Technological Change, Organizational Capacity and Rural Conflict: Land Occupations in Brazil

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Abstract

When do the rural poor become politically active? In this paper we estimate the effect of technological innovation on redistributive conflict. We study conflicts between landless peasants and landed élites in the form of land occupations in Brazil. Our results show that labor-saving technological innovation led to a decline in agricultural labor demand and increased the incidence of land occupations by the rural poor. We identify this effect exploiting exogenous differences in the local potential gains associated to the adoption of the new technology. We then show that these effects strongly depend on the organizational capacity of the local population. We find that the labor-saving technological shock caused significantly more land occupations in municipalities with a higher share of Catholic priests per Catholic individual. We interpret these results as showing that the ability of rural poor to politically mobilize depends on the existence of networks of potential leaders able to gather information and coordinate action. (*JEL* J43, P16, O33, Q15, Q34, D74)

Keywords: Social Conflict, Technological Change, Organizational Capacity

1 Introduction

Recent literature has shown the importance of economic factors in determining and shaping social and redistributive conflicts. Countries with high level of poverty and inequality, weak institutions and high rent opportunities tend to experience a relatively high level of social conflict. In this paper we focus on the determinants of rural conflict over land access in Brazil: land occupations.[1] Peasants

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[1]Land occupations are often defined as land "invasions". We use the two terms interchangeably.

without land often resort to land occupations to gain access to productive capacity, in the absence of alternative means to improve their economic conditions.

Most of the literature on the economic determinants of rural conflict has studied the effect of transitory income shocks determined by international price adjustments or rainfall variation (Bazzi and Blattman, 2014; Wright, 2015; Miguel and Satyanath, 2011). This paper explores the role of technological innovation and unemployment in the agricultural sector using a dataset of 9,268 land invasions from 1988 to 2014 in Brazil. Following Bustos et al. (2016), we exploit the differential potential gains from genetically-engineered (GE) soybean seeds to show that the more widespread adoption of the modified seeds led to an increase in the incidence of land invasions in the same municipality. We explore two main channels. First, we look at changes in the number of individuals employed in the agricultural sector. We show that, changes in the type of seeds put to use in a given municipality affect the productivity of labour and the quantity of labour needed for agricultural production. Such changes determine an increase in rural unemployment which eventually affects local incentives toward land occupations. To substantiate our findings, we compare soy production to maize production. Maize is a relatively more labour-intensive crop with respect to soy. Since the beginning of the 1990s, maize culture underwent important transformations, leading to the increase in the demand of labor for its cultivation. Comparing changes in soy- and maize-growing municipalities, we show that the incidence of land occupations is decreasing in the hectares cultivated with maize with respect to soy.

The second channel we explore is related to the organizational capacity of the potential occupiers. If it is relatively well understood that economic incentives are important determinants of redistributive conflicts, less is known about the coordination problems involved in the organization of events such as land occupations. The probability of a successful occupation is increasing in the number of participants. This fact implies that the classic strategic considerations are in place and that an individual's participation is shaped by his beliefs about the participation of others. Coordination devices are needed to spread information about individuals' willingness to participate to land occupations. Several recent articles have looked at the effect of information's networks on protests' participations. Most of the recent literature has looked at the effect of the introduction of technological devices such as VK online social network in Russia (Enikolopov et al., 2016) or mobile phones coverage (Manacorda and Tesei, 2016), on protests' participations. We study a rather different phenomenon which affects the organizational capacity of potentially rebel groups, the effect of a pre-existing network of individuals able to coordinate the efforts and beliefs and successfully lead the occupation processes: the Brazilian Catholic Church. The Church committed to the "cause of the poor" since the late 1970s and provided a crucial coordination device for its ability to effectively gather and spread informations across the territory. As noted by Houtzager (2001), "Progressive clergy and lay activists in Brazil were able to mobilize rural social groups (primarily small farmer and peasant groups) and local resources through the Church's impressive associational web, its own elaborate organizational structure, and a popular religious identity".

We show that the technological shock causes significantly more land occupations in municipalities with a greater number of catholic priest per capita in 1966 - ten years before the ideological shift of the Brazilian Church. At the same time, a higher number of Catholic priests reduces the number of occupations in the absence of the labor-saving technological shock and in municipalities where the cultivation of the labor-intensive crop (maize) was extended. These results point toward a role of the underlying ideology of the individuals embedded in the organizational network (Liberation Theology).

Most of the empirical literature on conflict have lately looked at the individual or group choice to exert violent effort to appropriate some sort of material benefit as either determined by a decrease in the opportunity cost of violence, or by an increase in the return to violence. Dube and Vargas (2013) show the interplay of both channels: they argue that a fall in the price of coffee lowers wages and increases violence through the opportunity cost effect, while a rise in oil prices increases violence through the rapacity effect. Several works on Africa focus on the role of commodities' prices in shaping incentives for rebels to control specific areas where lootable goods are found, therefore determining patterns of conflict, the most recent being Berman et al. (2017).

These findings are in line with the theoretical framework in which positive shocks to capital intensive activities foster conflicts while positive shocks to labour intensive activities reduce them (Dal Bó and Dal Bó, 2011). However, this theory has being challenged by works suggesting no or even positive relationship between labor income shocks and conflict. Berman et al. (2011) find that high unemployment is associated with reduced violence in the context of Afghanistan, Iraq and the Philippines. The authors propose an information-based theory as an alternative for the opportunity cost explanation: when times are bad, anti-insurgency forces find it easier to gather information. Vanden Eynde (2016) reconciles the two approaches by looking at the structure of the rebels' tax base. He argues that negative labor income shocks reinforce the counterinsurgency ability to gain information if rebel groups are highly dependent on taxing the local economy as a source of revenue. As opposed to Berman et al. (2011) and Vanden Eynde (2016), we study conflicts with explicit redistributive purposes, that is, between workers and owners of land. Our paper finds that, consistently with the opportunity cost theory, unemployment induced by the adoption of a labor-saving technology increases the incidence of conflicts over land. The closest paper to ours is Hidalgo et al. (2010) in which the authors study the same rural context but focus on the effect of transitory income shocks determined by droughts and rainfall. Secondly, they study the heterogeneous effect of income shocks depending on land inequality: they show that income shocks appear to be negligible in low-inequality municipalities but increase dramatically with the land Gini.

Our findings contribute to the literature on the determinants of rural conflicts by showing that technological innovation can lead to social unrest. In a similar spirit, Caprettini and Voth (2017) show that the introduction of labor-saving technologies in 19th century UK led to social instability and uprising. Our paper shows that structural transformation in developing countries can lead to conflict if not accompanied by measures of social relief and redistribution. Structural transformation in Brazil deteriorated the conditions of rural workers. This resulted partially in a movement toward the manufacturing sector, as documented by Bustos et al. (2016), and partly in social violence and unrest. This paper is consistent with a growing literature showing that technological innovation - even if potentially welfare-enhancing - can lead to the deterioration of certain sectors of the labor force (Acemoglu, 1998; Autor et al., 2003).

Our results also relate to the literature on collective action, showing that organizational capacity, in the form of a pre-existing network of potential leaders, implies the ability to overcome the coordination problems inherent in social uprising, and increases the effect of technological adoption on land occupations. This result is part of a new empirical literature on the role of networks and information diffusion in protests and unrest. Cantoni et al. (2017) address the problem of individual participation in protests being strategic complements or substitutes, finding consistently a substitution effect in the case of Hong Kong's anti-authoritarian movement. Our paper relates to a series of works on social media and political unrest which reveals the link between the increase in information's availability and the reduction in collective action's cost. Enikolopov et al. (2016) present evidence that the diffusion of an online social network increased protest turnout in Russia; Gonzalez (2016) provides evidence that peers' participation in Chilean student protests increased one's own; Hollenbach and Pierskalla (2013) and Manacorda and Tesei (2016) substantiate that mobile phones' diffusion fostered mass political mobilization in Africa.

Finally, we contribute to the literature on social capital by showing that the presence of a network of connection between groups sharing the same identity, facilitates the rise of a common ideology. Satyanath et al. (2017) study the case of pre-Nazi Germany, illustrating that Germany's vibrant "civic society", its dense network of social clubs and associations, facilitated the rise of Hitler by bringing more people into contact with his party's message. They focus on one aspect of social capital - the dense network of clubs and associations. In our paper, we look at one particular feature of the presence of priests: the number of Catholic priests per Catholic individual, as a proxy for the density of potential leaders and information nodes. Hence, we also connect with the literature on the importance of leaders shaping beliefs in networks (Acemoglu and Jackson, 2015). Our research is also in line with Madestam et al. (2013) on the rise of the Tea Party in the United States: the authors find evidence for a "social multiplier", with more people favoring a radical movement if they see support in large numbers.

The remainder of the paper is organized as follows. Section 2 describes the overall Brazilian context. Section 3 presents the data. Section 4 outlines the empirical strategy. Section 5 studies the effects of the adoption of GE soy and small-harvest maize on rural unemployment and land occupations. Section 6 shows that the effects of the two technological shocks depend on the presence of the Catholic Church at the municipal level. Section 7 concludes.

2 Overall Context

Since the colonial period, Brazil has been characterized by one of the most skewed distribution of land in the world (FAO, 2005). In 1532, the Portuguese Crown offered generous privileges to affluent Portuguese families in the form of twelve donatary Captaincies, whose captains were entitled with the ownership and control of land. The system, abolished in 1821, left the country divided in *latifúndios*, or large rural landholdings, which are today reflected in the high concentration of land property (Bethell, 1987). The largest 3.5% of landholdings represent 56% of total agricultural land (Hoffmann, 1988). The Gini coefficient of land inequality remained stable between 1967 and 1998, measuring 0.84 at both the beginning and the end of the period (Hidalgo et al., 2010). Despite several apparent attempts to promote redistribution, all political coalitions have failed due to the decisive role of the landed élite, both in the case of Getúlio Vargas (1930–1945) and of the military dictatorship (Morissawa, 2001).

