VANESSA DA FONSECA PEREIRA

EFFECTS OF LAND REFORM ON AGRICULTURAL PRODUCTIVITY AND INCOME IN BRAZIL

Tese apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Economia Aplicada, para obtenção do título de *Doctor Scientiae*.

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APROVADA: 30 de Julho de 2013.

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Steven M. Helfand
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To my dear father, Joaquim Rezende Pereira, who will always be the greatest example and motivation for all my achievements.

Ao meu querido pai, Joaquim Rezende Pereira,
que sempre será o meu maior exemplo e maior motivação para todas as minhas conquistas.

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I thank God, for giving me strength and surrounding me with special people.

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BIOGRAPHY

VANESSA DA FONSECA PEREIRA, daugher of Joaquim Rezende Pereira and Regina Célia da Fonseca Pereira, was born in Além Paraíba, Minas Gerais, on April 15, 1983.

She started the B.A. in Business Administration course at the Federal University of Juiz de Fora in February 2001, and concluded it in June 2005.

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In August 2008, she started the Doctorate course at the *Stricto sensu* Graduate Program in Applied Economics at Federal University of Viçosa. Between September 2010 and August 2011, she was a research scholar at the University of California, in Riverside, through the *Doutorado Sanduíche* Program. She defended the dissertation in July 2013.

She started working at the Brazilian Agriculture Research Corporation (Embrapa - Empresa Brasileira de Pesquisa Agropecuária) in September 2011.

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ABSTRACT

PEREIRA, Vanessa da Fonseca, D.Sc., Universidade Federal de Viçosa, July of 2013. **Effects of land reform on agricultural productivity and income in Brazil**. Adviser: Steven M. Helfand. Co-Advisers: Marcelo José Braga and João Eustáquio de Lima.

The impact of land reform is a very important question in the field of agricultural development, and is perhaps an even more important question for public policy in Brazil. Thus the problem that motivated this research was "what were the effects of land reform on productivity and income in Brazil, between 1985 and 2006?" Nearly one million families were settled through land reform through 2006, according to official INCRA data. This dissertation focused on approximately 330,000 land reform beneficiaries that can be identified in the 2006 Agricultural Census as having obtained their land through land reform, with or without title. Two different approaches were used: a cross section analysis with data from the 2006 Agricultural Census aggregated by farm size and type of farmer, and a panel data analysis with data from the 1985 and 2006 Agricultural Censuses aggregated at the municipal level. Both approaches showed important macro regional differences in the effects of land reform in Brazil. The 2006 data showed that, in general, beneficiaries of land reform were younger, had less education, and were in charge of the farm for fewer years. In all macro regions, use of credit among land reform beneficiaries (LRB) was higher than owners. They also had more technical assistance and participated more in unions, associations and social movements in all macro regions but the South. Also, poverty rates were higher among LRB. Based on agricultural income alone, for instance, poverty was between four and

five percentage points higher for LRB than for owners. The package of public policies—including credit, technical assistance, and electricity—even if inadequate, appears to have been reaching beneficiaries at similar or slightly higher rates than for owners. The cross sectional regressions showed an unconditional productivity advantage of owners over LRB. They suggested that unobserved municipal characteristics, farm size, characteristics of the farmer, and access to institutions and public goods were important factors for explaining differences between land reform beneficiaries and owners in Brazil. In the second part of the analysis, data from 1985 showed that land reform in Brazil happened in locations that had: a higher share of very small and large farms, substantially less access to infrastructure (as measured by electricity), establishments that were less technologically advanced, and considerably lower land productivity. Binary models showed that having LRB in the municipality did not contribute significantly to change land productivity in that municipality. Fixed effects estimates with intensity of treatment showed that effects of land reform on land productivity growth in Brazil tend to occur when land reform intensity was higher. While these models showed more rapid land productivity growth for municipalities with 10% to 20% LRB in the North and the Northeast, they also showed less rapid productivity growth for municipalities with 10% to 20% LRB in the South. The results for small farms were similar to the results at the municipal level in Brazil. Therefore, the impact of land reform on small farms appears to be driving the municipal level results described above. Finally, access to institutions and public goods, as well as use of technology and inputs seemed to be an important part of the explanation for productivity differences across municipalities as well as among small farms.

RESUMO

PEREIRA, Vanessa da Fonseca, D.Sc., Universidade Federal de Viçosa, julho de 2013. **Efeitos da reforma agrária sobre produtividade e renda agrícola no Brasil**. Orientador: Steven M. Helfand. Co-orientadores: Marcelo José Braga e João Eustáquio de Lima.

O impacto da reforma é uma questão muito importante na área de desenvolvimento agrícola e, possivelmente, é uma questão ainda mais importante para as políticas públicas no Brasil. Portanto, o problema que motivou esta pesquisa foi "quais foram os efeitos da reforma agrária sobre produtividade e renda no Brasil, entre 1985 e 2006?" Aproximadamente um milhão de famílias foram assentadas pela reforma agrária até 2006, de acordo com dados oficiais do Instituto Nacional de Colonização e Reforma Agrária (INCRA). Essa dissertação focou nos cerca de 330.000 beneficiários da reforma agrária que podem ser identificados no Censo Agropecuário de 2006 por terem obtido terra por meio de reforma agrária, com ou sem título. Duas abordagens diferentes foram adotadas: uma análise de seção cruzada com dados do Censo Agropecuário de 2006, agregados por tamanho do estabelecimento e condição do produtor, e uma abordagem de dados em painel com dados dos Censos Agropecuários de 1985 e 2006, agregados no nível municipal. Importantes diferenças macrorregionais dos efeitos da reforma agrária no Brasil foram identificadas em ambas as abordagens. Os dados de 2006 mostraram que, em geral, os beneficiários da reforma agrária eram mais jovens, tinham menos instrução e estavam na direção do estabelecimento por menos anos. Em todas as macrorregiões, o uso de crédito foi maior entre os beneficiários da reforma agrária (BRA) do que entre proprietários. Os BRA também tinham maior acesso à assistência técnica e participavam mais de sindicatos, associações

e movimentos sociais em todas as macrorregiões, exceto no Sul. Além disso, as taxas de pobreza eram maiores entre os beneficiários da reforma agrária. Considerando-se somente a renda agrícola, por exemplo, a taxa de pobreza era de quatro a cinco pontos percentuais maior entre os beneficiários do que entre os proprietários. O pacote de políticas públicas — incluindo crédito, assistência técnica e eletricidade — mesmo que inadequado, parecia estar alcançando os beneficiários de forma similar ou melhor do que os proprietários. As regressões de seção cruzada mostraram uma vantagem incondicional, em termos de produtividade, dos proprietários sobre os BRA. Tais resultados sugeriram que características não observadas dos municípios, tamanho dos estabelecimentos e acesso a instituições e bens públicos foram fatores importantes para explicar as diferenças entre beneficiários da reforma agrária e proprietários no Brasil. Na segunda parte da análise, os dados de 1985, mostraram que a reforma agrária ocorreu em locais que tinham: maior parcela de estabelecimentos muito pequenos e grandes, acesso à infraestrutura substancialmente menor (medido pela energia elétrica), estabelecimentos menos avançados em termos de tecnologia e produtividade da terra consideravelmente menor. Os modelos binários mostraram que o fato de existir BRA em um determinado município não contribui significativamente para mudar a produtividade da terra naquele município. Os modelos de efeitos fixos com intensidade do tratamento mostraram que a reforma agrária tende a ter efeito sobre o crescimento da produtividade da terra no Brasil quando a intensidade de reforma agrária é maior. Ao mesmo tempo que esse modelos mostraram um crescimento mais rápido da produtividade da terra para municípios no Nordeste e no Norte com 10 % a 20% de BRA, eles também mostraram crescimento mais lento em municípios com 10% a 20% de BRA no Sul. Os resultados para os pequenos estabelecimentos foram similares aos resultados em nível municipal no Brasil. Dessa forma, o impacto da reforma agrária sobre os pequenos estabelecimentos parece estar impelindo os resultados municipais descritos acima. Por fim, o acesso a instituições e bens públicos, bem como o uso de tecnologias e de insumos, mostraram-se uma parte importante da explicação para as diferenças entre municípios e entre pequenos estabelecimentos.

1. INTRODUCTION

1.1. Initial Considerations

The agrarian question[1] in Brazil has historically been at the center of the debates on agricultural development and social equity. Social inequality and land concentration originated when Brazil was still a Portuguese colony. The productive structure was based on large monoculture plantations and slave labor, and the output was directed to foreign countries. Family farming, in small properties, exists since that time. However, it was historically seen as a low priority in the Brazilian agricultural context.

The modernization of Brazilian agriculture furthered the escalation of social inequalities and deepened land concentration. According to Kageyama (1987), the process of agricultural modernization was unequal in two senses: regionally, since the states from the Center-South, mainly São Paulo, were the principal beneficiaries; and within each state, because it prioritized medium and large farms, and products demanded by agroindustry or directed to export. Nevertheless, this author emphasizes that the inequalities at the state and establishment level were already sharp in 1960, due to the historical evolution of each region and the particular forms of participation in the accumulation of capital.

For Martine and Bescow (1987) the modernization process resulted in a change in the access to land. Thus, changes in the structure and availability of credit, in the production and adoption of modern technologies, and in the destination of the products greatly influenced changes in the distribution of land. Two important processes went on at the same time. The scale of production changed, especially in the areas where the adoption of the new technology intensive system was greatest. The introduction of that

[1] According to Prado Junior (1981) the agrarian question refers to the relationship of cause and effect between the agrarian structure in Brazil and misery. Its essential feature is the concentration of land.

technological package, encouraged by agricultural policy instruments such as rural credit, favored medium and large farmers, in detriment of small ones. On the other hand, land speculation, triggered by the productive scale of the new model, by the credit and fiscal mechanisms and by public investments, also contributed to expel squatters and all types of small farmers.

In essence, the instruments and the ways of implementing agricultural modernization resulted in an increase of the scale of production and/or an increase of land prices. As a consequence, land concentration rose. This means that agricultural modernization limited the access of small farmers to land. Silva et al. (1983) argue that the adopted technological standard focused on the expansion of the agro industrial complex. Besides, it was not completely absorbed by small farmers, which thus remained technologically backward in comparison to modernized establishments.

This process – called conservative modernization – took place in the military period, between 1965 and 1982, and emerged when the movement for land reform was defeated. Modernization preserved and deepened the heterogeneity that characterized Brazilian agriculture in terms of technology use and the prevailing labor relations. Therefore, there was modernization in terms of technology, whereas socially there was conservation due to the maintenance of existing social inequalities (Delgado 2005).

The theory of de Janvry and Sadoulet (1989) reinforces this view of the modernization process. According to them, Latin American countries chose to first modernize medium and large farms, before trying to generate net social gains via land reform. However, the successful modernization generated economic power among landowners. This, in turn, reinforced the existing political power. Large landowners obtained credible state commitments of non-expropriation if they would modernize. Therefore land expropriation and redistribution were not put in practice, but only used as a threat to large farmers. This threat was taken seriously and led to defensive strategies on the part of landlords.

Even though agricultural modernization had prioritized large farms, the debate on land reform existed before and during the entire process. This debate weakened during the military period; the period when modernization took off, agricultural production and productivity increased, but the agrarian structure remained unchanged. Nevertheless, the end of a long period of economic growth, in the early 1980‘s, and of

the military dictatorship in 1985, created a scenario propitious to important changes in the agrarian context (Delgado 2005).

The political opening allowed for articulation of social movements and agrarian entities. According to Medeiros (2003), protest tactics, pressure from the church, and the intensification of land-related violence in frontier areas all contributed to place agrarian reform on the political agenda in the early 1980s. Yet policy initiatives were quite timid. The First National Agrarian Reform Plan (PNRA-I) was proposed in 1985. The 1988 Constitution dedicated a chapter from the topic on –Social and Economic Order" to land reform. Protest for land and land occupations gradually grew during the late 1980s, and intensified dramatically in the mid-1990s.

Land reform and the agrarian question became very important during the 1990s and 2000s in Brazil. Many land conflicts happened, important changes in legislation were made, and many settlements were created. The social movements' actions during the 1990s were partially responsible for bringing this problem to the forefront of the political agenda. In part as a reaction to this, the data and the literature show considerable government enthusiasm with land reform during these two decades. Between 1985 and 2006 more than 4,500 farms were obtained through expropriations for settlement projects and hundreds of thousands of families were settled.[2]

Brazil is not the only Latin American country where land reform took place. In general Latin American land reforms generated limited and mixed results for the beneficiaries. There were comprehensive land reforms in four Latin American countries: Mexico (1917), Bolivia (1952), Cuba (1959) and Nicaragua (1979). In each case, land reform was part of a profound socio-political revolution. There were more modest land reforms in a number of other Latin American countries, e.g. Chile, Colombia, Ecuador, El Salvador and Peru. In a few cases, the redistributive measures were reversed (Guatemala, 1954) or partially rescinded (Chile, 1973). In most cases, however, the small farmers who benefited from these modest reforms were left to fend for themselves. Governments continued to pursue policies with an _urban bias' and, within agriculture, a _landlord bias' (Griffin et al. 2002).

The lack of continuity, and complementary investments in infrastructure and support services, were problems common to all of them. Governments prioritized urban and industrial investments and abandoned attempts at strengthening land reform through

[2] Based on INCRA's data, presented in Table 4.1. The exact number of families is the subject of considerable debate. The issue will be addressed in the third section of this dissertation.

the provision of technical support. Small farmers received neither the financial nor the technical support needed to make land reform a success; governments continued to neglect investment in human capital in the countryside; and public investment in rural transport, power and communications continued to be scarce, particularly in areas where small farms predominated. As a result, the benefits from land reform often were disappointing. On the other hand, landowners were given access to subsidized credit and new technological packages, as well as a provided with a generous span of time to adjust productivity levels. The defensive modernization was implemented in Colombia (1961), Ecuador (1964), Chile (1962-67), Peru (1963-68), Brazil (1964), Honduras (1973), and Venezuela (1960) (de Janvry et al. 2001).

Previous experiences with land reform in Latin American countries cannot be considered very successful, certainly not in comparison to the cases of land reform in Asian countries such as Japan, Taiwan, South Korea, China and Vietnam. In the period since the Second World War, these countries successfully transformed their agrarian structures into systems based on individual peasant farming with a highly egalitarian access to land. The redistribution of land in these five countries was perhaps the most comprehensive ever implemented and their experience is unmatched. Japan, Taiwan and South Korea distributed land ownership rights among households in a highly egalitarian manner. China and Vietnam also followed radically redistributive policies after expropriating the landlords, but they quickly replaced peasant farming by collective farming. Thus, land reforms are not necessarily destined to fail. But the evidence from Latin America strongly suggests that they are more likely to succeed when they are part of a comprehensive strategy of rural development (Griffin et al 2002).

Several studies have attempted to evaluate the impact of land reform in Brazil.[3] In general, they are based on descriptive statistics of beneficiaries and simple methodologies that do not control for important variables that may affect the beneficiaries. Although such analyses may indicate some improvements in the beneficiaries‘ lives, these improvements cannot necessarily be attributed to land reform. Most studies, in addition, have selected specific groups of beneficiaries, or locations, to analyze. These beneficiaries may not capture the totality of local contexts. The samples of the studies mentioned in the third Chapter of this dissertation are generally small and not randomly selected, and the beneficiaries tend to be representative of a specific area,

[3] Chapter 3 (A historical review of land reform in Brazil) describes this literature.

which may be more (or less) developed than other beneficiaries in the same state, for instance.

Some studies invested in comparisons between the situation of the beneficiaries before and after the creation of the settlement. This provides interesting information, but is characterized by subjectivity, because it is based on personal statements. It also does not compare changes among beneficiaries to changes for a control group, thus making it extremely difficult to attribute any perceived improvement to participation in the program. The quantitative analysis of the results of land reform, especially the ones adopted by the government, tend to rely on counting the number of families settled, the area expropriated, or the financial resources allocated to the beneficiaries or to support the settlements. These numbers are compared to the goals defined by the government and to the results from previous governments. This information is interesting and relevant, but simplifies the analysis of land reform, and is clearly insufficient to evaluate the results of a public policy.

The review of the literature on impacts of land reform in Brazil identifies a number of analyses that provide interesting and important insights into the dynamics of the beneficiaries. The present research seeks to extend this literature, and improve the understanding of the impacts of land reform in Brazil.

1.2. The problem and its importance

Land reform represents one possible pathway to reduce rural poverty. An important component of success relates to achieving adequate levels of productivity and income generation among the beneficiaries. These are necessary to produce a stream of income for the beneficiaries, and to justify the costs of land expropriation and the creation of settlement projects. Thus, while the impact of land reform is a very important question in the field of agricultural development, it is perhaps an even more important question for public policy in Brazil. This dissertation seeks to evaluate the effects of State-led land reform on agricultural productivity and rural income in Brazil.

Thus the problem that motivates this research is "what were the effects of land reform on productivity and income in Brazil between 1985 and 2006?" Because land reform is a process that may or may not generate income and reduce poverty, measuring

the effects of land reform on productivity, income and poverty is essentially an empirical question, which depends on a broad context, consisting of economic, social and politic variables.

When combined with variable inputs and other assets, access to land can provide a means of generating income and food for its beneficiaries. Thus, providing access to land can be an effective strategy to help small farmers increase their income, so that they can overcome poverty. In spite of land‘s contribution to the income generation process, land is not enough as a road out of poverty (de Janvry et al. 2002). Land reform involves several processes, which begins with selection of beneficiaries and includes provision of access to institutions, public goods, adequate technology and inputs, as well as continuous technical assistance. So even though land is essential for small farmers to generate income and grow, this factor is not enough. Access to credit and better infrastructure, as well as technology and education, are also important. Because small farmers face many challenges that arise from production and markets, technical assistance is also important.

The research problem raises two other key questions that will be investigated in this dissertation. The first one is: to what extent are land reform beneficiaries becoming similar to existing small farmers, and thus reproducing the low levels of living standards that exist for a large portion of small farms in Brazil? Alternatively, are they more productive – and less poor – than existing small farmers? The second question follows the first one. Are land reform beneficiaries becoming more productive – and less poor – because of the whole package of policies accompanying the distribution of land? Or are they less productive – and probably poorer – because of the insufficiency of the policy package or execution of the package? This latter case has often been the result of land reforms in Latin America in the 20th century. The package of policies includes credit, technical assistance, education, and electricity.

The answers to these questions are going to shed light on the impacts of land reform in Brazil between 1985 and 2006. Theoretically, land reform is expected to increase production and income, and reduce poverty. But because the effectiveness of land reform to generate income and reduce poverty depends on a package of policies, these questions become essentially empirical. Arguments in favor or against land reform contribute to make the empirical analysis relevant.

The importance of small farms, especially family farming, in Brazil reinforces the need to study this empirical question. Many large farms increased their productivity, competitiveness and income during the modernization process. Nevertheless, most establishments in Brazil are small, even though the area occupied by this group is much smaller than the total area of large farms. In this sense, it is important to mention the debate on the future of small farms. According to Hazell et al. (2007) some changes represent great challenges to small farmers. Falling prices for most of the agricultural commodities that small farmers grow and more open domestic markets; mounting pressure on natural resources from population growth; intensified international competition; and new demands on potential suppliers for quality, consistency, and timeliness are new driving forces that pose serious challenges to the viability of small-scale farming. Policy interventions toward small-farm agriculture are thus needed. Otherwise, there is a growing risk that rural poverty could increase dramatically and waves of migrants to urban areas could overwhelm available job opportunities, urban infrastructure, and support services. Land reform and Pronaf (the National Program for Strengthening Family Farms) are examples of policies intended to support small (family) farmers in Brazil.

Unequal distribution of income and assets in Brazil is seen as an important obstacle to poverty reduction. Research about poverty and inequality in Brazil emphasizes that the prevalence and depth of poverty is related to the concentration of income, not to a shortage of resources. Per capita income in Brazil is above the poverty line, yet poverty remains high. According to Helfand et al. (2009), this situation is seen also in rural areas. Rural per capita incomes were above the poverty line in 1992, 1998 and 2005. Nevertheless, the proportion of poor was high.

Based on the Gini index, the distribution of land in Brazil has been remarkably stable between 1975 and 2006 (Hoffmann and Ney, 2010). The Gini has only varied between .855 and .858 in this period. According to other measures, such as the Atkinson index, inequality may have even risen somewhat in this period. This concentration of assets is an important determinant of the concentration of income in rural areas. Ney and Hoffmann (2003) used data from the National Household Sample Survey (PNAD) in 2001 and obtained a value of 0.84 for the Gini index of agricultural land distribution. For that same year, the Gini for income distribution calculated by Hoffmann (2006) was 0.59. The highly concentrated land structure indicates that a large

share of the rural population either does not have land or has an insufficient amount. This is one of the arguments for land reform in Brazil, which is reinforced by the theoretical expectation that land redistribution contributes to generate income and reduce poverty (Deininger and Binswanger, 1999).

On the other hand, some arguments against land reform should be mentioned. Using data from the 2006 Agricultural Census, Alves and Rocha (2010) show that 8.19% of the establishments were responsible for 84.89% of the value of production in Brazil. Therefore, land reform is unlikely to make a significant contribution to increasing food supply in Brazil, and may even work in the opposite direction. In fact, food supply is not the problem in Brazil; the lack of purchasing power by the poor is. Besides, the costs of land reform are high and grew in the 1990s. Gasques (2001) and Gasques et al. (2006) show that the expenditures with land policy, which includes land reform, colonization and financial assistance, had an important increase between the 1980s and 2005.[4] Another argument is based on previous experiences with land reform in Latin American countries. These experiences suggest that land reform in Brazil may in fact fail if the package of policies accompanying the distribution of land is not sufficiently developed. In summary, the concentration of land ownership and the existence of hundreds of thousands of families of agricultural producers with little or no land shape the context of the Brazilian agrarian question. Different points of view mark this debate and, especially after the increase in the number of settlements during the 1990s and 2000s, the discussion about the importance and the results of land reform intensified. The claim for land reform in Brazil comes from a number of alleged benefits in terms of equity and efficiency. Theoretical and empirical arguments are used either to justify land reform, or to oppose it. Some arguments for land reform include benefits in terms of efficiency, equity, poverty, and democracy. The concentration of land ownership generates inequality, inefficiency and poverty. Redistribution is a possible way to change that. Arguments against land reform include the high costs of land reform programs in Brazil, the supply of food by large farms, and previous unsuccessful experiences throughout the world.

The present research seeks to contribute to the existing literature in different ways. It will (1) analyze land reform beneficiaries at the national and regional levels--

[4] The expenditures with land policy (that include land reform, colonization, and financial assistance) were close to zero in the early 80. However, these expenditures were close to R$14 billion between 2000 and 2005.

not only from specific areas of the country--by using the 2006 Agricultural Census to investigate a) all owners who declared that they obtained their land through land reform, and b) all establishments that have a majority of their land waiting for title through land reform. By doing this, the analysis is going to consider different contexts in the country with the most comprehensive dataset available; (2) describe land reform beneficiaries, with and without land title, in comparison to landowners (who are not beneficiaries). This evaluation is going to answer if land reform beneficiaries are simply reproducing existing small farmers, which is one of the key questions of this dissertation. The relationships between productivity, income and variables such as credit, technical assistance, and land size are going to be analyzed for selected groups of farmers. This analysis is going to answer the key question about the role of the package of policies accompanying the distribution of land. In addition, municipalities with and without land reform beneficiaries are going to be described before and after the creation of land reform settlement projects; (3) use alternative methods and datasets to evaluate the effect of land reform. Cross sectional regressions have the advantage of providing unconditional and conditional comparisons of beneficiaries to other farmers in 2006. Difference-in-differences and fixed effects models have the advantage of comparing the changes in municipalities with and without land reform--or with different degrees of land reform--over the period in which almost 100% of land reform projects were created; and (4) consider heterogeneous effects of land reform depending on a) the share of beneficiaries in the municipalities or their average time of existence, and b) farm size classes.

1.3. Objectives

The main objective of this dissertation is to evaluate the effects of redistributive land reform on agricultural productivity and income in Brazil between 1985 and 2006. Specifically, the objectives are:

a) Describe land reform beneficiaries in comparison to landowners.
b) Identify and explain productivity and income differences between land reform beneficiaries and other farmers.
c) Identify the intensity of land reform across municipalities – both in terms of time and space – that condition its effects on productivity.

d) Analyze effects of land reform on small establishments.

1.4. Outline

In addition to this introduction, this dissertation consists of six more Chapters. The second Chapter presents some theoretical relationships that provide the basis for the empirical strategies. The third Chapter provides an historical review of land reform in Brazil. The objective is to explore aspects that contribute to the complexity of the agrarian question. The fourth Chapter presents relevant data on the magnitude of land reform in Brazil, descriptive statistics on 2006, and the empirical strategy and results of the cross sectional analysis of 2006. The fifth Chapter presents the empirical strategy and results of the panel data analysis. The sixth Chapter summarizes the main facts and results presented in the previous Chapters. Finally, the conclusions are presented in the last Chapter. This Chapter reflects on the relevance of the main findings for debates about land reform around the world, and highlights aspects that may be useful to policy decisions related to land reform.

2. THEORETICAL FRAMEWORK

The empirical models estimated in this dissertation with both cross-section and panel data rely on the relationships that exist between land reform, productivity, income generation and poverty reduction. These relationships are useful to explain the expected impacts of land reform. The empirical strategy is also based on a set of variables that are theoretically expected to affect productivity. Therefore, this Chapter presents some theoretical background on these relationships and on the determinants of productivity. The theory shows a relationship between productivity growth and income growth, as well as between income growth and poverty reduction. Nevertheless, the relationships between land reform and productivity, or between land reform and income, or between land reform and poverty are not unambiguous. The following paragraphs are going to shed some light on these relations and the importance of the context for the definition of effects of land reform.

Agricultural productivity growth can drive pro-poor growth, benefiting poor farmers and landless laborers by increasing both production and employment. It can also benefit the rural and urban poor through growth in the rural and urban nonfarm economy. In addition, it can empower the poor by increasing their access to decision-making processes, increasing their capacity for collective action, and reducing their vulnerability to shocks, through asset accumulation (Hazell & Haddad, 2001). Agricultural growth that improves productivity on small farms has proven to be highly effective in slashing poverty and hunger and raising rural living standards (Hazell et al. 2007).

Irz et al. (2001) highlight theoretical expectations of the effects of agricultural growth on poverty. The most direct contribution of agricultural growth is through generating higher incomes for farmers. However, the degree to which the poor are

engaged in farming and the extent to which output growth raises incomes are conditions that affect the influence of agricultural growth on poverty. Should increased output drive down product prices, or raise the costs of production as the demand for inputs increases, the rise in gross margins may be small or even negative.[5] The ability of the poor to adopt improved technology is also important. When output increase is due to technical innovation, benefits to the poor who farm, and for whom farming provides the majority of their income, may be limited. Technology adoption by the poor can be limited by a lack of access to inputs and to the knowledge necessary to use the technology, as well as by a scale bias in the new technology. Alternatively market imperfections or policies might limit the access of small farmers to inputs, including credit. Finally, new technology might not suit the agro-climatic conditions typical of many smallholdings.

Although theoretical expectations point out reasons to expect agricultural growth to reduce rural poverty, these are contingent on several qualifications dependent on certain circumstances. Empirical work tends to show strong poverty-alleviating effects of agricultural growth. This implies that the hypothesized linkages from agricultural production to poverty probably operate significantly and strongly in many circumstances. In particular, it is likely that the ability of agriculture to generate employment, to stimulate the rural economy through linkages, and to reduce the real cost of food accounts for much of the poverty-reducing effects of agricultural production (Irz et al. 2001).

Together with migration, monetary transfers, and pluriactivity, agriculture is one of the key pathways out of rural poverty (de Janvry e Sadoulet 2002). Land reform and rural development can contribute to this pathway by helping to secure access to land and enhance the competitiveness of the beneficiaries. According to these authors, access to land is necessary to activate the exit path through family farming, and it is also the platform on which pluriactive strategies are built. However, the agricultural pathway out of poverty is not only based on land reform. This pathway is also a possibility to all existing small farmers.

[5] The impact of falling product prices on the poor depends on their net sales to the market. Food deficit farmers could benefit from falling prices, as would all poor non-agricultural families who are net consumers of food.

According to Griffin et al. (2002), redistributive land reforms that reduce land concentration could have multiple benefits. Based on the widely observed inverse relationship between farm size and productivity, land redistribution could raise total output and average income. In other words, it could increase allocative efficiency in the use of resources. One consequence of this is that it would increase the demand for labor and would generate more employment in the countryside, partially by increasing the labor intensity of agricultural activities and partially by creating more employment opportunities in non-farm rural activities. A redistribution of land to tenants, wageworkers and minifundists would lead to a more equal distribution of productive wealth. The net effect on the distribution of assets, however, would depend on the extent to which land is expropriated, the compensations to landowners, and the provisions made for the beneficiaries to purchase land in order to obtain a legal title.

Griffin et al. (2002) examine the implications of a high degree of land concentration for the rural population. They describe a small, local labor market in the rural area of a developing country. The economic effect of concentrated land ownership in a context of small, fragmented, local labor markets is to give large landowners a high degree of monopsony power in the labor markets in which they operate. Land concentration leads to a decline in the rural wage, and a decline on total employment on large farms. Compared to competitive conditions, there is exploitation of labor. The reduction of total employment is the origin of rural underemployment or surplus labor. The combination of surplus labor and depressed wages reduces the „reservation wage" in urban areas and thereby accentuates urban poverty. This occurs through low incomes in the „informal sector" or open unemployment, or both.

Concentrated land ownership also reduces total output. Nevertheless, the large landowners benefit absolutely: their income rises. As a consequence, inequality in the distribution of income increases. Finally, concentration also leads to a decline of the total wage bill, or the income of workers and tenants, both because there is less employment and because the rate of remuneration declines. That is, land concentration produces widespread rural poverty.

Nevertheless, the benefits of land redistribution to low income groups are unlikely to be uniform unless special efforts are made to be inclusive. Because average incomes tend to rise as a result of increased efficiency in the allocation of resources and the distribution of income tend to become more equal, land reform could make a major

contribution to reducing both rural and urban poverty. In addition, if _urban biased' and _landlord biased' policies are removed at the time of implementation of the redistributive land reform, the trend rate of growth of rural incomes could accelerate (Griffin et al. 2002).

According to Lipton (1974), the primary motivation of land reform is to alleviate poverty by reducing economic inequality. Nevertheless, the agricultural path out of poverty requires not only sufficient land, but also adequate levels of productivity. Thus, land reform programs need to be accompanied by other institutional reforms that contribute to the competitiveness of the beneficiaries. Similarly, for existing small farmers, policy needs to help reduce high transactions costs by providing public goods, facilitating access to input and output markets and to technologies that can help raise productivity. Increased human capital can also create large income effects. Because of this, rural development initiatives must seek complementarity in interventions between building the asset position of the poor and improving the productivity of those assets, particularly through technological change. The delivery of technological change for rural poverty reduction needs to be tailored to the specific features of poverty in particular regional settings (de Janvry and Sadoulet, 2000).

De Janvry et al (2002) analyze the welfare and efficiency effects of gaining access to land. In order to do this, they list the advantages of accessing land comparatively to either fixed rent or ownership with fully mortgaged land. The first benefit of access to land, when land is combined with variable inputs and other assets, is the provision of a source of income to beneficiary households. They point out, however, that access to land is neither the only strategy out of poverty, nor is it sufficient to guarantee escaping poverty. Access to land is not sufficient to secure higher household incomes when the policy context is adverse to farm profits, competitiveness is undermined by a lack of supportive institutions, asset transfers are not valorized by complementary public goods (e.g. access roads) and investment is deterred by insecurity regarding the conditions for access. It may not be the best pathway out of poverty for some households. A second benefit of access to land would be helping to give value to assets held by a household with zero or low opportunity cost outside the land. These assets include captive family labor and draft animals, for instance. Access to land also allows direct use of factors of production held by the household at a lower cost than for buyers of these factors. Having access to sufficient land avoids being a buyer of food,

and provides cheap food when there are food market failures. Similarly, access to land is a source of insurance against price shocks on the food and labor markets. Finally, access to land serves as a component in an income strategy based on a portfolio that includes wage labor, self-employment in microenterprises, and migration. They conclude that both welfare and efficiency gains can be achieved if flexible and low-cost channels of access to land exist and are usable by the rural poor.

Similarly, Griffin et al. (2002) emphasize that land reforms are most likely to succeed when they are part of a comprehensive strategy for rural development. The potential benefits of redistributive reforms do exist, but in order to realize those benefits more is required than a transfer of property rights in land from large landowners to tenants and agricultural workers. Price reforms, improved access to credit, greater emphasis on human capital formation and improved physical infrastructure are also required. To be effective, land policy reforms need to be embedded in comprehensive policy and institutional reforms, and to be complemented by effective rural development interventions in support of the competitiveness of beneficiaries (de Janvry et al. 2002). According to Besley and Burgess (2000), land reforms in developing countries are often aimed at improving the poor's access to land, although their effectiveness has often been hindered by political constraints on implementation. This supports the notion that a comprehensive strategy is necessary to generate the benefits of land reform.

Similarly, Griffin et al. (2002), emphasize that the case for land reform rests not on the existence of defective tenure contracts but on the concentration of land ownership rights and the inefficiency, inequality and poverty which this creates. The core of a land reform is thus a redistribution of property rights in cultivable land. Two important biases must be simultaneously eliminated in order to achieve a successful redistributive land reform: landlord bias and urban bias. The first one refers to agricultural policies that discriminate against small farmers and in favor of large landowners. This bias discriminates against the rural poor and accentuates agrarian poverty. Its removal is essential, especially if there is a redistributive land reform. The reason for this is that redistributive reforms will alter the balance of land holdings in favor of small farmers and hence the negative quantitative impact on total output and the incomes of small farmers will increase if the policy bias against them persists. The latter bias refers to a development strategy that neglects agriculture and the rural areas,

adopted by many countries. Policy is sometimes said to have an ‗urban bias'. This general bias of policy against the rural areas makes it difficult to reduce rural poverty regardless of the distribution of property rights in land.

Removing these biases is very important in a process of redistributive land reform. One cannot, as has often happened, simply give land to the peasants and then abandon them, and expect that all will be well.

The economic basis for land reform is founded on the interlinked assumptions that large farms under-utilize land, while small farms are wasteful of labor, resulting in low levels of land and labor productivity (respectively) and consequently leading to poverty (Borras et al., 2007). Most explanations of the inverse relationship between farm size and land productivity are based on market imperfections that determine at the same time the farm size and the shadow prices of some inputs (Assunção and Braido, 2007). Feder (1985) and Eswaran & Kotwal (1986) theoretically formalize these explanations. According to Hazell el at (2007), with regard to equity and poverty reduction, there is a strong case for preferring small to large farms. Small farms are typically operated by poor people who use considerable labor, both from their own households and from their equally poor, or poorer, neighbors. Likewise, when small-farm households spend their incomes, they tend to spend them on locally produced goods and services, thereby stimulating the rural nonfarm economy and creating additional jobs. Farm size is thus an important determinant of land productivity and poverty.

According to Hayami and Ruttan (1970), empirical research supports a classification of the sources of productivity differences into three broad categories: (a) resource endowments, (b) technology, as embodied in fixed or working capital, and (c) human capital, broadly conceived to include education, skill, knowledge and capacity. Because a large set of variables can be used to explain productivity, they can help explain the effects of land reform. So, farm size, access to institutions and public goods, human capital (and other characteristics of farmers) and use of technology and inputs are important variables for the objective of this dissertation. Besides, these variables should be part of the comprehensive strategy required in order for land reform to generate the potential benefits mentioned above.

The models estimated in this dissertation are based on the expected benefits of land reform and the productivity potential to increase income and reduce poverty.

Productivity is measured by partial and total factor productivity indices. The partial index refers to land productivity. Total factor productivity is based on the idea of a Tornqvist index. The Tornqvist index is exact for the homogeneous translog production function. Such production functions are often referred to as flexible because they can approximate production structures with arbitrary substitution possibilities. The translog function does not require inputs to be perfect substitutes. If the relative price of an input increases, the producer decreases its use, substituting other inputs, until all marginal productivities are proportional to the new prices (Christensen 1975). Because the index in this dissertation applies to only one year (2006), it is obtained as a simple relation between total value of agricultural production and total value of production costs.

3. A HISTORICAL REVIEW OF LAND REFORM IN BRAZIL

According to the Land Statute of 1964, land reform is a set of resolutions adopted to promote a better distribution of land. These resolutions include changes in the system of land ownership and use, in order to address the principles of social justice, sustainable rural development, and to increase the production. In Brazil, the Land Statute determines the conception of land reform. According to the statute, land reform should be able to reduce the concentration of land structure; produce basic foods; generate income and jobs; reduce poverty and misery; diversify rural trade and services; provide basic public services; reduce migration to urban areas; democratize power structures; and promote social justice and citizenship (Law 4504, 1964).

An important conceptual difference refers to agrarian and land reform. The first one encompasses not only redistributing land due to land concentration -- which is land reform. This also includes the implementation and redefinition of agricultural and other public policies related to the retention of the rural population in the countryside and oriented to rural development, such as fiscal incentives, agricultural credit, and infrastructure (sanitation, transport, electricity, education, health centers, warehouses, outers, etc.) (Neto, 2006).

Land reform‘s importance is due to the fundamental role that access to land plays in economic development. According to de Janvry and Sadoulet (2005), land is not only a factor of production, and as such a source of agricultural output and income, it is also an asset, and hence a source of wealth, prestige, and power. Because it is a natural asset, its use affects environmental sustainability or degradation.

