants, driven by the appropriation of land for subsistence purposes, rather than by the increased value of the asset.