During the transition to democracy, the question of *reforma agrária* (land reform) returned to the political agenda with the announcement of a major program of land redistribution. However, the new Constitution of October 1988, while affirming the "social function" of land, also stated that "productive" properties could not be expropriated. Between 1990 and 1992, repression against landless activists intensified, reflecting the conservative political climate. It was during this period that the Landless Workers' Movement (*Movimento dos Trabalhadores Sem Terra*, MST) affirmed itself as the main voice of the rural poor (Ondetti, 2008). The explicit goal of the movement, in line with the principles expressed in the Constitution, was to impose a radical restructuring of the Brazilian landholding system, based on the expropriation of private farms either unproductive or beyond a maximum size limit. Since the late 1980s, the forcible occupation of land consolidated itself as the MST's core tactic.

2.1 Land Occupations

A land occupation consists in the physical occupation of an estate for productive purposes. Leaders of the MST expect occupiers to be present in the settlement camps and contribute to routine tasks, such as digging latrines, mounting security patrols and attending organizational meetings. In addition, occupiers are supposed to participate in complementary protest tactics, such as marches and demonstrations in urban areas; road blockages; and occupations of public agencies, such as state branches of the national land reform agency (*Instituto Nacional de Colonização e Reforma Agrária*, INCRA) (Ondetti, 2008). The tasks and dynamics involved in a land occupation are highly complex. First, the rural properties that are likely to be expropriated must be identified - in particular, under-utilized land that does not fulfill its "social function". Once a target property is identified, participants must secretly develop plans for occupation, gather food and materials for housing and arrange caravans of buses and cars (Paiero and Damatto, 1996).

Government responds to land occupations in three ways: by granting official private property titles to invaders in occupied lands; by confering them ownership of lands in other regions of the country;[2] by forcibly expelling them, often resulting in violent clashes and deaths of militants and military forces. Figure 2 shows the widespread distribution of land occupations and invading families from 1988 to 2014, highlighting how endemic is this conflict in Brazilian political life.

2.2 Structural Transformation

Technical Change in Soy Cultivation

The first generation of GE soy seeds, the Roundup Ready (RR) soybean, is different from traditional one due to its resistance to glyphosate.[3] This herbicide-resistant property of GE soy constitutes its main productive advantage with respect to traditional seeds, in which case all unwanted weeds need to be removed manually before plantation. Commercially released in the United States in 1996, GE soy was field-tested in Brazil in 1998 and eventually authorized in 2003. However, smuggling from foreign countries was detected before legalization.

According to the Agricultural Census released by the *Instituto Brasileiro de Geografia e Estatística* (the Brazilian National Statistical Institute IBGE, 2006), GE soy was used in Brazil in 46.4% of the area cultivated with soy by 2006, covering 85% by 2011-2012 (USDA, 2012). Bustos et al. (2016) document a reduction in labor demand in the agricultural sector due to the adoption of GE soy. This effect took place through two channels. First, the amount of rural workers per hectare of land dedicated to the cultivation of soy decreased. Second, the area cultivated with soy partly replaced the one devoted to more labour-intensive crops. Overall, the adoption of GE soy contributed to the process of structural transformation with displaced rural workers moving within municipalities in search for a job in the manufacturing sector.

Technical Change in Maize Cultivation

In Brazil, maize used to be cultivated between August and December. However, starting from the 1980s, a second harvesting season for maize started to be introduces between March and July. This second-harvest maize, or *milho safrinha* (small-harvest maize) spread all over Brazil since the beginning of the 1990s.

Cultivation of small-harvest maize is land-augmenting for several reasons. First, a more intensive use of land requires fertilizers in substitution of the soil nitrogen. Second, small-harvest maize can be successfully cultivated only with careful timing, which requires attentive study of soil conditions. Third, when preparing the second plantation, herbicides are used to clear the field from the first harvest. Finally, the second season is faster than the first and requires higher mechanization for plantation.

[2] In Brazil, land invaders are frequently settled in the Amazon frontier where land is abundant, labor scarce and the rule of law weak.

[3] The resistance of crops to glyphosate is obtained with genetic-engineering techniques that modify the DNA of plants to include those of the herbicide-resistant bacteria *Agrobacterium tumefaciens.*

Contrary to GE soy, Bustos et al. (2016) document an increase in labor demand in the agricultural sector due to the adoption of small-harvest maize. This effect also took place through the within-crop and across-crop channels, maize being among the most labour-intensive crops cultivated in Brazil. Overall, the adoption of small-harvest maize, although increasing the productivity of labor, contributed to attenuate the process of structural transformation spurred by the adoption of GE soy.

3 Data

To study the effect of the adoption of GE soy on redistributive conflict, we combine data from several resources, described in detail below.

Land occupations. Data on the number of land occupations are provided by the Pastoral Commission on Land (*Comissão Pastoral da Terra*, CPT) and Dataluta (*Banco de Dados da Luta pela Terra*). The CPT collects this information from its own regional reports, news articles, government and other organizations' reports, and citizen depositions.[4] The variable **Dummy for land occupation** takes the value 1 in municipality-year observations with more than one land occupation.

Invading families. The CPT also provides the number of families involved in land occupations. We create the variable **Families per land occupation** by dividing the number of families by the number of land occupations conditional on experiencing at least one land occupation.

Differential productivity. Data on technological change in the production of soy and maize comes from the FAO-GAEZ database. This latter provides estimates of potential yields in tons per hectare in rain-fed crops by considering soil and weather characteristics. Moreover, the database distinguishes between low and high technology. As in Bustos et al. (2016), we substract the average potential yield under low technology from the one under high technology to construct the average differential productivity brought about by the adoption of GE soy and small-harvest maize.

Rural population, Income inequality, Share of individuals without land and **Share of population in extreme poverty.** These data are provided by the 1991 IBGE national census. We use the log of rural population in 1991. The share of landless population is created by dividing the number of people without land by the total population.

Share of adult rural population. Data on the share of rural population come from the Sample Supplements of the Brazilian Population Censuses (IBGE, 1980; IBGE, 1991). The variable, calculated considering only people ten years or older, is the total number of people living in rural areas divided by the total number of people. As in Bustos et al. (2016), rural population is defined as everybody who does not live within the boundary of a city or village. Original data come at the individual level and is subsequently aggregated at the municipality level using the individual weights provided by IBGE.

Agricultural income. Data on crop production is provided by IBGE. As in Hidalgo et al.

[4] When collecting data, the CPT considers as one land invasion a property invaded more than once in a given year.

(2010), we measure agricultural income as a revenue-weighted sum of the log crop yields (tons per hectare) of the eight most important crops in Brazil: beans, coffee, corn, cotton, rice, soy, sugar and wheat. In the calculation of the crop revenue at the municipal level, prices are assumed to be given in national and international markets.

Land inequality. We use the distribution of land in 1992 and 1998 calculated by Rodolfo Hoffmann (1988), based on INCRA's data. Then, as in Hidalgo et al. (2010), we adjust the land Gini coefficients with the share of landless population.

Polarization. The measure of economic polarization is constructed following Esteban and Ray (1994) and Duclos et al. (2004). This variable, although closely linked to the land Gini, considers the degree of bimodality in the distribution of land. Esteban and Ray (1999) argue that polarization is a more convincing rationale of conflict than the land Gini.[5]

Share of land with fixed-rent, ownership and **sharecropping tenures.** Data on these three types of land tenure come from the 1995-1996 Agricultural Census of IBGE (1996).

Social security. Data on social security is administered by the Institute for Applied Economic Research (*Instituto de Pesquisa Econômica Aplicada*, IPEA). We calculate the average spending in social security from 1990 to 1995.

Priests per Catholic. Data for Catholic priests and Catholic population is administered by the Catholic Census of Brazil compiled by the Centre for Religious Studies and Social Research (*Centro de Estudos Religiosos e Investigações Sociais* CERIS, 1997).The variable Priests per Catholic is constructed by dividing the number of Catholic priests by the number of Catholics in 1966.

Table 1 reports the summary statistics of the variables used in our analysis with values encompassing the period from 1988 to 2014. Here, we provide a short discussion on the statistical characteristics of the main variables used in our study: land occupations (and the dummy for land occupation), invading families, families per land occupation, differential productivity in soy and maize, priests per Catholic and rural unemployment rate. For further details on the remaining variables, please refer directly to Table 1.

Land occupations occurred in around 3.4% of the 153,264 municipality-year observations of our dataset.[6] This leads to a mean value of 0.060 land occupations in our dataset. However, as already shown in Figure 2, land occupations are a widespread phenomenon all over Brazil, with a total of 9,267 invasions and more than 30% of *municípios* having experienced at least one land occupation.[7] Land occupations reach their peak in the *município* of Mirante do Paranapanema, in the state of São Paulo (SP), with 31 occurrences both in 1994 and 1995. This same *município* has also experienced a total number of 174 land occupations, thus outpacing the second most conflictual *município* of

[5] Polarization is calculated by $\sum_i \sum_j \pi_i^{(1+\alpha)} \pi_j |\mu_i - \mu_j|$, where i and j are two groups, π is the fraction of landowners in each group and μ is the share of land owned by landowners in each group (Esteban et al., 2005). As in Hidalgo et al. (2010), we let $\alpha = 0.5$.

[6] This corresponds to the mean value of the dummy for land occupation of 0.034 meaning that the probability of counting at least one land occupation is around 3.4%.

[7] In our dataset, we count 1,734 out of a total of 5,626 *municípios* with at least one land invasion, thus leading to a proportion of around 30%.

Marabá, in the state of Pará (PA), with 96 events.

The mean number of invading families per municipality-year is around 8.3. Exactly 1,273,881 families participated in the 9,267 land invasions, with 12,540 families only in the *município* of Mirante do Paranapanema (SP) in 1995. This same municipality is again the most conflictual one with a total of 33,450 invading families, almost doubling the second most conflictual municipality of Itaquiraí in Mato Grosso do Sul (MS) with 18,332 families involved.

The mean value of families per land occupation is around 149, thus pointing at the high average size of this form of conflict. Although there have been land occupations with only one family, the municipality of Barreiras in Bahia (BA) experienced one land invasion with 5,100 families in 2000.