The distribution of land can be pursued via different strategies. An important distinction is between state-let and market-assisted land reform. The state-led mechanism is applied through expropriation of selected properties and its redistribution. In this case, the state is responsible for choosing the beneficiaries and determining the

criteria to expropriate land. Therefore, the state controls the process. This type of land reform is the one emphasized in this dissertation.

The beneficiaries of all types of land reform are part of a long-standing debate in Brazil: the agrarian question. The distribution of land in Brazil is recognized as one of the most skewed in the world. Social inequality and land concentration have their origins in the period when Brazil was still a colony of Portugal. The organization of production in the colonial period relied on large export-oriented monoculture properties, based on slave labor. This process of colonization contributed to define the appropriation of land in Brazil. Family farming, in small properties, has always existed, but in a secondary position in the Brazilian agricultural context. According to Rezende (2006), Brazilian agricultural development followed a pattern of increasing concentration, expressed in the prevalence of large-scale production, high levels of mechanization and low levels of unskilled labor.

The main institution to distribute land throughout the colonial period was the *sesmarias*, which lasted until 1822. The Crown offered large tracts of land to be explored and cultivated, which was a concentrating initiative (Assunção 2008). Between 1822 and 1850, occupation was the only way to acquire land in Brazil. During those years, the squatters occupied unproductive land when the owner of the *sesmaria* was not able to meet the requirement of cultivation. According to Mueller (2006), given the absence of regulation, conflicts and violence became a common problem. More violence and informal institutions were the ways to deal with them. The process of land distribution in Brazil was not well organized, besides contributing to the land concentration.

However, in the mid-nineteenth century, the farmers began to face difficulties to find slave labor due to the public condemnation of the slave trade. The debate about new labor sources for big farms became a debate about land use and its appropriation. Even though there were people in favor of land partitioning, the landowners were more powerful. The debate on land use and appropriation resulted in the Land Law, passed in 1850. This Law regulated the situation of land possession and ownership, after a long legal vacuum that followed the end of the *sesmarias* regime (Medeiros 2003).

It stated that vacant land should only be acquired through purchase and no more new concessions or occupations via possession should be allowed. At the same time, the land law revalidated the *sesmarias* or other concessions made by the General

Government. The revalidation happened in case the land was either being cultivated, or with initial cultivation, and was the usual housing for the *sesmeiro*. Under the same circumstances, the revalidation applied also for land under possessions. This law marks the transformation of land into a commodity and is a consequence of its price increase. However, at that time few people already controlled a substantial portion of lands in the form of large rural properties, the *latifundia*. The prohibition of occupations and the imposition of a monetary payment as a requirement to get land reinforced the power of big landowners (latifundiários), since the occupations by small producers had become illegal. Hence, the law worked recognizing and perpetuating the concentrated land structure (Mueller 2006). Furthermore, Nugent and Saddi (2004) mention a political view that considers the land law as a deliberate attempt to exclude the majority non-landholding population from acquiring land, thereby re-enforcing the inherited high concentration of landholdings.

Mueller (2006) notes that the ownership of land comes with some level of political power. For this reason, changing the concentrated[6] agrarian structure became a necessarily difficult process. The owners of land acquired power that could be used to prevent changes that would potentially make them worse off. Therefore, the years between discovery of Brazil and the Land Law were very important to define the unequal and concentrated land distribution.

The debate on the agrarian question was confined to a few groups of intellectuals and politicians until the 1950s. Despite the recurrent conflicts for land, there was no large social movement for land reform. Nevertheless, in the late 1950s and early 1960s, land reform became an ample demand that encompassed different social forces. The different forms of conflict in the rural areas began to consolidate via a common platform. The conceptions of the Brazilian Communist Party (Partido Comunista Brasileiro – PCB) influenced this process that made land reform the main demand of rural workers. For the PCB, the end of latifúndios was a necessary step to promote fast growth of production in the countryside and in urban areas (Medeiros 2003).

[6] Unequal distribution and concentration of land are not necessarily synonymous. High land inequality is marked by a large proportion of total area occupied by a small proportion of establishments. Landless people are not part of the inequality estimates, which only consider the distribution among those that have land. Thus, inequality refers to the distribution among the existing establishments. Concentration is associated with oligopolies. For example, a small number of establishments may have equally sized areas. The inequality is zero, but the concentration is elevated (Hoffmann and Ney 2010).

At the same time, the Peasant Leagues were the political expression of conflicts that happened in the Northeast. The emergence of the Peasant Leagues in the 1960s, initially supported by PCB militants, made agrarian reform a major political issue for the first time. They became nationally prominent due to the successive mobilizations that represented a new political act by rural workers through manifestations such as marches, meetings and other events gathering workers on the streets. In the late 1950s, the Leagues broke with the PCB.

The Catholic Church also took sides on this debate. According to Wolford (2003), in 1961, the Roman Catholic Church officially decided to focus on land tenure issues in Latin America, publishing a series of educational documents to inform rural workers in Brazil of the biblical statement that _the land is a gift of God'. The pastoral letters and manifests from the Episcopate during the 1950s and the 1960s attempted to apply the Catholic Church's social doctrine to the extreme social inequity and exclusion that existed in Brazil. These views played an important political role in the organization of Brazilian syndicalism (Delgado 2005). The Catholic Church advocated the protection to instituted property right; at the same time it recognized the need for a land reform through expropriation and fair compensation.

The Economic Commission for Latin America and the Caribbean (Comissão Econômica para América Latina e Caribe – CEPAL) was responsible for the formation of many important Latin American economists and policy makers after the Second World War. The economic development of Latin American countries and the promotion of their industrialization were necessary at that time. Given that context, agriculture based on large properties and low technology adoption was considered an obstacle to development. This commission stood up for agricultural modernization and the improvement of the standard of living of the rural population so that they could join the market of the emerging industries.

PCB, the Catholic Church, and CEPAL contributed to the emergence of land reform at the center of the political debates on the need for structural reforms in the early 1960s. Different point of views and projects highlighted the need for structural reforms and converged on a critical position with respect to the concentration of land ownership. On the other hand, the landowners were organized in the Brazilian Rural Confederation (Confederação Rural Brasileira – CRB) and Brazilian Rural Society

(Sociedade Rural Brasileira – SRB), demanding technological modernization and governmental support to agricultural production (Medeiros 2003).

In spite of the demand for land redistribution, the land reform projects and the attempts to change property rights sent to the National Congress did not pass due to the political power and articulation of landowners that were supported by industry members. Conservative ideas were gradually imposed on the discussion of issues related to supply and demand of agricultural products, and their effects on prices, employment, and external trade. Meanwhile questions related to land structure and its effects on poverty and living standards were increasingly being omitted. The conservatives denied the existence of an agrarian question. In other words, they did not consider the prevailing land structure and labor relations in rural areas as a relevant economic problem because this agrarian structure was able to accomplish the agricultural functions necessary for the process of economic development. Hence their debate focused on the role of agriculture in economic development after World War II, and land reform was unimportant in this context (Delgado 2005).

According to Medeiros (2003), the military coup changed the course of the debates since the new government curtailed popular protests, persecuted workers‘ organizations, and censored the political debate. The debate on the development of the country and the agrarian question took a different path. Nevertheless, the intense workers‘ mobilizations had left some important marks. In 1962, the government regulated the right of rural workers to constitute union organizations. In 1963, the government passed the Rural Workers Statute, which guaranteed some rights to the rural workforce, after more than 10 years of debate in the National Congress. The president João Goulart created Supra (Superintendência de Reforma Agrária), a state-owned organization, under the presidency, focused on land reform.

Once in power, the military adopted an approach to rural areas intended to solve the agrarian problem by redistributing land through colonization and modernizing agricultural production. The initial idea of the military was to solve the problem of landless people, and the conflicts they could cause, at the same time as they secured the borders of the country through colonization. The military aimed to satisfy the demand for land that was generating disorder in the Northeast and South of the country by moving landless people to unpopulated locations. The plan involved settling 200,000 families in the sparsely populated savannahs of the Center-West as well as in the

Amazon Basin. Thus, the military hoped to also secure the Northwest border of the country through effective occupation (Wolford 2003).

The colonization was able to occupy the spaces and to meet some needs of many landless people. However, the programmed goals were frequently not accomplished. Many families that received land were not inserted in the productive process because they lacked other productive factors. The process was heterogeneous in the sense that the colonists got different amounts of land with different levels of quality. Besides, the concession of other productive factors also differed among the beneficiaries (Miranda 1987).

Despite the conservatism of the military government, the Land Statute was passed in 1964, eight months after the coup. The statute was a long, detailed and comprehensive text, which sets the foundations and important concepts related to land reform. Among other things, this document defines which criteria a property must meet in order to fulfill its social role. Besides, the Statute defines the means to promote the redistribution and access to land. The Law created the Brazilian Institute for Agrarian Reform (IBRA) and the National Institute for Agricultural Development (INDA) in order to carry out the Statute[7]. This was an attempt to undermine the pressure for land redistribution from social movements, especially the Peasant Leagues and the emerging activism of the Catholic Church.

The Statute and some complimentary legislation that came afterwards classified the rural properties into four categories, according to their size and criteria of land use and "rational exploration". The objective of land reform was to gradually extinguish the establishments with less than one rural module[8], which were considered not enough to provide the subsistence to the owner and his family, and with more than 600 rural modules. The coexistence of these two types of producers was seen as a source of social tension in the countryside (Medeiros 2003).

Notwithstanding the formalization of criteria and ways to pursue land reform, the redistribution was not put into practice. The modernization of agriculture that resulted from the military's rural-development strategy did not contribute to reduce the unequal distribution of land. On the contrary, a common idea is that modernization

[7] In 1971, IBRA and INDA were merged into the National Institute for Colonization and Agrarian Reform (INCRA).

8 The Land Statute defines a rural module as the minimum size needed for a family to subsist and progress economically. Modules vary significantly in size between different macro regions of the country. The maximum area is fixed according to the macro region and type of activity.

followed a conservative pattern. Helfand (1999) points out some reasons behind this assertion. First, modernization was pursued in order to increase production without reforming the distribution of landownership. Second, modernization was involved in an alliance among the state, agro-industrial groups, and the agricultural elite. Important complementary aspects of the development strategy were creating incentives for growth for processors of agricultural goods as well as for producers of modern agricultural inputs such as tractors, hybrid seeds, and fertilizers. The economic policies that sustained this alliance through the early 1980s relied on a combination of taxation through price policy and selective subsidization through credit. On the other hand, the large producers of most crops received direct compensation for the discriminatory price policies through credit subsidies. In terms of price policy, only the goods that competed with imports, such as wheat, benefited from direct protection.

De Janvry and Sadoluet (1989) emphasize the role of the state and the landowners during the 1970s, and the way their interaction was decisive for the land reform process in Latin American countries. The thesis of these authors is that Latin American states lost the opportunity to create net social gains via redistributive land reform because they chose to first modernize medium and large farms, using expropriation as a threat instead of proceeding with outright expropriation and redistribution. At the same time the landlords took seriously this threat and adopted defensive strategies. The threat of expropriation was combined with generous programs of subsidized credit and agricultural development (public goods such as extension services, infra-structure investments, and new technologies) to induce modernization of medium and large farms. Modernization, however, enhanced the economic and, hence, political power of these farmers which allowed them to gain or reinforce their privileged access to the state. As a consequence, this political power could be used either to force the state into making the promise of nonexpropriation of modernizing farms credible, or to successfully engage in rent-seeking activities. Land reform ended in many Latin American countries in the 1970s because of the growing influence of the medium and large farmers over the state. In the case of Brazil, this influence remained even after the beginning of the modernization process.

The modernization of agriculture during the 1970s demonstrated that land reform was not indispensable for economic development. Yet, the concentration of land remained a problem and many rural families demanded that essential productive asset.

Many groups that did not take part in the modernization process joined social movements in the countryside, questioning the model of development and its results. According to Grzybowski (1987), some groups emerged in the social movements in the countryside and formed the group of land demanders. These movements for land encompass squatters, landless people, people affected by dams, indigenous, women, and workers dissatisfied with the new forms of labor exploitation.

Organized protest for land reform was rare during the first fifteen years of the military regime in Brazil. Nonetheless, land occupations and other forms of protests began to intensify at the end of the 1970s. The movement emerged in various regions, intensifying and diffusing geographically during the 1980s. It took on its most massive and organized expression in the South of Brazil, where the producers are mostly smallholders, creating the social identity of the *sem terra*, or landless rural worker. Over time this term would come to be applied to all rural workers with little or no land who struggled for land redistribution through protest (Ondetti 2008a).

The Catholic Church was the main institution denouncing rural violence and supporting the organization of rural workers both morally and materially in the late 1970s and early 1980s. The Pastoral Land Commission (Comissão Pastoral da Terra, CPT), created in 1975 by progressive Catholic bishops, came to play a major role in legitimizing forms of resistance by the poor and their struggle for land, as well as in training a new generation of rural leaders (Deere and Medeiros 2007).

At the same time, the National Confederation of Agricultural Workers (Confederação Nacional dos Trabalhadores na Agricultura - CONTAG) was the principal organization for rural workers. The forces from CONTAG and the Catholic Church were very important during the land conflicts of the late 1970s and early 1980s (Deere and Medeiros 2007). Catholic activists played an instrumental role in the creation of the MST in 1984, in the South. Founded in 1984, the MST has fought for radical agrarian reform, which means they want state intervention to reverse the historical concentration of land, distribute good agricultural land to needy workers, and reallocate resources to support small and cooperative farming. The movement considers these changes as fundamental to the development of a stronger, more democratic and just society (Welch 2006).

Protest tactics, pressure from the church, and the intensification of land-related violence in frontier areas all contributed to place agrarian reform on the political agenda

in the early 1980s, yet policy initiatives were quite timid. The rural and urban popular movements, in the end of the military government, generated expectations that land reform could be accomplished. The First National Agrarian Reform Plan (PNRA-I) was proposed in 1985 and preceded the process of defining the Federal Constitution (1988). That Plan established land reform as a governmental priority, and highlighted its positive impact on income, jobs, food production and supply, migration, etc. The main instrument to carry it out would be expropriation in the social interest. This idea was opposed to the one from the military government, which considered expropriation as the last option. This Plan estimated to settle 7 million families, in 15 years. The total number of rural workers without land, or with little, was 10.5 million. The PNRA-I considered the involvement of rural workers representations throughout all the process. CONTAG was the main one at that time (Medeiros 2003).

Given the possibility of expropriation defined in that document, there were several forms of opposition to its adoption. The announcement of the plan helped accelerate the pace of landless protest, but also provoked a massive landlord counter-offensive, which contributed to the setbacks experienced during the constitutional convention. Protest for land continued to grow gradually during the late 1980s and was increasingly dominated by the MST. An organized counter-movement called the Rural Democratic Union (UDR) emerged in opposition to the MST and as an answer to the PNRA-I. The landowning elite formed the UDR with the major purpose of influencing the drafting of the new Federal Constitution (1985-88), and to defeat the proposal to include a progressive agrarian reform in it (Payne 2000 cited by Wolford 2005). After achieving its goal, the UDR officially disbanded in 1993[9]. Its myopic focus on land reform without including issues of agricultural policy in any significant way and its radical right-wing image proved limiting in the long run (Helfand 1999).

In spite of the defeat of the PNRA-I, the Federal Constitution of 1988 dedicates a chapter to land reform in the section on "Social and Economic Order". The text determines that properties that do not satisfy their social function are subject to

[9] However, the UDR laid the basis for the constitution of the Bancada Ruralista, a powerful rural bloc in Congress that provides the sector with legislative support. According to Medeiros (2003), the UDR was the main reference at the core of this block that defended the maintenance of the prevailing landownership structure.

expropriation[10] for redistributive purposes. The social function criterion is based on the definition from the Land Statute, which encompasses adequate and rational use of natural resources, environmental preservation, observance of labor legislation, and generation of welfare for the workers. A rural property must be economically and rationally explored in order to be considered productive by INCRA.

The Constitution and the legislation on land reform have been among the many polemical issues related to the agrarian question. The Constitution did not address the criteria to define the minimum limits for land use and its efficiency. These limits came five years later, in the Agrarian Law (Law 8.629, February 25, 1993), which regulates the Constitutional apparatus related to land reform. During that time interval, expropriations were not possible. This apparatus includes two indexes to define if a property is meeting its economic and rational use: the rate of land use (Grau de Utilização da Terra – GUT) and a measure of efficiency in production (Grau de Eficiência na Exploração – GEE). According to the Agrarian Law, in order to be considered productive, a property must have a GUT above 80% and a GEE of at least 100%, and follow the environmental, social, and labor regulations. This Law also determined that only properties greater than 15 fiscal modules were subject to expropriation.

A critical aspect of the rules of expropriation is the fact that the legislation has not been updated since its definition, in 1993. The Law defined indexes that are required to be used when calculating the GEE. It includes a set of productivity indexes for agricultural products, livestock, and products extracted from the forest. Due to the dynamic nature of the sector, these instruments should be updated periodically. It means that as the technological resources and the productive techniques evolve, reviews in the previously fixed indexes must be done. It is necessary to adjust the average productivity indexes in agriculture to the improvements experienced by the agricultural sector in Brazil. In spite of the acknowledged lag of the indexes, they have not been changed since 1993. Updating them is a controversial topic, since it affects the possibilities of expropriations (Santos 2011).

Another controversial aspect in the Constitution is the determination that the payment of the expropriations must preserve their market value and that the judicial

[10] The articles 184 and 186 of the Federal Constitution present the basic criteria for land reform via expropriation. They regulate expropriation as a sanction when landowners do not satisfy their social function of making the land productive, and establish the cases when the social function is met.

costs must be met. It is common to evaluate a property for a price above the market price, as well as the payment of compensatory interest and attorney‘s fee. Therefore, the costs of land reform through expropriation are high and paid by the society. According to Buainain et al. (2010), social movements and rural workers claim that expropriation should be an instrument to create incentives for landowners to produce on their idle land, and to penalize the owners in case they do not meet this requirement. However, the preservation of the market value means that there is no punishment for those that do not comply with the social function. Besides, the price of land becomes an important determinant of how much land redistribution can be undertaken.

The legislation was also subject to another criticism. The process was centralized in the Federal Government and local administrations did not have any power. Given the complexity of the process and the particularities of each region in Brazil, this centralization may reduce the efficiency of the process. According to Deininger (2010), centralized land reform is more expensive and slower than decentralized.[11] Additionally, the Legislation sets up the preclusion of expropriation of small and medium properties, as well as of the productive ones. Since only unproductive properties can be expropriated, land of low quality or inadequate to the objectives and capabilities of the beneficiaries tend to be left to redistribution.

The Legislation contributed to impede expropriations, mainly during the five years of absence of legal mechanisms to intervene in the agrarian question that followed the Constitution. As a consequence, pressure by social movements made the State governments active agents of land reform. Governors expropriated land for public use (and paid for that), used state land, and bought properties in order to obtain land to solve the conflicts that were going on (Medeiros 2003).

Protest for land continued to grow gradually during the late 1980s and was increasingly dominated by the MST. These protests stagnated somewhat under the conservative Fernando Collor, but accelerated moderately in 1993 and 1994, after the approval of the Agrarian Law. After growing gradually during the preceding years, in late 1995 and 1996 land occupations intensified dramatically (Ondetti 2008a). Collective protest for land also grew in the mid-1990s due to the powerful political impact of two brutal massacres of landless protestors by official security forces, at Corumbiara, in1995, and Eldorado do Carajás, in 1996.

[11] Araújo (2010) discusses the decentralization of land reform and the complexity of this process.

These two episodes catalyzed domestic and international public opinion, and mobilized civil society. As a consequence, the land question became a focus of Brazilian authorities, and they were then obliged to accelerate the pace of reform and apply greater caution in repressing the movement. These changes also triggered a significant intensification of land occupations by people who wished to be included in the reform process and who were determined to force authorities to make good on their policy commitments (Ondetti 2008b).

From that moment on, the pressure for land redistribution became a factor that contributed to the pace of land reform. Hundreds of thousands of families were settled during Cardoso's two mandates (1995 to 2002). The increasing pressure from social movements for land redistribution is considered one of the main causes of the growth in the number of settled families (Wolford 2005).

According to Martins (2003), Cardoso's agrarian policy aimed at executing a land reform, and moderating and managing conflicts. In addition to the expansion of market-assisted and state-led land reform, the reaction to the growth of social movements consisted of a set of actions in the form of acts, complimentary laws, interim measures, and ordinances. These actions[12] were able to change the way the executive power could deal with the conflicts. They aimed at both making land reform more agile and fighting the occupations, which were the main form of pressure for land. The program "Family Farming, land reform, and local development for a new rural world: Policy for rural development based on the growth of family farming and its insertion in the market", from 1999, consolidated the governmental initiatives. The slogan of this program was "taking quality to land reform beneficiaries" and its goal was to deal with the beneficiaries as family farmers. The proposal assigned new responsibilities to the beneficiaries and determined that their emancipation should happen two or three years after the land demarcation. At the same time, the government extinguished Procera[13] and the beneficiaries began to be assisted by the National Program to Strengthen Family Farms (Pronaf – Programa Nacional de Fortalecimento da Agricultura Familiar), which had a specific credit line for them.

[12] Medeiros (2003) and Santos (2011) highlight these legal changes.

[13] Procera (Special Program of Credit for Land Reform - Programa de Crédito Especial para Reforma Agrária), created in 1985, aimed at providing credit for land reform beneficiaries, so that they could increase their productivity, participate in the market, and, finally, emancipate from the government.

The prohibition on inspections of invaded land was a relevant decision. In 2001, the Agrarian Law determined that rural properties under trespass or invasion motivated by collective agrarian conflict were no longer qualified for inspection for the purpose of expropriation for land reform. This decision was an important attempt to reduce the conflicts that emerged with disputes over land. The Law summarily excluded from the Federal Land Reform program those that are identified as direct or indirect participants in invasions of rural properties (even the properties already under the administrative process for inspection for land reform or under the judicial process of expropriation), those that invade public buildings, threaten, kidnap, or keep public employers in private jail, or commit any violent act.

Therefore, land reform was an important issue during Cardoso‘s two mandates. A lot of conflicts happened, many families were settled, and important changes in the legislation were made. Subsequently, Lula was elected President in 2002 and the rural social movements expected agrarian reform to be among his top priorities. Nevertheless, a new PNRA was only adopted in November 2003. PNRA-II emphasized the importance of carrying out a sustainable and high quality agrarian reform. Thus the plan focused on the need to complement the provision of land with social and physical infrastructure and access to credit, technical assistance and marketing channels. The goal was to guarantee that the beneficiaries would be able to earn adequate levels of income. Compared with the Cardoso period, the PNRA-II de-emphasizes market-based mechanisms of land acquisition. In this plan these mechanisms are considered complementary to land reform via expropriation (Deere and Medeiros 2007). But in practice, the program Crédito Fundiário continued to expand.

The PNRA-II included different instruments to redistribute land; regulate ownership; provide the means necessary for rational use by land reform beneficiaries and family farmers; and to boost the economic, social, and cultural aspects of the territories. They were supposed to be adopted according to the characteristics of the region and the groups. The Program stipulated the involvement of state and local governments, acting in an integrated and complementary way to accomplish land reform and rural development. Land reform figures from Lula‘s first term (2003-06) are more modest than Cardoso‘s. Nevertheless, many settlements were created during the early 2000.

In spite of the number of settlements created in Brazil, Veiga (2003) emphasizes that Brazil has not done a real agrarian reform. The creation of settlements is a necessary but not sufficient condition for agrarian reform. The effects of the program of creation of settlements on the distribution of land are below expectations. The program transfers to agricultural families a low percentage of land owned by large landowners. Therefore, there is not a significant change in the unequal agrarian structure. Nevertheless, this is considered a powerful way of poverty alleviation, and, as such, an important complementary social policy.

Finally, market-assisted land reform is an alternative to redistributive land reform. In this case, the state provides credit for land purchases, with different degrees of subsidy. Transactions occur between willing sellers and willing buyers, and subsidies are granted to the poor in addition to credit so that they can afford purchases at market prices that are in excess of the productive value of the land (de Janvry and Sadoulet 2005). This is also called negotiated land reform. Compared to redistributive land reform this model is said to have lower costs, and not to cause conflicts with landowners. Proponents argue that other advantages include its voluntary, decentralized, and demand-driven features. The government takes part in the market-assisted land reform in a subsidiary way. It provides credit for land acquisition; inspects the title of negotiated properties in order that they avoid the transaction of illegal lands; monitors the evolution of land markets, and advises those willing to buy land, so that they avoid that land is sold at a price above the market price (Leite et al. 2004)

The Brazilian experience with negotiated agrarian reform is the most comprehensive, long-standing, and diverse program of any in the world. The governmental programs "Cédula da Terra", "Projeto São José" (known as "reforma agrarian solidária"), "Banco da Terra" and "Crédito fundiário" follow the market-led approach to land reform (Pereira 2005).

The Recent Literature on Land Reform

The historical review shows aspects behind the unequal distribution of land in Brazil and how the agrarian question emerged in that context. The data to be presented in the next Chapter show an enthusiasm with land reform in Brazil during Cardoso and Lula's mandates. As a consequence, many studies about land reform in Brazil were

conducted. The literature on land reform contributes to the main topic of this research: the evaluation of the economic impacts of land reform and the aspects that contributed to generate these impacts. The review of the literature on impacts of land reform in Brazil identifies a number of studies that provide interesting insights about the dynamics of the settlements and the beneficiaries. The present research is going to be part of a larger set of studies that explore the results of land reform. Three main field surveys provided the basis for these analyses since the late 1990's. The first one is the First Census of Land Reform, from 1997, which was demanded by INCRA in order to identify and construct a profile of all settled families in land reform projects of the Federal government. INCRA and the Council of Provosts of Brazilian Universities made an agreement, and the University of Brasília (UnB) coordinated the investigation.it involved 29 Universities, reached more than 161,000 families settled in 1,460 projects spread throughout Brazil. They also carried out a sample survey to compliment the results found.

Bergamasco (1997) and David et al (1998) describe the results from the First Census of Land Reform and highlight its main findings. The data allow the authors to describe the context of the land reform settlements based on education and schooling; gender, marital status and age; previous occupation, housing; health; income; technology; and credit. Bergamasco highlights the limitations to the comprehension of the settlements based only on numbers. However, she considers that the Census allows us to identify that several serious social problems persist. David et al. (1998) organized the data into the micro regional level and presented the demographic and social profile of the beneficiaries in maps.

The second study is –Os impactos regionais da reforma agrária: um estudo sobre áreas selecionadas" (The regional impacts of land reform: a study of selected areas), carried out from January 2000 through December 2001, by CPDA/UFRRJ and Nuap/PPGAS/MN/UFRJ. This research considered settlements implemented by INCRA from 1985 to 1997. The focus of this study was a given set of Brazilian regions with a large concentration of settlement projects and a great density of settled families per land unit, based on the assumption that this would increase the chances of understanding the processes of change underway. Six large zones were chosen: the Federal District and surrounding areas, the Northeastern Sugar Cane Region, the Sertão (semiarid region) of the State of Ceará, the Southern region in the state of Bahia, the Southeastern region in

the state of Pará, and the Western region in the state of Santa Catarina. It resulted in the selection of 39 municipalities, 11,113 settled families in 92 settlement projects. The research addressed questions on the perception of the beneficiaries related to their situation before and after being part of the program.

Heredia et al. (2002, 2005); Leite (2000); and Leite et al. (2004) used the results of the field research in the so-called termed zones to analyze the effects of land reform on that group of settlements. By using the descriptive statistics from those regions, Heredia et al. (2002, 2005) observed that most of the settlements had contributed to diversifying the farming products in their areas by introducing new crops and significantly increasing the production of some secondary crops. They also assessed the productivity of relevant products, by comparing the average productivity in the settlements (1998/99 harvest) with the average productivity in their respective municipalities, according to the 1996 Agricultural Census. This analysis revealed that in 42% of cases, the projects attained greater productivity than the average farms in the region. In 11%, their productivity was largely the same and in 48% it was well below that of the other farms. Leite (2000) emphasized that the creation of settlements tends to rearrange the productive processes in the regions and this process often has a multiplier effect. This means that small producers are going to adopt the good practices they see in the settlements, in order to be more productive.

The third study is "A qualidade dos assentamentos da reforma agrária brasileira" (The quality of the agrarian reform settlements in Brazil), from the end of 2002. A group of researchers at the University of São Paulo agronomy school (Esalq USP) coordinated 14,414 interviews in 4,340 settlement projects created between 1985 and 2001, in all Brazilian States. They collected information from three different points of view in each settlement: the INCRA official responsible for that project; the president or head of the project`s association; and a beneficiary that does not hold any position in the association.

Veiga (2003), Sparovek (2005), França and Sparovek (2005) and Monte and Pereira (2009) used this study. Sparovek (2005) classified the territories according to the regional dynamics and the activities necessary to develop them. They used geo processing to represent the dynamics obtained through indexes. Monte and Pereira (2009) went beyond the description of the dynamics and characteristics of the settlements and tried to measure the influence of some of those characteristics on the

income generated in the settlements. They considered some interesting variables such as participation in cooperatives or associations, geographical location, the current phase of the implementation of the project, and the time of existence of the settlement. These variables were part of regressions to explain the income generation in the settlements. Their main findings showed that basic infrastructure, access to credit (either from Pronaf or Procera), consolidation of the settlement project, and engagement in cooperatives contribute in a positive way to generate income for the families.

The need for understanding the results of the increasing number of land reform projects inspired many other case studies and focused analyses. Bittencourt et al. (1998) performed a study in order to identify the variables that contributed to the development of the settlement projects, as well as those that constrained it. According to them, some settlements had already achieved a certain level of development, characterized by income and job generation, and food production for subsistence. On the other hand, many settlements had not been able to achieve those conditions. They selected 10 settlements from each group, keeping in mind the regional representativeness, and compared them. The variables considered in their analysis are related to the natural resources (soil, water, and relief), previous occupation (landowner, tenant, partner, or salaried worker) and origin of the beneficiary (rural or urban), the process that resulted in the land occupation, the socioeconomic context (the existence of agroindustry nearby), the productive system and organization, rural credit, technical assistance, political organization, institutional relations, and agricultural income. Presence of credit, the natural resources and the organization of its use, the economic environment, the productive organization, and technical assistance were found to be the most relevant factors (respectively) to stimulate development. At the same time, the natural resources (its deficits), lacking infrastructure (mainly related to the roads inside the settlement and to access it), the lack of technical assistance, and the absence of productive and political organization among the beneficiaries were considered, respectively, the main limiting factors.

Mello (2007) used a data set generated by a study from an agreement signed by INCRA, Fapeg (Fundação de Pesquisa Edmundo Gastal) and Embrapa (Brazilian Agricultural Research Corporation), which involved providing technological diffusion and training to the beneficiaries. The data was collected in 2003 and 2004; through structured interviews with representatives from 148 settlements created between 1986

and 2003 in Rio Grande do Sul. The author compared the data of the beneficiaries to the results of small farmers (area between 10 and 50 hectares) in the same micro regions of the settlements. In some cases, the production per area in the settlements was found to be higher than in the other farms. The author refers to this result to point his main conclusion: there is agricultural production in the settlements.

These above mentioned studies adopt different methodologies, which do not easily lend themselves to direct comparisons of their results. They complement each other, and will be useful for the present research. In general, they describe the beneficiaries, but do not compare them to other farmers. The existing descriptive analyses are important, especially because they are based on information from the settlers that is not found in data such as agricultural or demographic censuses. Variables on the quality of life of the beneficiaries living there and their perception of changes are examples of information not found in the censuses. However, the descriptive analyses do not lend themselves to generating solid conclusions about the impacts of land reform. Without a control group, and observations over time on both treatment and control groups, it is very difficult to isolate the influence of confounding factors and arrive at a reasonable estimate of the impacts of the land reform program being studied.

4. CROSS SECTION ANALYSIS

This Chapter presents the initial analysis of land reform beneficiaries in terms of land productivity, net per capita income and total factor productivity. The cross section analysis takes advantage of many variables that were included for the first time in the 2006 Agricultural Census, such as characteristics of the farmer and form of obtaining land. The variables used in this section are listed in Appendix A.1.

The first part of the analysis shows the descriptive statistics on land reform beneficiaries that already had land title (LRBt), land reform beneficiaries without land title (LRBw) and owners. These groups are compared in terms of characteristics of the farmer and the establishment, as well as productivity, income, and poverty. All municipalities are included.

The second part of the cross section analysis presents regressions that compare land reform beneficiaries (LRBt and LRBw) to all other owners. In addition, there are regressions run only for land reform beneficiaries. The idea here is to analyze if the productivity and income of land reform beneficiaries differ due to "years in charge of the farm". In both comparisons, there are regressions for land productivity, net per capita income, and total factor productivity. There are separate models for Brazil and each macro region.

4.1. Land Reform Beneficiaries in Brazil: Descriptive Statistics

This section presents descriptive statistics on land reform beneficiaries that already had land title (LRBt), land reform beneficiaries without land title (LRBw) and owners. The use of owners as a comparison group provides an idea of where the beneficiaries could be in terms of productive structure, productivity and poverty. In other words, landowners are used as a reference group to indicate the possible impacts

of land reform. Additionally, the division of beneficiaries into two groups –with and without land title– gives an idea of the evolution of beneficiaries over time and allows us to consider the importance of property rights in the form of land title.

The descriptive statistics are organized in three parts. The first part presents the numbers on land reform in Brazil, in an attempt to answer the question –how much land reform is there?" The second part describes land reform beneficiaries and landowners. The comparison includes characteristics of farmers and establishments,[14] poverty, income and productivity measures. The data show that land reform beneficiaries differ from landowners in terms of the characteristics of farmers and establishments. In spite of these differences, characteristics of owners, LRBt and LRBw vary in a similar way across macro regions. Moreover, there is more poverty among land reform beneficiaries, with or without land title, and they are also less productive than landowners. Finally, section 3.1.5 presents numbers and selected characteristics of land reform beneficiaries according to an alternative approach from a study by Marques *et al.* (2012).

4.1.1. How much land reform is there?

Official data from INCRA reports almost one million families settled through 2006 (the year of one of the Agricultural Censuses used in this research). Table 4.1 shows that most settlements were created after 1994. On average, about 77,000 families were settled per year between 1995 and 2006. According to the INCRA data, only 6% of the existing establishments in 2006 were older than 12 years (created before 1995). About 29% of them had between 8 and 11 years of existence, 26% existed for between 4 and 7 years, and 39% had less than 4 years of existence.

[14] According to IBGE an establishment is any production unit fully or partially dedicated to agriculture, forestry or aquaculture, subject to a single manager: the farmer or manager. An establishment can be of any size, any legal form and located in rural or urban area. Its purpose is production for subsistence and/or sale. We use the terms –establishment" and –farm" interchangeably.

Table 4.1 – Number of families settled according to official INCRA data

Period	Families settled
Before 1995	58,317
Cardoso I: 1995 – 1998	287,994
Cardoso II:1999 – 2002	252,710
Lula I: 2003 – 2006	381,419
Total (until 2006)	980,440
Lula II: 2007 – 2010	232,669
2011	22,021
Total (until 2011)	1,235,130

Source: INCRA, 2012. DT/Gab-Monitoria – Sipra Web 06/02/2012 http://incra.gov.br/index.php/reforma-agraria-2/questao-agraria/numeros-da-reforma-agraria/file/1148-familias-assentadas. Access 05/15/2012.

Although controversial, official INCRA data show nearly one million families settled via land reform through 2006. Data from other sources suggest that there has been less land reform than what INCRA shows. Table 4.2 consolidates data from the 2006 Agricultural Census and all possible forms[15] it provides us in order to count land reform beneficiaries. The data for this table come from the aggregation of data in groups of establishments, according to the municipality, tenure type and form of obtaining the land. These groups are called "representative farms." They represent the average of all farms in a particular cell (for example, owners in the municipality of Viçosa who obtained their land through land reform). The aggregation is needed because it is not permitted to have information that identifies a specific establishment when using data from the Agricultural Census. Therefore, it is not possible to work with individual data for establishments. In case one representative farm in the aggregation has less than 3 establishments, its information is not available. Nevertheless, when removing cells with less than 3 observations, only 1.3% of observations are lost. The IBGE publication reports a total of 5,175,489 establishments in Brazil, whereas the aggregated data used in Table 4.2 is based on 5,108,266 establishments.

[15] Marques et al. (2012) use additional information from outside the census and an alternative methodology. They conclude that there were approximately 575 thousand beneficiaries. The sub section "Alternative approach to the numbers of land reform", in the appendix, describes their analysis more carefully.

The 2006 Agricultural Census has three questions related to land reform. The answers to each one provides alternative information on the number of land reform beneficiaries. The aggregated data on these questions was used to build Table 4.2. The first question is "Did this establishment originate from a land reform settlement created after 1985?" This question is not in the official IBGE publication that consolidates the data from the Agricultural Census,[16] but it was possible to construct it from the micro data. In 2006, Table 4.2 shows that there were 346,592 establishments originated from a land reform settlement project created after 1985. The right column of Table 4.2 presents the distribution of these establishments according to the answer to the two other questions in the Agricultural Census.

The second form of counting land reform beneficiaries with data from the Agricultural Census is based on the composition of area. The farmers were asked how much land they had in each of the following categories: owned, rented, sharecropped, occupied, and granted by a land agency still without definitive title. [17] This question was used to define the type of the farmer (condição do produtor) in relation to the land. They could be owners, renters, sharecroppers, occupants, a "producer without area,"[18] or a land reform beneficiary without land title. If they had any land that was owned, they were classified as an owner. If not, they were assigned to one of the other categories based on which one had the most land. The middle column of table 3.2 shows that 187,804 farmers were classified as having had land granted by a land agency still without title. This group did not own any land, and held more land "granted from a land agency still without title" than it had in any other form (rented, sharecropped, etc.).

The third question that can be used to identify land reform beneficiaries relates to the form of obtaining land, asked of farmers that had in their land composition either land owned or land granted by a land agency still without definitive title. The possible answers are through purchase; purchase through *crédito fundiário* (a market assisted land reform program); title through land reform, resettlement project, or waiting for title; inheritance; homesteading; unknown; and other. The middle column of Table 4.2

[16] IBGE. Censo Agropecuário 2006, Rio de Janeiro, 2009.
[17] INCRA is the national land agency, but there are others.
[18] "Producer without area" refers to an employee who resides on an establishment and has agricultural production that he supervises himself. In this case, the employee was treated as a separate establishment, and considered to be a "producer without area," answering the census questionnaire relative to that production. Had the production been supervised by the landowner, it would have been counted as part of the main establishment's output. IBGE created this category in 2006. It is important to note that these producers are not necessarily landless in the sense of the Landless Movement.

reports the answers to the composition of land and the form of obtaining it. 142,056 farmers that were owners said that they obtained land through land reform, whereas 148,186 farmers that had land granted by a land agency still without definitive title said that they obtained it through land reform. Therefore, 290,242 establishments obtained through land reform, either with or without title. [19]

Table 4.2 shows that there is not a clear relationship between the three forms of counting land reform beneficiaries. The right column shows that of the 346,592 farmers that said that their establishment originated from a land reform settlement, approximately half were owners (174,076). But of these owners, only 97,760 stated that the form of obtained their land was through land reform. Thus, 76,316 establishments that originated from a land reform settlement belonged to owners that did not obtain land through land reform. Two thirds of these farmers (50,850) stated that they obtained their land through purchase. There are also 31,428 establishments that originated from a land reform settlement where the farmer was not an owner. They might have been renting, sharecropping, or simply occupying the land. The middle column also shows 39,618 farmers that had land granted by a land agency, even though they did not say that they obtained land through land reform. These farmers were working on land granted by a land agency, but obtained land through any other option different than land reform. They may have bought or rented the land informally, for instance.

When combined, the answers to the three questions captures the total number of farmers that either declared their establishment originated from a land reform settlement, or obtained land through land reform, or were working land on a settlement. The combination of these answers is an attempt to generate a more accurate estimate of land reform beneficiaries in Brazil in 2006. By adding up 290,242 (obtained through land reform, either with or without title); 76,316 (originated from a land reform settlement, but belonged to owners that did not obtain land through land reform); 31,428 (originated from a land reform settlement, but the farmer was not the owner); and 39,618 (the land was granted by a land agency, but the farmer is not a land reform beneficiary waiting for title), the total is 437,605 establishments. This number encompasses establishments that either a) originated from a land reform settlement, or b) were obtained through land reform – land reform beneficiaries − with or without title, or c) were working land on land reform settlements in one form or another. It is an

[19] IBGE (2009) publishes this number as the total of land reform beneficiaries in Brazil.

upper bound estimate for the total number of land reform beneficiaries based strictly on data from the Agricultural Census.[20]

Table 4.2 – Different forms of counting land reform beneficiaries using the Agricultural Census

Type of producer by composition of area/form of obtaining land	Establishments		Establishments originated from a land reform settlement project created after 1985	
Owners	3,895,975		174,076	
Land Reform Beneficiaries (LRBt)		142,056		97,760
Not Land Reform Beneficiaries		3,753,919		76,316
Purchase		1,995,495		50,850
Inheritance		1,145,637		2,763
Not owners (renters, sharecroppers, occupants)	1,024,487		31,428	
Land granted by land agency still without title (LRBw)	187,804		141,088	
LRB waiting for the title		148,186		
Others		39,618		
Total	5,108,266		346,592	
LRB = LRBt + LRBw = 142,056 + 187,804 = 329,860				

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: Not land reform beneficiaries include purchase, inheritance, donation, homesteading, unknown, and others.

Although it is possible to identify a total of 437,605 establishments that satisfy one or more of the three criteria described above, a decision was made in this dissertation not to use the question based on whether the establishment originated from a LR settlement. This decision was made because 107,744 (or 31%) of the 346,592 establishments that said that they had originated from a LR settlement were not identified as beneficiaries according to the other two criteria. This includes 50,850 establishments that purchased their land, and another 31,428 who were renters, sharecroppers or occupants. Our fear was that these establishments might be qualitatively different from the beneficiaries, and warrant a separate analysis. Instead,

[20] Section A.3, in the appendix, discusses the approach used by Marques et al. (2012) for counting the number of land reform beneficiaries. Their approach incorporates external information provided by INCRA on the location of settlements.

we chose to work with LR beneficiaries (142,056 in Table 4.2) and the establishments that had their land granted by a land agency still without title (187,804 in Table 4.2). This yielded a total of 329,860 establishments to be studied in the statistical analysis below. This group of 329,860 establishments includes 69% (or 238,848) of the establishments that "originated from a LR settlement".

IBGE appears to have made a similar decision not to use the variable "originated from a LR settlement" at the time that they published the Census results in 2009 (*Censo Agropecuario 2006: Brasil, Grandes Regiões e Unidades da Federação*). In Table 1.1.3 (page 182) of the Census publication they show the category "land granted by a land agency still without title" as having 189,191 establishments. In contrast to Table 4.2, which used aggregated data and thus lost a small number of observations due to confidentiality, the published data from IBGE (2009) have slightly more establishments in this category (189,191 vs. 187,804). Similarly, in Table 1.1.7 (p. 195) they show land reform beneficiaries with title plus establishments with land granted by a land agency still without title as having 290,242 establishments. This is the maximum number of LR beneficiaries as reported in the publication. This number can be obtained from Table 4.2 by adding the LR beneficiaries waiting for title (148, 186) with the LR beneficiaries who already have title (142,056).

Unless otherwise noted, all subsequent tables and figures, and all of the statistical analysis in this dissertation is based on the group of 329,860 establishments defined above. Table 4.3 presents the number and area of establishments by type and macro region. The definition of type in Table 4.3 is based on the variables "type of producer" and "form of obtaining the land". Table 4.3 shows three types of establishments: owners (which include LRBt), a combination of land reform beneficiaries with title plus establishments with land granted by a land agency still without title (this combined category is called LRB), and solely establishments with land granted by a land agency still without title (LRBw). Table 4.3 shows that there were 142,056 LRBt, and 187,804 LRBw.

About 80% of Brazilian farmers were owners in 2006. The highest percentage of owners was found in the Southeast, 88%, and the lowest percentage was in the Northeast, 74%. Land reform beneficiaries (LRB)—either with or without title—were 7% of all farmers in Brazil. In the Center-West, they were 20%, whereas in the Southeast and in the South, they only accounted for 3% and 4% of the farmers,

respectively. As for the share of total area, owners held more than 90% of it, with land reform beneficiaries accounting for only 3%.

The right side of Table 4.3 presents the share of the total in Brazil, rather than the share within each macro region. The Northeast is the macro region with the highest percentage of establishments: 43% of all owners in Brazil, and 44% of all LRB, were located there. The North and the Center-West had 18% and 19% of LRB, respectively. The distribution of area across types of producers was different than the distribution of number of establishments. Only 22% and 26% of total area held by owners and LRB, respectively, were in the Northeast. On the other hand, LRB accounted for 27% and 33% of the area in the Center-West and in the North, respectively. These two macro regions have bigger establishments of all types. Land reform beneficiaries are no exception.

Table 4.3 – Number and area of establishments by type and macro region

Region	Type	Establishments	Share of region	Area (ha)	Share of region	Brazil share					
						Establishments			Area		
						Owners	LRB	LRBw	Owners	LRB	LRBw
Brazil	Total	4,853,242		310,000,000							
	Owners	3,895,975	0.80	291,000,000	0.94	1.00			1.00		
	LRB	329,860	0.07	9,305,856	0.03		1.00			1.00	
	LRBw	187,804	0.04	5,102,153	0.02			1.00			1.00
North	Total	438,715		51,900,000							
	Owners	369,484	0.84	48,300,000	0.93	0.09			0.17		
	LRB	58,845	0.13	3,095,913	0.06		0.18			0.33	
	LRBw	26,517	0.06	1,428,291	0.03			0.14			0.28
Northeast	Total	2,242,163		69,900,000							
	Owners	1,660,611	0.74	65,200,000	0.93	0.43			0.22		
	LRB	144,503	0.06	2,435,992	0.04		0.44			0.26	
	LRBw	85,562	0.04	1,419,430	0.02			0.46			0.28
Southeast	Total	890,034		49,100,000							
	Owners	782,982	0.88	46,800,000	0.95	0.20			0.16		
	LRB	29,613	0.03	526,446	0.01		0.09			0.06	
	LRBw	17,812	0.02	310,730	0.01			0.09			0.06
South	Total	972,138		38,800,000							
	Owners	828,090	0.85	35,500,000	0.91	0.21			0.12		
	LRB	34,720	0.04	710,264	0.02		0.11			0.08	
	LRBw	22,140	0.02	440,896	0.01			0.12			0.09
Center-west	Total	310,192		101,000,000							
	Owners	254,808	0.82	95,600,000	0.95	0.07			0.33		
	LRB	62,179	0.20	2,537,241	0.03		0.19			0.27	
	LRBw	35,773	0.12	1,502,806	0.01			0.19			0.29

Source: IBGE - Agricultural Census, aggregated data.

4.1.2. Land Productivity, Net Per Capita Income, and Total Factor Productivity

This sub-section presents descriptive statistics[21] for income and productivity, the dependent variables in this dissertation. Land productivity is the ratio between total value of agricultural production and total area (R$/hectare/year). Net per capita income is the ratio between total value of agricultural production minus variable costs, and the number of full-time adult equivalent family members (R$/ adult equivalent /year). Finally, Total Factor Productivity (TFP) is the ratio between total value of agricultural production and total costs.

The tables are presented conditional on farm size in order to control for the importance of this variable as a determinant of productivity. Table 4.4 presents land productivity by size and type of farmer in Brazil. Owners were more productive than LRBt and LRBw, except in the class of area between 0 and 5 hectares. The difference is very large. As for farmers with 50-100 hectares, owners produce more than 3 times per hectare than LRBt and LRBw.

Table 4.4 – Land productivity by size and type of farmer in Brazil

Type of Tenure	Average	Farm Size					
		0-5	5-10	10-20	20-50	50-100	100-500
LRBt	269.00	2226.57	1241.84	660.67	240.81	102.00	98.02
LRBw	277.19	1906.48	896.50	547.56	244.55	118.02	86.95
Owners	477.42	1743.23	1319.77	1046.22	645.16	398.24	275.47

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Land productivity is expressed in Reais per hectare (R$/hectare). Size classes are in hectares.

Table 4.5 presents net per capita income by size and type of farmer in Brazil. Similar to what happens with land productivity, owners have higher per capita income than LRBt that have more than 10 hectares and LRBw that have more than 5 hectares.

[21] Because the data used here comes from the Census, significance of the descriptives statistics becomes less relevant to compare the groups. The averages can be considered as the population average.

The difference increases with size. Considering establishments with 10-20 hectares, a member of a family that owns a farm makes R$808 per year more than a member of a family that got the land through land reform. In the case of establishments with 100-500 hectares, this difference goes up to R$3,462. This happens because per capita income of owners increases a lot as farms become bigger, whereas income of beneficiaries is more constant.

Table 4.5 - Net per capita income by size and type of farmer in Brazil

Type of Tenure	Average	Farm Size					
		0-5	5-10	10-20	20-50	50-100	100-500
LRBt	2,200.60	1,586.95	2,691.35	2,865.03	1,977.64	1,591.43	3,132.15
LRBw	1,912.48	1,262.53	1,925.47	2,185.17	2,083.74	1,818.78	2,579.57
Owners	3,243.95	995.57	2,536.22	3,673.15	4,411.50	5,009.84	6,594.76

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Net per capita income is expressed in Reais per adult equivalent (R$/AE). Size classes are in hectares.

Table 4.6 presents total factor productivity (TFP) by size and type of farmer in Brazil. TFP is the ratio between value of agricultural production and total costs. Total costs include variable and fixed costs. Fixed costs included depreciation, as described in the construction of the long run poverty measures. The agricultural census does not have family labor costs. A ½ minimum wage from August 2000 was imputed, inflated to July 2006, as the opportunity cost for the work of each family member (considered as adult equivalent). Interestingly, LRBt are the most productive among farmers with less than 20 hectares and with 100-500 hectares. Owners are more productive only among farmers with more than 20 and less than 100 hectares. In general LRBt are more productive than LRBw.

Table 4.6 - Total Factor Productivity by size and type of farmer in Brazil

Type of Tenure	Average	Farm Size					
		0-5	5-10	10-20	20-50	50-100	100-500
LRBt	1.128	0.995	1.355	1.339	1.054	0.884	1.118
LRBw	1.040	0.848	1.091	1.112	1.088	0.948	1.018
Owners	1.108	0.719	1.275	1.262	1.180	1.180	1.025

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Total factor productivity (TFP) is an index that relates total value of production and total costs. Size classes are in hectares.

Table 4.7 represents land productivity by farm size and categories of farmer for each macro region. Owners are more productive than LRBt and LRBw in most size classes in the Southeast, South and Center-West. The difference is usually large. In the case of farms that have more than 20 hectares in the Southeast, for instance, owners are at least two times more productive than LRBt or LRBw. Beneficiaries and owners have more similar land productivity in the North and Northeast. In all macro regions, LRB are more productive than owners with less than 5 hectares. Land productivity of LRBt and LRBw is usually more similar.

Table 4.7 - Land productivity by size, type of farmer and macro region

Region	Type of Tenure	Farm Size					
		0-5	5-10	10-20	20-50	50-100	100-500
North	LRBt	3,222.43	**1,008.58**	**666.55**	204.04	106.83	**110.66**
	LRBw	**3,579.62**	946.59	570.78	171.14	137.80	67.62
	Owners	2,513.13	991.31	658.14	**284.92**	**159.61**	68.82
Northeast	LRBt	**2,205.11**	**1,131.99**	**487.02**	236.77	121.98	64.41
	LRBw	1,873.33	946.15	354.85	205.18	122.40	113.46
	Owners	1,363.55	790.94	484.45	**284.80**	**206.72**	**136.27**
Southeast	LRB	**2,371.87**	**2,394.34**	846.79	301.81	141.92	35.68
	LRBw	1,471.07	850.31	595.50	302.38	86.35	120.92
	Owners	2,202.64	1,532.87	**1,144.76**	**883.30**	**675.93**	**547.42**
South	LRB	**2,481.41**	979.36	1,032.65	550.81	309.09	6.87
	LRBw	2,377.33	1,448.47	836.72	620.74	529.71	29.47
	Owners	2,303.99	**2,014.81**	**1,653.74**	**1,212.85**	**853.97**	**514.29**
Center-West	LRB	1,301.22	641.40	365.90	201.11	73.10	115.57
	LRBw	**1,461.68**	368.87	396.69	227.93	98.61	120.59
	Owners	1,249.58	**815.03**	**518.42**	**315.71**	**200.24**	**156.21**

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Land productivity is expressed in Reais per hectare (R$/hectare). Size classes are in hectares.

Table 4.8 represents net per capita income by farm size and categories of farmer for each macro region. In general, the highest per capita income was generated in the South and in the Southeast, whereas family members in the Center-West had the smallest income. A comparison across types of tenure shows that in the Southeast, the South and in the Center-West, owners usually had higher net per capita income than LRBt and LRBw. The opposite is seen in the North. Compared to owners, land reform beneficiaries in the Northeast had greater per capita income when among establishments with less than 20 hectares. The contrary is seen for farms with more than 20 hectares.

Table 4.8 - Net per capita income by size, type of farmer and macro region

Region	Type of Tenure	Farm Size					
		0-5	5-10	10-20	20-50	50-100	100-500
North	LRBt	2,201.86	**2,218.33**	2,827.11	1,908.09	1,819.10	**3,384.45**
	LRBw	**2,015.04**	1,969.34	**2,609.14**	1,648.62	**2,745.68**	2,264.06
	Owners	1,243.70	1,957.51	2,492.65	**2,354.78**	2,459.00	805.95
Northeast	LRBt	**1,628.27**	**2,421.86**	**2,199.78**	2,253.38	2,351.47	3,078.04
	LRBw	1,225.38	2,134.79	1,650.82	2,132.13	2,307.85	**7,426.23**
	Owners	811.14	1,702.47	1,986.06	**2,418.23**	**3,492.96**	4,793.36
Southeast	LRB	**1,701.24**	**5,780.35**	3,721.73	2,236.48	1,974.01	-248.92
	LRBw	1,089.42	1,774.53	2,349.48	2,463.34	1,083.40	1,401.11
	Owners	1,324.91	2,919.88	**4,020.31**	**6,613.48**	**9,652.53**	**19,181.52**
South	LRB	781.37	1,777.79	4,098.80	3,073.44	1,629.43	790.73
	LRBw	881.25	2,818.12	3,071.12	4,431.55	**9,281.08**	5,442.49
	Owners	**1,417.80**	**3,802.63**	**5,527.29**	**7,140.80**	9,022.32	**12,467.20**
Center-West	LRB	728.92	380.40	**1,596.95**	1,283.00	402.43	**2,549.58**
	LRBw	**1,515.52**	466.46	1,151.71	1,355.35	765.40	890.46
	Owners	362.01	**953.96**	1,498.97	**1,645.13**	**1,116.37**	2,495.15

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Net per capita income is expressed in Reais per adult equivalent (R$/AE). Size classes are in hectares.

Table 4.9 shows total factor productivity by farm size for each macro region. In general, land reform beneficiaries had higher TFP than owners in the Northeast. The difference is large between farms with less than 5 hectares (0.4) but falls as the farm size increases. The results were mixed for the other macro regions. LRBt are more productive than owners and LRBw among establishments with less than 20 hectares in the North, Northeast and Southeast. LRBt are the most productive with less than 20 hectares and owners are the most productive with more than 20 hectares in the Southeast. In the South owners are the most productive with less than 10 hectares and

with between 100 and 500 hectares, LRBt are the most productive with 10 to 20 hectares; and LRBw have the greatest TFP between 20 and 100 hectares. Owners are the most productive farmers with 5 to 10 and 20 to 100 hectares in the Center-West. LRBt had higher TFP than LRBw in most size classes in the North, in the Northeast, and in the Southeast. The South was the only macro region where LRBw had higher TFP than LRBt in most size classes.

Table 4.9 - Total factor productivity by size, type of farmer and macro region

Region	Type of Tenure	Farm Size					
		0-5	5-10	10-20	20-50	50-100	100-500
North	LRBt	**1.33**	**1.24**	**1.52**	1.05	0.95	**1.21**
	LRBw	1.25	1.15	1.39	0.96	**1.30**	1.00
	Owners	0.84	1.11	1.26	**1.15**	1.08	0.67
Northeast	LRBt	**1.02**	**1.28**	**1.22**	**1.26**	**1.28**	1.53
	LRBw	0.84	1.20	0.99	1.21	1.26	**2.61**
	Owners	0.62	1.01	1.09	1.16	1.27	1.12
Southeast	LRBt	**0.99**	**2.28**	**1.45**	1.11	1.07	0.39
	LRBw	0.76	0.97	1.08	1.17	0.72	0.84
	Owners	0.82	1.13	1.20	**1.30**	**1.25**	**1.18**
South	LRB	0.61	0.97	**1.54**	1.19	0.89	0.59
	LRBw	0.66	1.26	1.31	**1.61**	**2.01**	2.08
	Owners	**0.83**	**1.28**	1.41	1.34	1.20	**1.05**
Center-West	LRB	0.63	0.59	**0.91**	0.78	0.57	**0.95**
	LRBw	**0.92**	0.49	0.77	0.82	0.67	0.79
	Owners	0.55	**0.74**	0.85	**0.86**	**0.77**	0.68

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Total factor productivity (TFP) is an index that relates total value of production and total costs. Size classes are in hectares.

4.1.3. Land Reform Beneficiaries and Poverty

Table 4.10 presents poverty measures for Brazil, calculated for LRBt, LRBw and owners.[22] The second column lists the sources of income included in each measure. There are three possible combinations: the first one includes income only from

[22] A small error in the construction of the poverty measure was found. This mistake however would lead to underestimating the level of poverty. Thus, the results presented here are lower bounds. Because the calculation of poverty measures requires microdata, we are waiting for IBGE‘s approval to run the corrected program.

agricultural production, the second includes income from production and other earned income, and the third adds income from transfers (including social security, social programs such as Bolsa Família, and donations).

The third column refers to the measures of family size: AE refers to adult-equivalent full-time family labor involved in farm production and N refers to the total number of family members who were involved in the production. The calculation of the variable AE took advantage of information on age of the family members and number of days that they worked in 2006. Thus, the construction of AE family labor considered males and females as equal, while family labor under 14 years of age only counted as half. Family members and producers that worked for less than 60 days were weighted by 1/8, those that worked between 60 and 180 days were weighed by ½, whereas those that worked for more than 180 days were weighted by 1.

The next two columns present poverty rates, and the two last columns present rates of extreme poverty. The poverty line used is equivalent to ½ minimum wage per capita from August 2000, inflated to July 2006, and the extreme poverty line is based on ¼ minimum wage per capita. The minimum wage was R$151 in August 2000. By doing this, the poverty line is R$120.40. The extreme poverty line was R$60.20. These poverty and extreme poverty lines were used by Atlas of Human Development in Brazil (Atlas do Desenvolvimento Humano no Brasil 2003), Helfand and Levine (2004), and Moreira *et al.* (2009), so that they can be compared. Farms with annual income in 2006 under R$ 1.444,80 are classified as poor, and under R$ 722,40 are extremely poor. Agricultural profit is calculated with the value of output, rather than sales, in order to account for non-monetary income. Both poverty and extreme poverty rates were calculated for the short and long run (SR and LR). Short run measures deducted only variable costs (monetary expenditure) from the value of output, while long run measures also deducted a value for depreciation[23] of buildings, machines, trees and cattle.

The comparison of poverty measures calculated with the three different sources of income shows the importance of other earned income and government transfers. For instance, 59% of owners were poor, when considering only income from agricultural production; 56%, when considering other sources of earned income as well; and 46%, when also including government transfers. Therefore, other sources of income contributed to reduce poverty among owners by 3 points, while government transfers

[23] The life cycle of buildings, machines, trees and cattle was assumed to be 25, 15, 25 and 5 years, respectively.

contributed to reduce poverty by 10 points. Earned income contributed to reduce poverty by 4 points among LRBw, and 2 points among LRBt. Interestingly, the reduction in poverty among owners due to government transfers was greater than among LRBw (7 points) and LRBt (6 points). This suggests that owners might have had better access to governmental social programs.

The difference between poverty and extreme poverty rates is not large. This means that most poor families are also below the extreme poverty line. The proportion of poor families among LRBt and LRBw is very similar, but higher than the proportion of poor among owners. Depending on the poverty measure adopted, this difference can vary from 3 to 8 points for LRBt, and from 4 to 7 points, for LRBw.

Table 4.10 – Poverty Measures for Brazil

Type	Income sources	Family size	Poverty		Extreme Poverty	
			SR	LR	SR	LR
LRBt	Production	AE	0.63	0.67	0.52	0.57
	Prod. + labor	AE	0.60			
	Prod. + labor + transfers	AE	0.54	0.58	0.43	0.47
	Production	N	0.65			
	Prod. + labor + transfers	N	0.57	0.60	0.45	0.49
LRBw	Production	AE	0.64	0.68	0.53	0.58
	Prod. + labor	AE	0.60			
	Prod. + labor + transfers	AE	0.53	0.57	0.41	0.45
	Production	N	0.67			
	Prod. + labor + transfers	N	0.56	0.60	0.44	0.48
Owners	Production	AE	0.59	0.64	0.51	0.57
	Prod. + labor	AE	0.56			
	Prod. + labor + transfers	AE	0.46	0.51	0.38	0.43
	Production	N	0.62			
	Prod. + labor + transfers	N	0.49	0.53	0.40	0.45

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

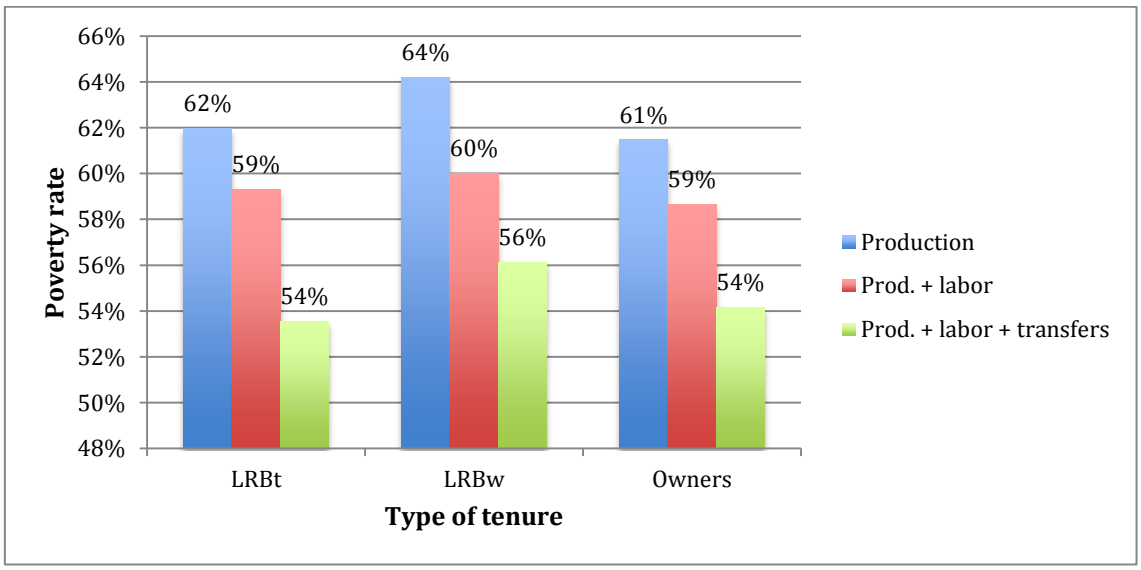
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. SR= short run (only variable costs are deducted from value of output); LR=long run (estimated depreciation of assets is added to variable costs to obtain total costs); Poverty lines: 1/2 and 1/4 minimum wage of August 2000 converted to 12/2006 values.

Figures 4.1a to 4.1e present poverty by type of farmer and income source in the macro regions. Poverty rates of LRBt, LRBw and owners were similar in all macro regions irrespective of the income sources. Comparing across macro regions, poverty

rate of LRBt and LRBw was at most 3 points higher than poverty among owners. Few exceptions occurred when income from production, labor and transfers were considered: compared to owners, poverty rate of LRBt and LRBw was almost 7 points higher in the Northeast.

Using only production as income source, about 70% of LRBt, LRBw and owners are poor in the Northeast. Adding labor income, about 68% of them are poor. The contribution of labor income to reduce poverty varies from 2 to 4 points in the Northeast, and from 2 to 7 points in the Center-West. The contribution of transfers to reduce poverty appears to be relevant for the Northeast. As for LRBt and LRBw, transfers seem to reduce poverty by 8 points. This reduction is greater for owners: 14 points.

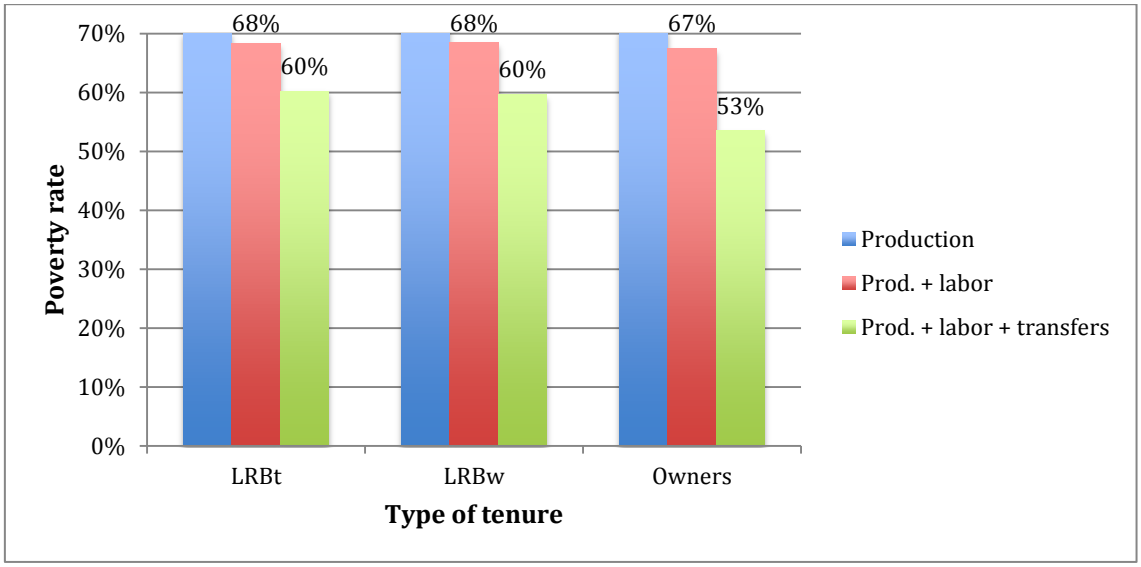
These Figures show that, controlling for type of farmer, the poverty rate in the Northeast is between 9 and 11 points higher than in the Center-West, considering only income from production. However, this difference falls to between 0 and 9 points when all income sources are considered together. The reduction of 14 points in poverty among owners due to transfers in the NE contributes to equalize poverty level of owners in the NE to the level of owners in the CW.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.1a – Poverty by type of tenure and income source in the North.

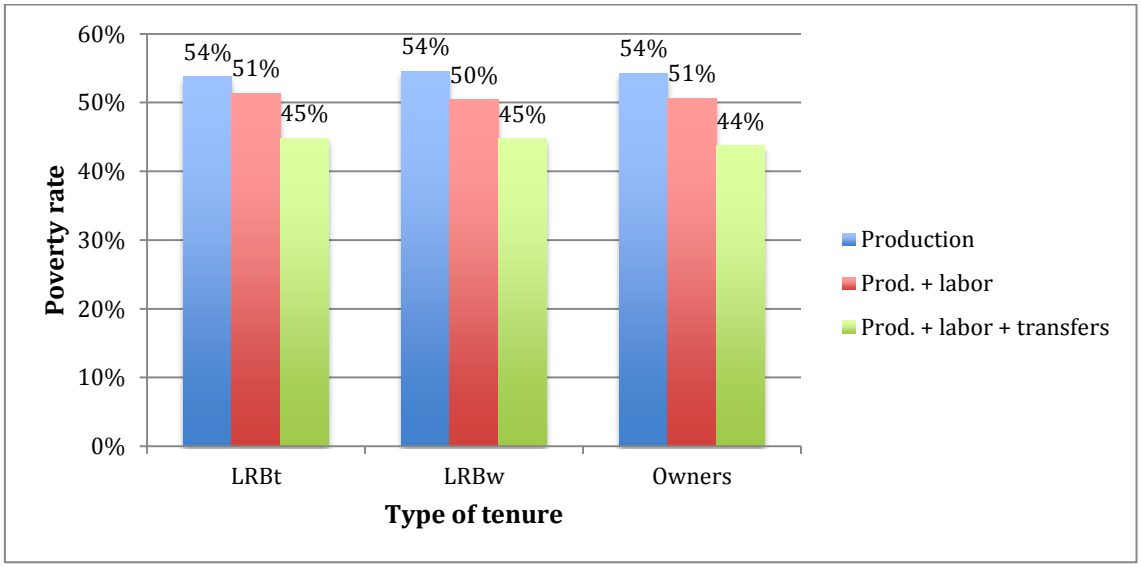
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; Income calculated per adult equivalent.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.1b – Poverty by type of tenure and income source in the Northeast.

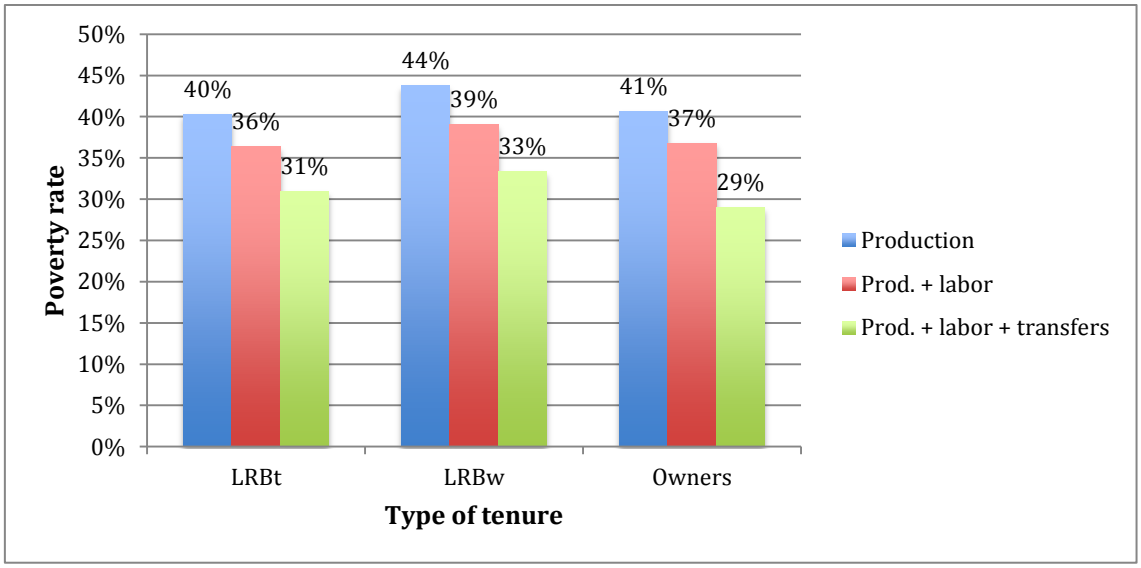
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; Income calculated per adult equivalent.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.1c – Poverty by type of tenure and income source in the Southeast.

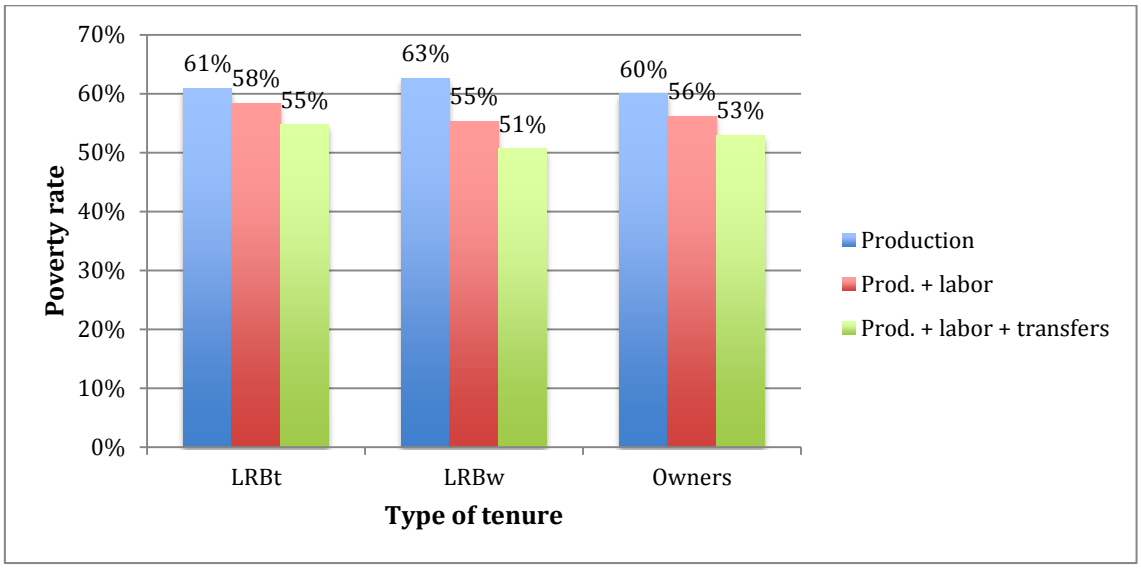
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; Income calculated per adult equivalent.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.1d – Poverty by type of tenure and income source in the South.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; Income calculated per adult equivalent.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

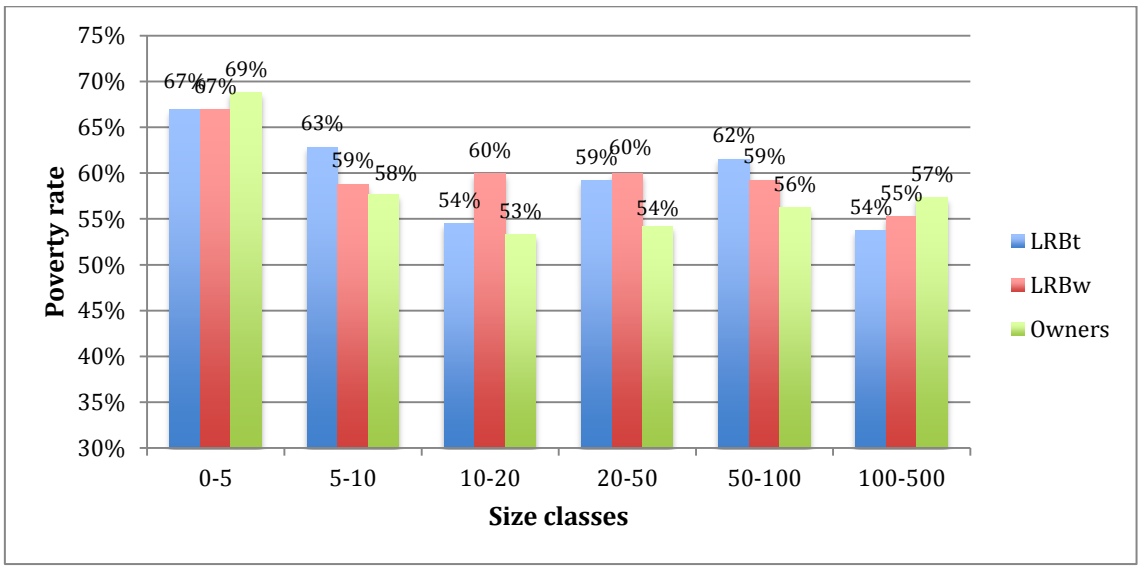
Figure 4.1e – Poverty by type of tenure and income source in the Center-West.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; Income calculated per adult equivalent.