The average change in potential yields in soy production is around 1814, meaning that the introduction of GE soy would increase the production of soy by 1814 tons per hectare on average if it was adopted in all municipalities of Brazil. The increase in soy production reaches the level of 4,146 tons per hectare in the municipality of Arambaré in Rio Grande do Sul (RS). Notice that there are 23 municipalities that would reduce and 14 that would not alter soy productivity if they adopted the new GE seed: this probably due to characteristics of the weather and soil. Small-harvest maize is more generous than GE soy: the average change in potential yields is around 3,107 tons of maize per hectare, reaching the maximum value of 9,584 in Aceguá (RS). As for GE soy, values can be negative because of soil and weather characteristics: we count 28 municipalities with negative values and only one with no change in potential maize yields. As shown in Figures 3 and 4, the majority of *municípios* predicted to more intensively adopt GE soy and small-harvest maize are concentrated in the South region of Brazil, especially in the state of Rio Grande do Sul.

Concerning Catholic priests, there was, on average, 1 priest every 6,305 Catholic individuals in 1966.[8] Priests range from a maximum of around 1 per 47 Catholics in the *municípios* of Alto Paraguai and Nortelândia, both in the state of Mato Grosso (MT), to a minimum of 1 priest per 270,270 Catholics in Lago Verde, Olho d'Água das Cunhãs, Poção de Pedras and Vitorino Freire, all in the state of Maranhão (MA). As illustrated in Figure 5, the highest concentrations of priests per Catholic are in the South-East and in the Amazon.

Finally, the mean value of the rural unemployment rate is around 4.8%, reaching the skyrocketing level of around 68% in Campos Lindos, located in Tocantins (TO), in 2000.

4 Empirical Framework

Our analysis is conducted on a panel of Brazilian municipalities (*munícipios*) from 1988 to 2014. To identify the causal effect of GE soy adoption on land occupations, we follow Bustos et al. (2016). First, our strategy exploits the timing of the commercial release of GE soy in the United States in 1996. As argued in Bustos et al. (2016), GE soy was developed in the United States for local productive purposes, and hence the date of release is arguably exogenous to economic events in Brazil.

[8]This corresponds to 1.586 priests per 10,000 Catholic individuals, as reported in Table 1.

The ideal timing of comparison is therefore before and after 1996. Second, the new technology had a differential impact on potential yields depending on soil and weather characteristics. Thus, we exploit these exogenous differences in potential yields across geographical areas as our source of cross-sectional variation in the intensity of the treatment. As already mentioned in Section 3, we construct the variable ΔSoy by subtracting the average potential yield of soy under the low technology to the average potential yield under the high technology. Since this latter is calculated also considering the gains in potential production brought about by GE soy, the difference between the values under high and low technologies captures the differential productivity between GE soy and traditional soy.[9]

Our empirical strategy relies on the assumption that there are no changes starting from the year 1996 affecting differently municipalities with high and low adoption of GE soy, which could also explain different patterns in land occupations not passing through changes in the agricultural labor market.

To make our strategy more robust we include in the analysis the adoption of a second crop: maize. As described in Section 2.2, during the 1990s, the cultivation of maize moved from one single harvesting season to two harvesting seasons per year. This process requires modern techniques that are intensive in the use of fertilizers, herbicides, and tractors. Therefore, we expect that the variable ΔMaize, that is, the difference in FAO-GAEZ average potential yields between high and low technologies in maize's cultivation, captures the profitability of introducing a second harvesting season. Since this change in cultivation techniques is land-augmenting, we expect that, everything else being equal, higher differential productivity in maize between high and low input regimes would mitigate the effect on land occupations of the adoption of GE soy. From an identification point of view, the inclusion of small-harvest maize implies a milder assumption to be satisfied: we now assume no changes starting from the year 1996, affecting differently places with high and low potential yields both in soy and maize productions, but in the opposite direction and unrelated to changes in the agricultural labor market.

A final potential concern with our identification strategy is that the soil and weather characteristics driving the variation in potential yields might be correlated with initial levels of development across Brazilian municipalities. For example, different pre-treatment values of agricultural income may have led to different growth paths, eventually determining diverging trends in political activities across municipalities. To eliminate the potential bias induced by these differences, we estimate a specification allowing for trends of pre-treatment levels of several socioeconomic municipal characteristics. To choose the socioeconomic characteristics to include in our baseline regression, we perform a balancing test capturing their statistical difference across below and above ΔSoy median in 1991 levels. Table 2 reports a list of socioeconomic characteristic that fail to pass the test and that we include in trend in our baseline regression. Therefore, our baseline estimating equation is

$$y_{it} = \gamma_i + \delta_t + \beta_1(\Delta\text{Soy}_i \times T_{1996}) + \beta_2(\Delta\text{Maize}_i \times T_{1996}) + \beta_3(\mathbf{X}_i \times t) + u_{it} \tag{1}$$

[9] For further details about the underlying agricultural model in the FAO-GAEZ database and its relationship to GE soy, please refer to Bustos et al. (2016).

where y_{it} is the outcome for municipality i in year t, ΔSoy is the change in soy potential yields and ΔMaize the change in maize potential yields. By including municipality fixed effects γ_i and year fixed effects δ_t, the estimation of β_1 and β_2 is realized from changes in agricultural technologies within the same municipality over time, compared to other municipalities in a given year. T_{1996} is a dummy which takes value 1 starting from the year 1996 and $\mathbf{X}_i$ is a vector of the municipal characteristics measured in 1991 that failed the balancing test. The outcome takes value of 0 if no land occupation occurs in municipality i in year t, while it takes value of 1 if at least one land invasion takes place. Standard errors are clustered at the municipal level and municipal boundaries are fixed to 2000 to keep geography constant.[10]

5 Results

Table 3 reports the estimates of equation (1). Column (1) shows that an increase in one standard deviation in the differential productivity in soy production in a given municipality leads to an increase of around 1.2 percentage points in the probability of a land occupation between 1996 and 2014 as compared to the period between 1988 and 1995. Column (2) reports the estimates obtained when we include the socioeconomic controls. In this latter case, an increase in one standard deviation in the change in soy potential yields leads to an increase of around 0.6 percentage points in the probability of a land occupation. Allowing for trends in the pre-treatment levels of these control variables reduces substantially the magnitude of the effect, indicating the relevance of these socioeconomic characteristics in explaining the trend in land occupations.

The second coefficient of interest is the one associated to the differential productivity in maize production. The estimates in this case are always significant and negative showing that, for a given level of differential productivity in soy production, an increase in one standard deviation in the differential productivity in maize production reduces the incidence of land occupation by around 0.8 percentage points without controls and around 0.6 percentage points with controls.

To understand the size of the change in the probability of experiencing at least one land occupation, consider that the average incidence per municipality-year is around 3.8%: therefore an increase of 1.2 percentage points represents an increment of more than 30%, while an increase of 0.6 percentage points corresponds to a rise of around 17%. As a benchmark, Hidalgo et al. (2010) find in their reduced-form estimates that a standard deviation increase in the rainfall measure is associated with a 0.28 to 0.35 percentage point increase in the probability of a land invasion. This points to the fact that the effect of technological change in the agricultural sector on social conflict might double the one stemming from bad weather conditions.

[10] Since borders of municipalities often change, IBGE provides Minimum Comparable Area (*Área Mínima Comparável*, AMC). In the Appendix, we show that results are unchanged when using AMC instead of municipal borders in 2000.

5.1 Mechanism

In this section, we bring evidence in favor of the idea that the channel relating the adoption of GE soy to the increased incidence of land occupations is rural unemployment. First, we confirm Bustos et al. (2016) by showing that the adoption of GE soy has decreased the number of workers per hectare of land while small-harvest maize had the opposite effect. Second, we show that GE soy and small-harvest maize are not only labor-saving and land-augmenting respectively but that their adoption had an impact on rural unemployment rates.

Rural Labor Intensity

Bustos et al. (2016) show that the expansion of the area planted with GE soy is explained by the differential productivity that we use for our estimates. Their analysis demonstrates that changes in potential yields when switching to high technology are good measures of crop-specific technical changes in soy and maize productions during this period. Motivated by these observations, we estimate

$$\text{Workers}_{it} = \gamma_i + \delta_t + \beta_1(\Delta\text{Soy}_i \times T_{1997}) + \beta_2(\Delta\text{Maize}_i \times T_{1997}) + \beta_3(\text{Rural}_i \times t) + \beta_4(\mathbf{X}_i \times t) + u_{it} \quad (2)$$

where Workers_{it} is the log number of rural workers between 16 and 55 years old per hectare of land, and Rural_i is the share of adult rural population over total population at the municipal level in 1991. By counting how many workers are employed per hectare of land, Workers_{it} is a measure of rural labor intensity. Contrary to equation (1), we control in both columns for the 1991 level in trend of the share of adult rural population to avoid capturing mechanical effects due to municipal demographic dynamics. The set of socioeconomic controls $\mathbf{X}_i$ is as in equation (1), with the exception of Rural_i as already explained. Since we have data on the number of rural workers in *municípios* only in 1996 and 2006, we use the dummy T_{1997} which takes value 1 starting from the year 1997. Standard errors are clustered at the municipal level.

Alternatively, we could estimate a first-difference equation which would yield identical results to equation (2).[11] Therefore, estimates of β_1 and β_2 of equation (2) represent the average change in the log of rural workers per hectare of land predicted by the cross-sectional variation of the differential potential yield in soy and maize respectively.

Results are reported in Table 4, showing that a higher differential potential yield in soy leads to a decrease in the number of agricultural workers per hectare of land between 1996 and 2006, while the opposite occurs for higher differential potential yield in maize. This confirms the results in Bustos et al. (2016) who, however, find stronger effects. The difference in the magnitude of estimates between Bustos et al. (2016) and our study is probably due to the fact that we control for a higher number of variables.