Figures 4.2a to 4.2e represent poverty rates for each macro region, controlling for type of farmer and farm size. Income from production and labor are used. The

highest poverty level was generally observed among establishments with less than 5 hectares. Farms that had between 10 and 50 hectares had less poverty than very small or big farms in the Southeast, South and Center-West. The Northeast, represented in Figure 4.2b, had higher poverty levels. 73% of LRBt, 77% of LRBw and 78% of owners with less than 5 hectares were poor in the Northeast.

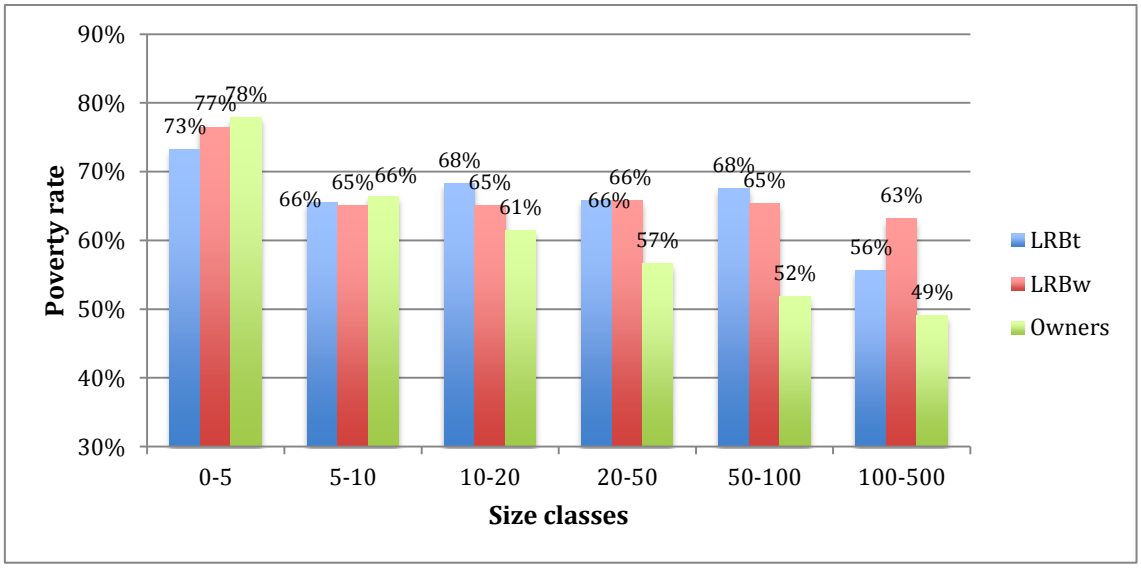
In general, the percentage of poor families among LRBt and LRBw was higher than among owners in all size classes but below 5 hectares. The comparison of poverty in different size classes shows interesting differences. In the Southeast, for instance, the poverty rate was 65% for LRBw with less than 5 hectares and 44% for LRBw that had between 10 and 20 hectares. The difference of 21 points is large. Another interesting difference between size classes is seen in the South: poverty among LRB and owners that had between 0 and 5 hectares was 31 and 29 points higher than poverty among these groups in the size class between 20 and 50 hectares. This confirms the importance of size for poverty. Less than 5 hectares seem to be not enough to generate income that takes families out of poverty.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.2a – Poverty by size and type of tenure (income from production and labor) in the North.

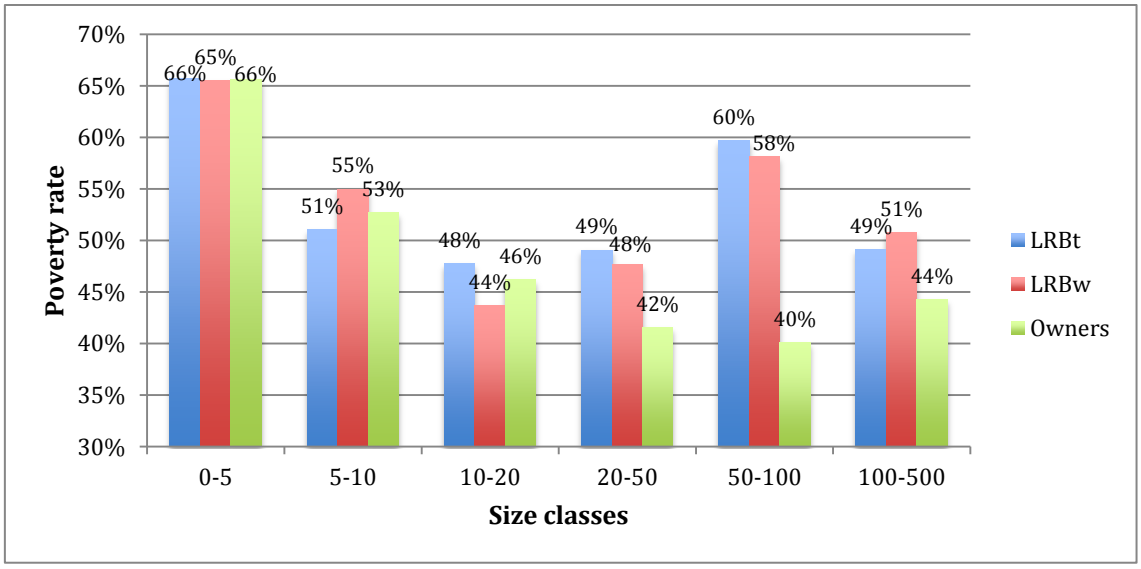
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; income calculated per adult equivalent. Size classes are in hectares.



Source: Author's calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.2b – Poverty by size and type of tenure (income from production and labor) in the Northeast.

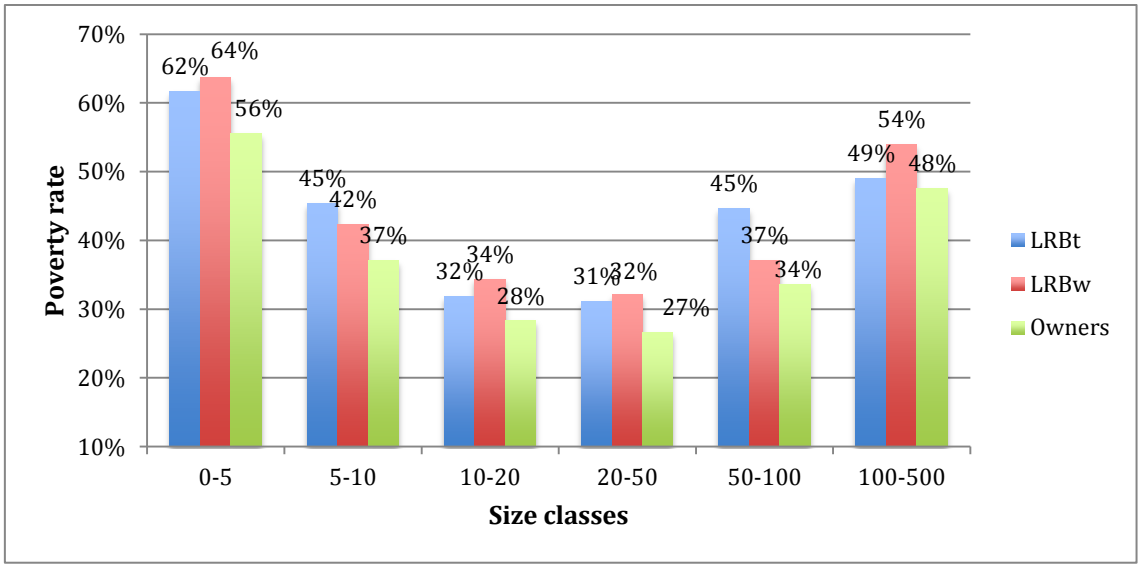
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; income calculated per adult equivalent. Size classes are in hectares.



Source: Author's calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.2c – Poverty by size and type of tenure (income from production and labor) in the Southeast.

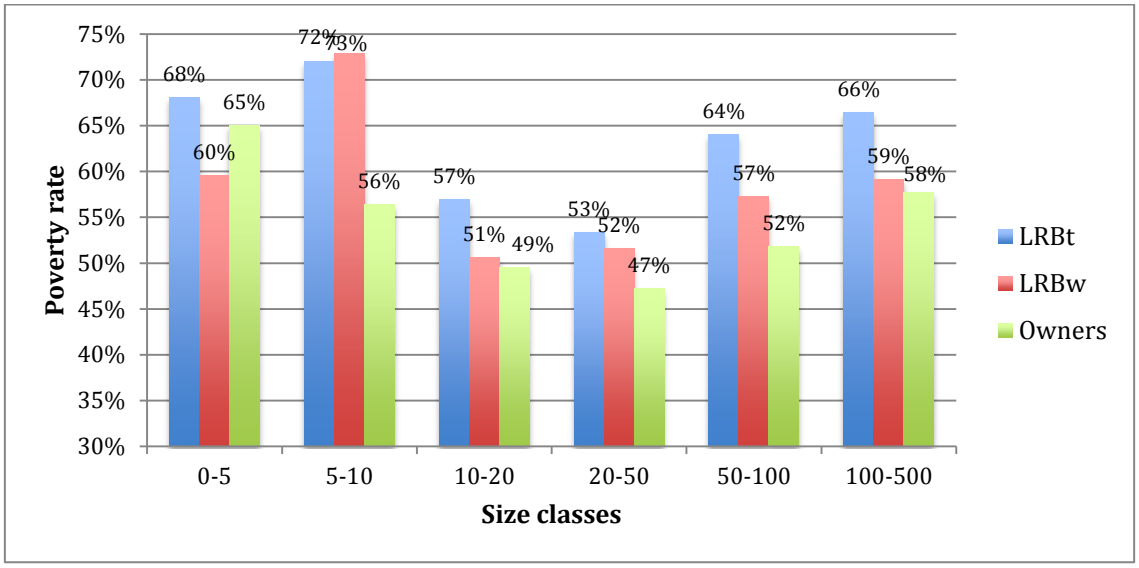
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; income calculated per adult equivalent. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.2d – Poverty by size and type of tenure (income from production and labor) in the South.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; income calculated per adult equivalent. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), microdata.

Figure 4.2e – Poverty by size and type of tenure (income from production and labor) in the Center-West.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Poverty line: 1/2 minimum wage of August 2000 converted to 12/2006 values; income calculated per adult equivalent. Size classes are in hectares.

4.1.4. Characteristics of land reform beneficiaries

This sub-section describes land reform beneficiaries with title (LRBt), land reform beneficiaries without title (LRBw), and landowners. Both groups of beneficiaires together sum to 329,860 establishments as defined above. Farm size, educational level, age, years in charge of farm, participation in cooperatives and unions, technical assistance, credit, and electricity are variables presented hereafter. These are relevant variables in the productive process, and are likely to affect productivity and income. Measures of poverty, income and productivity are presented subsequently.

Table 4.11 shows the average size of establishments for each macro region, while Figures 4.3a to 4.3f show the distribution of establishments across classes of farm size for Brazil and its macro regions. On average LRBt in Brazil had 30 hectares and LRBw had 28 hectares. Figure 3.1a shows that more than 30% of LRBt and LRBw in Brazil were in the category between 20 and 50 hectares. The average size of owners, in contrast, was 78 hectares, but the category with the most owners in Brazil (32%) was 0-5 hectares. Thus, owners had a higher share of very small and very large farms.

Table 4.11 – Average Size of LRB, LRBt, LRBw and owners by macro region

	Average Size (hectares)					
Type	Brazil	North	Northeast	Southeast	South	Center-West
LRB	28.02	52.21	16.42	18.33	21.30	40.05
LRBt	29.84	51.63	17.34	18.72	22.22	39.27
LRBw	26.64	52.93	15.79	18.06	20.77	40.62
Owners	72.49	132.53	37.25	55.54	41.47	403.83

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

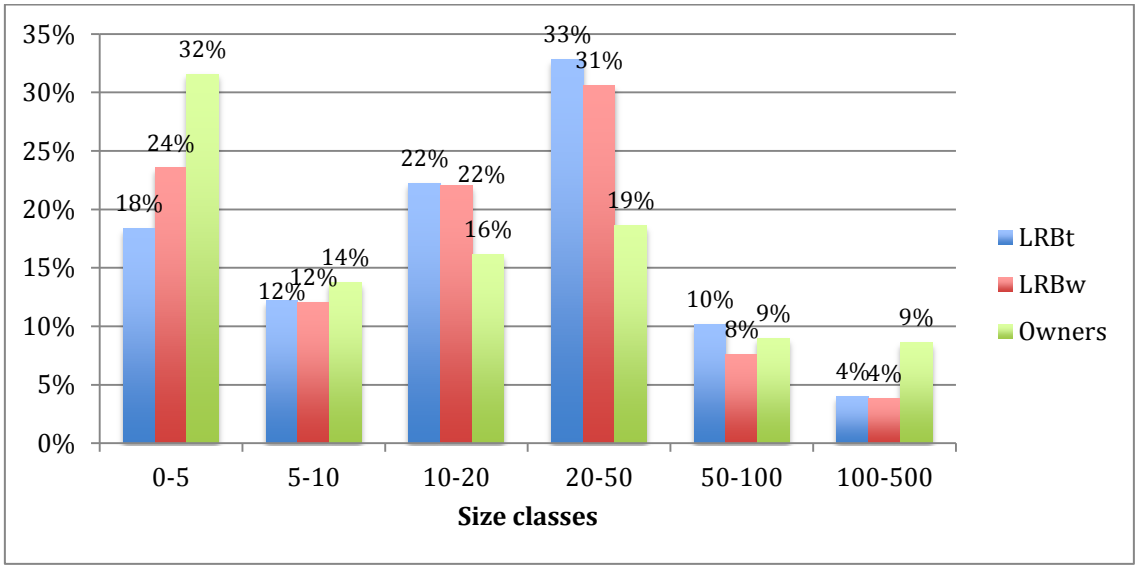
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title; LRB= LRBt+LBRw. Average size in hectares per establishment.

Figures 4.3b to 4.3f show that the modal size classes of LRBt and LRBw are between 20 and 50 hectares in the North and in the Center-West, between 10 and 20 hectares in the Southeast and in the South, and between 0 and 5 hectares in the Northeast. As for owners, the Center-West has the largest establishments, whereas the Northeast has the smallest ones. Average area of owners in the Center-West was more than 10 times the average area of owners in the Northeast.

A comparison of beneficiaries and owners shows that their farm size is more similar in the South, where owners have approximately 2 times more area than LRBt and LRBw. This difference goes up to 10 times in the Center-West, 3.3 times in the Southeast, and around 2.5 times in the North and in the Northeast.

Figure 4.3c shows that that 29%, 38% and 45% of LRBt, LRBw and owners, respectively, have less than 5 hectares in the Northeast. These numbers show that a large percentage of the three types of producers may not have enough land to generate sufficient income for their families, unless they have very high levels of productivity (or access to off-farm work). This is going to be important for the evaluation of productivity and poverty levels in this macro region.

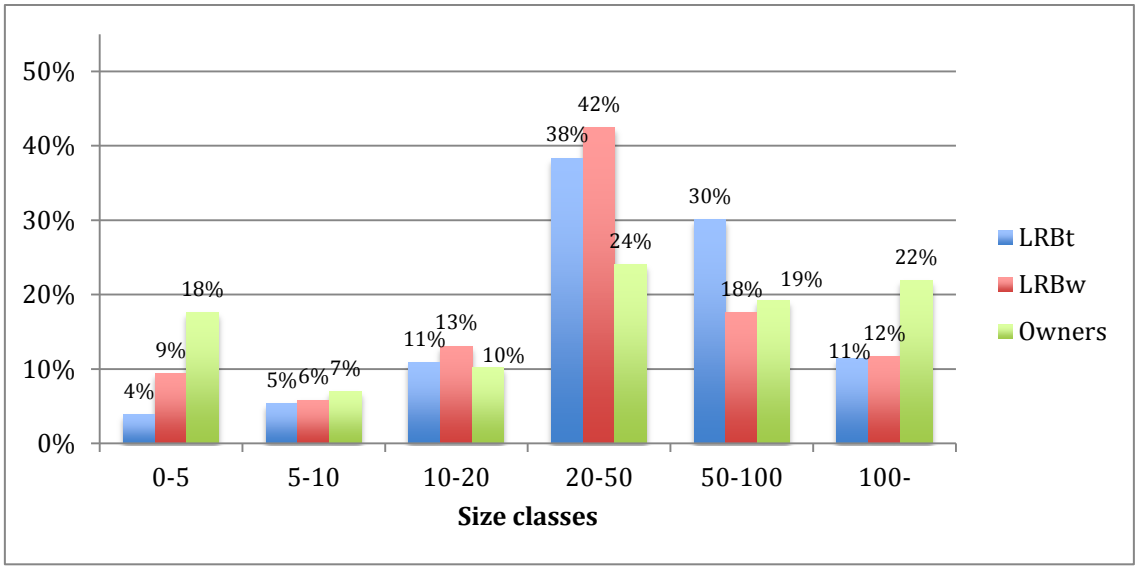
Figures 4.3b to 4.3f show that the percentage of LRBw that have less than 5 hectares is greater than the percentage of LRBt. Additionally, the percentage of owners in that farm size class is greater than the percentage of LRBt and LRBw. This farm size class is the most representative of owners in the Northeast and in the Southeast. The classes with the most owners are: between 10 and 20 hectares in the South; between 20 and 50 hectares in the North; and over 100 hectares in the Center-West.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.3a – Establishments by farm size in Brazil.

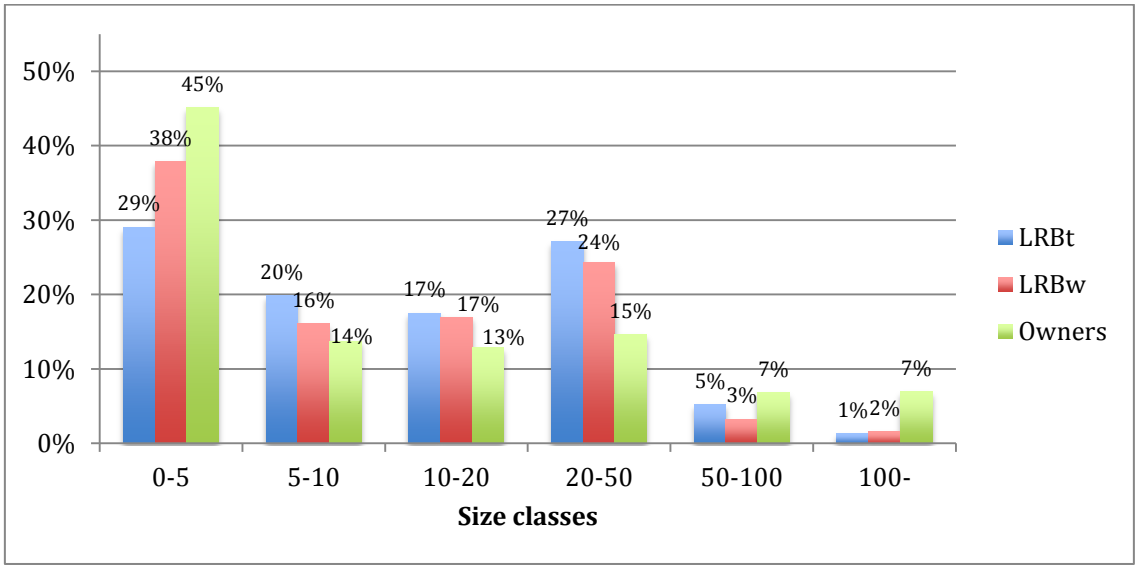
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.3b – Establishments by farm size in the North.

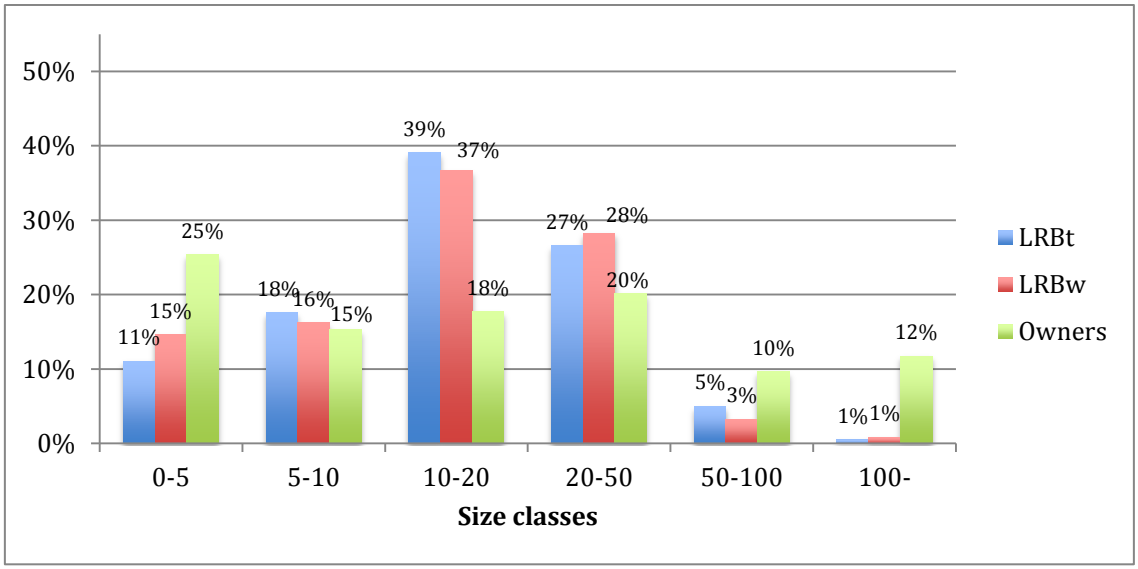
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.3c – Establishments by farm size in the Northeast.

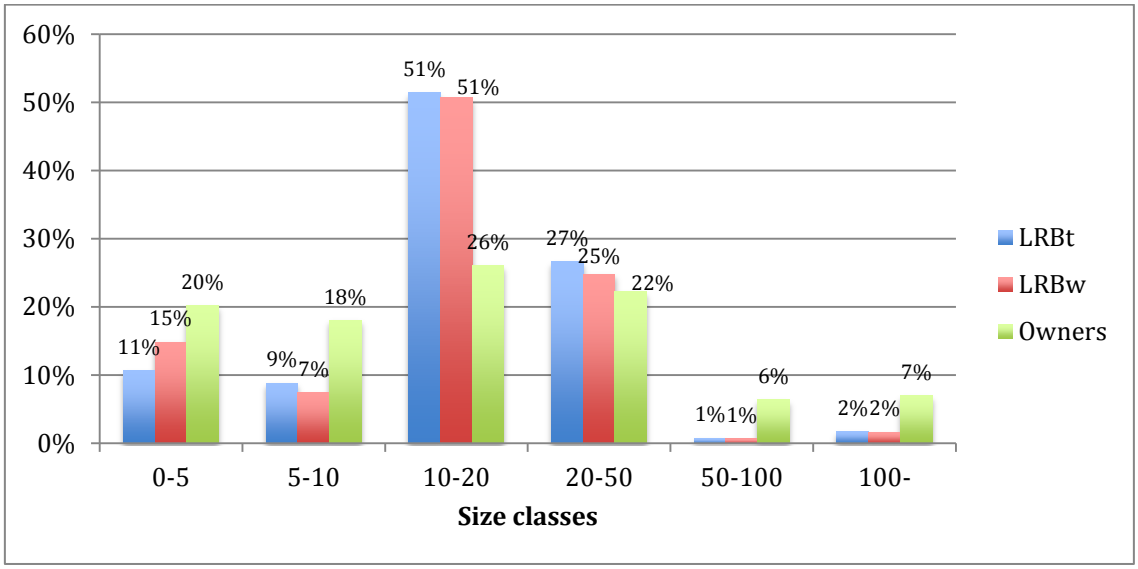
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.3d – Establishments by farm size in the Southeast.

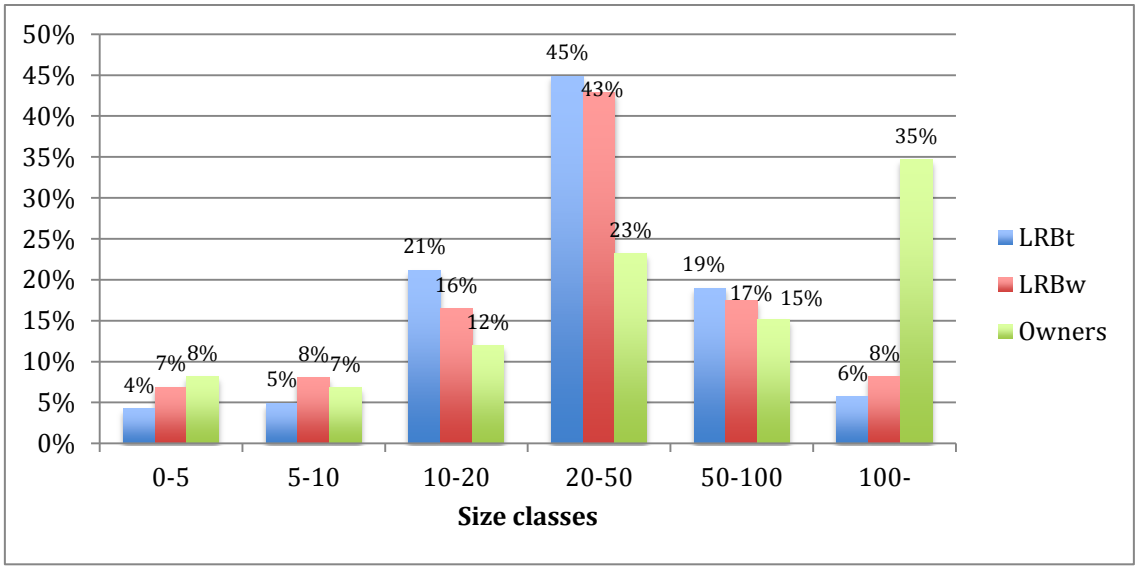
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.3e – Establishments by farm size in the South.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.3f – Establishments by farm size in the Center-West.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.

Table 4.12 presents educational levels of LRBt, LRBw and owners for Brazil and the five macro regions, while Figure 4.4 presents the same information for LRBt and LRBw combined.[24] Table 4.12 shows that LRBt and LRBw have less education than owners in all macro regions. Compared to owners, a higher percentage of LRBt and LRBw are illiterate or literate but without schooling, and a lower percentage have secondary or higher education. 43% of landowners had primary education incomplete and only 11% had secondary or higher education. Educational levels in the Northeast were lower than in the other regions. 88% of landowners in the NE had less than primary education -- they were either illiterate (40%); literate without schooling (19%); or had primary incomplete (29%). On the other hand, the South had better educational levels: only 4% of owners were illiterate. Nevertheless, 76% had less than a primary education.

[24] LRBt and LRBw are together in Figure 4.4 because they have very similar educational level.

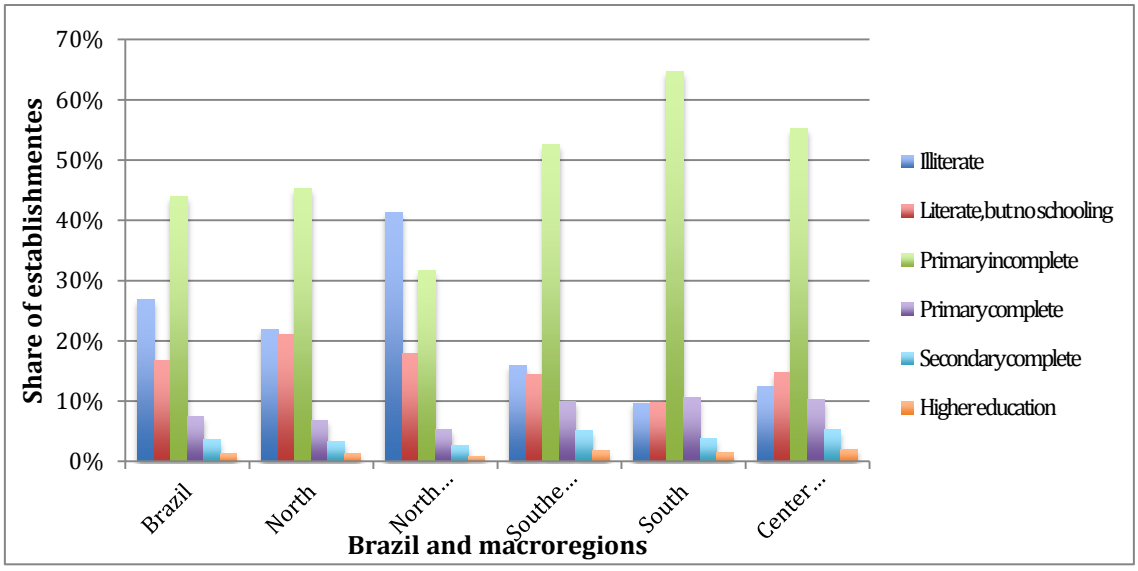
Table 4.12 – Educational level of LRBt, LRBw and owners by macro region

Region	Type	Educational Level					
		Illiterate	Literate, but no schooling	Primary incomplete	Primary complete	Secondary complete	Higher education
Brazil	LRBt	27%	18%	43%	7%	3%	1%
	LRBw	26%	16%	44%	8%	4%	1%
	Owners	22%	15%	43%	9%	6%	5%
North	LRBt	22%	21%	45%	7%	3%	1%
	LRBw	22%	21%	45%	7%	4%	2%
	Owners	17%	19%	48%	8%	4%	3%
Northeast	LRBt	42%	19%	31%	5%	2%	1%
	LRBw	41%	17%	32%	5%	3%	1%
	Owners	40%	19%	29%	5%	4%	2%
Southeast	LRBt	18%	13%	53%	10%	5%	1%
	LRBw	15%	16%	53%	10%	5%	2%
	Owners	10%	12%	47%	12%	10%	9%
South	LRBt	10%	10%	65%	10%	3%	1%
	LRBw	9%	10%	64%	11%	4%	2%
	Owners	4%	7%	65%	12%	7%	5%
Center-West	LRBt	13%	17%	54%	10%	5%	2%
	LRBw	12%	13%	56%	11%	6%	2%
	Owners	8%	13%	46%	13%	11%	10%

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title.

Data from Table 4.12 and Figure 4.4 shows that the educational levels of LRBt and LRBw followed a similar pattern to owners across macro regions. The Northeast was the region with the worst education levels, while the South had much better results. However, LRBt and LRBw have a bigger challenge to improve their education: Compared to owners, they have more illiterate farmers (27% and 26% *vs.* 22%) and fewer farmers with secondary or higher education (4% and 5% *vs.* 11%). 43% and 44% of LRBt and LRBw, respectively, have primary incomplete. In the Northeast, 32% have primary incomplete and 91% have less than primary education; 41% are illiterate. In the South, 10% are illiterate, which is much lower than in the Northeast, but higher than illiteracy among owners in the South. These numbers reflects the need to increase educational policies directed to land reform beneficiaries, but also to landowners.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.4 – Educational level of land reform beneficiaries (LRB) by macro region.

Notes: LRB=Land reform beneficiaries with land title (LRBt)+ land reform beneficiaries without land title (LRBw).

Table 4.13 shows the distribution of LRBt, LRBw and owners across categories of years in charge of their establishment. Less than 5% of farmers in Brazil were in charge of the farm for less than one year. The largest group of LRBt in Brazil was in charge of the farm for more than 10 years (43%), with another 33% having been in charge for 5-10 years. LRBw, in contrast, tended to be of a more recent vintage, with a larger share of them having been in charge for 5 to 10 years. As for owners, the majority of them (67%) had more than 10 years in charge of the current establishment.

The variable years in charge of the farm refers to the experience of the farmer managing the same establishment. It does not capture their total experience with agricultural activities. Nevertheless, this variable is related to the time of existence of the establishment. In the case of LRBt and LRBw, this variable can be an alternative to measure the time of existence of the settlement. The creation of settlements in the North was part of the initial process of land reform. This is confirmed by the high percentage of LRBt in charge of farm for more than 10 years there. The creation of settlements in the Center-West is more recent. This can be a reason why a smaller share of LRBt and LRBw were in charge of the same farm for more than 10 years.

Table 4.13 – Distribution of farmers according to years in charge of farm

Region	Type	Years in charge of farm 0-1	1-5	5-10	10-
Brazil	LRBt	3%	20%	33%	43%
	LRBw	5%	29%	36%	30%
	Owners	2%	14%	17%	67%
North	LRBt	2%	17%	31%	50%
	LRBw	4%	30%	36%	30%
	Owners	4%	20%	24%	52%
Northeast	LRBt	2%	20%	31%	48%
	LRBw	3%	27%	33%	36%
	Owners	2%	13%	15%	69%
Southeast	LRBt	3%	24%	32%	41%
	LRBw	5%	30%	35%	30%
	Owners	2%	15%	17%	66%
South	LRBt	3%	17%	40%	40%
	LRBw	5%	28%	41%	26%
	Owners	2%	11%	14%	72%
Center-West	LRBt	6%	26%	39%	29%
	LRBw	8%	34%	42%	16%
	Owners	5%	21%	23%	51%

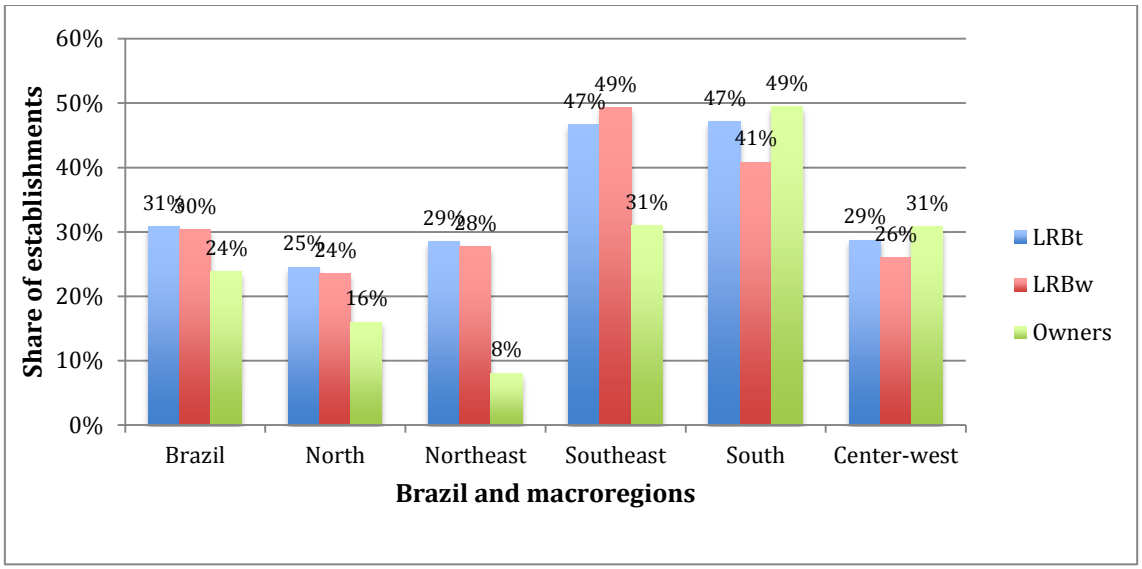
Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title.

Figure 4.5 presents the use of technical assistance by LRBt, LRBw and owners and allows us to compare them across regions. It is important to note that more than 60% of farmers that used technical assistance declared that it happened occasionally, and less than 40% of them had technical assistance on a consistent basis. Therefore, even in cases with a high percentage of farmers served by technical assistance, there is still a big chance that it is not enough to help them to make better productive decisions.

LRBt and LRBw received more technical assistance than owners in the North, Northeast and in the Southeast. Possibly, this difference reflects government efforts to provide technical assistance to LRBt and LRBw, at the same time owners face the free market. The difference is bigger in the Northeast and in the Southeast. Still, owners had

more technical assistance than LRBt and LRBw in the South and the Center-West. This difference was not big, though. The Figure also highlights a difference between regions. In general, farmers from the Southeast and the South receive more technical assistance, whereas farmers from the North and the Northeast receive less.

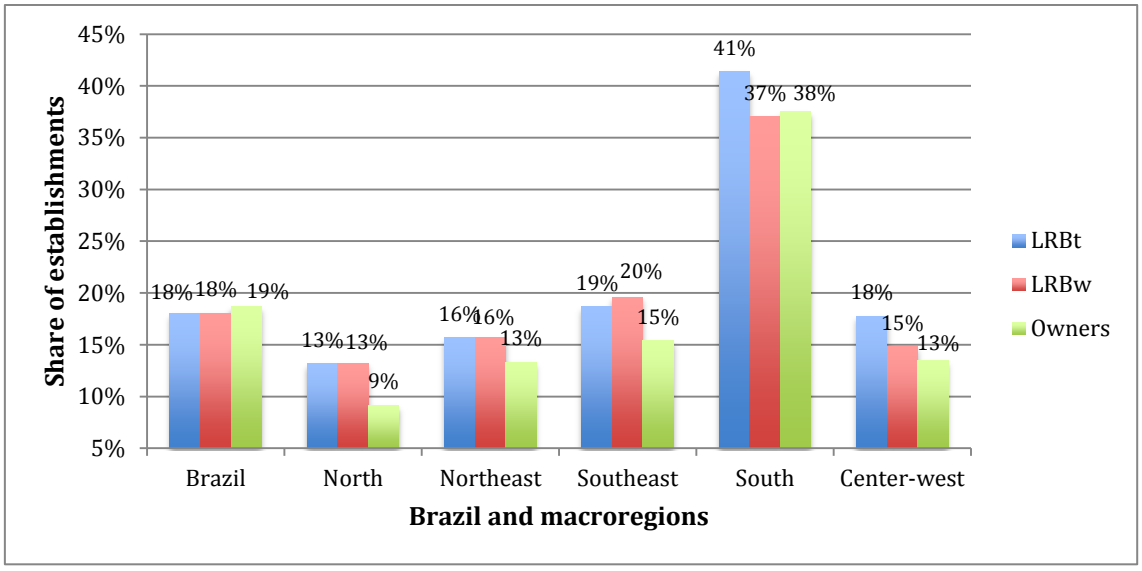


Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.5 – Use of technical assistance by macro region (LRB).

Notes: LRB=Land reform beneficiaries with land title (LRBt)+ land reform beneficiaries without land title (LRBw).

Figure 4.6 represents the use of credit by LRBt, LRBw and owners across macro regions. In almost all macro regions, the percentage of owners that obtained credit was smaller than the percentage of beneficiaries. Comparing farmers inside each macro region, the difference between the percentage of LRBt and LRBw that used credit is zero or very small in the North, Northeast and Southeast. There is some difference in the South and in the Center-West, where the percentage of LRBt that used credit was slightly higher than use of credit by LRBw. This Figure highlights the need to invest in financing policies, not only to land reform beneficiaries, but also to owners, mainly in the North and in the Northeast.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4.6 – Use of credit by macro region (LRB).

Notes: LRB=Land reform beneficiaries with land title (LRBt)+ land reform beneficiaries without land title (LRBw).

4.1.5. Summary

The four previous sub-sections (4.1.1, 4.1.2, 4.1.3, and 4.1.4) presented information on the number of beneficiaries in Brazil, using INCRA data and the 2006 Agricultural Census, and descriptive statistics based on the latter data set. Official INCRA data show nearly one million families settled via land reform through 2006. This dissertation focuses on approximately 330,000 LRB that can be identified in the 2006 Agricultural Census as having obtained their land through land reform, with or without title. The definition excludes about 100,000 establishments that originated from land reform settlements, but did not obtain their land through land reform or did not have the majority of their land waiting for title through land reform. The excluded establishments mostly purchased their land, or are renters, sharecroppers, or occupants.

The 329,860 establishments studied in this dissertation represented 7% of all establishments in 2006, and 3% of area. These shares rose as high as 20% of establishments in the Center-West macro region of Brazil, and 6% of area in the North. The average size of LRB was around 29 hectares, considerably smaller than the average size of owners (78 hectares). The average size of the beneficiaries varies considerably across regions, from a low of around 17 in the Northeast to a high of 53 in the North.

On average, land productivity was 22% and 28% higher among owners than LRBt and LRBw, respectively (Table 4.4). On average, net income per capita was 52% and 30% higher among owners (Table 4.5). Poverty rates were higher among LRB. Based on agricultural income alone, poverty was between 4 (LRBt) and 5 (LRBw) percentage points higher for LRB than for owners. When off-farm labor income and transfers were included, poverty was between 7 and 8 percentage points higher for LRB.

LRBt and LRBw differed from owners also in terms of characteristics of the farmer and the establishment. In general, beneficiaries of land reform were younger, had less education, and were in charge of the farm for fewer years. In all macro regions, use of credit among LRB was higher than owners. They also had more technical assistance and participated more in unions, associations and social movements in all macro regions but the South. Compared to LRB, owners had more or similar access to electricity. They participated more in cooperatives, except in the Northeast, where more LRB belonged to cooperatives. In general, owners used more technology and inputs.

Additionally, the comparison of LRBt and LRBw showed that they were similar, with small differences. In general, data showed that establishments with land title were more productive and had higher income. This can either be due to the time of existence of the establishment or to incentives that farmers with title have.

4.2. Correlates of Productivity and Income

4.2.1. Empirical Strategy

Ordinary Least Squares (OLS) regressions are used to calculate correlates of land productivity, net per capita income and total factor productivity. Land reform beneficiaries and owners are aggregated in groups according to their size class and municipality. The construction of the dependent variables is briefly explained here, as well as the selected covariates for the OLS and treatment effect estimates.

Descriptive statistics of the variables used are presented in Tables 4.14 and 4.15. Their definition is listed below:

- LRB=1 for LRBt and LRBw; LRB=0 for owners (not LRB)
- Farm size: dummies for size classes. The reference is 0-5 hectares.

- Educational variables: share of farmers according to their educational level (literate, but no schooling; primary incomplete; primary complete; secondary complete, and higher are categories relative to illiterate).
- Years in charge of farm: share of farmers according to the number of years they have been in charge of farm. The categories are relative to less than one year.
- Age: Average age
- Age^2: Age squared
- Male: share of male farmers
- Same state: share of farmers that live in the state of birth
- Residence: share of farmers that live in the same municipality as the farm, and share of farmers that live in another municipality, relative to those that live on the establishment
- Farm management: share of farms that are managed by managers, group of farmers and other, relative to those that are managed by the own farmer
- Access to institutions/public goods: share of establishments that had access to credit, electricity, technical assistance, cooperatives, and unions. Market participation refers to the relation between agricultural income and value of production.
- Technology and inputs: share of establishments that had machines (plows, seed drills, planters, grain harvesters, fertilizer machines, reapers), vehicles, tractors and used irrigation, agricultural practices (planting in level curve, terrace, crop rotation, annual crops used to pastures recovery, fallow, biomass burning, slopes protection), limestone and/or soil corrective, fertilizer, and pesticide.
- Land productivity: Ratio between total value of agricultural production and total area (R$/hectare/year)
- Net per capita income: Ratio between total value of agricultural production minus variable costs, and the number of full-time adult equivalent family members (R$/ adult equivalent[25]/year)
- Total Factor Productivity (TFP): Ratio between total value of agricultural production and total costs.

Land productivity, net per capita income, and total factor productivity are the dependent variables. Each one uses a different denominator, and has a different

[25] The concept of Adults Equivalent is defined in the descriptive section.

interpretation. Therefore, they differ in magnitude, as Tables 4.14 and 4.15 show. Land productivity measures the value of agricultural production per hectare. It does not consider either costs, or the number of family members. Net per capita income represents the net returns to full time equivalent household labor. It does not consider the size of farms, but does consider variable costs and the number of family members. TFP measures the relationship between the total value of production and total costs. It does not consider the size of the farm or family. It represents return to every R$ spent in agricultural production. It is important to note that fixed costs were calculated based on the assumption that buildings, machines, trees and cattle have a life cycle of 25, 15, 25 and 5 years, respectively.

The vector of covariates includes variables that affect agricultural productivity, income, poverty, and also the assignment to treatment (which is being a land reform beneficiary). The number of family members, geographical variables (distance to capital and distance to sea), productive inputs (labor, machines, animals, fertilizers, chemicals such as pesticides and herbicides, seeds, fuel and feed, and medicine for animals), public goods and institutions (access to electricity, access to credit, technical assistance, membership of cooperatives) are the variables used. Land tenure[26] status and farm size[27] are also included as dummy variables. Data is aggregated according to the LRB category and size classed. The OLS regression is given by the following equation:

$$y_s = \alpha_s + \beta LRB_s + \gamma x_s + \varepsilon_s \quad (1)$$

where the subscript s indexes size class, y_s is the measurement of land productivity, net per capita income, or total factor productivity. LRB_s is the dummy variable that assumes value one for establishments that the land was obtained through redistributive land reform, and zero otherwise. x_s is a vector of control variables that include farm specific characteristics, such as inputs used, technology, and individual ability of the farmers; and environment specific characteristics, such as transaction costs that affect the access to input and output markets, and availability of public goods and institutions (given by

[26] The Agricultural Census 2006 classifies the farmers into landowners, renters, sharecroppers, occupants, land reform beneficiaries waiting for definitive land title, and landless farmers (category created only in 2006). The landowners can be classified according to how they obtained the land. In this case, land could be acquired through private purchase, purchase with resources from ―crédito fundiário", land reform, heritage, private donation, ―usucapião", and others.

[27] 7 farm size classes are considered with the following limits: 0, 0-5, 5-10, 10-20, 20-50, 50-100, 100-500, and over 500 ha.

the access to electricity, access to credit, technical assistance, participation in cooperatives and unions), ε_s is the error term. The estimative of β is the focus.

4.2.2. Cross section results

Regressions in sub-section (a) compare land reform beneficiaries (LRBt and LRBw) to all other owners. Sub-section (b) presents regressions run only for land reform beneficiaries. The idea is to analyze if the productivity and income of land reform beneficiaries differ due to "years in charge of farm".

a) Comparing land reform beneficiaries and owners

Before presenting the main analysis on regressions run, it is interesting to highlight some statistics comparing land reform beneficiaries and owners. Table 4.14 shows summary statistics for them in Brazil and Table 4.15 shows the same statistics for the macro regions. As for farm size classes, 54% of LRB had between 10 and 50 hectares. Farms with 0-50 hectares were the majority in all macro regions. However, the Northeast also had many LRB with less than 5 hectares. 32% of owners had less than 5 hectares in Brazil. This farm size class was the modal category of owners in the Northeast and the Southeast.

Most LRB (62%) were in the North and in the Northeast. Owners were mostly in the Northeast, South and Southeast. Most owners were in charge of farm for more than ten years in all macro regions. LRB were better distributed across categories 1-5, 5-10 and more than 10 years in charge of farm. Besides, owners were also older than LRB in all macro regions but the North. As for educational level, the proportion of illiterate and literate without schooling is higher among LRB. The opposite happens with the proportion of farmers with primary complete, secondary and higher education: more owners were in those categories.

Access to some institutions differed between LRB and owners. The proportion of establishments that had electricity, affiliated to cooperatives, or the market participation was higher among owners. On the other hand, the proportion of establishments that had access to technical assistance or were affiliated to unions was higher among LRB. The proportion of farms that had access to credit was similar. In

general, owners used more technology and inputs. The proportion of farms with machines, vehicles and tractors was higher among owners. The same happened with use of limestone and/or soil corrective, fertilization and pesticide. Use of agricultural practices was the exception: the proportion of LRB that used them was higher.

Finally, Table 4.14 shows that LRB had higher land productivity and net per capita income, but lower total factor productivity in Brazil. But this masked important regional differences. Table 4.15 shows that land productivity of LRB is higher in the Southeast, in the South and in the Center-West, but lower in the North and in the Northeast. Differences in size and intensity of use of inputs can explain this difference. Compared to owners, LRB had higher net per capita income in the North and in the Northeast, but lower in the Southeast, in the South and in the Center-West. Owners had higher TFP in all macro regions.

Table 4.14 - Summary Statistics for Land Reform Beneficiaries and Owners in Brazil

	LRB (LRBt + LRBw)				Owners			
Variables	Representative Farms	Obs.	Mean or proportion	Std. Error	Representative Farms	Obs.	Mean or proportion	Std. Error
Farm Size	15,423	328,892			140,549	3,658,944		
0-5	3,428	65,392	0.20	0.00	26,639	1,178,286	0.32	0.00
5-10	2,675	40,639	0.12	0.00	23,143	522,050	0.14	0.00
10-20	3,142	72,140	0.22	0.00	24,198	605,609	0.17	0.00
20-50	3,061	104,582	0.32	0.00	25,331	686,626	0.19	0.00
50-100	1,669	32,905	0.10	0.00	20,876	333,692	0.09	0.00
100-500	1,448	13,234	0.04	0.00	20,362	332,681	0.09	0.00
Region								
North	2,589	58,457	0.18	0.00	11,725	321,471	0.09	0.00
Northeast	6,606	144,185	0.44	0.00	48,970	1,582,336	0.43	0.00
Southeast	1,844	29,582	0.09	0.00	37,667	756,435	0.21	0.00
South	2,680	34,699	0.11	0.00	31,705	804,359	0.22	0.00
Center-West	1,704	61,969	0.19	0.00	10,482	194,343	0.05	0.00
Characteristics of the farmer								
Years in charge of farm								
0-1 year in charge of farm	589	12,556	0.04	0.00	3,075	80,057	0.02	0.00
1-5 years in charge of farm	3,930	83,803	0.25	0.01	19,703	512,921	0.14	0.00
5-10 years in charge of farm	5,420	115,587	0.35	0.01	22,523	586,348	0.16	0.00
more than ten years in charge of farm	5,484	116,946	0.36	0.01	95,248	2,479,618	0.68	0.00
Age	8,738	320,384	46.75	0.09	94,493	3,598,984	51.80	0.03
Educational level (relative to higher)								
Illiterate	4,143	88,359	0.27	0.00	31,341	815,910	0.22	0.00
Literate, but no schooling	2,586	55,149	0.17	0.00	20,748	540,128	0.15	0.00
Primary incomplete	6,776	144,502	0.44	0.00	61,032	1,588,868	0.43	0.00
Primary complete	1,152	24,564	0.07	0.00	12,190	317,342	0.09	0.00
Secondary complete	559	11,916	0.04	0.00	8,963	233,328	0.06	0.00
Higher	206	4,402	0.01	0.00	6,996	182,135	0.05	0.00
Male	13,477	287,393	0.87	0.00	122,686	3,193,924	0.87	0.00
Same state	10,647	227,046	0.69	0.01	122,282	3,183,383	0.87	0.00
Residence								
Establishment	12,685	270,512	0.82	0.01	108,764	2,831,471	0.77	0.00
Same municipality	2,543	54,223	0.16	0.01	26,385	686,874	0.19	0.00
Other municipality	195	4,157	0.01	0.00	5,401	140,599	0.04	0.00

Table 4.14 - Summary Statistics for Land Reform Beneficiaries and Owners in Brazil, continuation

	LRB (LRBt + LRBw)				Owners			
Variables	Representative Farms	Obs.	Mean or proportion	Std. Error	Representative Farms	Obs.	Mean or proportion	Std. Error
Farm management								
Farmer	14,818	316,001	0.96	0.00	133,402	3,472,897	0.95	0.00
Manager	459	9,783	0.03	0.00	6,351	165,348	0.05	0.00
Group of farmers	89	1,902	0.01	0.00	52	1,362	0.00	0.00
Others	57	1,206	0.00	0.00	743	19,337	0.01	0.00
Access to institutions/public goods								
Credit	2,786	59,404	0.18	0.00	26,275	684,020	0.19	0.00
Electricity	9,707	206,993	0.63	0.01	100,911	2,627,034	0.72	0.00
Technical Assistance	4,710	100,441	0.31	0.01	32,444	844,611	0.23	0.00
Cooperatives	1,081	23,049	0.07	0.00	17,209	447,993	0.12	0.00
Unions	8,250	175,922	0.53	0.01	47,201	1,228,786	0.34	0.00
Market participation	10,233	218,221	0.66	0.01	104,978	2,732,926	0.75	0.00
Technology and inputs								
Machines	1,466	31,263	0.10	0.00	31,139	810,655	0.22	0.00
Vehicles	4,174	89,015	0.27	0.00	47,489	1,236,289	0.34	0.00
Tractors	484	10,315	0.03	0.00	16,240	422,792	0.12	0.00
Irrigation	989	21,100	0.06	0.00	9,312	242,434	0.07	0.00
Agricultural practices	9,237	196,978	0.60	0.01	80,354	2,091,862	0.57	0.00
Limestone and/or soil corrective	1,794	38,247	0.12	0.00	25,186	655,672	0.18	0.00
Fertilization	3,902	83,214	0.25	0.01	55,807	1,452,830	0.40	0.00
Pesticide	3,807	81,185	0.25	0.01	43,849	1,141,532	0.31	0.00
Land Productivity	8,361	318,352	270.67	9.78	91,241	3,586,757	482.24	4.90
Net per capita income	8,981	319,056	2,021.38	72.30	95,626	3,591,552	3,301.91	40.66
Total Factor Productivity	8,981	319,056	1.07	0.02	95,626	3,591,552	1.11	0.02
Average Total Cost	15,423	328,892	6,857	88.05	140,501	3,658,886	15,131	117.02
Average fixed Cost	15,423	328,892	881	17.65	140,549	3,658,944	2,352	19.72
Average Opportunity Cost	15,423	328,892	3,394	20.37	140,501	3,658,886	3,052	5.47
Average Value of Production	8,981	319,056	7,192	194.99	95,626	3,591,552	16,562	158.90

Notes: Means are presented for Age, Family members, land productivity and family labor productivity only.
For all other variables, the proportion of establishments is presented.

Table 4.15 - Summary Statistics for Land Reform Beneficiaries and Owners across macro regions

Variables	LRB(LRBt + LRBw)					Owners				
	North	Northeast	Southeast	South	Center-West	North	Northeast	Southeast	South	Center-West
Observations	58,457	144,185	29,582	34,699	61,969	321,471	1,582,336	756,435	804,359	194,343
Farm Size										
0-5	0.06	0.34	0.13	0.13	0.06	0.20	0.46	0.26	0.21	0.10
5-10	0.06	0.18	0.17	0.08	0.07	0.08	0.14	0.16	0.18	0.08
10-20	0.12	0.17	0.38	0.51	0.19	0.11	0.13	0.18	0.26	0.13
20-50	0.40	0.25	0.28	0.25	0.44	0.24	0.14	0.20	0.23	0.24
50-100	0.25	0.04	0.04	0.01	0.18	0.19	0.07	0.10	0.07	0.17
100-500	0.11	0.01	0.01	0.02	0.07	0.19	0.06	0.10	0.06	0.27
Characteristics of the farmer										
Years in charge of farm										
0-1 year in charge of farm	0.03	0.03	0.04	0.04	0.07	0.04	0.02	0.02	0.02	0.04
1-5 years in charge of farm	0.23	0.24	0.27	0.24	0.31	0.21	0.13	0.14	0.11	0.20
5-10 years in charge of farm	0.33	0.32	0.34	0.41	0.41	0.23	0.15	0.17	0.14	0.21
more than ten years in charge of farm	0.41	0.41	0.34	0.31	0.21	0.53	0.70	0.67	0.73	0.54
Age	47.07	46.73	48.60	44.48	46.88	47.05	52.22	53.18	51.72	51.20
Educational level (relative to higher)										
Illiterate	0.22	0.41	0.16	0.10	0.12	0.17	0.40	0.10	0.04	0.08
Literate, but no schooling	0.21	0.18	0.15	0.10	0.15	0.19	0.19	0.13	0.07	0.13
Primary incomplete	0.45	0.32	0.53	0.65	0.55	0.49	0.29	0.47	0.65	0.47
Primary complete	0.07	0.05	0.10	0.11	0.10	0.08	0.05	0.12	0.12	0.13
Secondary complete	0.03	0.03	0.05	0.04	0.05	0.04	0.04	0.10	0.07	0.11
Higher	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.09	0.05	0.08
Male	0.88	0.87	0.86	0.89	0.87	0.90	0.83	0.90	0.91	0.90
Same state	0.38	0.92	0.75	0.80	0.37	0.53	0.95	0.94	0.85	0.57
Residence										
Establishment	0.89	0.69	0.92	0.97	0.92	0.87	0.76	0.72	0.82	0.76
Same municipality	0.10	0.29	0.07	0.03	0.07	0.12	0.21	0.22	0.14	0.18
Other municipality	0.01	0.02	0.01	0.00	0.01	0.01	0.03	0.06	0.04	0.06
Farm management										
Farmer	0.97	0.95	0.94	0.98	0.97	0.95	0.96	0.91	0.97	0.91
Manager	0.03	0.04	0.05	0.01	0.02	0.04	0.03	0.09	0.03	0.09
Group of farmers	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01

Table 4.15 - Summary Statistics for Land Reform Beneficiaries and Owners across macro regions, continuation

Variables	LRB(LRBt + LRBw)					Owners				
	North	Northeast	Southeast	South	Center-West	North	Northeast	Southeast	South	Center-West
Access to institutions/public goods										
Credit	0.13	0.16	0.19	0.39	0.16	0.09	0.13	0.15	0.38	0.13
Electricity	0.40	0.62	0.80	0.87	0.64	0.46	0.63	0.84	0.86	0.78
Technical Assistance	0.24	0.28	0.48	0.43	0.27	0.15	0.08	0.30	0.49	0.26
Cooperatives	0.03	0.04	0.09	0.26	0.06	0.03	0.02	0.17	0.32	0.12
Unions	0.56	0.64	0.42	0.32	0.45	0.33	0.36	0.24	0.42	0.17
Market participation	0.64	0.65	0.76	0.64	0.66	0.68	0.70	0.82	0.71	0.77
Technology and inputs										
Machines	0.02	0.09	0.13	0.25	0.08	0.04	0.13	0.27	0.44	0.18
Vehicles	0.21	0.19	0.38	0.43	0.38	0.26	0.21	0.37	0.56	0.45
Tractors	0.01	0.01	0.06	0.09	0.04	0.03	0.02	0.17	0.27	0.16
Irrigation	0.02	0.09	0.10	0.04	0.04	0.03	0.06	0.12	0.05	0.04
Agricultural practices	0.57	0.66	0.55	0.78	0.40	0.48	0.56	0.54	0.73	0.33
Limestone and/or soil corrective	0.04	0.05	0.28	0.36	0.14	0.03	0.03	0.31	0.41	0.17
Fertilization	0.11	0.21	0.42	0.63	0.21	0.11	0.23	0.53	0.74	0.28
Pesticide	0.14	0.25	0.24	0.57	0.16	0.16	0.21	0.28	0.64	0.19
Land Productivity	160.34	352.81	510.46	581.74	172.18	155.72	271.59	727.07	984.98	199.50
Net per capita income	2119.33	1906.28	2611.39	3245.47	1148.14	1843.18	1776.61	5688.34	5508.54	295.89
Total Factor Productivity	1.10	1.12	1.20	1.35	0.77	0.92	0.99	1.18	1.22	0.73
Average Total Cost	7054.16	5187.88	8060.67	9567.26	8464.78	9903.67	6666.30	23929.62	23533.76	23665.59
Average fixed Cost	1078.88	441.98	1212.49	1341.88	1302.11	1788.80	793.37	3791.35	3818.32	4298.88
Average Opportunity Cost	3787.23	3270.66	3423.43	3586.15	3188.62	3769.42	3010.18	2756.94	3197.16	2756.86
Average Value of Production	7718.42	5664.26	9343.20	12360.67	6440.90	9112.32	6493.76	28022.12	28499.72	17286.69

Notes: Means are presented for Age, Family members, land productivity and family labor productivity only.
For all other variables, the proportion of establishments is presented.

Models (2) to (6) in Tables 4.16, 4.18 and 4.20 have municipality fixed effect. Model 1 does not. Municipality fixed effects take account of spatial heterogeneity across municipalities, such as differences in soil quality, which are not captured in the regressors. It means that all comparisons are made within municipalities. Due to the inclusion of municipality fixed effects, regional fixed effects are not used. Model 4 is considered the main model. It controls for variables that can be considered exogenous in the census. Size class is considered exogenous because it is not a choice variable for beneficiaries and the land market is relatively thin for owners. Educational level might be considered exogenous because it is predetermined for adults. Most adults are done with schooling by the time they are observed in the census. Finally, age and gender are considered exogenous because they are predetermined. Model 5 incorporates other characteristics of the farmer, access to institutions and public goods, as well as use of technology and inputs. Some, though not all, of these variables are likely to be endogenous. They reflect choices made by the farmer. The use of credit and technical assistance, for example, reflect farmer choices, whereas access to electricity has much more to do with public investments in infrastructure. The analysis in sections (a) and (b) is going to focus on model 4, the one that has only exogenous variables.

a.1) Land reform beneficiaries and land productivity

Regressions for Brazil, in Tables 4.16, 4.18 and 2.20, show that municipality fixed effects are relevant to explain land productivity, net per capita income and TFP: the coefficients of LRB are different when fixed effects are included. The addition of more controls also generates different coefficients for LRB. Models (3) to (5) show that farm size classes, characteristics of the farmer, and access to institutions and public goods seem to be relevant to explain differences between land reform beneficiaries and other owners.

Table 4.16 presents OLS regressions for land productivity in Brazil. The coefficient on LRB can be interpreted by considering the mean for owners, presented in Table 4.2. Model 1 shows that, on average a group of owners would produce R$482 per hectare (Table 4.14), whereas a group of LRB would produce R$174. This difference drops when other variables are controlled for. When the main model is analyzed (4), the difference is

not statistically significant. In fact, the difference is only big in model 1, which does not control for anything -- not even municipal fixed effects. So, controlling for unobserved municipal differences, farm size, characteristics of the farmer, access to institutions and public goods, use of technology and inputs, there is no statistically significant difference between output per hectare of owners and LRB.

Coefficients on farm size classes from model 4 show the inverse relationship. Farms with less than 5 hectares produce more per hectare. However, this relationship must be associated with the relationship between income and TFP with farm size. Table 4.18 and Table 4.20 show that both net per capita income and TFP increase with farm size. So, small farms are more efficient, but the land is not enough to generate higher income, and probably not to take people out of poverty. This is important because the purpose of land reform is to allow beneficiaries to generate income and have more quality of life.

Land productivity seems to increase until some age, and decrease afterwards. The turning point was 52 years. Conditional to the exogenous variables, productivity is lower among illiterate farmers, and increases with educational level. Compared to illiterate farmers, a farmer that is literate, even without schooling, produces R$568 more per hectare in a year. This difference goes up to R$968 for those with higher education.

Table 4.16 - OLS regressions for land productivity in Brazil

Variable	(1)	(2)	(3)	(4)	(5)
LRB	-308.83	-17.04	-23.28	2.83*	-2.14*
Farm Size (relative to 0-5)					
5-10			-591.61	-687.49	-804.97
10-20			-898.45	-1,032.56	-1,192.13
20-50			-1,163.20	-1,335.60	-1,515.21
50-100			-1,323.25	-1,541.71	-1,747.98
100-500			-1,420.11	-1,704.02	-1,966.68
Characteristics of the farmer					
Age				-93.44	-103.05
Age^2				0.90	0.96
Educational level (relative to illiterate)					
Literate, but no schooling				568.32	485.23
Primary incomplete				747.90	441.19
Primary complete				976.23	666.28
Secondary complete				992.37	634.19
Higher				968.79	452.70
Male				1,320.76	917.29
Years in charge (relative to less than 1)					
1-5					288.65
5-10					568.42
10-					598.07
Same state					34.13
Residence (relative to establishment)					
Same municipality					124.08
Other municipality					-47.70
Farm management (relative to farmer)					
Manager					275.81
Group of farmers					344.93
Others					-33.74*
Access to institutions/public goods					
Credit					-38.58
Electricity					32.87
Technical Assistance					263.17
Cooperatives					-150.59
Unions					-278.21
Market participation					517.99
Technology and inputs					
Machines					121.81
Vehicles					545.30
Tractors					-438.14
Irrigation					1,555.80
Agricultural practices					108.18
Limestone and/or soil corrective					322.69
Fertilization					477.88
Pesticide					397.74
constant	1,155.97	1,132.18	1,841.50	2,620.01	2,144.05
Adjusted R2	0.00	0.49	0.55	0.55	0.58
Municipal Fixed Effects	no	yes	yes	yes	yes
Observations (Representative farms)	99,602	99,602	99,602	99,602	92,680
Observations (Establishments)	3,905,109	3,905,109	3,905,109	3,905,109	3,869,931

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions (2) to (5) have municipal fixed effects, not reported. * Not significant at 5%.

Table 4.17 shows results from model 4 for the macro regions and Brazil. Land reform beneficiaries have greater land productivity in the North and in the Northeast, but are less productive than owners in the Southeast, South and Center-West. These results help to explain the insignificant difference of land productivity between land reform beneficiaries and owners when the model is estimated for Brazil as a whole. Controlling for exogenous variables, land reform beneficiaries produce on average R$177 more than owners per hectare in the North. This means that owners produce half the production of LRB per hectare. In the Southeast, land productivity of land reform beneficiaries is R$196 below the productivity of owners. In this case, owners produce one quarter more than LRB per hectare.

In all macro regions, land productivity significantly differs between establishments that have less than 5 hectares and all other size classes. Establishments with less than 5 hectares are more productive, and productivity appears to decrease with size. The coefficients are big, which shows that size makes a difference for land productivity.

Land productivity increases with age until a turning point, and beyond that value, age has a negative impact on land productivity in the North, the Northeast and in the Southeast. The maximum productivity in the North happens when farmers are 47 years old. The opposite happens in the other macro regions: land productivity decreases as farmers get older, and after a turning point, land productivity increases. The minimum productivity in the South happens when farmers are 14 years old.

In all macro regions, farmers with higher educational level have greater land productivity than those who are illiterate. On average, farmers with higher education produce R$969 per hectare more than illiterate farmers in Brazil. In the North and in the Northeast there is more variation due to education. Male farmers seem to produce more per hectare in all macro regions. On average, a farm managed by a man produces R$1,320 per hectare more than a farm managed by a woman. Only in the Center West this value is quite smaller than the Brazilian average. A possible explanation for this big difference could be the number of hours worked by men and women as managers. However, the agricultural census does not inform this.

Table 4.17 - OLS regressions for land productivity in Brazil and macro regions (Model 4)

Variable	Brazil	North	Northeast	Southeast	South	Center-West
LRB	2.83*	177.81	44.23	-196.49	-217.74	-81.25
Farm Size (relative to 0-5)						
5-10	-687.49	-1884.28	-664.97	-713.25	-502.95	-530.14
10-20	-1,032.56	-2225.96	-970.71	-1043.77	-901.18	-731.48
20-50	-1,335.60	-2532.50	-1239.47	-1250.51	-1264.21	-890.25
50-100	-1,541.71	-2694.75	-1455.42	-1437.85	-1467.27	-1017.86
100-500	-1,704.02	-2837.20	-1682.66	-1587.79	-1587.38	-1099.28
Characteristics of the farmer						
Age	-93.44	-89.52	-69.35	-200.15	10.01	46.61
Age^2	0.90	0.95	0.72	1.77	-0.35	-0.45
Educational level (relative to higher)						
Literate, but no schooling	568.32	722.79	334.67	837.58	831.43	70.97
Primary incomplete	747.90	808.70	418.48	850.25	1146.78	150.46
Primary complete	976.23	1410.77	649.29	1019.88	965.68	298.52
Secondary complete	992.37	321.17	1267.22	790.78	803.48	244.25
Higher	968.79	3060.81	1423.63	622.50	761.44	114.64
Male	1,320.76	1105.28	1292.04	1193.40	1199.72	268.73
constant	2,620.01	3357.93	1792.37	5972.17	760.73	-329.30
Adjusted R2	0.55	0.47	0.53	0.59	0.60	0.68
Observations (Representative farms)	99,602	8,298	36,261	25,684	22,254	7,105
Observations (Establishments)	3,905,109	370,313	1,698,340	765,868	822,314	248,274

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions have municipal fixed effects, not reported. * Not significant at 5%.

a.2) Land reform beneficiaries and net per capita income

Table 4.18 shows OLS regressions for net per capita income in Brazil. Land reform beneficiaries have greater net per capita income in Brazil when the model controls for exogenous variables (model 4) and potentially endogenous variables (model 5). According to model 4, the average net income of full-time equivalent family members who were land reform beneficiaries would be R$4,060 per year, whereas net income for owners was R$3,302 (Table 4.14). In one year, land reform beneficiaries make R$759 per adult equivalent more than owners in Brazil, conditional on farm size, age, level of education and gender. The difference means that a member of a LRB family made R$63 more than an owner every month.

Net per capita income increases monotonically with size. The difference is very big. A member of a family that had a farm with 5-10 hectares made R$1,401 more than a member of family in a farm with less than 5 hectares. This difference goes up to R$6,780 if

farms with less than 5 hectares are compared to farms with 100-500 hectares. Illiterate farmers appear to have higher net per capita income than farmers with higher educational level, except when compared to higher education. Members of a family of a farmer with higher education made R$21,344 more than members of a family of an illiterate farmer.

Model 5 shows the relation between some endogenous variables and net per capita income. More years in charge of farm appear to be correlated with higher per capita income. As for access to institutions and public goods, credit and technical assistance seem to make no difference in per capita income. Electricity is correlated with lower income. Cooperatives, unions and market participation are correlated with higher income. Net per capita income of farmer associated to cooperatives is R$5,299 higher than of those that are not associated. Use of machines and vehicles appear to make no difference in terms of per capita income. On the other hand, use of inputs is correlated with higher per capita income, except for fertilizers.

Table 4.18 - OLS regressions for net per capita income in Brazil

Variable	(1)	(2)	(3)	(4)	(5)
LRB	-1378.09	-50.94*	531.15	758.73	877.09
Farm Size (relative to 0-5)					
5-10			1294.64	1401.54	545.97
10-20			2450.72	2525.36	875.85
20-50			4267.14	4072.66	1511.22
50-100			6176.54	5471.12	2195.73
100-500			8663.57	6779.62	2284.17
Characteristics of the farmer					
Age				-390.11	-393.06
Age^2				3.15	3.82
Educational level (relative to higher)					
Literate, but no schooling				-3417.58	-1818.82
Primary incomplete				-4351.57	-3922.71
Primary complete				-5700.57	-5850.01
Secondary complete				-1268.98	-97.00*
Higher				21344.67	17006.77
Male				-751.17	-3770.51
Years in charge (relative to less than 1)					
1-5					1979.92
5-10					2562.16
10-					2406.01
Same state					1690.98
Residence (relative to establishment)					
Same municipality					-1792.36
Other municipality					571.63
Farm management (relative to farmer)					
Manager					6509.68
Group of farmers					-79.06*
Others					187.53*
Access to institutions/public goods					
Credit					-13.76*
Electricity					-748.49
Technical Assistance					27.94*
Cooperatives					5299.24
Unions					733.34
Market participation					5693.14
Technology and inputs					
Machines					124.13*
Vehicles					-143.86*
Tractors					7261.78
Irrigation					2928.83
Agricultural practices					2017.68
Limestone and/or soil corrective					4400.94
Fertilization					-1187.29
Pesticide					3819.51
constant	3442.78	3334.50	537.58	15171.79	7050.39
Adjusted R2	0.00	0.14	0.16	0.17	0.19
Municipal Fixed Effects	no	yes	yes	yes	yes
Observations (Representative farms)	104,607	104,607	104,607	99,601	92,680
Observations (Establishments)	3,910,608	3,910,608	3,910,608	3,905,102	3,869,931

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions (2) to (5) have municipal fixed effects, not reported. * Not significant at 5%.

Table 4.19 shows the OLS results for net per capita income in Brazil and macro regions. There are important differences across macro regions, similar to what happened with land productivity. Controlling for the exogenous variables, LRB have higher net per capita income in the North, the Northeast, the Southeast and in the Center-West. Per capita income of LRB is 55% and 36% higher than of owners in the Center-West and in the North, respectively. On the other hand, LRB seem to have smaller net per capita income than owners in the South.

As expected, net per capita income rises with farm size. For Brazil as a whole, for example, farms with 10-20ha generate around R$2,525 more per adult equivalent family member than farms with 0-5ha. It is interesting to compare the conditional net per capita income to the poverty line. On average, a LRB with less than 5 hectares, generates R$1,835 for each family member per year in the Northeast. It means that each member makes R$153 per month, slightly above the poverty line of R$120.40 per month. This value is even smaller in the Center-West: conditional monthly per capita income of a LRB is R$55. This shows that very small farms are not enough to take families out of rural poverty in the Northeast and in the Center-West.

The only exception is found in the Center-West: establishments that have between 100 and 500 hectares appear to have smaller net per capita income than establishments with less than 5 hectares.

Net per capita income increases as farmers get older, and after a turning point (62 years in Brazil), it decreases in Brazil and all macro regions but the South. Surprisingly, higher educational level is correlated with lower per capita income. In the North, the Southeast, the South and the Center-West, illiterate farmers are those with higher per capita income. The Northeast presents a different relation: farmers with primary complete, secondary, or higher education have higher per capita income than illiterate ones. These relationships are all conditional to the exogenous variables.

Establishments managed by men generate smaller net per capita income than establishments managed by women in Brazil, in the North, the Southeast, and the Center-West. The South and the Northeast behave differently: women generate greater per capita income than men.

Table 4.19 - OLS regressions for net per capita income in Brazil and macro regions (Model 4)

Variable	Brazil	North	Northeast	Southeast	South	Center-West
LRB	758.73	1035.40	59.50	1131.58	-244.45	369.11
Farm Size (relative to 0-5)						
5-10	1401.54	1888.13	899.48	2089.36	2135.58	370.25
10-20	2525.36	2149.29	1358.16	3652.84	3889.07	1355.42
20-50	4072.66	2763.98	1854.17	7153.60	5673.61	1878.40
50-100	5471.12	3396.21	2555.35	10878.87	7895.62	1564.17
100-500	6779.62	1435.53	2576.85	20892.81	11437.54	-1798.61
Characteristics of the farmer						
Age	-390.11	-405.58	-357.58	-194.82	433.27	-409.18
Age^2	3.15	4.29	3.36	0.38*	-5.01	4.22
Educational level (relative to higher)						
Literate, but no schooling	-3417.58	-4385.21	-876.38	-14891.34	-7398.77	-569.94*
Primary incomplete	-4351.57	-4168.30	-137.60*	-21815.03	-7161.90	-2141.07
Primary complete	-5700.57	-3359.97	1986.78	-26372.17	-7572.37	-1820.34
Secondary complete	-1268.98	-1305.26	1336.80	-20727.75	-1465.19	-4569.75
Higher	21344.67	-1164.91	38723.94	-3036.87	-2300.33	-1417.61
Male	-751.17	-1093.25	1318.36	-3607.88	2528.41	-3943.73
constant	15171.79	13342.10	8624.23	30503.69	-3534.41	14807.21
Adjusted R2	0.17	0.19	0.12	0.20	0.18	0.30
Observations (Representative farms)	99,601	8298	36260	25684	22254	7105
Observations (Establishments)	3,905,102	370,313	1,698,333	765,868	822,314	248,274

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions have municipal fixed effects, not reported. * Not significant at 5%.

a.3) Land reform beneficiaries and total factor productivity

Table 4.14 shows that each R$1 spent by land reform beneficiary produced R$1.07, whereas each R$1 spent by owners produced R$1.11. This is unconditional. According to the five models in Table 4.20, compared to owners, land reform beneficiaries have bigger total factor productivity in Brazil. The difference is not big and reduces a little when other controls are included in the regressions. Considering the average TFP of owners (1.11 from Table 4.14), the coefficient from model 4 results in a TFP of 1.21 for LRB, conditional on the exogenous variables.