[11] If we define $\text{Workers}_{2006-1996,i}$ as the difference between the log number of rural workers per hectare in 2006 and in 1996 at the municipal level, then the first-difference equation $\text{Workers}_{2006-1996,i} = \Delta\gamma + \beta_1\Delta\text{Soy}_i + \beta_2\Delta\text{Maize}_i + \beta_3\text{Rural}_i + \beta_4\mathbf{X}_i + u_i$ would yield identical estimates to equation (2).

Our estimates show that the increase in the probability of experiencing at least one land occupation in municipalities growing GE soy is mediated by the decrease of the number of rural workers per hectare, while the opposite is true in the case of small-harvest maize. These findings are consistent with the hypothesis that the local adoption of labor-saving agricultural technologies increased land occupations by reducing the opportunity cost of violence through through their effect on unemployment.

Rural Unemployment

Although Table 4 confirms one of the main results in Bustos et al. (2016), labor intensity is not necessarily an appropriate measure of rural unemployment. Motivated by this fact, we estimate

$$\text{Rural Unemployment}_{it} = \gamma_i + \delta_t + \beta_1(\Delta\text{Soy}_i \times T_{1996}) + \beta_2(\Delta\text{Maize}_i \times T_{1996}) + \beta_3(\mathbf{X}_i \times t) + u_{it} \quad (3)$$

in which Rural Unemployment$_{it}$ is the rural unemployment rate at the municipal level from 1991 to 2000. Results in Table 5 show that, when all controls are included, one standard deviation increase in ΔSoy leads to an increment by 0.0719 percentage points in the rural unemployment rate. On the contrary, one standard deviation increase in ΔMaize produces a 0.133 percentage points decrease in the rural unemployment rate. The magnitude of the effect is not particularly high, 1.49% and 2.76% for GE soy and small-harvest maize respectively. However, the effect is strong enough to account for the rise in the number of people involved in land occupations, according to our own calculations.

6 Collective Action, Ideology and Organizational Capacity

In this section, we examine whether the effect of GE soy adoption is affected by the density of Catholic priests at the municipal level. From a theoretical point of view, the effect of any pre-existing organization is ambiguous, and it may or may not depend on the ideology motivating the action of its members.

We would expect that the effort of land invaders increases in the size of the local organization if these two have similar ideologies and share the same goals. On the contrary, we would expect a negative effect if the local organization has an opposite ideology and acts against the efforts of land invaders, increasing the cost of their collective action. Moreover, the effect of the local organization could depend on whether its members condition their behavior on the state of the world. Finally, the organization's ideology could be orthogonal to the underlying motivation of the individuals engaging in social conflict. Also in this last case, the effect are theoretically ambiguous. An organization which connects individuals potentially participating in a collective action with political goals can increase participation due to its non-exclusive nature and its effect on information diffusion, independently from ideological instances. This seems to be the case analyzed in the recent empirical literature on the role of information transmission on collective action (Enikolopov et al., 2016; Gonzalez, 2016;

Hollenbach and Pierskalla, 2013; Manacorda and Tesei, 2016). The importance of local organizations in information diffusion and collective action is also evident in the case of the rise of Nazis in Germany, where the presence of a dense network of associational clubs implies high permeability to new political and ideological instances (Satyanath et al., 2017).

The Brazilian Catholic Church

> "The mission of the Church is to call all men to live as brothers overcoming all forms of exploitation, as wanted by the only God and common Father of men. Moved by the Gospel and the grace of God, we must not only listen but also assume the sufferings and anguish, the struggles and hopes of the victims of the unjust distribution and possession of land..." (CNBB, 1980)

The position of the Church with respect to the *reforma agrária* has changed over time. During the 1970s, the Church experienced the rise of a strong progressive movement within its body (Wright and Wolford, 2003). In that period, clergy and lay activists gathered with this movement creating numerous grassroots organizations to bring the Church closer to the people and to diffuse a new theological perspective. A new ideological framework rose, calling on Catholics to fight against social injustice. Against this backdrop, the question of land reform soon emerged as the central issue. The commitment of the Church to a more egalitarian redistribution of land was formalized in 1975, with the creation of the Pastoral Land Commission (CPT) to help rural workers defend their rights to farmland. The basic operational units were formed with the so-called "Basic Ecclesial Communities" (*Comunidades Eclesiales de Base*, CEBs), Bible study groups characterized by *basismo*, an ideology of grassroots democracy and popular participation. Dedicated to foment solidarity and discussions on material conditions and class consciousness among the poor, CEBs became a breeding ground of progressive social identity. In CEBs, participants could justify their struggle for land based on biblical scripture, focusing on social injustice in the here-and-now. Activists would ask "Does God want it to be this way? If not, what can we do about it?".[12]

In this context, the Church provided both the ideological justification to the use of extralegal means and, at the same time, the logistic support needed for the organization of collective action. On the one hand, the organizational capacity of the Church was put at the service of the cause, by providing resources, leadership and coordination to otherwise unorganized landless peasants. On the other hand, the Church contributed to the Brazilian land conflict by its moral legitimization of the struggle, raising the political cost of repression. In fact, religion alleviated ideological opposition to the landless movement, hollowing allegations of its rivals that rural workers were "dangerous communists".[13]

Identification

[12] Interview with CPT activist Friar Wilson Tallagnol, in March 1998, in Porto Alegre (RS) (Ondetti, 2008).

[13] Interview with Darci Maschio, MST activist and member of the first Rio Grande do Sul state landless commission, in March 1998, in Ronda Alta, (RS); see Ondetti (2008).

Identification of heterogeneous effects is complicated by the endogeneity of the presence of the Church at the municipal level. For example, it may be possible that the density of priests in a given municipality reflects the need for social services that a Church committed to social justice may be willing to provide, or even that the presence of priests is directly related to the organizational needs of local landless. To exclude reverse causality, we consider the number of priests at the municipal level in 1966, around ten years before the foundation of the CPT and the ideological shift of the Church towards the progressive ideas incarnated in Liberation Theology.

Although not influenced by considerations related to land conflict, the density of priests in 1966 may reflect socioeconomic characteristics of the municipality. These characteristics may persist over time and drive different patterns of land invasions through the density of priests, thus confounding the effect of presence of the Church. To avoid these potential confounding effects, we allow the vector $\mathbf{X}_i \times t$ to capture time-trends in the pre-treatment level of socioeconomic municipal characteristics, as in the previous regressions. The remaining of the identification strategy follows the same logic expressed in Section 4. We estimate

$$\begin{aligned} y_{it} = \gamma_i + \delta_t + \beta_1\,(\Delta\text{Soy}_i \times T_{1996}) + \beta_2\,(\Delta\text{Maize}_i \times T_{1996}) + \beta_3\,(\Delta\text{Soy}_i \times T_{1996} \times P_i) + \\ + \beta_4\,(\Delta\text{Maize}_i \times T_{1996} \times P_i) + \beta_5\,(T_{1996} \times P_i) + \beta_6(\mathbf{X}_i \times t) + u_{it} \end{aligned} \tag{4}$$

where P_i is the number of Catholic priests per Catholic individual in municipality i in 1966. The outcome variable y_{it} is either the dummy for land occuption or the number of families per land occupation.

Results

Results are reported in Table 6. Columns (1) and (2) estimate the effect of the density of priests on the incidence of land occupations after the GE soy shock. When controls are added in the estimation, it appears that the presence of priests increase the probability of a land invasion in municipalities adopting the labor-saving GE soy.

Columns (3) and (4) estimate the effect of priests on the number of families per land occupation. The number of families per land occupation is a measure of the size of an invasion and therefore a proxy for the effectiveness of priests in the organization of landless' collective action. When controlling for trends in pre-treatment socioeconomic variables, the presence of priests has two effects: first, priests increase the scale of land occupations in municipalities adopting GE soy; second, priests reduce the size of land occupations when controlling for the adoption of the two new technologies.

Our calculations point at a strong effect of the Church on the incidence of land invasions conditional on technological change. For example, in a municipality with the median presence of the Church (1.061 priests per 10,000 Catholics),[14] one standard deviation increase in the change in soy potential yields leads to an increment of 0.49 percentage points in the probability of a land occupation, representing an increase of around 13%. However, if the presence of the Church reaches the

[14] This is equivalent to 1 priest per 9,425 Catholics.

level of the 75^{th} percentile of its statistical distribution (1.957 priests per 10,000 Catholics),[15] then a standard deviation increase in the change in soy potential yields leads to an increment of 0.92 percentage points in the probability of a land occupation, representing an increase of around 24%.

Our calculations also highlight an even stronger effect of priests per Catholic on the size of land occupations. At the median presence of the Church, one standard deviation increase in the change in soy potential yields leads to an increment of 91 families per land occupation, representing an increase of around 61%. At the 75^{th} percentile of the statistical distribution of priests per Catholic, one standard deviation increase in the change in soy potential yields leads to an increment of 146 families per land occupation, representing an increase of around 98%.

7 Robustness Checks

7.1 Parallel Trends

If municipalities more highly suited for GE soy were already experiencing an exacerbation of land conflict before the adoption of this technology in Brazil, our exogenous measure of technological change would capture a long-term trend instead of the effect of the new soybean's diffusion. To test the parallel trend assumption, we regress the dummy for land occupation on a dummy for each year of the time window of our study (1988-2014), estimating year coefficients separately for the top 25% and the bottom 25% of ΔSoy's sample distribution. The first group represents the highly treated (treatment group) while the latter group the lowly treated (control group). To estimate coefficients, we choose the last pre-treatment year 1995 as the base year to be compared with all other years. Standard errors are clustered at the municipal level.

Figure 6 shows the plot of all year coefficients where it appears that from 1988 to 1995 there was no statistical difference (at 95% confidence interval) in the probability of land occupations between treatment and control groups. This result is sufficient to argue that the parallel trend assumption is respected. Moreover, before the GE soy shock in 1996, there was no trend at all in the probability of land occupations in our sample. Starting from 1996, the treatment group registers a higher probability of land occupations than the control group, and this effect lasts for four years until 1999 included. Since 2000, the effect tends to disappear, probably due to out-migration and structural transformation. Further investigation on the reabsoption of the effect after four years is needed.