As for farm size classes, TFP is greater among larger establishments. The relationship is not monotonically because TFP decreases a little among farms with 100-500 hectares. Model 4 shows that size explains better TFP than the fact of being LRB or owner.

The greatest difference occurs when farms with 20-50 hectares and 50-100 are compared to farms with less than 5 hectares. Controlling for exogenous variables, illiterate farms seem to have higher TFP than all other educational levels in Brazil. Only farmers with primary education have higher TFP than illiterate. Farms managed by men are more productive than those managed by women. The difference is bigger than the difference due to the fact of being LRB or owner.

A few comments can be made about endogenous variables (model 5). More years in charge of farm are correlated with higher TFP. Access to institutions and public goods are correlated with lower TFP. The difference is not big. The only exception is market participation: it is positively related with TFP. In general, use of technology and inputs is positively associated with TFP. Use of tractors and vehicles is an exception.

Table 4.20 - OLS regressions for total factor productivity in Brazil

Variable	(1)	(2)	(3)	(4)	(5)
LRB	0.09	0.16	0.12	0.10	0.10
Farm Size (relative to 0-5)					
5-10			0.41	0.39	0.35
10-20			0.55	0.53	0.49
20-50			0.60	0.58	0.58
50-100			0.60	0.59	0.60
100-500			0.45	0.46	0.50
Characteristics of the farmer					
Age				-0.05	-0.04
Age^2				0.00	0.00
Educational level (relative to illiterate)					
Literate, but no schooling				-0.05	-0.13
Primary incomplete				0.20	0.09
Primary complete				-0.09	-0.16
Secondary complete				-0.09	-0.08
Higher				-0.15	0.01*
Male				0.25	0.20
Years in charge (relative to less than 1)					
1-5					0.26
5-10					0.39
10-					0.43
Same state					0.29
Residence (relative to establishment)					
Same municipality					-0.02
Other municipality					-0.46
Farm management (relative to farmer)					
Manager					-0.07
Group of farmers					-0.15
Others					0.04*
Access to institutions/public goods					
Credit					-0.07
Electricity					-0.06
Technical Assistance					-0.04
Cooperatives					-0.10
Unions					-0.08
Market participation					0.85
Technology and inputs					
Machines					0.10
Vehicles					-0.07
Tractors					-0.52
Irrigation					0.35
Agricultural practices					0.34
Limestone and/or soil corrective					0.00*
Fertilization					0.22
Pesticide					0.17
constant	0.99	0.98	0.6228521	1.542888	0.292683
Adjusted R2	0.00	0.25	0.27	0.27	0.29
Municipal Fixed Effects	no	yes	yes	yes	yes
Observations (Representative farms)	104,607	104,607	104,607	99,601	92,680
Observations (Establishments)	3,910,608	3,910,608	3,910,608	3,905,102	3,869,931

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions (2) to (5) have municipal fixed effects, not reported. * Not significant at 5%.

Table 4.21 shows the results of model 4 for TFP in Brazil and the macro regions. LRB were more productive in all macro regions. As an illustration, land reform beneficiaries generated R$0,10 more than other owners per each R$1 of costs in Brazil, conditional on the exogenous variables. However if looking at the unconditional average costs and average value of production, in Tables 4.14 and 4.15, it is clear that LRB had lower costs (except for opportunity costs) and lower average production. This seems to be the case that the difference in terms of costs compensates the difference of value of production. It might suggest that use of inputs among owners could become more efficient.

It is interesting to use average TFP of owners, presented in Table 4.15, as a parameter to estimate conditional TFP of LRB. In this case, the largest differences between owners and LRB occurred in the North and in the Southeast. Unconditional TFP of owners was 0.92 in the North and 1.18 in the Southeast. Compared to that, conditional TFP of LRB would be 23% larger in the North (1.19) and 12% larger in the Southeast (1.34). The difference in the other macro regions was below 5%. Again, average costs of LRB are below of owners in all regions. Average value of production is smaller as well, but the difference of costs can be more relevant.

All farm size classes present higher TFP than farms with less than 5 hectares in Brazil. In Brazil and in the North, Northeast and Southeast it rises with size until the class 50-100. In the South and in the Center-West it rises until the class 20-50. TFP increases as farmers get older, and after a turning point at age 51 in Brazil, it decreases in all macro regions but the Center-West.

Literate without schooling, and farmers with primary incomplete, farmers with higher education appear to be more productive than illiterate in Brazil. On the other hand, farmers with primary and secondary seem to be less productive than farmers with higher education. Farms managed by women are less productive than farms managed by men in Brazil and in the Northeast and in the Southeast. This relation reverses in the South and in the Center-West.

Table 4.21 - OLS regressions for total factor productivity in Brazil and macro regions (Model 4)

Variable	Brazil	North	Northeast	Southeast	South	Center-West
LRB	0.10	0.27	0.05	0.16	0.06	0.03
Farm Size (relative to 0-5)						
5-10	0.39	0.67	0.36	0.33	0.44	0.10
10-20	0.53	0.96	0.46	0.43	0.59	0.28
20-50	0.58	0.91	0.55	0.57	0.59	0.30
50-100	0.59	0.98	0.55	0.58	0.52	0.21
100-500	0.46	0.77	0.37	0.53	0.46	0.09
Characteristics of the farmer						
Age	-0.05	-0.20	-0.04	-0.05	-0.01	0.01
Age^2	0.00	0.00	0.00	0.00	-0.00*	0.00
Educational level (relative to higher)						
Literate, but no schooling	-0.05	-1.27	0.04	0.26	0.12	-0.09
Primary incomplete	0.20	-0.06*	0.25	0.13	0.03*	0.01*
Primary complete	-0.09	-1.11	0.17	-0.07	-0.30	0.12
Secondary complete	-0.09	-1.70	0.39	-0.16	-0.43	-0.21
Higher	-0.15	-0.92	0.66	-0.34	-0.56	0.07
Male	0.25	0.60	0.38	-0.08	0.14	-0.03
constant	1.54	5.06	1.20	2.09	1.27	0.11*
Adjusted R2	0.27	0.22	0.28	0.29	0.37	0.38
Observations (Representative farms)	99,601	8,298	36,260	25,684	22,254	7,105
Observations (Establishments)	3,905,102	370,313	1,698,333	765,868	822,314	248,274

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions have municipal fixed effects, not reported. * Not significant at 5%.

b) Comparing land reform beneficiaries according to years in charge of the farm

b.1) Years in charge of the farm and land productivity

Years in charge of the farm are related to greater land productivity among land reform beneficiaries in Brazil (Table 4.22). This is not true in the Northeast, where farmers with less than one year in charge of the farm have greater land productivity. Assuming that years in charge of the farm is correlated with years since the creation of the land reform settlements, time is expected to be a relevant variable for land reform settlements to become more productive. Newly created settlements have smaller land productivity. Since the regression is controlling for other important characteristics of the farmer (such as

education, age, and gender), the age of the settlement and the time it takes to create infrastructure seem to significantly contribute to increasing productivity. Applied to the Northeast, this idea may point to possible difficulties in the creation of infrastructure on the settlements.

Very small land reform beneficiaries have higher land productivity. Farmers that do not have higher education are less productive. Men are more productive in all macro regions but the Southeast, where there is no significant difference due to gender.

Table 4.22 - OLS regressions for years in charge of farm and land productivity among LRB in Brazil and macro regions (Model 4)

Variable	Brazil	North	Northeast	Southeast	South	Center-West
Years in charge (relative to less than 1)						
1-5	209.70	898.59	-809.56	298.64	717.54	529.60
5-10	676.78	2190.65	-667.84	870.78	1260.77	736.57
10-	735.10	1671.45	-378.71	1231.27	1088.56	736.79
Farm Size (relative to 0-5)						
5-10	-1009.41	-3256.30	-899.20	-385.71	-878.22	-1091.75
10-20	-1491.14	-3709.81	-1337.50	-1166.85	-1051.10	-1146.73
20-50	-1794.52	-3853.24	-1674.30	-1303.98	-1333.54	-1305.09
50-100	-2089.33	-3915.73	-2194.53	-1545.34	-1533.24	-1422.65
100-500	-2346.07	-4038.17	-2919.10	-1869.37	-2566.08	-1484.32
Characteristics of the farmer						
Age	-65.79	-736.11	108.33	-24.85*	24.82	-25.32
Age^2	0.80	7.50	-0.82	0.28*	-0.19*	0.22
Educational level (relative to higher)						
Literate, but no schooling	135.69	-370.99	229.87	1082.99	250.26	146.26
Primary incomplete	435.91	61.94	626.08	832.22	798.56	66.76
Primary complete	827.93	1282.14	247.08	379.75	978.10	503.97
Secondary complete	2340.51	-1702.04	4113.94	6816.83	2421.90	-293.66
Higher	3885.13	4079.35	4493.02	7569.51	1885.76	177.08
Male	1163.90	2086.43	1411.97	-203.16	447.33	53.12
constant	1508.38	18513.80	-2239.03	623.62*	-857.89	1445.99
Adjusted R2	0.64	0.48	0.76	0.61	0.81	0.75
Observations (Representative farms)	8,361	1597	3,829	801	1,152	982
Observations (Establishments)	318,352	56,834	140,193	28,129	32,690	60,506

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions have municipal fixed effects, not reported. * Not significant at 5%.

b.2) Years in charge of farm and net per capita income

Land reform beneficiaries in charge of the farm for more time appear to have higher net per capita income in Brazil (Table 4.23). Exceptions occur in the Northeast, where beneficiaries in charge of farm for less than one year have higher per capita income, and in the Center-West, where only farmers in charge of the farm for more than ten years have higher per capita income than those in charge for less than one year. Seemingly more years in charge of the farm are not contributing to increase income of land reform beneficiaries in the Northeast and in the Center-West.

As for farm size, land reform beneficiaries with more than 5 hectares have higher income. A few exceptions occur with farms that have between 100 and 500 hectares in the North, and, farms that have between 10 and 20 hectares or more than 500 hectares in the Center-West. Per capita income decreases with age of land reform beneficiaries and increases after a turning point. This relation reverses in the Center-West.

Higher education contributes to increase per capita income in Brazil. The North is an exception: compared to higher education, all educational levels are related to higher per capita income. Men generate higher income in the Northeast, South and Center-West, whereas women generate higher income in the North and in the Southeast.

Table 4.23 - OLS regressions for years in charge of farm and net per capita income among LRB in Brazil and macro regions (Model 4)

Variable	Brazil	North	Northeast	Southeast	South	Center-West
Years in charge (relative to less than 1)						
1-5	784.66	4908.86	-1233.21	3583.85	5246.04	-280.27
5-10	1499.74	6104.97	-677.82	6311.70	5729.26	-159.54*
10-	1489.81	5067.55	-649.82	5468.67	6317.54	893.27
Farm Size (relative to 0-5)						
5-10	833.11	89.63*	890.00	2524.99	541.14	-738.06
10-20	1317.99	-621.21	1337.40	2312.19	2275.38	708.39
20-50	1345.14	-266.65	1325.49	3202.81	2553.17	340.09
50-100	1236.99	158.83*	735.89	2216.07	4219.41	-193.33
100-500	1626.34	362.15	3554.88	-175.50*	5724.29	-357.71
Characteristics of the farmer						
Age	-505.85	109.44*	-606.24	-1268.59	-559.41	-40.23*
Age^2	5.59	-0.35*	6.58	12.21	5.07	0.94
Educational level (relative to higher)						
Literate, but no schooling	967.99	-1327.26	2040.49	1846.21	217.34*	-591.04
Primary incomplete	1092.72	471.03	647.83	1724.82	1462.66	457.25
Primary complete	1034.05	-2869.45	1275.64	1466.81	6332.58	-1762.24
Secondary complete	4378.46	-3104.55	3179.44	12719.74	13132.13	1473.43
Higher	7904.43	-11439.05	7230.52	202.10*	10042.79	23038.74
Male	160.12*	-1896.48	437.54	-4586.06	1721.67	2024.86
constant	10005.34	-4886.28	14603.31	29911.79	6802.09	-1644.93*
Adjusted R2	0.60	0.80	0.40	0.44	0.68	0.47
Observations (Representative farms)	8,361	1,597	3,829	801	1,152	982
Observations (Establishments)	318,352	56,834	140,193	28,129	32,690	60,506

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions have municipal fixed effects, not reported. * Not significant at 5%.

b.3) Years in charge of farm and total factor productivity

According to Table 4.24, TFP appears to increase with more years in charge of the farm. However, TFP of land reform beneficiaries in charge of the farm for more than one year is significantly lower than TFP of beneficiaries in charge of farm for less than one year in the Northeast. Besides, the effects of being in charge of farm for more years on productivity are higher in the North. On the other hand, the lowest impact of years in charge of farm on productivity occurs in the Center-West.

Compared to farms with less than 5 hectares, LRB with more than 10 hectares in Brazil are less productive. A few exceptions are seen in the Northeast, Southeast and South. TFP of beneficiaries with higher education is significantly below TFP of illiterate

beneficiaries in Brazil. This happens in the North and in the South, but reverses in the Southeast and Center-West.

Table 4.24 - OLS regressions for years in charge of farm and total factor productivity among LRB in Brazil and macro regions (Model 4)

Variable	Brazil	North	Northeast	Southeast	South	Center-West
Years in charge (relative to less than 1)						
1-5	0.39	3.11	-0.78	1.21	1.33	0.32
5-10	0.62	3.49	-0.53	1.41	1.45	0.58
10-	0.50	2.97	-0.60	1.24	1.41	0.59
Farm Size (relative to 0-5)						
5-10	0.34	-0.03*	0.36	0.76	0.33	-0.35
10-20	0.41	-0.56	0.53	0.55	0.71	-0.01*
20-50	0.39	-0.33	0.50	0.74	0.67	-0.11
50-100	0.31	-0.10	-0.01	0.36	0.15*	-0.21
100-500	0.43	0.01*	0.60	-0.48	1.75	-0.21
Characteristics of the farmer						
Age	-0.07	0.19	-0.13	-0.24	-0.14	-0.01*
Age^2	0.00	0.00	0.00	0.00	0.00	0.00
Educational level (relative to higher)						
Literate, but no schooling	0.26	-0.49	0.59	0.51	0.27	0.19
Primary incomplete	0.31	0.36	0.20	0.14*	0.31	0.37
Primary complete	0.01*	-1.14	-0.50	-0.05*	0.75	0.68
Secondary complete	0.88	-1.06	0.53	4.39	2.29	-0.18
Higher	0.44	-4.10	1.01	2.69	3.34	0.57
Male	0.22	-0.29*	0.33	-0.73	0.71	0.31
constant	1.16	-6.24	3.62	5.35	1.83	-0.25*
Adjusted R2	0.70	0.82	0.45	0.52	0.63	0.58
Observations (Representative farms)	8361	1,597	3,829	801	1,152	982
Observations (Establishments)	318,352	56,834	140,193	28,129	32,690	60,506

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.
Notes: Regressions have municipal fixed effects, not reported. * Not significant at 5%.

4.2.3. Conclusions

This chapter presented regressions with 2006 data aggregated by farm size and form of obtaining land. The first part of the subsection compared land reform beneficiaries (LRB) and owners. Land productivity, net per capita income and total factor productivity were the dependent variables in regressions run for Brazil and the macro regions. In all

cases, six different specifications were run. The first one is a simple unconditional comparison between land reform beneficiaries and owners, and the sixth one is the most complete one. So, moving from the first to the sixth, more controls are added. Model 4 is the preferred specification because it only includes variables that are largely exogenous. The second part of this subsection analyzed only LRB, comparing them according to the time that the farmer was in charge of the establishment. This part also had 6 different specifications.

Cross-sectional regressions for Brazil revealed that the unconditional land productivity advantage of owners fell from around R$300 to R$17 when municipal fixed effects were controlled for. Thus, unobserved local differences—such as in land quality, infrastructure, etc.—explain most of the difference. The difference became statistically insignificant when differences in farm size, age, education, and gender were also controlled for (model 4).

The lack of any statistically significant difference between LRB and owners at the level of Brazil in 2006 hides significant differences across macro regions. When model 4 was run for each macro region, it showed a statistically significant land productivity advantage for LRB in the less developed North and Northeast, and a disadvantage in the three more modern regions of the country. These results are consistent with the descriptive data discussed in the previous subsections. The analysis with the 1985 and 2006 dataset, in the next chapter, will explore whether this pattern is due to differences in initial conditions, or differences in the growth of land productivity between 1985 and 2006.

As in the case of land productivity, the unconditional advantage in net per capita income of owners in Brazil appears to be largely attributable to unobserved municipal level characteristics. When municipal fixed effects were included in the model, the difference between owners and LRB became statistically insignificant. Unlike with land productivity, however, LRB earn over R$530 more than owners per capita when differences in farm size are also controlled for. The addition of age, education and gender (model 4) led to a conditional advantage of over R$750 per capita for LRB. As for the macro regional regressions, model 4 showed that conditional net income per capita of LRB is higher in four of the five macro regions in Brazil. Only in the South do owners continue to earn more

once unobserved municipal characteristics, farm size, age, education and gender are controlled for.

The regression for Brazil showed that land reform beneficiaries have greater total factor productivity in Brazil. The unconditional difference was 0.09. However, the inclusion of municipal fixed effects increased this difference. Again, the inclusion of age, education and gender reduced the gap. LRB were more productive in all macro regions. The difference was higher in the North (0.27), and lower in the Center-West (0.03).

Regression results restricted to LRB show that land productivity rises sharply with the amount of time the producer has been in charge of the establishment. This could be due to lags for investments to be made and then to generate results, or it could be due to learning and experience. The conditional results from model 4 suggest that land productivity rises by 77%, 251% and 277% for producers with 1-5, 5-10, and more than 10 years in charge of the farm relative to producers with less than one year.

The relationship between years in charge of the farm and land productivity varies across macro regions. In four of the five macro regions it is strongly positive, but not always monotonic. In the North and South farmers with 5-10 years in charge of the farm outperform farmers with more than 10 years. Only in the Northeast do farmers with less than 1 year have higher land productivity than the other three groups.

The relationship between net per capita income and years in charge of the farm is similar to that of land productivity. For Brazil as a whole it rises strongly with 1-5 and 5-10 years in charge of the farm, but then plateaus. The relationship is positive but not necessarily monotonic in three of the five macro regions, and non-linear in the other two. Total factor productivity rises with years in charge of the farm in Brazil and four of the five macro regions, but again the relationship is sometimes non-linear.

5. PANEL DATA ANALYSIS

This chapter is divided into four sections. Section 5.1 describes the methodology. Difference-in-Differences and fixed effect estimation techniques are used. In both cases, treatment is first modeled as a binary variable that captures the existence of any LR in a given municipality. Intensity is then modeled with a variety of more realistic approaches, depending either on the share of LRB in each municipality or on the average age of the settlements. Because the fixed effects model is the main one, the tables from the difference-in-differences models are presented in the appendix. Section 5.2 discusses the results, section 5.3 discusses the results for small farms and section 5.4 provides conclusions. The data used in this section is described in the appendix.

5.1. Empirical Strategy

Measuring the effects of land reform on productivity is an empirical question that depends on a diverse set of economic, political, and social variables. The models estimated in this section seek to evaluate the outcomes of redistributive land reform in Brazil while controlling for some of the key factors that influence the process. This section presents the methodology adopted to estimate the effects of land reform on land productivity.

The models are estimated with a panel data set from two years: 1985 and 2006. The use of panel data permits removing unobservable variables that are constant over time. In the first model, which uses a Difference-in-Differences (DD) approach, unobservables are removed at the level of groups (treated vs. control). In the second model, which uses a fixed

effects (FE) approach, unobservables are removed at the municipality level, which is the level at which agricultural establishments are aggregated.

The main advantage of longitudinal estimators over cross-sectional methods is that they allow there to be unobservable determinants of outcomes—such as fixed differences in soils and climate—that are removed and thus do not influence the estimated coefficients. However, the fixed effect error structure that is assumed here only incorporates the potential influence of time-invariant unobservables at the municipal level, or at the municipal and farm size level in the case of the final model that is estimated (Todd, 2007). Thus, the model does not allow us to control for farm level characteristics that influence outcomes. Unobservables like these may or may not be randomly distributed across beneficiaries and non-beneficiaries. If they are not, our estimates may be biased. For instance, if beneficiaries were not as apt to develop agricultural activities, due to their personal characteristics, the effect of land reform on productivity would be biased downward.

The possibility of unobservables affecting both the treatment and the outcome variable (productivity) does not allow us to claim that the models are estimating the causal impact of land reform. Nevertheless, because unobserved fixed characteristics that might confound the analysis are removed, and because the models use panel data from all of Brazil, the results come closer to estimating the causal impact of the program than what exists in the literature. They also provide a relevant descriptive comparison of municipalities with and without land reform beneficiaries at a national level. Similarly, the inclusion of heterogeneous effects permits identifying if municipalities with a larger share of beneficiaries or older settlement projects had different trajectories of land productivity relative to municipalities with no land reform. This analysis has not been done previously in Brazil

Only variables that were present in both the 1985 and 2006 Agricultural Censuses could be included in the regressions. Therefore, some variables used in the cross section analysis are not part of the panel data models. Characteristics of the farmer, for example, were not asked in 1985. Thus, education, years in charge of farm, age, gender, birthplace, place of residence, and farm management are excluded from the panel data regressions.

Similarly, use of machines, tractors and vehicles were categorized differently in the two Censuses. For this reason it was not possible to use them as a share of establishments that had each one of these items. As an alternative, the longitudinal models use the value of these assets to capture their importance.

Most variables are calculated as a share of establishments that had certain characteristics within each municipality. The exceptions are value of production and value of machines. The 1985 values of these variables were inflated to 2006. As for the total value of production, the Gross Domestic Product implicit deflator for agriculture (from Ipeadata) in years 1985 and 2006 was used. The choice of this index aims to mimic the results that would have been obtained by constructing an output quantity index had farm level data been available. Agricultural production and productivity rose substantially between 1985 and 2006 (Gasques et al. 2012). In part as a consequence, agricultural prices fell and so too did the real value of agricultural production. In this case, using a general inflation index that does not take into account the real decline of agricultural prices would not have been adequate to measure the increase in production per area. As will be discussed in the results section, the increase in the real value of output is broadly comparable to what Gasques et al. (2012) finds based on a quantity index.

The value of machines, tools and vehicles was also converted to 2006 *reais* with the implicit GDP deflator for agriculture. However, in this case the average of 1985 and 1986, and 2006 and 2007, were used instead of the index values from 1985 and 2006, respectively. While the value of production refers to the entire reference year of the Census (1985 or 2006), the value of machines refers to the value on the reference date, 12/31 of the reference year. Taking the average value over two years permits centering the index close to the 12/31 reference date of the Census. Additionally, the 1985 Census reports the values of production and of machines in Cruzados (Cz$). Therefore, it was necessary to divide the values by 2,750,000,000 in order to convert them into *reais* (R$).

Land acquisition through land reform is another question that did not exist in the 1985 Agricultural Census. According to INCRA data, only 44 municipalities out of the 4,090 municipalities that were in both Censuses had settlements that existed before 1985. Because of this, our model considers that there were no settlement projects in the

baseline.[28] The variable of interest (LRB) is built with data from the 2006 Agricultural Census. In the binary treatment approach, the dummy LRB assumes a value of 1 for municipalities that had at least one establishment obtained through land reform in 2006, with or without land title, and 0 for municipalities with no land reform beneficiary at all. In the continuous treatment approach, the intensity of treatment depends on either the share of beneficiaries, or on the average duration of treatment, in each municipality.

The estimation methods adopted are Difference-in-Differences and fixed effects. Both models are estimated first with binary and then with intensity of treatment specifications. The models are presented sequentially below.

a) Binary treatment

The basic models aggregate establishments at the municipal level and consider that the variable of interest (LRB) is binary. The simplest Difference-in-Differences (DD) setting is one where outcomes are observed for establishments in one of two groups, and in one of two time periods. Only units in one of the two groups, in the second time period, are exposed to a treatment. There are no units exposed to the treatment in the first period, and units from the control group are never exposed to the treatment. The average gain over time in the non-exposed (control) group is subtracted from the gain over time in the exposed (treatment) group. This double differencing removes biases in the second period comparisons between the treatment and control group that could be the result of permanent differences between those groups, as well as biases from comparisons over time in the treatment group that could be the result of time trends unrelated to the treatment (Imbens and Wooldridge, 2009).

In the present context, the binary treatment DD strategy amounts to comparing the change in land productivity among municipalities with LRB, between 1985 and 2006, to the change in land productivity among municipalities with no LRB in the same period. Municipality m belongs to a group $G_m \in \{0,1\}$, where group 1 is the treatment group and is observed in time period $T \in \{0,1\}$. The DD approach entails estimating equation (2):

$$Y_{mt} = \alpha + \beta * time_t + \gamma * LRB_m + \pi(time * LRB)_{mt} + \delta X_{mt} + \varepsilon_{mt} \quad (2)$$

[28] As a robustness check, all regressions were run with and without those 44 municipalities. The qualitative results did not change.

where *Y* is land productivity (deflated value of output per hectare); time is an indicator variable that equals one in the follow-up period (2006), and zero in the baseline (1985), LRB is an indicator variable that equals one if there was at least one LRB in the municipality (m) in 2006, and zero if there was no LRB in the municipality. *Time * LRB* is an indicator variable that equals one if both time is equal to one and *LRB* is equal to one, and zero otherwise. The subscripts m and t index municipalities and time (baseline or follow-up). π is the estimate of the effect of treatment. It should be noted however that this does not necessarily have a causal interpretation because there was not exogenous program placement. ε is a mean zero normally distributed error term, and X is a vector of covariates that control for time varying observable factors that are hypothesized to influence productivity. The vector includes:

- Farm size: dummies for size classes. The reference group is 0-5 hectares.
- Access to institutions/public goods: share of establishments that had access to credit, electricity, technical assistance, and cooperatives.
- Technology and inputs: average value of machines, tools and vehicles per establishment, share of establishments that used irrigation, agricultural practices (planting in level curves, terraces, crop rotation, pasture recovery, fallow, biomass burning, slope protection), limestone and/or soil correction, fertilizer, and pesticide.

In this way, for LRB=1 equation (2) becomes:

$$E(Y_{mt}|LRB=1, time=2006, X_{mt}) - E(Y_{mt}|LRB=1, time=1985, X_{mt}) = (\alpha+\beta+\gamma+\pi+\delta X_{mt}) - (\alpha+\gamma+\delta X_{mt}) = \beta+\pi \quad (3)$$

And for LRB=0:

$$E(Y_{mt}|LRB=0, time=2006, X_{mt}) - E(Y_{mt}|LRB=0, time=1985, X_{mt}) = (\alpha+\beta+\gamma+\pi+\delta X_{mt}) - (\alpha+\gamma+\delta X_{mt}) = \beta\,, \quad (4)$$

taking (4) – (3) we have the estimate of the effect of treatment, π.

The DD identification strategy relies on $E(\varepsilon_{mt}|\ \text{time}, X_{mt}) = 0$. In other words, land reform effects are identified based upon the relationship between differences in land

productivity and differences in treatment statuses (LRB=1 or 0). There can be no omitted factors that are causing both the growth in the outcome variable and the treatment status.

A fixed effects (FE) model is another way of estimating the impact of land reform. The FE is a superior model because it controls for unobserved municipal level characteristics that are fixed over time. The cross-sectional models estimated in Chapter 4 demonstrated the importance of controlling for these local effects. The model will be estimated using first differences so that the FEs drop out – otherwise there would be more than 4,000 dummy variables to be estimated. The DD estimator can be interpreted as a fixed effects estimator that uses only aggregate (group level) data. This means that the DD estimator uses differencing at the group level (LRB=1 or 0), not at the municipal level as in the FE approach. Because local level characteristics such as soil quality, temperature and rainfall, and access to markets, are extremely important in agriculture, the FE model does a better job at controlling for differences in these variables across space.[29]

According to Greene (2008), the advantage of first differencing is to remove latent heterogeneity from the model, regardless of the true underlying model: fixed or random effects. The first difference transformation removes from the model any variable that is constant over time. In case we are not interested in the effect of those variables, first differencing is a robust approach that can consistently estimate parameters of the variables that change with time. The error term ε_{mt} can be decomposed into time-invariant (u_m) and time-varying (η_{mt}) components. In this case, we have:

$$Y_{mt} = \alpha_t + \beta * LRB_{mt} + \gamma X_{mt} + u_m + \eta_{mt}, \quad (5)$$

where η is normally distributed mean zero error term, *X* represents the vector of time varying control variables and *LRB* is an indicator variable that equals one if there was at least one LRB in the municipality (m) in 2006. If we lead this equation forward by one period, we have:

$$Y_{m(t+1)} = \alpha_{t+1} + \beta * LRB_{m(t+1)} + \gamma X_{m(t+1)} + u_m + \eta_{m(t+1)}, \quad (6)$$

taking (6) – (5), we have:

[29] In the future the plan is to include microregion dummies in the DD model in order to better control for unobserved local characteristics that are constant over time.

$$\Delta Y_m = \Delta\alpha + \beta * \Delta LRB_m + \gamma \Delta X_m + \Delta\eta_m. \quad (7)$$

In this way, the time invariant unobservable characteristics at the municipality level are removed (Wooldridge, 2002). The β coefficient shows if the creation of LR settlements contributed to changes in land productivity. [30]

b) Intensity of treatment based on the share of beneficiaries in each municipality or the time of existence of land reform settlements

The analysis with panel data will be based on three different definitions of treatment, including the binary *LRB* measure. The other two measures seek to evaluate if there is a non-linear relationship between intensity and the outcome variable. Intensity is going to be measured as the share of LRBs within each municipality and as the average time of existence of LR settlement projects.

The first measure of intensity is the binary treatment approach:

$$LRB_m = 1, if\ there\ was\ at\ least\ one\ LRB\ in\ the\ municipality\ m,$$
$$LRB_m = 0, otherwise.$$

A more flexible approach would be to specify a non-linear parametric function, or to include a family of variables that allow for non-linear effects. Thus, the second and third measures allow for the possibility that the relationship between the treatment and its outcome might be non-linear. If, for example, the effects of LR on land productivity take 10 years from the creation of the settlement project to materialize, then estimates with a linear specification may understate the average treatment effect. Non-linear impacts, with aggregate data, can also be seen in terms of the percentage of beneficiaries. Non-linearities can occur simply due to the composition of farms in a municipality if LRB are different from other farms. If, for example, the productivity of LRB grows faster over time than that

[30] Size specific models can be estimated for small, medium, and large farms. Estimates for small farms are presented in the end of this chapter. In the future the plan is to extend the above models to explore different impacts across farm sizes. Small farms would be impacted directly as a result of the creation of LR settlements. Large farms would be impacted both by redistributing unproductive farms and through indirect impacts on the non-reform sector. For example, large farms that are not expropriated might be frightened into making defensive investments that increase productivity in order to avoid possible expropriation in the future. The direction of impact on medium size farms is unclear.

of owners, a higher share of LRB in a municipality should lead to faster productivity growth. Another possibility relates to the possibility of spillover effects due to the concentration of beneficiaries in a certain area. For example, municipalities where less than 10% of establishments were created by land reform can have effects on productivity or poverty different than municipalities where LRBs represent 50% of the establishments.

Land reform usually happens for groups, so that finding only one LRB in a municipality is uncommon. The balanced[31] panel data set with municipalities that were present both in the 1985 and 2006 Agricultural Censuses shows that only 449 (or 11%) of a total of 4049 municipalities had only one LRB. The total number of municipalities that had LRBs was 2,645. Most municipalities with LRBs had less than 10% of establishments that were obtained through land reform (Table 5.4). However, there were many municipalities with a higher concentration of LRBs. The geographical concentration of beneficiaries can contribute to potentiate the effects of land reform. The use of non-linear measures that consider the share of beneficiaries within municipalities might allow us to isolate the effect on the municipalities that were impacted most. This might get swamped in a linear specification that has a concentration of municipalities with either no LRBs (35% of the total), or with only 1-10% LRBs (47% of the total), where the effects of land reform are expected to be small.

In light of the above discussion, the second measure of intensity relies on a set of dummy variables based on the share of establishments treated in 2006.[32] INT_m is defined as the intensity of treatment observed in a given municipality (m):

$$INT_m = \frac{\sum LRB_m^{2006}}{\sum estab_m^{2006}} \tag{8}$$

In this case, the DD would be estimated through the following equation:

[31] There were 4,105 and 5,547 municipalities in the 1985 and 2006 Agricultural Censuses, respectively. However, many municipalities were created in the interval between these years. The use of minimum comparable areas (AMC), from IBGE, preserves data on municipalities that were not part of the sample in both of the years. AMCs are going to be used in the future.

[32] Another alternative is to calculate intensity as the share of establishments treated among small farms in the municipality. Most LRB are small. This approach will be discussed further below.

$$Y_{mt} = \alpha + \beta * time_t + \gamma * LRB + \pi LRB1\_10\%_{mt} + \lambda LRB11\_20\%_{mt} + \phi LRB21\_30\%_{mt} + \tau LRB31\_40\%_{mt} + \theta LRB40\%_{mt} + \delta X_{mt} + \varepsilon_{mt}. \quad (9)$$

Where the dummy variables *LRBx_y%* were constructed from INT_m as follows: *LRB1_10%* is a dummy for municipalities where up to 10% of establishments were LRBs, *LRB11_20%* is for municipalities where more than 10% and up to 20% of establishments were LRBs, *LRB21_30%* is for municipalities where more than 20% and up to 30% of establishments were LRBs, *LRB31_40%* is for municipalities where more than 30% and up to 40% of establishments were LRBs, and *LRB40%* is for municipalities where more than 40% of establishments were LRBs.[33] Thus the intensity of treatment dummies replace the interaction term-- $\pi(time * LRB)_m$ --in the binary treatment DD model in order to capture the potential heterogeneous impacts of treatment. These indicator variables measure the non-linear effects of the concentration of settlement projects. Since settlement projects tend to be created in specific areas, this analysis is important. For the FE model, the equivalent intensity of treatment equation is:

$$\Delta Y_m = \Delta\alpha + \pi\Delta LRB1\_10\%_m + \lambda\Delta LRB11\_20\%_m + \phi\Delta LRB21\_30\%_m + \tau\Delta LRB31\_40\%_m + \theta\Delta LRB40\%_m + \delta\Delta X_m + \Delta\eta_m. \quad (10)$$

Programs do not necessarily attain full steady-state effectiveness after implementation commences. Learning by providers and beneficiaries may take time, transformation of relationships of accountability may not happen immediately, or the behavioral responses may be slow in becoming apparent. The observable gains from a social program after only a few years of implementation may not represent an accurate estimate of its full potential impact for reasons that are external to the program design (King and Behrman, 2009). This is even more true in the case of land reform where investments in infrastructure, land preparation, and machinery do not necessarily take place immediately, and can take time to have an impact.

[33] Data from the 2006 Agricultural Census shows that 35% of municipalities had no LRBs, 47% had up to 10% of establishments as LRBs, 8% of municipalities had more than 10% and up to 20% of LRBs, and 10% of them had more than 20% of establishments as LRBs. In some macro regions, the concentration of LRBs was substantially higher. In the North and Northeast, 5% of municipalities had over 40% LRBs, and in the Center-West this figure rose to 10%.

Therefore, the third measure of intensity is a set of dummy variables related to the average time of existence of land reform settlement projects in each municipality (m). Average time of existence was calculated with data from INCRA on the number and date of creation of settlement projects in each municipality. This is based on the average number of years of existence of settlement projects in each municipality.[34] In this case, the DD would be estimated through the following equation:

$$Y_{mt} = \alpha + \beta * time_t + \gamma * LRB_m + \phi LRB5_{mt} + \pi LRB6\_10_{mt} + \lambda LRB11\_15_{mt} + \theta LRB16_{mt} + \delta X_{mt} + \varepsilon_{mt} \quad (11)$$

Where *LRB5* is an indicator variable for municipalities with land reform settlements that have an average of five or less years of existence in 2006 (which only includes municipalities with at least one LRB), *LRB6_10* is for municipalities with settlements that have an average of six to ten years of existence, *LRB11_15* is for municipalities with eleven to fifteen years, and *LRB16* is for municipalities that have settlements that on average were created more than sixteen years prior to 2006. These indicator variables measure the effect of increasing years of existence of the settlement without assuming that the effects increase in a linear fashion. It is expected that the impact of being a land reform beneficiary for less than six years, for instance, is smaller than the impact of being a land reform beneficiary for more than sixteen years.[35]

It is important to note that the number of establishments in each municipality was used to weight all difference-in-differences and fixed effects regressions.

5.2. Panel Data Results

Table 5.1 compares municipalities with and without land reform in Brazil and macro regions in the baseline (1985). The more similar the observations are in the baseline,

[34] In future research I plan to construct an alternative estimate of average time of existence based on the 2006 Census question for "time in charge of the establishment." This was shown in Chapter 4 to be positively correlated with land productivity.

[35] Another planned extension is to estimate a model that measures intensity as the joint impact of the share of beneficiaries in each municipality and the average time of existence of the settlements. Thus, a municipality with 30% LRBs and settlements that were created more than 15 years ago should be expected to have a larger impact on productivity than a municipality with the same share of LRBs but settlements that were created less than 5 years ago.

the better is the control group, and the more likely it is that the differences observed in 2006 are a result of the intervention (in this case, the creation of land reform settlements). When the two groups are not similar in the baseline, the DD approach controls for these differences though groups specific intercepts and with the time varying controls in X. The FE approach removes the time invariant differences at the municipal level, and controls for the time varying differences with the vector X. The municipalities with and without land reform were quite similar in the North, but not in the other macro regions.

For Brazil as a whole, Table 5.1 shows that land reform happened in locations that had: a higher share of very small and large farms, substantially less access to infrastructure (as measured by electricity), establishments that were less technologically advanced, and considerably lower land productivity. In fact, municipalities with and without land reform in 2006 only had land productivity that was statistically equal in 1985 in the North and South. In the Northeast, Southeast and Center-West, land productivity was lower in 1985 in municipalities where settlement projects were subsequently created. The baseline difference in these macro regions was as low as 36% in the Southeast and as high as 56% in the Center-West. Therefore, if LR were associated with more rapid productivity growth after 1985, it might only reduce the gap in relation to the other municipalities.

These differences in the baseline can be controlled for through matching based on 1985 data as well as by testing for "parallel trends" in key variables prior to 1985. This approach is going to be adopted in future research. In the present analysis, the baseline variables in Table 5.1 are going to be used as controls in the regressions.

Table 5.2 compares the two groups of municipalities in 1985 and 2006 at the level of Brazil. The farm size distributions change very little over time, even when they are statistically significant in some cases. Access to electricity grew much more rapidly in municipalities with LR (289% vs. 131%), while use of technical assistance nearly doubled in both groups. Access to credit rose by around 20% where LR took place, and fell slightly where it did not. In general, the use of technology and inputs increased, although there was a significant decline in the share of establishments using pesticides in both groups. Finally, land productivity in municipalities without land reform increased by R$307 between 1985 and 2006, whereas it only grew by R$236 in municipalities with land reform. This is suggestive of a possible adverse impact of land reform. It represents an unconditional DD

estimate of R$ -70.83. But there are many factors that need to be controlled for before such a conclusion can be reached.

Table 5.1- Descriptive statistics of municipalities with and without land reform in Brazil and macro regions in 1985

	Brazil		North		Northeast	
Variables	No LR after 1985 (LRB=0)	With LR after 1985 (LRB=1)	No LR after 1985 (LRB=0)	With LR after 1985 (LRB=1)	No LR after 1985 (LRB=0)	With LR after 1985 (LRB=1)
Farm Size (Share of establishments in each class)						
0-5	0.23***	0.34	0.20	0.20	0.47***	0.54
5-10	0.13*	0.13	0.09	0.09	0.13***	0.11
10-20	0.16***	0.14	0.12	0.11	0.11***	0.10
20-50	0.20***	0.17	0.23	0.19	0.12*	0.11
50-100	0.10***	0.09	0.13	0.14	0.06	0.06
100-500	0.12***	0.11	0.17	0.21	0.07**	0.06
500-	0.02***	0.04	0.07	0.06	0.01**	0.02
Access to institutions/public goods						
Credit	0.15**	0.15	0.04	0.03	0.11	0.10
Electricity	0.36***	0.19	0.02	0.02	0.08***	0.06
Technical Assistance	0.20*	0.14	0.03	0.03	0.05	0.04
Cooperatives	0.25***	0.18	0.04	0.02	0.07**	0.06
Technology and inputs						
Average value of machines and vehicles	11807.9***	7140.63	3427.32	2595.43	5378.74*	1793.59
Irrigation	0.07***	0.04	0.01	0.00	0.03	0.04
Fertilization	0.60***	0.35	0.07	0.06	0.18*	0.16
Limestone	0.14***	0.07	0.01	0.01	0.01	0.01
Pesticide	0.77***	0.61	0.47**	0.30	0.54***	0.45
Agricultural practices	0.25***	0.15	0.01	0.01	0.03	0.03
Land Productivity	643.27***	394.99	162.49	170.45	396.02***	285.16

Table 5.1 - Descriptive statistics of municipalities with and without land reform in Brazil and macro regions in 1985 (continuation)

	Southeast		South		Center-West	
Variables	No LR after 1985 (LRB=0)	With LR after 1985 (LRB=1)	No LR after 1985 (LRB=0)	With LR after 1985 (LRB=1)	No LR after 1985 (LRB=0)	With LR after 1985 (LRB=1)
Farm Size (Share of establishments in each class)						
0-5	0.18	0.19	0.22	0.21	0.10*	0.13
5-10	0.13	0.13	0.17*	0.19	0.08	0.08
10-20	0.16**	0.16	0.25	0.24	0.10	0.09
20-50	0.22***	0.22	0.23*	0.22	0.19***	0.17
50-100	0.12*	0.12	0.07	0.07	0.15***	0.12
100-500	0.14*	0.15	0.04***	0.06	0.27**	0.24
500-	0.02***	0.04	0.01***	0.02	0.10***	0.16
Access to institutions/public goods						
Credit	0.15	0.16	0.26**	0.29	0.12	0.13
Electricity	0.41***	0.34	0.56***	0.42	0.22***	0.14
Technical Assistance	0.21**	0.19	0.34	0.32	0.17	0.15
Cooperatives	0.28***	0.24	0.40**	0.46	0.16	0.15
Technology and inputs						
Average value of machines and vehicles	14137.83	12363.94	10125.16	10730.82	12320.25***	18394.92
Irrigation	0.10	0.09	0.06***	0.04	0.04***	0.02
Fertilization	0.70*	0.59	0.70***	0.64	0.55***	0.35
Limestone	0.17***	0.15	0.17*	0.16	0.05	0.06
Pesticide	0.81***	0.77	0.85	0.84	0.86***	0.77
Agricultural practices	0.31***	0.27	0.31**	0.37	0.21***	0.12
Land Productivity	744.18***	548.54	745.12	684.87	183.25***	117.05

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Means are presented for land productivity and average value of machines and vehicles only.
For all other variables, the share of establishments within the municipalities is presented.
(Stars indicate that the mean for municipalities where land reform settlements were created is statistically significantly different from municipalities where no settlement project was created, where: ***Significant at 1%; ** Significant at 5%; * Significant at 10%).

Table 5.2 – Descriptive statistics for 1985 and 2006 on municipalities with and without land reform, Brazil

	With LR after 1985 (LRB=1)		No LR after 1985 (LRB=0)	
Variables	1985	2006	1985	2006
Farm Size (Share of establishments in each class)				
0-5	0.34	0.34	0.23***	0.26
5-10	0.13	0.13	0.13***	0.14
10-20	0.14***	0.15	0.16	0.17
20-50	0.16***	0.17	0.20***	0.20
50-100	0.09	0.08	0.10***	0.10
100-500	0.10***	0.09	0.12***	0.11
500-	0.03*	0.03	0.03	0.03
Access to institutions/public goods				
Credit	0.15***	0.18	0.16	0.15
Electricity	0.19***	0.74	0.36***	0.83
Technical Assistance	0.14***	0.27	0.20*	0.38
Cooperatives	0.17***	0.12	0.25*	0.18
Technology and inputs				
Average value of machines and vehicles	7140.62***	19095.39	11807.9***	33177.64
Irrigation	0.04	0.07	0.07***	0.10
Fertilization	0.35***	0.38	0.60	0.52
Limestone	0.07***	0.18	0.14***	0.30
Pesticide	0.60***	0.31	0.77***	0.33
Agricultural practices	0.15***	0.60	0.25***	0.56
Land Productivity	394.98***	630.85	643.27***	949.97

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Means are presented for land productivity and average value of machines and vehicles only.
For all other variables, the share of establishments within the municipalities is presented.
(Stars indicate that the mean for 2006 is statistically significantly different from 1985, according to LRB status, where: ***Significant at 1%; ** Significant at 5%; * Significant at 10%)

Table 5.3 shows the number of municipalities in the panel data set. The 2006 Agricultural Census had 5,547 municipalities. 1457 of these were not present in 1985. Thus, the balanced panel used in this section has 4,090 municipalities. The sample has 2,645 municipalities that had establishments obtained through land reform (with or without land title), and 1,445 where there was no establishment obtained through land reform. These are the two main groups compared in this section: LRB=1 and LRB=0, respectively. It is important to note that these groups were created with data from the 2006 Agricultural Census. If we consider data from INCRA, the number of municipalities with at least one land reform settlement project in the balanced panel is only 1,312.

Table 5.3 – Number of municipalities in Brazil in the panel data set

	Total in 2006	Not in 1985	Panel
Total of municipalities	5547	1457	4090
With land reform settlement project (LRB=1)	3668	1023	2645
With land reform settlement project with title (LRBt=1)	2474	711	1763
With land reform settlement project without title (LRBw=1)	3303	902	2401
With land reform settlement project (INCRA)	1823	511	1312

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

The 4,090 municipalities are distributed across categories defined by the share of land reform beneficiaries among all agricultural establishments. Table 5.4 shows that most municipalities in the North, Northeast and South had greater than 0 but less than 10% of land reform beneficiaries. It is interesting to note the existence of municipalities where more than 50% of the agricultural establishments were obtained through land reform. This situation occurred in 6% of municipalities in the Center-West and 2% in the North and Northeast. Table 5.5 shows that among municipalities that had LR settlements, on average 9% of establishments were obtained through land reform in Brazil. This average reaches 18% in the Center-West, where there were municipalities with 83% of establishments obtained through land reform.

Table 5.4 – Percentage of municipalities across intensity categories - % of LRB

	Brazil	North	Northeast	Southeast	South	Center-West
No LRB	0.35	0.06	0.18	0.63	0.28	0.29
LRB 0-10%	0.47	0.56	0.58	0.31	0.61	0.34
LRB 10-20%	0.08	0.20	0.11	0.03	0.07	0.12
LRB 20-30%	0.04	0.09	0.05	0.01	0.03	0.09
LRB 30-40%	0.02	0.05	0.03	0.01	0.01	0.05
LRB 40-50%	0.02	0.03	0.03	0.01	0.01	0.04
LRB>50%	0.01	0.02	0.02	0.01	0.00	0.06
Total	4090	246	1384	1400	753	307

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Note: Share of LRB calculated with data from the 2006 Agricultural Census

Table 5.5 – Intensity of land reform: Descriptive statistics on the percentage of LRB in municipalities with settlements

	Brazil	North	Northeast	Southeast	South	Center-West
Average	0.09	0.12	0.09	0.06	0.04	0.18
Standard deviation	0.13	0.14	0.13	0.13	0.08	0.19
Maximum	0.89	0.69	0.75	0.89	0.64	0.83
Total of municipalities	2645	232	1133	523	540	217

Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Note: Share of LRB calculated with data from the 2006 Agricultural Census

Table 5.6 shows the average time of existence of land reform settlements across municipalities. In this case, the number of land reform beneficiaries and the date of creation are from INCRA. About half of the municipalities with land reform in Brazil had settlements that existed for 6 to 10 years on average. 7% of municipalities in Brazil, and 15% in the North, had settlements with an average age larger than 10 years. All macro regions had municipalities in all 4 categories. Therefore, it will be important to evaluate if there is a productivity difference across those categories. The hypothesis is that more time as a beneficiary might contribute to increased productivity.

Table 5.6 – Percentage of municipalities across intensity categories - average time of existence as of 2006

	Brazil	North	Northeast	Southeast	South	Center-West
No LRB (INCRA)	0.68	0.36	0.53	0.86	0.79	0.52
<5 years	0.10	0.22	0.16	0.05	0.03	0.13
6-10 years	0.16	0.28	0.24	0.06	0.11	0.26
11-15 years	0.05	0.10	0.06	0.02	0.05	0.07
>15 years	0.02	0.05	0.02	0.01	0.02	0.02
Total	4090	246	1384	1400	753	307

Source: Author‘s calculation with INCRA data on settlement projects and 2006 Agricultural Census on number of establishments.

Note: Time of existence calculated with data from INCRA on number and date of creation of settlement projects

Table 5.7 – Intensity of land reform among municipalities with settlement projects (average time of existence in years)

	Brazil	North	Northeast	Southeast	South	Center-West
Average	7.34	7.67	6.83	7.66	8.82	7.21
Standard deviation	4.78	5.72	4.00	6.68	4.46	3.80
Minimum	0.12	0.38	0.12	0.14	0.59	0.64
Maximum	53.36	34.06	22.00	53.36	24.93	20.59
Total of municipalities	1312	158	657	190	160	147

Source: Author‘s calculation with INCRA data on settlement projects and 2006 Agricultural Census on number of establishments.

Note: Time of existence calculated with data from INCRA on number and date of creation of settlement projects

The results of the panel data set models are presented in Tables 5.8 to 5.12 (fixed effects model) and 9A to 12A (difference-in-difference model, in the appendix). Tables 5.8 through 5.12 each show three different specifications of the fixed effects model. The first column presents the results only with the land reform variables – either binary or intensity. The second column includes the change in shares of establishments in the

farm size classes. The last column also includes potentially endogenous variables, including access to institutions and public goods, as well as use of technology and inputs. The preferred specification is the one that does not include endogenous variables, which is the second column.

Table 5.8 displays the results of the regression with first differenced variables; land reform is included as a binary variable. Municipalities with land reform settlements appeared to have had slightly slower growth in land productivity from 1985 to 2006. However, this result is not statistically significant in any of the models. The results are quite consistent with the estimated coefficients from the DD model, Table 9A in the appendix. The results of the preferred specification across macro regions (not shown here) show positive and insignificant effects.

This impact of land reform is further investigated with regressions that consider different intensities of land reform across municipalities. Table 5.9 shows that land productivity grew less quickly in municipalities with land reform beneficiaries than in municipalities without land reform. According to the preferred specification, the increase of land productivity in municipalities where 40% of establishments were LRBs was R$59.62 below the increase in municipalities without LRBs. The difference, however, was not statistically significant in municipalities where less than 40% of establishments were obtained through land reform. The differences in the growth of land productivity remain statistically significant for the group with more than 40% of LRBs even when additional controls are added in column 3.

Table 5.8 – Effects of land reform on land productivity in Brazil – First differences with binary treatment

Variable	(1)	(2)	(3)
d_LRB	-22.17*	-5.28*	-37.98*
	(22.35)	(22.75)	(22.87)
Farm Size (relative to 0-5)			
d_5-10		515.09	498.08
		(182.04)	(174.41)
d_10-20		89.71*	-81.77*
		(137.07)	(128.01)
d_20-50		-545.70	-441.06
		(87.42)	(80.85)
d_50-100		-211.34*	-267.09*
		(156.27)	(144.60)
d_100-500		-82.23*	-422.59
		(149.39)	(142.60)
d_500-		-231.85*	-644.94
		(316.89)	(333.83)
Access to institutions/public goods			
d_Credit			272.24
			(93.27)
d_Electricity			32.96*
			(36.62)
d_Technical Assistance			-49.23*
			(98.64)
d_Cooperatives			-303.40
			(75.60)
Technology and inputs			
d_Average value of machines			0.00
			(0.00)
d_Irrigation			465.05
			(168.42)
d_Fertilization			86.55
			(68.46)
d_Limestone			710.23
			(121.34)
d_Pesticide			221.24
			(38.28)
d_Agricultural practices			38.86*
			(42.90)
Constant	252.11	236.80	157.78
	(19.10)	(19.24)	(40.21)
R2	0.00	0.01	0.10
Observations (Municipalities)	4084	4084	4073

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 5.9 – Effects of land reform on land productivity in Brazil – First differences with intensity measured by % of LRB

Variable	(1)	(2)	(3)
% of LRB (relative to no LRB)			
d_LRB 0-10%	-11.10*	3.38*	-29.36*
	(23.58)	(23.66)	(23.58)
d_LRB 10-20%	-46.07*	-27.41*	-55.11*
	(36.73)	(37.40)	(34.44)
d_LRB 20-30%	-59.46*	-33.62*	-89.06*
	(49.81)	(49.20)	(50.55)
d_LRB 30-40%	-124.73	-81.58*	-113.75
	(35.99)	(39.18)	(40.25)
d_LRB>40%	-51.33*	-59.62	-135.19
	(44.92)	(54.79)	(57.10)
Farm Size (relative to 0-5)			
d_5-10		533.50	517.05
		(182.82)	(175.99)
d_10-20		130.58*	-20.42*
		(134.46)	(126.48)
d_20-50		-489.73	-371.98
		(93.30)	(87.68)
d_50-100		-226.43*	-288.42
		(153.69)	(141.74)
d_100-500		-124.28*	-485.60
		(150.16)	(145.02)
d_500-		-303.86*	-794.21
		(345.54)	(364.90)
Access to institutions/public goods			
d_Credit			257.80
			(94.15)
d_Electricity			34.23*
			(36.58)
d_Technical Assistance			-38.33*
			(98.47)
d_Cooperatives			-308.00
			(75.74)
Technology and inputs			
d_Average value of machines			0.00
			(0.00)
d_Irrigation			474.80
			(168.80)
d_Fertilization			84.73*
			(68.60)
d_Limestone			700.60
			(120.87)
d_Pesticide			227.68
			(39.06)
d_Agricultural practices			40.69*
			(42.91)
Constant	252.11	237.00	158.76
	(19.11)	(19.27)	(40.41)
R2	0.00	0.02	0.10
Observations (Municipalities)	4084	4084	4073

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 5.10 displays the results of the fixed effects regressions for the North. As discussed above, this was the one macro region with a statistically significant gain for the municipalities with LRB according to the binary fixed effects model. The preferred specification in column 2 shows that municipalities with more 10 to 20% of establishments that are LRB had a larger increase in land productivity between 1985 and 2006 compared to municipalities without LRB. However, these differences disappear once a fuller set of controls is included in column 3. This suggests that differences in the (endogenous) variables included in column 3 help to explain why land productivity grew more quickly in the municipalities with higher concentrations of LRB.

Table 5.11 presents the results for the Northeast. Changes in land productivity in municipalities where less than 10% or more than 20% of the establishments were LRBs were statistically equal to changes in municipalities where there was no beneficiary. However, the preferred specification indicates that land productivity in municipalities with 10% to 20% of beneficiaries increased by R$136.21 more than productivity of municipalities without LRBs. 152 municipalities were part of this group in the Northeast. This positive and significant relationship between land reform intensity and land productivity was only seen in the North and Northeast.

Table 5.10 – Effects of land reform on land productivity in the North – First differences with dummy variables for intensity of treatment

Variable	(1)	(2)	(3)
% of LRB (relative to no LRB)			
d_LRB 0-10%	14.02*	74.77*	24.26*
	(56.44)	(48.37)	(66.80)
d_LRB 10-20%	43.65*	81.01	41.01*
	(50.75)	(41.23)	(63.53)
d_LRB 20-30%	12.30*	0.09*	-14.61*
	(40.31)	(47.64)	(80.02)
d_LRB 30-40%	54.78*	64.45*	13.28*
	(53.36)	(48.79)	(67.42)
d_LRB>40%	56.85*	121.31*	75.58*
	(64.33)	(74.48)	(91.27)
Farm Size (relative to 0-5)			
d_5-10		556.31*	503.52*
		(393.64)	(403.17)
d_10-20		-287.33*	-208.27*
		(234.37)	(233.26)
d_20-50		-473.14	-431.65
		(132.93)	(138.94)
d_50-100		-491.94	-463.46
		(206.52)	(199.70)
d_100-500		-440.32	-390.77
		(197.31)	(194.64)
d_500-		-574.26	-741.56
		(201.49)	(268.03)
Access to institutions/public goods			
d_Credit			120.62*
			(239.93)
d_Electricity			9.36*
			(84.57)
d_Technical Assistance			-46.86*
			(192.22)
d_Cooperatives			830.18
			(439.43)
Technology and inputs			
d_Average value of machines			0.00*
			(0.00)
d_Irrigation			1069.57*
			(635.50)
d_Fertilization			340.64*
			(243.07)
d_Limestone			-163.66*
			(423.24)
d_Pesticide			-38.90*
			(81.12)
d_Agricultural practices			52.41*
			(95.09)
Constant	20.44*	-29.80*	-75.35*
	(35.99)	(25.37)	(85.21)
R2	0.00	0.17	0.25
Observations (Municipalities)	246	246	239

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 5.11 – Effects of land reform on land productivity in the Northeast – First differences with dummy variables for intensity of treatment

Variable	(1)	(2)	(3)
% of LRB (relative to no LRB)			
d_LRB 0-10%	45.51*	46.15*	43.23*
	(42.04)	(41.89)	(41.30)
d_LRB 10-20%	120.33	136.21	120.49
	(63.87)	(64.67)	(56.28)
d_LRB 20-30%	134.34*	129.04*	98.24*
	(96.69)	(86.42)	(91.27)
d_LRB 30-40%	38.60*	39.70*	-32.39*
	(64.89)	(76.74)	(84.00)
d_LRB>40%	65.53*	40.34*	-31.86*
	(66.82)	(92.43)	(97.09)
Farm Size (relative to 0-5)			
d_5-10		136.98*	131.96*
		(233.73)	(220.11)
d_10-20		-382.52*	-371.98*
		(221.10)	(232.58)
d_20-50		-233.03*	-149.51*
		(184.85)	(194.85)
d_50-100		577.50*	611.31*
		(518.32)	(490.15)
d_100-500		-850.43*	-574.00*
		(674.59)	(596.52)
d_500-		-1947.54*	-4927.18*
		(2800.84)	(2629.75)
Access to institutions/public goods			
d_Credit			-43.52*
			(135.61)
d_Electricity			263.58
			(50.43)
d_Technical Assistance			-32.60*
			(151.76)
d_Cooperatives			-306.94*
			(246.72)
Technology and inputs			
d_Average value of machines			0.00
			(0.00)
d_Irrigation			908.76*
			(500.34)
d_Fertilization			492.16
			(117.94)
d_Limestone			219.53*
			(389.81)
d_Pesticide			62.03*
			(52.80)
d_Agricultural practices			52.80*
			(68.68)
Constant	115.82	109.59	-128.66
	(38.78)	(39.00)	(65.75)
R2	0.00	0.02	0.09
Observations (Municipalities)	1,383	1,383	1,381

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 5.12 displays the results of fixed effects models for the South. Land productivity in municipalities where 10% to 20% or more than 30% of establishments were LRBs increased less than municipalities with no LRBs. According to the second specification, having 10% to 20% of establishments as LRB in 2006, in comparison to no LRB at all, was associated with slower growth in land productivity by R$159.66 between 1985 and 2006.

Table 5.12 – Effects of land reform on land productivity in the South – First differences with dummy variables for intensity of treatment

Variable	(1)	(2)	(3)
% of LRB (relative to no LRB)			
d_LRB 0-10%	87.19*	84.29*	33.30*
	(61.20)	(57.47)	(55.49)
d_LRB 10-20%	-151.91	-159.66	-77.21*
	(74.39)	(83.52)	(75.97)
d_LRB 20-30%	-178.82	-187.37*	-86.25*
	(81.25)	(105.19)	(91.61)
d_LRB>30%	184.63*	-57.88*	75.64*
	(217.67)	(240.89)	(206.42)
Farm Size (relative to 0-5)			
d_5-10		2104.36	807.36*
		(755.57)	(705.15)
d_10-20		1381.80	261.35*
		(447.10)	(427.07)
d_20-50		-936.01	-701.67*
		(411.50)	(375.01)
d_50-100		884.11*	-1786.51 *
		(1074.05)	(1037.17)
d_100-500		-2100.57	-2221.15
		(848.69)	(785.23)
d_500-		475.97*	1312.30*
		(1497.09)	(1188.09)
Access to institutions/public goods			
d_Credit			491.38
			(169.05)
d_Electricity			-462.30
			(105.06)
d_Technical Assistance			-300.19
			(140.84)
d_Cooperatives			-175.59*
			(122.57)
Technology and inputs			
d_Average value of machines			0.00
			(0.00)
d_Irrigation			791.55
			(420.85)
d_Fertilization			112.62*
			(189.09)
d_Limestone			-32.56*
			(131.93)
d_Pesticide			598.88
			(101.15)
d_Agricultural practices			295.97
			(108.27)
Constant	404.31	446.40	630.53
	(53.41)	(51.03)	(80.20)
R2	0.02	0.09	0.23
Observations (Municipalities)	752	752	752

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

It is interesting to note that moving from the second to the third specification often reduces the benefits of land reform. This sheds light on the channels through which the effects are generated. In the North, for instance, land productivity of municipalities with LRBs increased more, and this is significant in the intensity category 10-20%. However moving from column 2 to column 3, the advantages fall and become statistically zero. This means that differences in all variables controlled for in specification 3 help to explain why municipalities with LRBs look superior in specification 2. Those municipalities must have had superior access to credit, electricity, cooperatives, and other variables that boost productivity. When regressions do not control for these variables, municipalities with LRBs appear superior. When regressions control for them, the difference disappears. This helps to explain what is included in the LR package, and how the components contribute to changes in productivity.

However, this does not happen in the South, where land reform appears to be related to slower growth in land productivity. The negative relationship with land reform intensity declines as we move from column 2 to column 3 in Table 5.16, and becomes statistically insignificant. This means that municipalities with LRBs improve productivity because of access to some institutions and public goods, and use of inputs. In fact, descriptive statistics show that use of credit and electricity in the South, compared to municipalities with no LRBs, increased more in the municipalities with LRB. The different results for the South, in the cross section and also in the panel data analysis, must be better investigated.

As for the control variables, the effect of changes of land structure on land productivity was either low or non-significant in most of the fixed effects models. This reflects the fact that there were not big changes in the composition of area in Brazil between 1985 and 2006. Access to institutions and public goods, and use of technology and inputs rarely had negative and significant relationships with land productivity. As expected, it was more common to find a positive correlation, whether significant or not.

The difference-in-differences and fixed effects models showed similar results. On average, the existence of land reform beneficiaries in a municipality does not seem to play a large role in explaining differences in land productivity. Therefore, with some exceptions, municipalities with land reform beneficiaries did not appear to exhibit better or worse performance between 1985 and 2006 than municipalities without LRBs. However, when we looked for heterogeneous effects across macro regions and

intensities, a number of relationships between land reform intensity and land productivity appeared in both the difference in difference and fixed effects estimates. There was no consistent behavior across macro regions. Besides, access to institutions and public goods, and use of technology and inputs contribute to explain changes of land productivity. Further evaluation of the heterogeneous situations is necessary in order to identify possible reasons for the differences across macro regions. The next step of this research is going to deal with effects of land reform on establishments in small size group. By doing this disaggregation, we have a better chances of identifying where the effects really took place.

In a complementary way, the DD results are presented in the appendix. Tables 9A-12A all display four different specifications, and the preferred one is in the third column. Time and treatment (LRB) dummies were included in all specifications. The first column in the tables shows the results from a specification without control variables. Starting with the second column, state fixed effects were included. Starting in the third column, the share of establishments in the farm size classes was included. The last column also includes access to institutions and public goods, as well as use of technology and inputs. This last specification includes endogenous variables related to production decisions. It helps us to understand what factors contribute to the estimated differences in productivity between the two groups of municipalities, but it should not be used for inference on the impact of the program. Therefore, the third column represents the preferred specification.

Table 7A displays the results for the binary DD estimation for Brazil, which compares land productivity in the group of municipalities that did not have LRB to the group of municipalities that had at least one LRB. The first column shows the unconditional DD of R$ -7.66. The inclusion of municipality fixed effects led to a positive but insignificant relationship between land reform and land productivity. The results in columns 3 and 4 show a consistently negative but statistically insignificant relationship between these two variables, irrespective of the specification. The regressions ran separately for the macro regions show similar results.

Table 10A shows the effect of land reform when the intensity of treatment variables are used. These are based on the share of land reform beneficiaries in each municipality. Results in column 1 and 2 suggest that an increase in the concentration of land reform beneficiaries contributed to reduce land productivity. According to

specification 1, the growth in land productivity for the group of municipalities where 30-40% of the establishments originated from land reform was R$259.64 smaller than the growth in the group with no LRB. However, this model does not include state fixed effects nor does it control for changes in the distribution of farm size over time. The coefficients of LR intensity become smaller and non-significant, as more control variables are included in specifications 2, 3 and 4. In the preferred specification (model 3), the coefficients on all of the intensity variables remain negative but none are statistically significant at the 5% level. Furthermore, the R2‘s across specifications suggest that the control variables explain land productivity better than the share of land reform beneficiaries within the municipalities.

Table 11A displays the results for the second DD intensity of treatment approach for Brazil. The intensity of land reform is defined here by the average time of existence of settlement projects per municipality. Columns 1, 2 and 3 of Table 5.10 suggest that municipalities with older land reform settlement projects might have had lower land productivity growth than municipalities where there were no land reform beneficiaries. The difference is significant for average time of existence between 0 and 15 years. In the preferred specification (model 3), municipalities that had beneficiaries that existed for less than 15 years, on average, had lower land productivity growth than municipalities with no LRB at all. Similar and insignificant results were found in macro regions, except in the South where the estimated coefficients were negative and significant in all models. Because the time of existence of settlements seems to matter more in the South, these results are shown in Table 12A. The preferred specification in column 3 shows that land productivity of the group of municipalities with settlement projects created more than 15 years before 2006 grew by R$441.48 less than the group with no projects at all.

The negative correlation should be further investigated. The expectation was that time as a beneficiary would facilitate the learning process and permit increased investment, thus contributing to a higher level of productivity. A possible explanation could be the different process to establish the settlements throughout time. Until 2000, the beneficiaries used to receive delayed resources to install the settlement and the productive projects. The newest settlements might have better productivity due to a more efficient system to establish the productive structure.

5.3. Differential Effects of Land Reform on Small Farms

Tables 5.13 - 5.17 show the results of regressions run for small farms at the municipal level. Small is defined according to the size of settlements created in each macro. The cutoffs for small farms attempted to analyze a group that includes more LRB. Therefore, establishments with less than 50 hectares are part of the small farms in the Northeast, Southeast and South. In the North and Center-West, 100 hectares is the cutoff for small farms.

These regressions compare groups of small farms across municipalities according to the share of LRB.

Table 5.13 presents the results for the fixed effects estimates for small farms at the municipal level in Brazil. Land productivity of small farms in municipalities where more than 40% of establishments were LRB increased less than small farms in municipalities with no LRB. The second specification shows that having more than 40% of small establishments as LRB in 2006, in comparison to no small LRB at all, was associated with slower growth in land productivity of small farms between 1985 and 2006. It is interesting to note that the slower productivity growth of small farms with more than 40% of LRB remains even when the regression controls for change in access to institution and use of technology and inputs (column 3). Thus, the impact of LR on small farms appears to be driving the municipal level results observed in Table 5.13.

On the other hand, land productivity of small farms in municipalities with less than 10% of LRB increased faster than small farms with no LRB. According to the second specification, having less than 10% of establishments as LRB in 2006, in comparison to no LRB at all, was associated with faster growth in land productivity by R$70.19 between 1985 and 2006. However, once again this difference becomes not significant when the regression controls for change in access to institution and use of technology and inputs. In general, comparing the coefficients of specifications (2) and (3) suggests that small farms with LRB possibly had better access to institutions and inputs compared to small farms with no LRB at all.

Table 5.13 – Effects of land reform on land productivity of small farms in Brazil – First differences with intensity measured by % of LRB

Variable	(1)	(2)	(3)
% of LRB (relative to no LRB)			
d_LRB 0-10%	77.24	70.19	-32.93*
	(33.46)	(33.47)	(32.18)
d_LRB 10-20%	81.56*	99.56*	1.27*
	(69.62)	(69.97)	(63.41)
d_LRB 20-30%	-83.77*	-41.87*	-112.8
	(101.37)	(102.94)	(101.7
d_LRB 30-40%	-185.06	-118.03*	-157.8*
	(89.52)	(89.70)	(84.0
d_LRB>40%	-287.14	-221.64	-246.13
	(60.67)	(68.84)	(58.84)
Farm Size (relative to 0-5)			
d_5-10		66.21*	-12.69*
		(238.19)	(224.91)
d_10-20		-499.20	-684.58
		(168.27)	(156.40)
d_20-50		-581.48	-516.36
		(108.94)	(105.84)
d_50-100		-610.09	-465.86
		(127.53)	(113.67)
Access to institutions/public goods			
d_Credit			167.35*
			(132.29)
d_Electricity			195.08
			(61.53)
d_Technical Assistance			-70.50*
			(170.00)
d_Cooperatives			-283.45
			(99.54)
Technology and inputs			
d_Average value of machines			0.00
			(0.00)
d_Irrigation			777.12
			(261.59)
d_Fertilization			73.88*
			(104.01)
d_Limestone			886.40
			(212.90)
d_Pesticide			362.20
			(54.79)
d_Agricultural practices			311.58
			(77.36)
Constant	375.67	399.87	133.92
	(24.89)	(29.29)	(63.31)
R2	0.01	0.03	0.13
Observations (Municipalities)	4073	4073	4073

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Different than other macro regions, the Northeast and the South have significant effects of the share of LRB in the second specification. Therefore, Tables 5.14 and 5.15 present the results for these two macro regions, respectively. According to the second specification, land productivity of small farms in municipalities where 0%-20% of establishments are LRB increased more than small farms in municipalities with no LRB in 2006 in the Northeast. Having 10% to 20% of small establishments as LRB in 2006, in comparison to no small LRB at all, was associated with faster growth in land productivity of small farms by R$388.79 between 1985 and 2006 in the Northeast (Table 5.14). Moving from the second to the third specification decreases the positive effects of land reform. Municipalities with more LRB in the Northeast appear to have had better access to the productivity enhancing institutions, technologies and practices.

The second specification shows that land productivity of municipalities with less than 10% of LRB among small farms increased by R$140.54 more than municipalities with no small LRB in the South (Table 5.15). On the other hand, having 20% to 30% of small establishments as LRB in 2006, in comparison to no small LRB at all, was associated with slower growth in land productivity by R$446.73 between 1985 and 2006.

These differences shrink when the model controls for changes in access to institutions and use of technology and inputs, but it remains statistically significant. Thus, similar to what the results at the municipal level suggested, the productivity growth of municipalities with higher concentrations of LRB would have been even worse had it not been for superior access to some institutions and public goods, and use of inputs.

Table 5.14 – Effects of land reform on land productivity of small farms in the Northeast – First differences with intensity measured by % of LRB

Variable	(1)	(2)	(3)
% of LRB (relative to no LRB)			
d_LRB 0-10%	146.81	121.15	111.24
	(58.84)	(56.01)	(55.21)
d_LRB 10-20%	355.91	388.79	292.15
	(104.60)	(103.68)	(94.54)
d_LRB 20-30%	168.44*	258.16*	164.80*
	(161.98)	(158.33)	(167.18)
d_LRB 30-40%	-11.74*	92.59*	28.20*
	(180.30)	(175.40)	(162.67)
d_LRB>40%	-23.11	16.36*	-58.36*
	(218.85)	(211.93)	(189.45)
Farm Size (relative to 0-5)			
d_5-10		-806.04	-558.91*
		(350.82)	(355.93)
d_10-20		-820.09	-746.43
		(293.01)	(294.90)
d_20-50		67.68*	-78.08*
		(188.58)	(190.91)
d_50-100		-1885.29	-1601.33
		(298.65)	(338.47)
Access to institutions/public goods			
d_Credit			452.58*
			(245.63)
d_Electricity			235.19
			(107.31)
d_Technical Assistance			36.14*
			288.57
d_Cooperatives			-195.57*
			(367.79)
Technology and inputs			
d_Average value of machines			0.00*
			(0.00)
d_Irrigation			1355.08
			(663.63)
d_Fertilization			240.62*
			(187.70)
d_Limestone			840.17*
			(480.90)
d_Pesticide			249.73
			(73.19)
d_Agricultural practices			412.54
			(108.64)
Constant	217.69	314.98	-111.41*
	(52.66)	(57.40)	(114.20)
R2	0.01	0.05	0.11
Observations (Municipalities)	1380	1380	1380

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 5.15 – Effects of land reform on land productivity of small farms in the South – First differences with intensity measured by % of LRB

	(1)	(2)	(3)
% of LRB (relative to no LRB)			
d_LRB 0-10%	130.64*	140.54	-16.89*
	(76.10)	(71.65)	(67.71)
d_LRB 10-20%	-201.77*	-172.59*	-169.59*
	(107.71)	(109.12)	(91.74)
d_LRB 20-30%	-470.90	-446.73	-258.16*
	(141.41)	(153.83)	(138.54)
d_LRB>30%	-162.50*	-107.21*	42.24*
	(144.48)	(161.34)	(161.17)
Farm Size (relative to 0-5)			
d_5-10		2317.32	810.32*
		(839.73)	(803.97)
d_10-20		1045.01	-372.81*
		(502.01)	(509.68)
d_20-50		-1466.40	-1403.04
		(441.81)	(393.20)
Access to institutions/public goods			
d_Credit			224.96*
			(208.75)
d_Electricity			-400.97
			(130.07)
d_Technical Assistance			-327.38*
			188.16
d_Cooperatives			-366.03
			(153.52)
Technology and inputs			
d_Average value of machines			0.00
			(0.00)
d_Irrigation			784.64*
			(493.60)
d_Fertilization			534.44
			(235.08)
d_Limestone			-51.16*
			(191.29)
d_Pesticide			665.00
			(162.05)
d_Agricultural practices			399.83
			(130.40)
Constant	591.36	596.21	662.76
	(65.68)	(62.18)	(106.82)
R2	0.03	0.09	0.24
Observations (Municipalities)	751	751	751

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

The difference-in-differences intensity estimates are presented in the appendix (Tables 13A and 14A). Table 13A shows that the share of LRB among small farms does not seem to contribute to differential land productivity changes between 1985 and 2006

in Brazil. The only statistically significant coefficient on the intensity dummies in specification 3, the preferred one, is positive: the land productivity of small farms in municipalities with 10% to 20% of LRBs grew more quickly than small farms in municipalities with no LRB. Nevertheless, without a clear pattern across intensity groups, it is difficult to read too much into these results. Specifications (1) and (2) show some negative and significant effects for municipalities where more than 40% of small establishments are LRB, as well as some positive and significant effects in municipalities where less than 20% of small establishments are LRB. However, both the inclusion of state fixed effects and variables for farm size classes reduce and convert this effect into a non-significant one.