In addition to the year coefficients plot, we show that our baseline results are robust to controlling for pre-existing trends. Hence, we regress a model similar to equation (1), but controlling also for the effect of ΔSoy in trend. In this way, we are able to distinguish between the effect of ΔSoy common to the period before (1988–1995) and after (1996–2014) the adoption of GE soy, and the differential effect of ΔSoy after the introduction of GE soy. Therefore, we estimate

$$y_{it} = \gamma_i + \delta_t + \beta_1(\Delta\text{Soy}_i \times T_{1996}) + \beta_2(\Delta\text{Maize}_i \times T_{1996}) + \beta_3(\Delta\text{Soy}_i \times t) + \beta_4(\mathbf{X}_i \times t) + u_{it} \quad (5)$$

[15] This is equivalent to 1 priest per 5,110 Catholics.

in which β_3 controls for the effect of the change in soy potential yields common to the whole period (1988-2014). In Table 7, we show the coefficients for the two technological adoptions, and the coefficients of the dummies for ΔSoy in each pre-treatment year, with the exclusion of 1995 which serves as the base year. Results in Table 7 show that there are no statistically significant pre-trends and that, when controlling for them, the effect of GE soy adoption instrumented by ΔSoy is stronger than the one reported in Table 2. This highlights the fact that pre-existing trends might bias downwards our baseline estimation, if anything.

7.2 Placebo Checks

We perform a falsification exercise in which we re-run regression (1) by substituting the change in soy potential yields with the change in potential yields in the following crops: coffee, sugar, tobacco and wheat. Reassuringly, results of this falsification exercise shown in Figures 7 to 10 imply no differential trends between the placebo and the control groups after 1996 in any crop.

7.3 Instrumental Variable Approach

Although results in Table 4 point at a higher increase in rural unemployment rate in municipalities more exposed to the GE soy shock after its introduction in 1996, we want to confirm this conclusion by adopting an instrumental variable approach. Therefore, we perform an IV-2SLS in which we regress the first stage estimation in a panel setting with municipal data from 1991 to 2000 as follows

$$\text{Unemp}_{it} = \gamma_i + \delta_t + \beta(\Delta\text{Soy}_i \times t) + u_{it} \tag{6}$$

where Unemp_{it} is the unemployment rate. The second stage regression is

$$y_{it} = \gamma_i + \delta_t + \beta_1 \widehat{\text{Unemp}}_{it} + \beta_2(\Delta\text{Maize}_i \times t) + \beta_3(\mathbf{X}_i \times t) + u_{it} \tag{7}$$

where y is the dummy for land occupation.

Results shown in Table 9 confirm that the rural unemployment rate instrumented by the change in soy potential yields increases the incidence of land occupations in municipalities suitable for GE soy more heavily than in less suitable ones after the technological shock in 1996. The magnitude of the effect is very strong: a standard deviation increase in the change in soy potential yields leads to an increment in the probability of land occupation by around 21 percentage points, an increase of 562%. This result points to a high sensitivity of land conflict to the conditions of rural poor in the labour market.

7.4 Information vs Ideology

The objective here is to establish that the effect of the organizational capacity elucidated in Section 6 actually derives from priests organizing collective action by providing relevant information. We want to verify that the effect does not stem from the density of Catholic priests as a proxy of social norms, ideology or values (Catholicism). To do so, we run regression (4) by substituting the share of Catholics over total population C_i to priests per Catholic P_i. As in regression (4), we use data in 1966 to circumvent potential reverse causality between the presence of Catholics and land conflict. Column (2) in Table 8 shows that, everything else being constant, the probability of a land invasion as a consequence of the GE soy shock is unaffected by the presence of Catholicism in the municipality. Column (4) corroborates this finding by revealing that Catholicism *per se* reduces the size of land occupations, thus acting as a dampening force on land conflict.

7.5 Spatial Correlation

Figures 3 and 4 suggest that changes in potential yields in soy and maize may be correlated across municipalities. Hence, we show here that the baseline result in Table 3 is robust to standard errors correlated at a larger geographical unit than the municipality. We provide estimates at the microregion level, an administrative unit containing around ten municipalities on average.[16]

Results at the microregion level suggest that the effect of GE soy adoption is more statistically significant than in our baseline framework. Moreover, the magnitude of the effect is higher at the microregion than at the municipal level: a standard deviation increase in the change in soy potential yields lead to an increment in the probability of land occupations by 5.35 percentage points, an increase of around 26%.

7.6 The Massacre of Eldorado do Carajás

On April 17, 1996 nineteen landless farmers squatting at a private ranch were murdered by military forces in the municipality of Eldorado do Carajás, in the northern state of Pará. To take into account a possible contagion effect in rural conflict from this locality outwards, we re-run regression (1) controlling for the differential effect before and after 1996 of the shortest distance between the centroids of all Brazilian municipalities and the locality of Eldorado do Carajás. Therefore, we estimate the regression as follows

$$y_{it} = \gamma_i + \delta_t + \beta_1(\Delta\text{Soy}_i \times T_{1996}) + \beta_2(\Delta\text{Maize}_i \times T_{1996}) + \beta_3(\text{Eldorado}_i \times T_{1996}) + \beta_4(\mathbf{X}_i \times t) + u_{it} \quad (8)$$

where Eldorado_i is the shortest distance between Eldorado do Carajás and all other Brazilian municipalities. Estimates in Table 11 show that the baseline effect does not lose statistical significance when controlling for potential geographic contagion. On the contrary, the magnitude of the effect appears slightly higher than in the baseline framework, thus pointing to the fact that the distance to this massacre is negatively correlated with the probability of land occupations and positively correlated with GE soy suitability at the municipal level. However, when controlling for municipal

[16]As of 2014, there were 557 microregions in Brazil. Microregions were extinguished in 2017 and replaced by "immediate geographic regions".

socioeconomic characteristics, it appears that the massacre of Eldorado do Carajás does not have explanatory power to land conflict.

8 Conclusion

Our research studies the effect of a potentially welfare-enhancing shock on land conflict in Brazil. Using data from 1988 until 2014, we have shown that the adoption of labor-saving technology, although potentially beneficial for all society, can be nevertheless inefficient when the reaction of "losers" from innovation is taken into account. If workers displaced from a new technology are not protected, conflict might unfold. The violence provoked by the adoption of new technologies can reduce incentives to invest in the economy, thus harming development. The overall effect of technological innovation might even be negative if the social cost associated to violence is higher than the gains induced by the increase in productivity and wages, and the relocation of labor to manufacturing activities. By showing the dark side of structural transformation, our estimates have direct policy implications, suggesting that overall welfare gains from technological innovation may be higher if technological change is prevented from translating into changes in the opportunity cost of violence for the weakest.

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Table 1: **Summary Statistics**

VARIABLES	Mean	Median	75^{th} Perc.	St. Dev	Min	Max	Obs.
Land occupations	0.060	0.000	0.000	0.466	0.000	31.000	153264
Invading families	8.324	0.000	0.000	90.412	0.000	12540	153069
Families per land occupation	148.593	95.000	170.000	212.830	1.000	5100.000	4986
Dummy for land occupation	0.034	0.000	0.000	0.181	0.000	1.000	153264
Differential productivity in soy	1813.972	1843.300	2457.000	852.948	-394.067	4146.000	150144
Differential productivity in maize	3107.122	2743.077	4381.000	1843.844	-1521.000	9584.000	150144
Rural population (log)	8.490	8.521	9.122	0.896	5.455	13.004	109723
Share of adult rural population	0.455	0.467	0.642	0.232	0.000	0.975	97139
Agricultural income (log)	7.522	7.420	7.907	1.258	3.779	11.348	122035
Income inequality	0.533	0.530	0.567	0.055	0.348	0.791	109750
Land inequality	0.739	0.762	0.836	0.139	0.147	0.997	121734
Polarization	0.591	0.590	0.650	0.121	0.000	1.075	121761
Share Individuals without Land	0.289	0.250	0.431	0.208	0.000	0.978	121813
Share of land with fixed-rent tenure	0.044	0.019	0.057	0.064	0.000	0.748	121813
Share of land with ownership tenure	0.896	0.922	0.968	0.100	0.036	1.000	121813
Share of land with sharecropping tenure	0.021	0.006	0.024	0.037	0.000	0.576	121813
Share of population in extreme poverty	0.304	0.283	0.465	0.186	0.012	0.773	132699
Social Security	0.161	0.032	0.072	2.290	0.000	143.736	133159
Education HDI	0.639	0.670	0.746	0.129	0.157	0.883	109750
Number of banks	1.393	1.000	2.000	2.034	0.000	57.333	132699
Share of unused arable land	0.051	0.022	0.064	0.073	0.000	0.619	121813
Priests per catholic	1.586	1.061	1.957	5.723	0.037	214.286	78895
Rural unemployment rate	4.819	3.664	6.461	4.436	0.000	68.293	41615
Number of workers per hectare (log)	-2.572	-2.499	-1.885	1.041	-7.136	2.600	7166

Note: the number of invading families is divided by 1,000; the number of priests per Catholic is multiplied by 10,000; and the total amount of spending in social security is divided by 1,000,000.

Table 2: **Balancing Test for Socioeconomic Characteristics**

	Below ΔSoy median	Above ΔSoy median	Difference
Rural population	8.587	8.391	0.196
Share of adult rural population	0.509	0.405	0.104
Agricultural income	7.266	7.787	-0.521
Income inequality	0.533	0.532	0.002
Land inequality	0.721	0.756	-0.035
Polarization	0.576	0.606	-0.030
Share Individuals without Land	0.259	0.319	-0.060
Share of land with fixed-rent tenure	0.029	0.059	-0.030
Share of land with ownership tenure	0.910	0.883	0.027
Share of land with sharecropping tenure	0.017	0.024	-0.007
Share of population in extreme poverty	0.345	0.260	0.084
Social Security	0.119	0.200	-0.081
Education HDI	0.616	0.663	-0.047
Number of banks	1.176	1.625	-0.449
Share of unused arable land	0.064	0.038	0.026

Note: the variables shown in this balancing test report statistically different (with 99% confidence interval) socioeconomic characteristics across below and above ΔSoy median municipalities in 1991.

Table 3: **Adoption of GE Soy and Probability of Land Occupation**

	Dummy for Land Occupation	
	(1)	(2)
ΔSoy $\times$ Treatment Period	0.0118***	0.00634**
	(0.00223)	(0.00309)
ΔMaize $\times$ Treatment Period	-0.00803***	-0.00559*
	(0.00219)	(0.00305)
Observations	150144	87363
Municípios FE	Yes	Yes
Year FE	Yes	Yes
Controls	No	Yes
Mean dep var	0.0377	0.0377

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: **Adoption of GE Soy and Rural Labor Intensity**

	Δ Workers (1996 - 2006)	
	(1)	(2)
ΔSoy	-0.0306*	-0.0414**
	(0.0172)	(0.0203)
ΔMaize	0.0490***	0.0558***
	(0.0168)	(0.0201)
Share Adult Individuals in Rural Areas in 1991	-0.105**	-0.0167
	(0.0516)	(0.0710)
Observations	3564	3235
Controls	No	Yes
Mean dep var	-0.0281	-0.0281

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: **Adoption of GE Soy and Rural Unemployment Rate**

	Rural Unemployment (1991 - 2000)	
	(1)	(2)
ΔSoy × Treatment Period	-0.0525**	0.0719**
	(0.0247)	(0.0325)
ΔMaize × Treatment Period	-0.0308	-0.133***
	(0.0254)	(0.0310)
Observations	40601	32350
Municípios FE	Yes	Yes
Year FE	Yes	Yes
Controls	No	Yes
Mean dep var	4.819	4.819

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: **Catholic Priests, Probability and Scale of Land Occupations**

	Dummy for Land Occupation		Families per Land Occupation	
	(1)	(2)	(3)	(4)
Priests per Catholic × ΔSoy × Treatment Period	0.571*	1.031*	5680.8	23649.7*
	(0.334)	(0.605)	(8238.2)	(12693.2)
Priests per Catholic × ΔMaize × Treatment Period	-0.748*	-0.776	9425.9	1738.2
	(0.453)	(0.707)	(10413.6)	(14155.5)
ΔSoy × Treatment Period	0.00392	-0.00308	-31.32	-56.53
	(0.00342)	(0.00559)	(55.18)	(85.87)
ΔMaize × Treatment Period	0.00140	0.00331	-66.67	-121.3
	(0.00406)	(0.00558)	(53.96)	(119.7)
Priests per Catholic × Treatment Period	-0.504*	-0.270	-5342.8*	-10995.4**
	(0.295)	(0.305)	(3066.9)	(5110.6)
Observations	77966	69406	2127	1835
Municípios FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Mean dep var	0.0377	0.0377	148.6	148.6

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: **Adoption of GE Soy and Probability of Land Occupation - Robustness to Controlling for Pre-existing Trends**

	Dummy for Land Occupation	
	(1)	(2)
ΔSoy $\times$ Treatment Period	0.0166***	0.00978**
	(0.00320)	(0.00429)
ΔMaize $\times$ Treatment Period	-0.00802***	-0.00560*
	(0.00219)	(0.00305)
Dummy for ΔSoy in 1988	-0.00129	0.00190
	(0.00182)	(0.00287)
Dummy for ΔSoy in 1989	-0.000504	-0.00165
	(0.00192)	(0.00281)
Dummy for ΔSoy in 1990	-0.00215	-0.00202
	(0.00179)	(0.00283)
Dummy for ΔSoy in 1991	-0.000517	-0.00119
	(0.00187)	(0.00283)
Dummy for ΔSoy in 1992	0.00207	-0.00223
	(0.00198)	(0.00267)
Dummy for ΔSoy in 1993	-0.0000861	-0.000757
	(0.00180)	(0.00255)
Dummy for ΔSoy in 1994	0.00146	0.00272
	(0.00159)	(0.00252)
Observations	150144	87362
Municípios FE	Yes	Yes
Year FE	Yes	Yes
Controls	No	Yes
Mean dep var	0.0377	0.0377

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: **Share of Catholics, Probability and Scale of Land Occupations**

	Dummy for Land Occupation		Families per Land Occupation	
	(1)	(2)	(3)	(4)
Share of Catholics × ΔSoy × Treatment Period	-0.121**	-0.0533	-1345.1***	-2902.1***
	(0.0502)	(0.0433)	(426.4)	(872.1)
Share of Catholics × ΔMaize × Treatment Period	0.0796	-0.00496	879.0	1080.4
	(0.0521)	(0.0549)	(566.9)	(1116.2)
ΔSoy × Treatment Period	0.0726***	0.0324	710.8***	1631.4***
	(0.0277)	(0.0236)	(225.7)	(469.5)
ΔMaize × Treatment Period	-0.0451	0.00167	-487.1	-684.3
	(0.0284)	(0.0294)	(311.8)	(601.5)
Share of Catholics × Treatment Period	0.0434	0.0163	335.8	1290.9***
	(0.0316)	(0.0358)	(274.6)	(405.5)
Observations	77885	69325	2127	1835
Municípios FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Mean dep var	0.0377	0.0377	148.6	148.6

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: **Instrumental Variable Approach**

	Dummy for Land Occupation	
	(1)	(2)
Rural Unemployment	-0.110***	0.212*
	(0.0295)	(0.113)
Observations	40601	32350
Municípios FE	Yes	Yes
Year FE	Yes	Yes
Controls	No	Yes
Mean dep var	0.0377	0.0377

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: **Adoption of GE Soy and Probability of Land Occupation - Robustness to Estimation at the Microregion Level**

	Dummy for Land Occupation	
	(1)	(2)
ΔSoy $\times$ Treatment Period	0.0467***	0.0535***
	(0.0152)	(0.0187)
ΔMaize $\times$ Treatment Period	-0.0311**	-0.0342**
	(0.0143)	(0.0170)
Observations	15066	14337
Microregions FE	Yes	Yes
Year FE	Yes	Yes
Controls	No	Yes
Mean dep var	0.207	0.207

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: **Adoption of GE Soy and Probability of Land Occupation - Robustness to Controlling for Distance to Eldorado do Carajás**

	Dummy for Land Occupation	
	(1)	(2)
ΔSoy $\times$ Treatment Period	0.0123***	0.00713**
	(0.00223)	(0.00327)
ΔMaize $\times$ Treatment Period	-0.00761***	-0.00630**
	(0.00218)	(0.00314)
Distance to Eldorado $\times$ Treatment Period	-0.000946***	0.000503
	(0.000212)	(0.000568)
Observations	150144	87364
Municípios FE	Yes	Yes
Year FE	Yes	Yes
Controls	No	Yes
Mean dep var	0.0377	0.0377

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: **Trend in Land Occupations, 1988 - 2014**

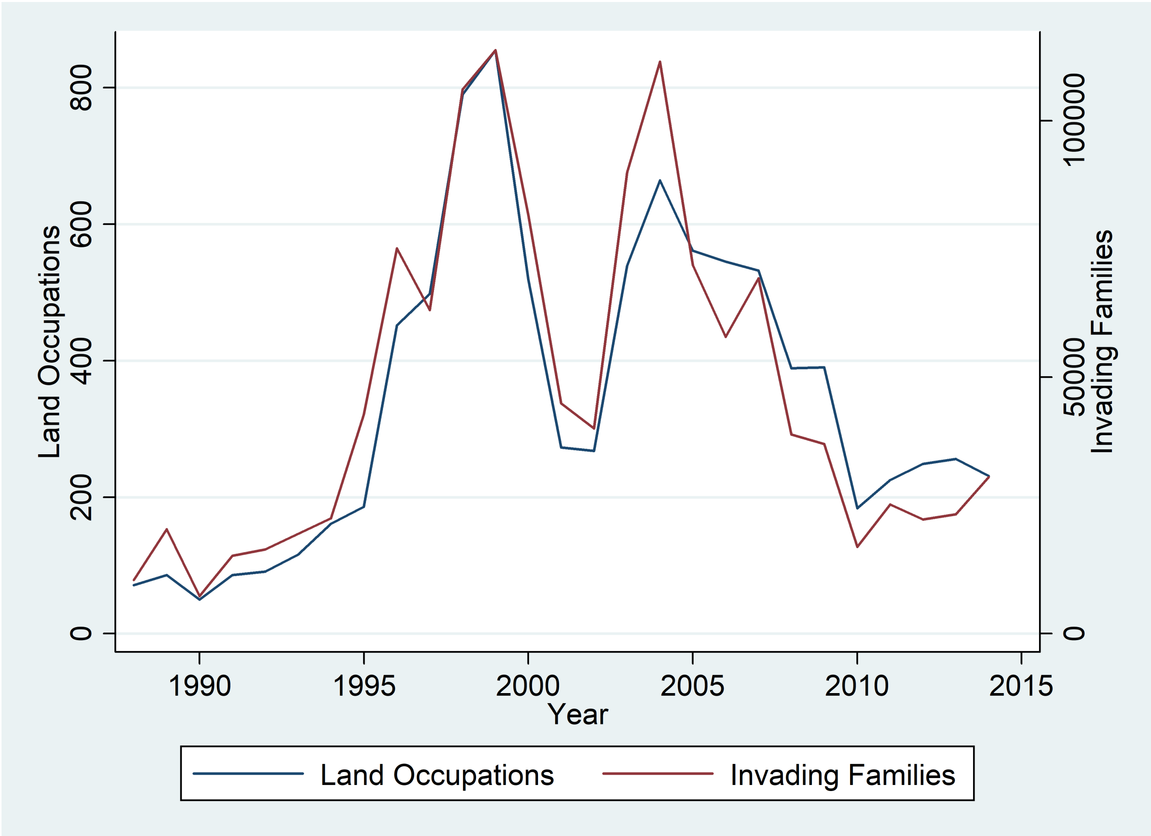

Figure 2: **Geographic Distribution of Land Occupations, 1988 - 2014**

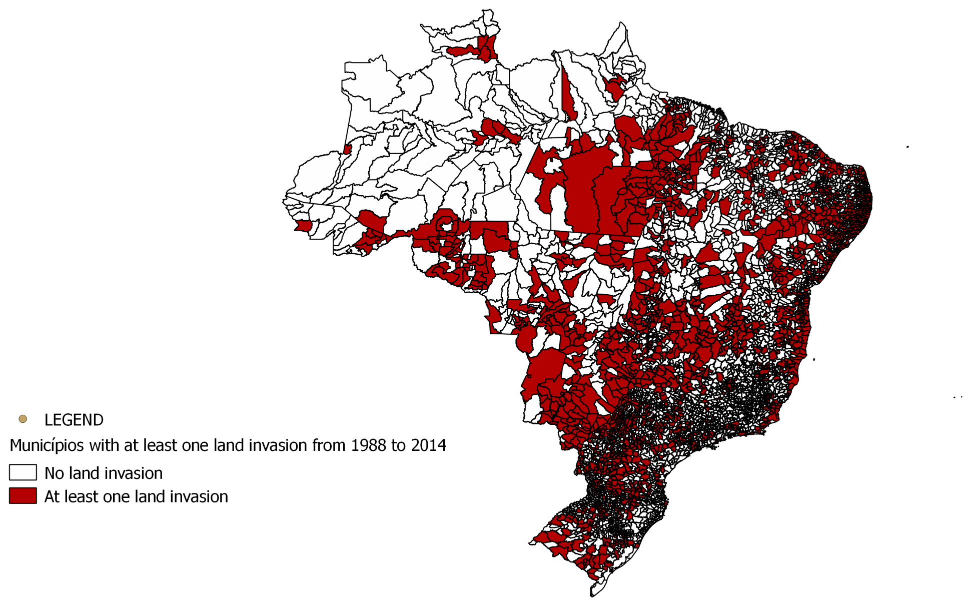

Figure 3: **Differential Productivity in Soy Production**

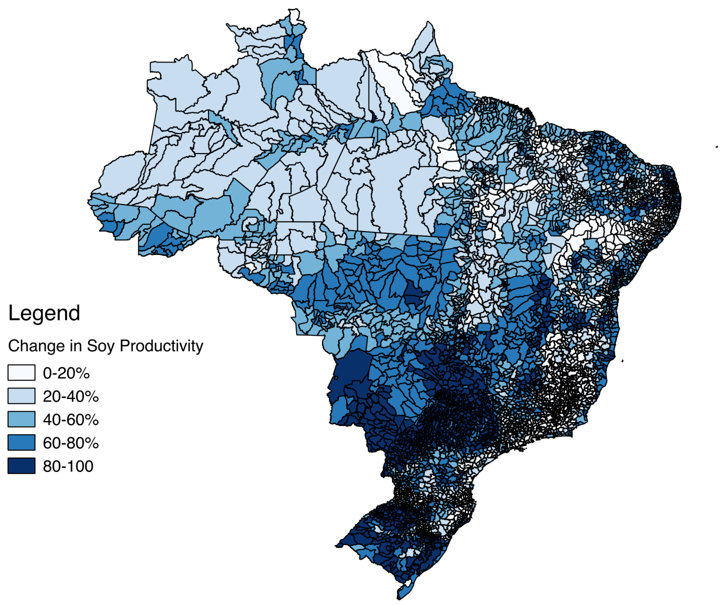

Figure 4: **Differential Productivity in Maize Production**

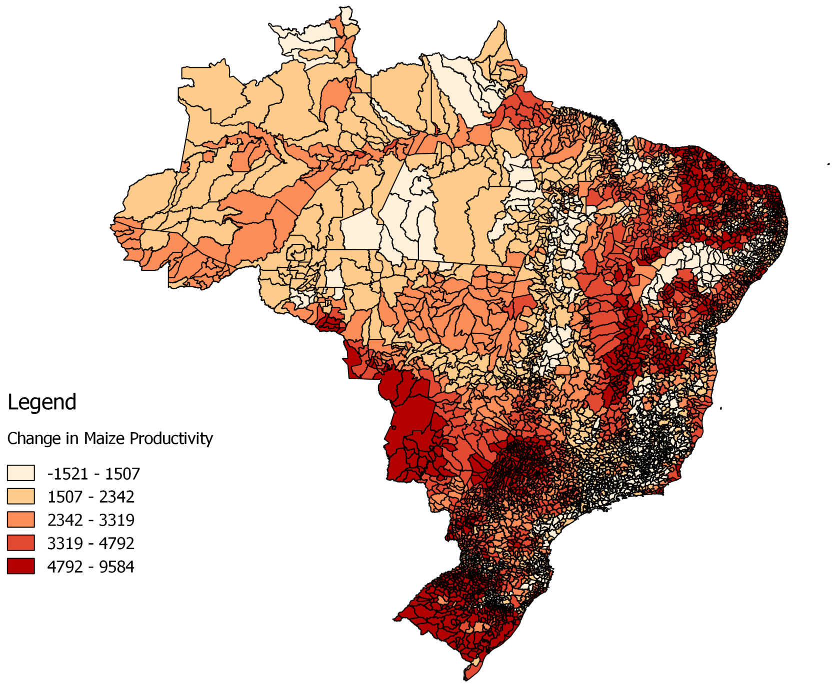

Figure 5: **Geographic Distribution of Priests per Catholic Individual, 1966**

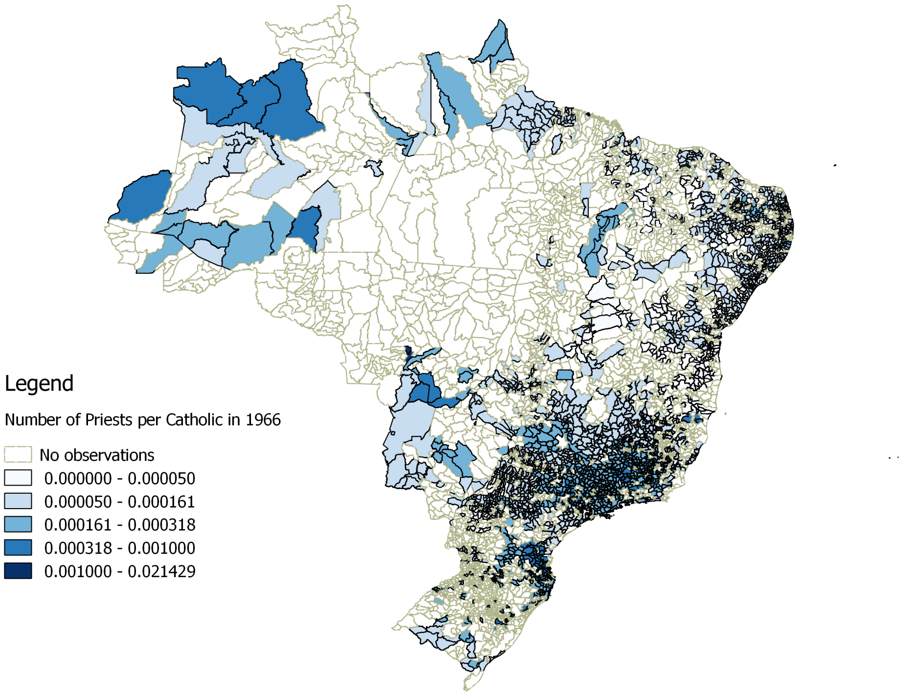

Figure 6: **Parallel Trends**

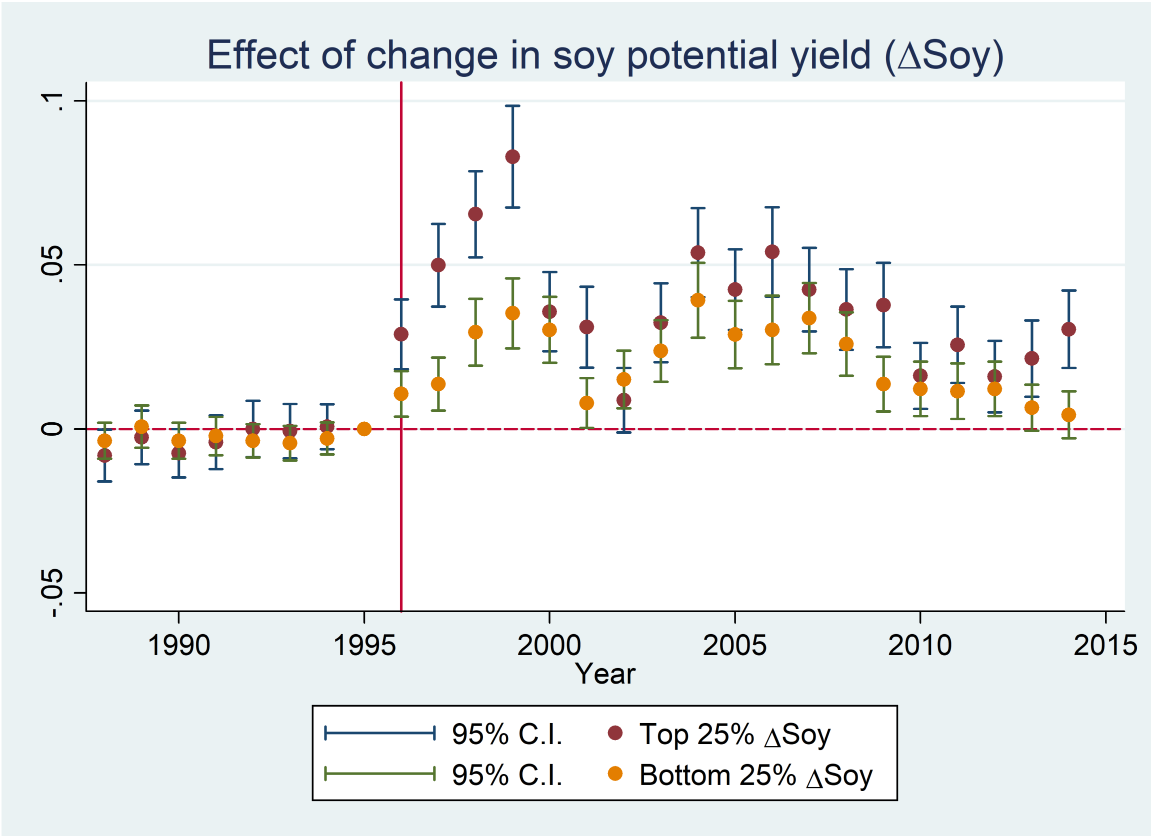

Figure 7: **Placebo Check with Technical Change in the Production of Coffee**

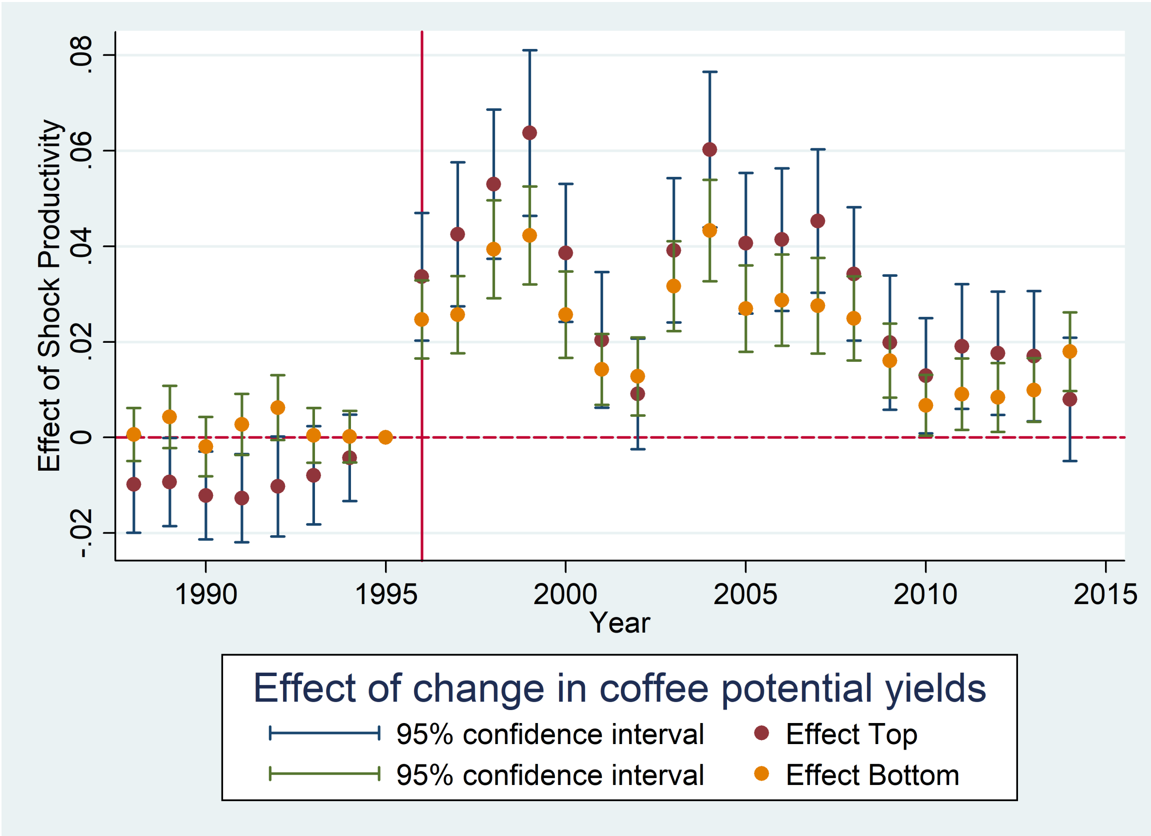

Figure 8: **Placebo Check with Technical Change in the Production of Sugar**

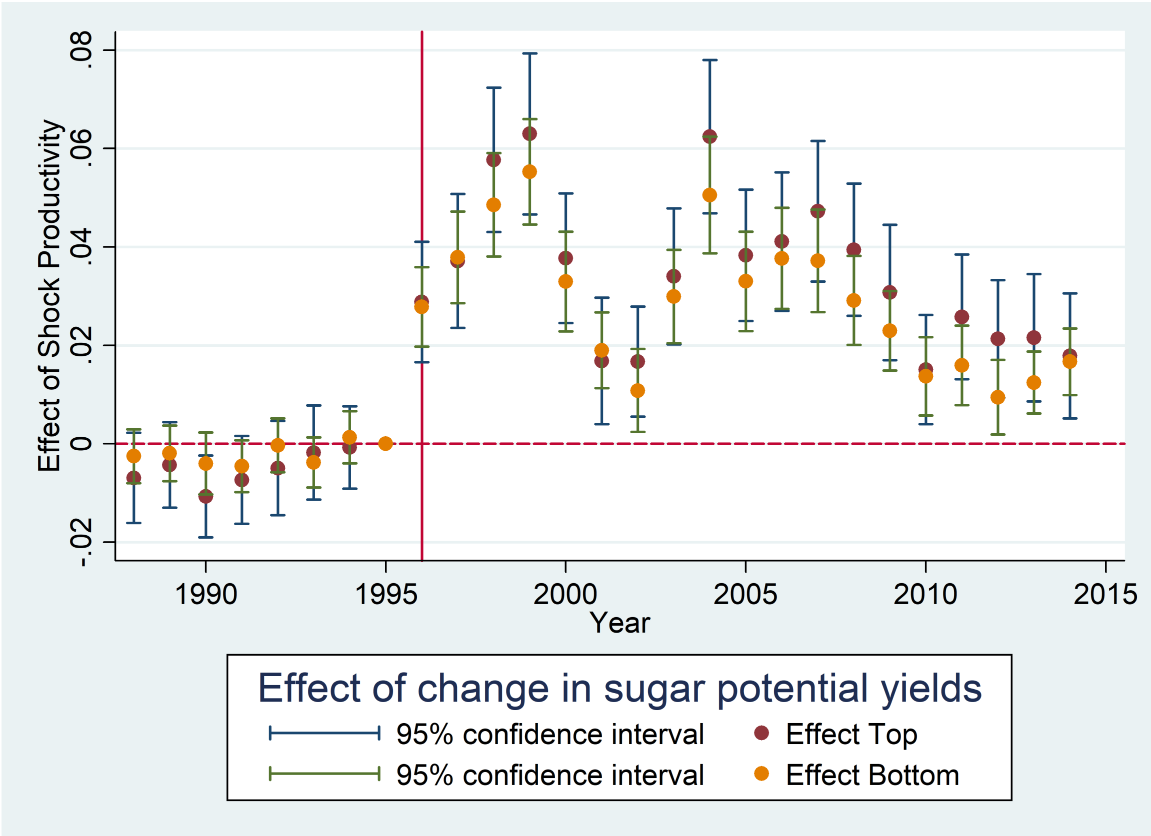

Figure 9: **Placebo Check with Technical Change in the Production of Tobacco**

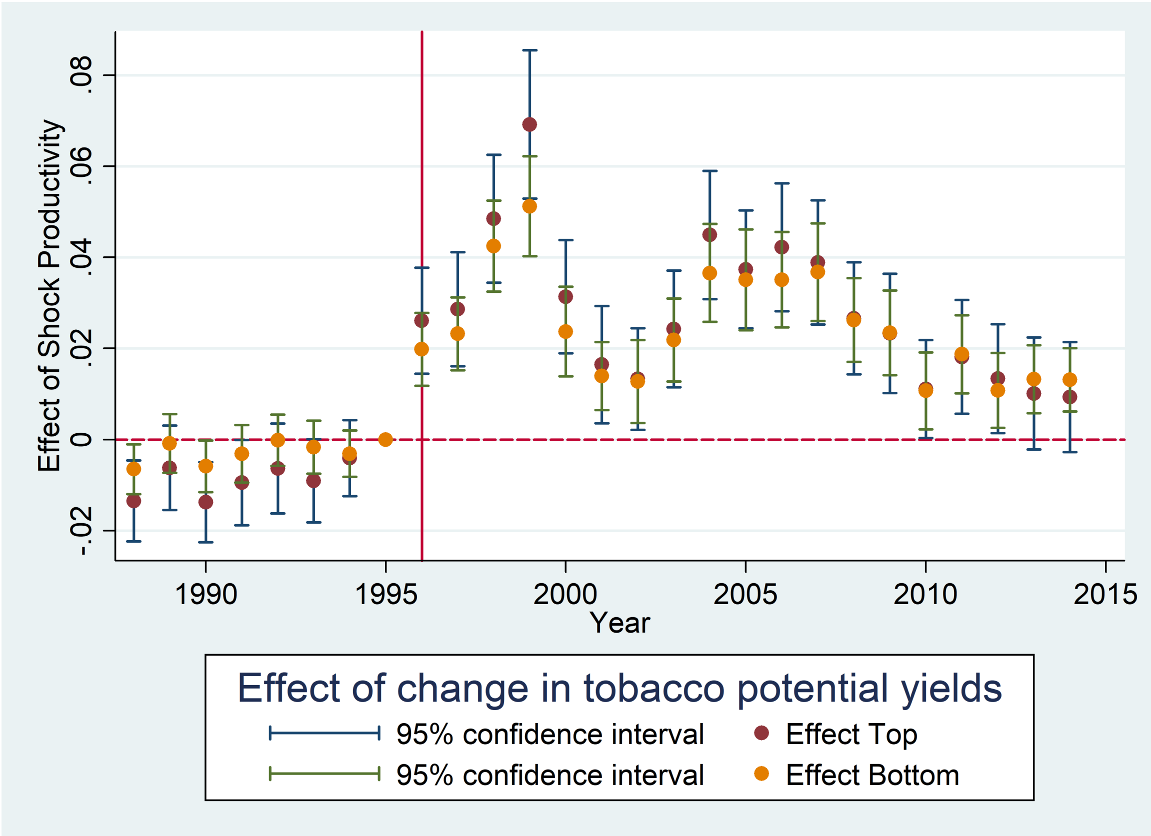

Figure 10: **Placebo Check with Technical Change in the Production of Wheat**