The South is the one macro region where the share of LRB among small farms appears to have an effect on the growth of land productivity for small farms. Column 3 in Table 14A suggests that the land productivity of small farms in municipalities with more than 10% LRB grew less quickly in comparison to small farms in municipalities with no LRB. The negative effect becomes insignificant in column 4 when the regressions control for access to institutions and public goods, and use of technology and inputs, suggesting that access to these items helped LRB differentially.

The results for small farms are similar to the results at the municipal level. Negative impacts of higher intensity of land reform were found in the intensity of treatment FE model for Brazil and the South both at the municipal level and for small farms. The results differed somewhat for the Northeast, where a positive effect of having 0-10% of LRB was found for small farms, but not at the municipal level. Alternatively, in the North a positive effect of LR was found at the municipal level but not among small farms. This similarity suggests that the results for the small farms are an important force driving the results for the municipalities. This possibility is going to be further investigated with models for medium and large size groups in a continuation of this dissertation.

5.4. Conclusions

This chapter was based on models intended to explain the growth of land productivity with a panel data set from two years: 1985 and 2006. Two approaches were adopted: Fixed effects (FE) and Difference-in-Differences (DD). Municipalities, with

and without land reform beneficiaries (LRB), were studied first. Small farms in municipalities with and without land reform were studied last. Land reform was measured by a binary variable and also by a set of dummy variables that captured the intensity of land reform in each municipality. Intensity was measured by the share of LRB within the municipalities and by the average time of existence of settlements in the municipalities. As with the cross section regressions, there were three, and four, different specifications for the FE and DD models, respectively. The first one is a simple unconditional comparison between municipalities with and without LRB, and the last one is the most complete one. Model 2 is the preferred FE specification, and model 3 is the preferred DD specification because they only include variables that are arguably exogenous.

There were large differences in initial conditions between municipalities where land reform would subsequently happen and those where it would not. In the 1985 baseline, land productivity was 63% higher in municipalities where land reform would not later happen. This was a result of lower land productivity among municipalities that would subsequently be treated in the Northeast, Southeast, and Center-West, and statistically equal productivity in the other two macro regions. Besides, Land reform would happen in municipalities that had substantially higher shares of small farms, were probably more remote (as indicated by much less access to electricity), and had significantly lower utilization of a variety of productivity enhancing technologies.

The descriptive statistics showed that around two thirds of municipalities in the panel had at least some LRB between 1985 and 2006. Around 10% of municipalities had at least 20% of their establishments created through land reform. There were significant differences across macro regions. The Center-West was the macro region with more municipalities that had more than 30% of LRB, and the Southeast was the one with more municipalities that had no LRB at all. As for the time-intensity of reform, the modal class was between 6 and 10 years of existence in Brazil. A comparison across macro regions showed that the North had the largest share of older settlements, but also had the largest share of newly created settlements.

Fixed effects estimates with intensity of treatment generated the most important and interesting results. They showed that the negative effects of land reform on land productivity growth in Brazil tend to be significant when land reform intensity is high

(above 40%). The model also suggests negative effect of lower intensity of land reform, but these were not statistically significant.

The intensity fixed effects model for the North and the Northeast showed more rapid growth for municipalities with 10% to 20% LRB. This either became statistically insignificant (North) or decreased (Northeast) in model 3, which suggests that differential access to institutions and technologies helps to explain the result. On the other hand, the intensity FE estimates in the South show statistically significant slower land productivity growth of municipalities with 10-20% or more than 30% LRB. Again, the effect declines in model 3 and becomes statistically insignificant.

Binary DD models for Brazil showed negative, but insignificant effects of land reform. Intensity of treatment also showed negative effects that tended to grow with intensity, but remained insignificant. The results with intensity based on time showed some significant relationship. The difference is significant for average time of existence between 0 and 15 years in Brazil. Municipalities that had beneficiaries that existed for less than 15 years, on average, had lower land productivity growth than municipalities with no LRB at all. This negative effect of time can be related to different processes of establishing the settlements across time. Newer settlements received better infrastructure and information about the project. At the macro regional level, time had a negative impact on the growth of land productivity in the South.

As in the case of binary DD estimates, binary FE estimates showed negative but insignificant effects for Brazil. The general lack of significant effects could be due to the weakness of binary model—Municipalities with one LRB were lumped together with municipalities with more than 50% LRB. This can be viewed as a form of measurement error, and measurement error is known to bias estimated coefficients toward zero.

The fixed effects model run separately for small farms showed that intensity of land reform had significant negative or positive effects on land productivity in Brazil, depending on the percentage of small LRB. The negative effect was significant for municipalities with more than 40% of LRB among the small farms (model 2). Having more than 40% of small establishments as LRB in 2006, in comparison to no small LRB at all, was associated with slower growth in land productivity of small farms by R$221.64 between 1985 and 2006.

The results also showed significant negative effects for municipalities with 20% to 30% of LRB among the small farms, and significant positive effect for municipalities with more than 0% and less than 10% of LRB in the South. Positive effects were also found in the Northeast: having more than 0% and less than 20% of LRB among small establishments was associated with faster land productivity growth.

Interestingly, having between 10% and 20% of LRB is associated with faster productivity growth in the North and the Northeast, but with lower productivity growth in the South. In the three cases, however, the difference shrinks when the model controls for institutions and input use.

The results for small farms are similar to the results at the municipal level in Brazil. Therefore, the impact of land reform on small farms appears to be driving the municipal level results described above. Finally, access to institutions and public goods, as well as use of technology and inputs seemed to be important to explain productivity differences across municipalities as well among small farms.

6. SUMMARY

The impact of land reform is a very important question in the field of agricultural development, and is perhaps an even more important question for public policy in Brazil. The data and the literature show considerable government enthusiasm with land reform in the 1990‘s and 2000‘s. Nevertheless, the studies on land reform impacts in Brazil are usually restricted to specific regions or groups of beneficiaries, and most of them evaluate beneficiaries based on information from a single point in time. They shed partial light on the impacts, but a more comprehensive evaluation is needed. The present research sought to extend this literature, and improve our understanding of the impacts of land reform in Brazil.

Thus the problem that motivated this research was ―what were the effects of land reform on productivity and income in Brazil, between 1985 and 2006?” Because land reform is a process that may or may not generate income and reduce poverty, measuring the effects of land reform on productivity, income and poverty is essentially an empirical question, which depends on a broad context, consisting of economic, social and politic variables. Land reform represents one among many possible pathways to reduce rural poverty. An important component of success relates to achieving adequate levels of productivity and income generation among the beneficiaries. These are necessary to produce a stream of income for the beneficiaries, and to justify the costs of land expropriation and the creation of settlement projects.

The research problem raised two other key questions that were investigated in this dissertation. The first one is: to what extent are land reform beneficiaries becoming similar to existing small farmers, and thus reproducing the low levels of living standards that exist for a large portion of small farms in Brazil? Alternatively, are they more productive – and less poor – than existing small farmers? The second question follows

the first one. Are land reform beneficiaries becoming more productive – and less poor – because of the whole package of policies accompanying the distribution of land? Or are they less productive – and probably poorer – because of the insufficiency of the policy package or execution of the package? The package of policies includes, among other things, credit, technical assistance, education, and electricity.

This dissertation consisted of seven chapters. The first one presented some initial considerations, the research problem and its importance, and the objectives. The second chapter presented some theoretical relationships that provide the basis for the empirical analysis. The third chapter provided an historical review of land reform in Brazil. The objective was to explore aspects that contribute to the complexity of the agrarian question. The fourth chapter presented relevant data on the magnitude of land reform in Brazil, descriptive statistics on 2006, and the empirical strategy and results of the cross sectional analysis of 2006. The fifth chapter presented the empirical strategy and results of the panel data analysis. The present chapter summarizes the main points of all previous chapters, reflecting on their relevance for debates about land reform in Brazil and around the world. Finally, the last chapter will highlight the most important findings from the entire dissertation, in an attempt to point out aspects that may be useful to policy decisions related to land reform.

The introduction and the historical review of land reform showed that the concentration of land ownership and the existence of hundreds of thousands of families of agricultural producers with little or no land shape the context of the Brazilian agrarian question. Different points of view mark this debate and, especially after the increase in the number of settlements during the 1990s and 2000s, the discussion about the importance and the results of land reform intensified. The claim for land reform in Brazil comes from a number of alleged benefits in terms of equity and efficiency. Theoretical and empirical arguments are used either to justify land reform, or to oppose it. Some arguments for land reform include benefits in terms of efficiency, equity, poverty, and democracy. The concentration of land ownership generates inequality, inefficiency and poverty. Redistribution is a possible way to change that. Arguments against land reform include the high costs of land reform programs in Brazil, the supply of food by large farms, and previous unsuccessful experiences throughout the world.

Following the historical review, Chapter 4 showed that nearly one million families were settled through land reform through 2006, according to official INCRA

data. This dissertation focused on approximately 330,000 LRB that can be identified in the 2006 Agricultural Census as having obtained their land through land reform, with or without title. The descriptive statistics and cross section models compared land reform beneficiaries (LRB) −with (LRBt) and without land title (LRBw) − to landowners.

The unconditional comparison showed that, on average, land reform beneficiaries had lower land productivity, total factor productivity, and net per capita income in Brazil (Table 4.14). Thus, poverty rates were higher among LRB. However, this masked important macro regional differences.

LRBt and LRBw differed from owners in terms of characteristics of the farmer and the establishment. In general, beneficiaries of land reform were younger, had less education, and were in charge of the farm for fewer years. In all macro regions, use of credit among LRB was higher than owners. They also had more technical assistance and participated more in unions, associations and social movements in all macro regions but the South. Compared to LRB, owners had more (in the North, Southeast and Center-West) or similar (in the Northeast and South) access to electricity. Thus, the package of public policies—including credit, technical assistance, and electricity—even if inadequate, appears to have been reaching LRB at similar or slightly higher rates than for owners. In contrast, owners used more technology and inputs.

Cross-sectional regressions compared land productivity, net per capita income and total factor productivity of LRB and owners in 2006. Establishments were aggregated according to farm size, municipality and form of obtaining land. The first regressions for Brazil showed that unobserved local differences—such as in land quality and infrastructure—explain most of the unconditional land productivity advantage of owners. The difference became statistically insignificant when differences in farm size, age, education, and gender were also controlled for.

The lack of any statistically significant difference between LRB and owners at the level of Brazil in 2006 hid significant differences across macro regions. When the preferred model was run for each macro region, which included only exogenous and predetermined variables, it showed a statistically significant land productivity advantage for LRB in the less developed North and Northeast, and a disadvantage in the three more modern macro regions of the country. These results were consistent with the descriptive data.

As in the case of land productivity, the unconditional advantage in net per capita income of owners in Brazil appeared to be largely attributable to unobserved municipal level characteristics. When municipal fixed effects were included in the model, the difference between owners and LRB became statistically insignificant. Unlike with land productivity, however, LRB earned more than owners per capita when differences in farm size were also controlled for. The addition of age, education and gender led to an even larger conditional income advantage per capita for LRB. As for the macro regional regressions, the preferred model showed that conditional net income per capita was higher in four of the five macro regions in Brazil. Only in the South did owners continue to earn more once unobserved municipal characteristics, farm size, age, education and gender were controlled for. The advantage of LRB in generating income appears to be attributable to their use of much less purchased inputs, without a proportionate decline in output. This is consistent with the results for total factor productivity.

The unconditional results for Brazil showed that land reform beneficiaries had higher total factor productivity. The inclusion of municipal fixed effects increased the difference found in the unconditional comparison. However, the inclusion of age, education and gender reduced the gap. The preferred specification showed that LRB were more productive in all macro regions. The difference was higher in the North, and lower in the Center-West.

Regression results restricted to LRB showed that years in charge of the farm, in general, contributed to increase land productivity, net per capita income and total factor productivity. This suggests that there might be a learning process, as well as lags before investments take place and then generate results. This finding has important implications for the design of public policies.

In sum, the cross sectional regressions suggested that unobserved municipal characteristics, size classes, characteristics of the farmer, and access to institutions and public goods were important factors for explaining differences between land reform beneficiaries and owners in Brazil.

Chapter 5 presented the methodology and results based on the second empirical approach, which used panel data from the 1985 and 2006 Agricultural Censuses. The analysis focused on municipalities with and without land reform beneficiaries, or with differing intensities of reform. The outcome variable was land productivity. Both fixed

effects (FE) and difference-in-differences (DD) approaches were used to remove time invariant characteristics that could confound the analysis. In the case of the FE estimation the time invariant characteristics were removed at the level of each municipality, while in the case of the DD estimation, these characteristics were removed at the level of groups (municipalities with and without beneficiaries). Because potentially important omitted variables related to differences in soils, climates, and local infrastructure are important determinants of agricultural productivity, as confirmed by the cross-section regressions, the preferred estimates come from FE approach.

Data from 1985 showed that land reform in Brazil happened in locations that had: a higher share of very small and large farms, substantially less access to infrastructure (as measured by electricity), establishments that were less technologically advanced, and considerably lower land productivity. In the 1985 baseline, land productivity was 63% higher in municipalities where land reform would not later occur. This was a result of lower land productivity among municipalities that would subsequently be treated in the Northeast, Southeast, and Center-West, and statistically equal productivity in the other two macro regions.

The descriptive statistics showed that around two thirds of municipalities in the panel had at least some LRB between 1985 and 2006. Around 10% of municipalities had at least 20% of their establishments created through land reform. There were significant differences across macro regions. The Center-West was the macro region with more municipalities that had more than 30% of LRB, and the Southeast was the one with more municipalities that had no LRB at all. As for the time-intensity of reform, the modal class was between 6 and 10 years of existence in Brazil. A comparison across macro regions showed that the North had the largest share of older settlements, but also had the largest share of newly created settlements.

Fixed effects estimates with intensity of treatment generated the most important and interesting results. They showed that the negative effects of land reform on land productivity growth in Brazil tend to occur when land reform intensity was higher. These negative coefficients were statistically significant for municipalities with more than 40% LRB.

The intensity of treatment fixed effects model for the North and the Northeast showed more rapid growth for municipalities with 10% to 20% LRB. This became statistically insignificant in the most complete model (model 3), which suggests that

(endogenous) differential access to institutions and technologies helps to explain the result. On the other hand, the intensity of treatment FE estimates in the South showed statistically significant slower land productivity growth of LRB. The effect declined in model 3 and became statistically insignificant.

Binary DD models for Brazil showed negative, but insignificant effects of land reform. The intensity of treatment DD model also showed negative effects that tended to grow with intensity, but remained insignificant. The results with intensity based on time were also insignificant. The only exception was the South where, unexpectedly, time had a negative impact on the growth of land productivity. As in the case of binary DD estimates, binary FE estimates showed negative but insignificant effects for Brazil. The general lack of significant effects could be due to the weakness of the binary model—Municipalities with one LRB were lumped together with municipalities with more than 50% LRB. This can be viewed as a form of measurement error, and measurement error is known to bias estimated coefficients toward zero.

The fixed effects model run separately for small farms showed that intensity of land reform had significant effects on land productivity in Brazil as a whole. This effect was either negative or positive, depending upon the share of small LRB. According to the preferred specification, the positive effect was significant for municipalities with between 10% and 20% LRB among the small farms. The negative effect was significant for municipalities with more than 40% of LRB. In the South, the results also showed significant negative effects for municipalities with 20% to 30% LRB among the small farms, and significant positive effect for municipalities with 0% to 10% LRB. Positive effects of land reform on land productivity of small farms also occurred in the Northeast. Municipalities where more than 0% and less than 20% of small farms were LRB had faster land productivity increase between 1985 and 2006.

The results for small farms were similar to the results at the municipal level in Brazil. Therefore, the impact of land reform on small farms appears to be driving the municipal level results described above. Finally, access to institutions and public goods, as well as use of technology and inputs seemed to be an important part of the explanation for productivity differences across municipalities as well as among small farms.

Several points must be considered in order to reconcile the results from the cross section and panel approaches. First, the identification of land reform beneficiaries

(LRB) in 2006 is more accurate than in the panel based on municipal shares of beneficiaries. The aggregate farms considered LRB in 2006 do not have establishments that were not LRB. So the comparisons were between beneficiaries and owners. In the panel data set, any form of obtaining land can be included in a beneficiary municipality. The use of land reform intensity in a given municipality sought to mitigate this problem. Second, it is important to note that even though the 2006 data refers to a specific point in time, the outcomes in that year reflect the starting values in 1985 and the changes over time between 1985 and 2006. Therefore, the two empirical strategies are related. The cross section deals with a static analysis whereas the panel deals with changes over time.

Finally, there are a number of ways in which the present analysis can be improved and extended. Among the most important are the following. First, the use of Minimum Comparable Areas could increase the number of municipalities in the panel analysis and provide a more comprehensive coverage of Brazil‘s territory. Second, the use of separate models for medium and large farms could show possible indirect effects of land reform. Third, the control group of municipalities could be selected—based on propensity score matching in the baseline and/or a comparison of trend productivity growth between 1975 and 1985—in order to increase the likelihood that the changes observed between 1985 and 2006 were in fact due to land reform rather than other possible causes. This would strengthen the credibility of the conclusions drawn from the panel analysis.

7. CONCLUSION

The results of the cross section and panel regressions provide information that contributes to answering the research problem of this dissertation as well as the related key questions. Regarding the central question of this dissertation—what were the effects of land reform on productivity and income in Brazil between 1985 and 2006? — both chapters showed that the effects were heterogeneous across macro regions. This prevents generalizing from a single analysis at the country level, at the same time that the analysis at the macro regional or state level becomes relevant. Compared to owners in 2006, land reform beneficiaries had higher land productivity, total factor productivity, and per capita income in the North and Northeast, conditional on arguably exogenous variables (model 4). This was also true for total factor productivity and per capita income in the Southeast and Center-West, but in these macro regions land productivity of owners was greater. The South was the macro region where LRB were comparatively worse off: they had lower land productivity and net per capita income.

While the above results are important, they are largely descriptive. They provide essential conditional information on the levels of key variables in 2006 after controlling for factors such as farm size and unobserved municipal characteristics that could confound the comparison. Yet because these cross-sectional results do not control for differences in initial conditions, variables that could affect program placement, or the differential evolution of other key determinants of outcomes, they cannot be interpreted as capturing the causal impact of land reform.

The fixed effects model is the one that comes closest to estimating the causal impact of the program. When the intensity of land reform was considered—measured as the share of land reform beneficiaries in each municipality—a statistically significant

negative relationship between land reform and productivity appeared in Brazil as a whole in municipalities with more than 40% of LRB. Yet once again, there was no consistent behavior across macro regions. The effect was negative in the South, and positive in the North and Northeast. However, it depended on the share of LRB in the municipalities. No statistically significant relationship was found in the other macro regions.

The superior performance of beneficiaries in the North and Northeast together with a worse performance in the South — both results from the cross section and panel data analysis —must be better investigated. The historical social and economic differences between the Northern macro regions and the South can suggest important variables to explain the differential effect of land reform. Equally important are the differential public policies directed to rural development.

The cross section chapter provided some insight into the first key question raised by the research problem: to what extent are land reform beneficiaries becoming similar to existing small farmers, and thus reproducing the low levels of living standards that exist for a large portion of small farms in Brazil? The results suggested that land reform beneficiaries are not becoming similar to existing farmers. That chapter showed that LRB have higher poverty rates than existing farmers. Besides, there are differences in terms of characteristics of the farmer, access to institutions and public goods, as well as use of technology and inputs. In some cases, these variables favor LRB over owners. In other cases, the opposite happens. Nevertheless, compared to owners, LRB were able to have higher land productivity in the North and Northeast, higher per capita income in all macro regions but the South, and higher TFP in all macro regions. Therefore, even though the level of poverty suggests that their levels of living standards is lower than a large portion of small farms in Brazil, they might be improving their capacity to produce and generate income.

The case of small farms deserves special attention. A productivity comparison suggests that the level of living standards of some beneficiaries is higher than a portion of owned farms in Brazil. This is more common among small farms: both the cross section and the panel data analysis suggested that small beneficiaries might have had better results in terms of land productivity, per capita income, total factor productivity compared to owners. Therefore, they might be improving their capacity to produce and

generate income. Explaining the reasons and the context behind a better performance of those beneficiaries constitute another important research question.

The second key question raised by the research problem relates to the importance of the whole package of policies that accompanies the distribution of land. In the panel data models, the package of policies included credit, technical assistance, electricity, and cooperatives. The panel data results showed that, together with use of technology and inputs, these variables contributed to explaining changes in land productivity. In the North it was differences in the use of credit, participation in cooperatives and use of some technologies and inputs that contributed to the superior performance of the municipalities with LRB. In the South, the inferior performance of municipalities with LRB became less pronounced because of access to some institutions and public goods, and use of inputs. These results suggest that access to the policy package, or execution of the package, has an important impact on productivity growth. This reinforces the importance of public policy support to land reform beneficiaries.

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Appendix

A.1. The data

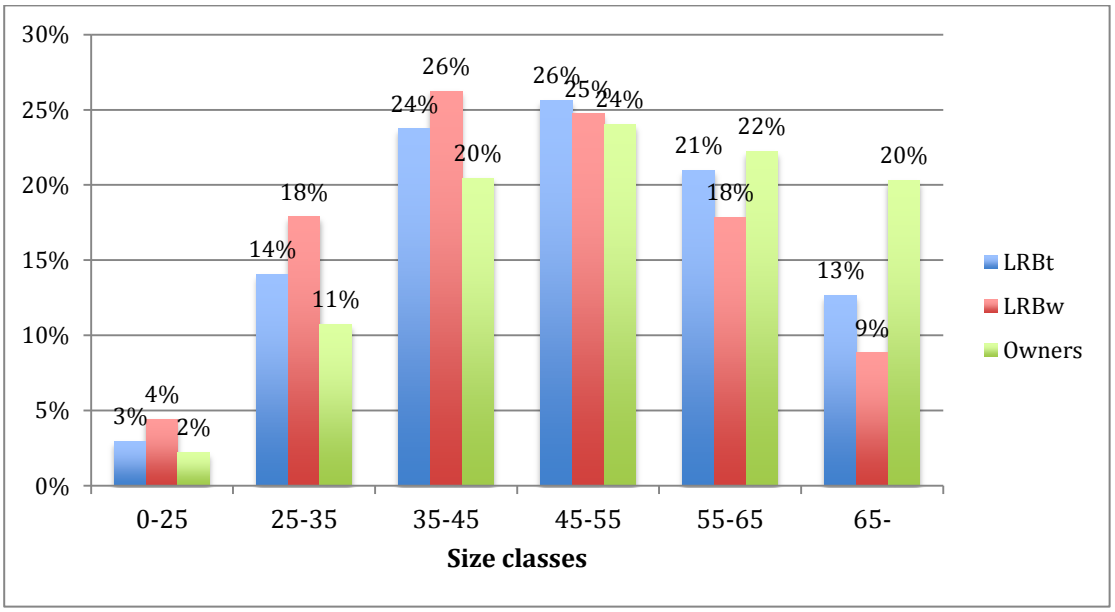
Table 1A - Description of the 2006 Agricultural Census data used in the cross section analysis in Chapter 4

Variable in this thesis	Description in the census - Variables/categories	Variable (Portuguese)
LRBt	Obtained land through land reform	Forma de obtenção das terras: Via reforma agrária
LRBw	Settled without land title	Condição do produtor em relação às terras: assentado sem título definitivo
Owner	Owner	Condição do produtor em relação às terras: proprietário
Number of establishments	Total of establishments	Total de estabelecimentos
Farm size	Total area	Área total
Educational level	Instruction level of the person that manages the farm	Nível de instrução da pessoa que dirige o estabelecimento
Illiterate	Illiterate	Não sabe ler e escrever
Literate, but no schooling	Adults literacy; literate but no schooling	Alfabetização de adultos; Nenhum nível de instrução, mas sabe ler e escrever
Primary incomplete	Primary incomplete	Ensino fundamental incompleto
Primary complete	Primary complete	Ensino fundamental completo
Secondary complete	Secondary complete	Ensino médio completo
Higher education	Agricultural Technician; Agronomist; Veterinary; Zootechnician; Forestry Engineer; Another Higher education	Técnico agrícola completo; Engenheiro agronômo; Veterinário; zootecnista; Engenheiro florestal; Outra formação superior
Years in charge of farm	Years in charge of farm	Tempo na direção do estabelecimento
Age	Age	Idade do produtor
Male	Gender	Sexo da pessoa que dirige o estabelecimento
Same state	Place of birth	Naturalidade da pessoa que dirige o estabelecimento
Residence	Place of residence: State of birth or another	Local de residência do produtor
Farm management	Farm management: managers, group of farmers, own farmer, and other	Direção do estabelecimento: Produtor (diretamente ou indiretamente); administrador, produtores, outra pessoa
Access to credit	Obtained credit in 2006	Estabelecimento obteve financiamento
Electricity,	Used electricity in 2006	Estabelecimento usou energia elétrica
Technical assistance	Used technical assistance in 2006	Estabelecimento recebeu orientação técnica
Cooperatives	Was associated to cooperatives in 2006	Estabelecimento é associado à cooperativa
Unions	Was associated to unions in 2006	Estabelecimento é associado à entidade de classe
Machines	The establishment had machines and agricultural implements	Tinha máquinas e implementos em 2006
Vehicles	The establishment had vehicles	Tinha veículos em 2006
Tractors	The establishment had tractors	Tinha tratores em 2006
Irrigation	The establishment used irrigation	Usou irrigação em 2006
Agricultural practices	Planting in level curve, terrace, crop rotation, annual crops used to pastures recovery, fallow, biomass burning, slopes protection	Usou práticas agrícolas em 2006: plantio em curva de nível, terraço, rotação de culturas, lavouras para recuperação de pastagens, pousio ou descanso dos solos, queimadas, proteção de encostas
Limestone and/or soil corrective	Used limestone and/or soil corrective in 2006	Aplicou calcário ou outros corretivos do solo em 2006
Fertilizer	Used fertilizer in 2006	Fez adubação em 2006
Pesticide	Used pesticide in 2006	Utilizou agrotóxico para controle de pragas ou doenças
Total value of agricultural production	Total value of agricultural production: total value of animal, agricultural and angroindustrial production	Valor total da produção agrícola
Total area	Total area of the establishment	Área total do estabelecimento
Variable costs	Sum of the following expenditures: electricity, machine rentals, soil corrective, fertilizer, pesticide, workers hired, wages paid, medicaments, land lease, production storage, raw material for agroindustry, transport, sacks and packages, seeds, salt and animal feed, interest and bank charges, fuel, purchase of animals, other expenditures	Despesas com eletricidade, aluguel de máquinas, corretivos, adubos, agrotóxicos, contratação de serviços em 2006, salários pagos em dinheiro ou produtos em 2006, medicamentos, arrendamento de terras, armazenamento da produção, compra de matéria prima para agroindústria, transporte da produção, sacarias e embalagens, sementes e mudas, sal e rações, juros e despesas bancárias, impostos e taxas, combustíveis, compra de animais, outras despesas
Fixed costs	Depreciation of the following properties: value of buildings, facilities and improvements, value of machines, value of cattle, value of permanent crops	Valor de prédios, instalações e benfeitorias, valor das máquinas, valor dos animais, valor da lavoura permanente
Value of production (for poverty measure)	Value of agricultural production, sale of animals, sale of humus, sale of manure, rural turism, mineral exploration, processing services, other nonagricultutal activities	Valor da produção agrícola, venda de animais criados em cativeiro, venda de húmus, venda de esterco, atividade de turismo rural, exploração mineral, serviço de beneficiamento para terceiros, outras atividades não agrícolas
Labor (for poverty measure)	Income earned out of the establishment	Salário obtido fora do estabelecimento
Transfers (for poverty measure)	Social security, donations, government social programs	Aposentadoria, pensão; doações ou ajuda; programas sociais do governo

Table 2A - Description of the 1985 and 2006 Agricultural Censuses data used in the panel data analysis in Chapter 5

Variable in this thesis	Year	Description in the census - Variables/categories	Variable (Portuguese)
LRB (LRBt + LRBw)	2006	Obtained land through land reform and Settled without land title	Forma de obtenção das terras e Condição do produtor em relação às terras
Number of establishments	1985/2006	Total of establishments	Total de estabelecimentos
Total area	1985/2006	Total area of the establishment	Área total do estabelecimento
Total value of agricultural production	1985	Total value of agricultural production:permanent and temporary crops, horticulture and floriculture, forestry, extraction, animal, rural industry	Valor total da produção agrícola: lavoura permanente, lavoura temporária, horticultura e floricultura, silvicultura, extração vegetal, animal de grande porte, animal de médio porte, aves e pequenos animais, produção da indústria rural
	2006	Total value of agricultural production: total value of animal, agricultural and angroindustrial production	Valor total da produção agrícola
Farm Size	1985/2006	Total area of the establishment	Área total do estabelecimento
Access to credit	1985	Obtained credit in 1985	Financiamento obtido: custeio, investimento, comercialização, ignorado
	2006	Obtained credit in 2006	Estabelecimento obteve financiamento
Electricity	1985	Did not use electricity in 1985	Estabelecimento não usou energia elétrica
	2006	Used electricity in 2006	Estabelecimento usou energia elétrica
Technical assistance	1985	Did not use technical assistance in 1985	Estabelecimento não utilizou assistência técnica
	2006	Used technical assistance in 2006	Estabelecimento recebeu orientação técnica
Cooperatives	1985	Was associated to no cooperative in 1985	Estabelecimento é associado a nenhuma cooperativa
	2006	Was associated to cooperatives in 2006	Estabelecimento é associado à cooperativa
Average value of machines and vehicles	1985	Value of vehicles and others, value of machines and agrarian tools	Valor dos veículos e outros, valor de máquinas e instrumentos agrários
	2006	Value of vehicles, tractores, machines and implements	Valor dos bens: veículos, tratores, máquinas e implementos
Irrigation	1985	The establishment used irrigation: flood, infiltration, sprinkling	Método de irrigação: inundação, infiltração, aspersão, outro método, mais de um método
	2006	The establishment used irrigation	Usou irrigação em 2006
Fertilization	1985	Chemical and organic fertilizer	Adubos químicos e orgânicos
	2006	Used fertilizer in 2006	Fez adubação em 2006
Limestone	1985	Used limestone and/or soil corrective in 1985	Calcário e outros corretivos
	2006	Used limestone and/or soil corrective in 2006	Aplicou calcário ou outros corretivos do solo em 2006
Pesticide	1985	Animal and vegetal defensive	Defensivo animal e vegetal
	2006	Used pesticide in 2006	Utilizou agrotóxico para controle de pragas ou doenças
Agricultural practices	1985	Planting in level curve, terrace, others	Conservação do solo: cultivo em curva de nível, terraceamento, outras
	2006	Planting in level curve, terrace, crop rotation, annual crops used to pastures recovery, fallow, biomass burning, slopes protection	Usou práticas agrícolas em 2006: plantio em curva de nível, terraço, rotação de culturas, lavouras para recuperação de pastagens, pousio ou descanso dos solos, queimadas, proteção de encostas
Total value of agricultural production	1985	Total value of agricultural production:permanent and temporary crops, horticulture and floriculture, forestry, extraction, animal, rural industry	Valor total da produção agrícola: lavoura permanente, lavoura temporária, horticultura e floricultura, silvicultura, extração vegetal, animal de grande porte, animal de médio porte, aves e pequenos animais, produção da indústria rural
	2006	Total value of agricultural production: total value of animal, agricultural and angroindustrial production	Valor total da produção agrícola

A.2. Additional descriptive statistics



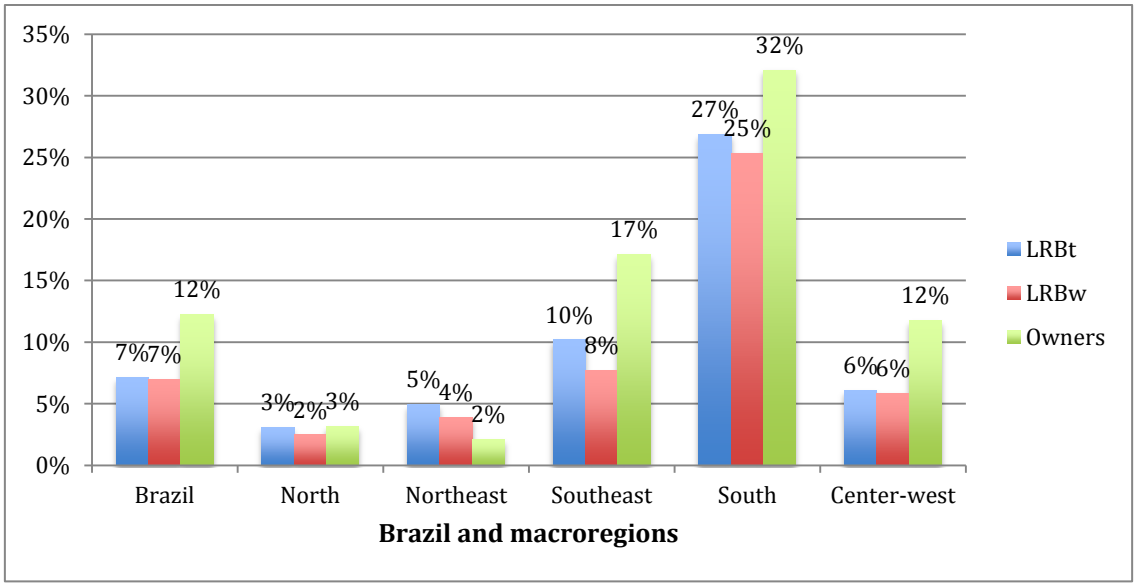
Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 1A – Distribution of Farmers Across Age Classes in Brazil

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.

Table 3A - Distribution of farmers across age classes, by macro region and type

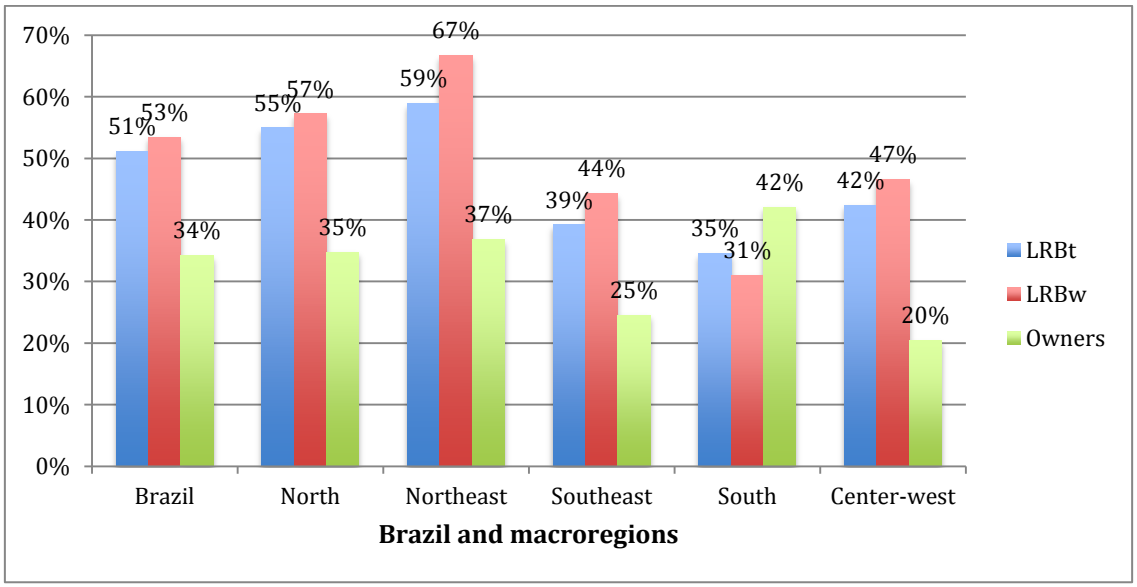
Region	Type	Age Classes					
		0-25	25-35	35-45	45-55	55-65	65-
Brazil	LRBt	3%	14%	24%	26%	21%	13%
	LRBw	4%	18%	26%	25%	18%	9%
	Owners	2%	11%	20%	24%	22%	20%
North	LRBt	3%	14%	22%	25%	22%	14%
	LRBw	5%	19%	26%	25%	17%	8%
	Owners	4%	17%	24%	24%	18%	13%
Northeast	LRBt	3%	15%	23%	24%	22%	13%
	LRBw	5%	19%	25%	23%	18%	9%
	Owners	3%	12%	19%	21%	22%	23%
Southeast	LRBt	2%	11%	23%	29%	22%	14%
	LRBw	2%	13%	26%	28%	19%	11%
	Owners	1%	8%	19%	25%	23%	23%
South	LRBt	3%	16%	28%	27%	18%	8%
	LRBw	5%	21%	30%	25%	14%	5%
	Owners	1%	9%	22%	27%	24%	18%
Center-West	LRBt	3%	14%	25%	27%	20%	11%
	LRBw	4%	16%	27%	27%	18%	9%
	Owners	2%	11%	22%	26%	22%	17%



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 2A – Participation in Cooperatives

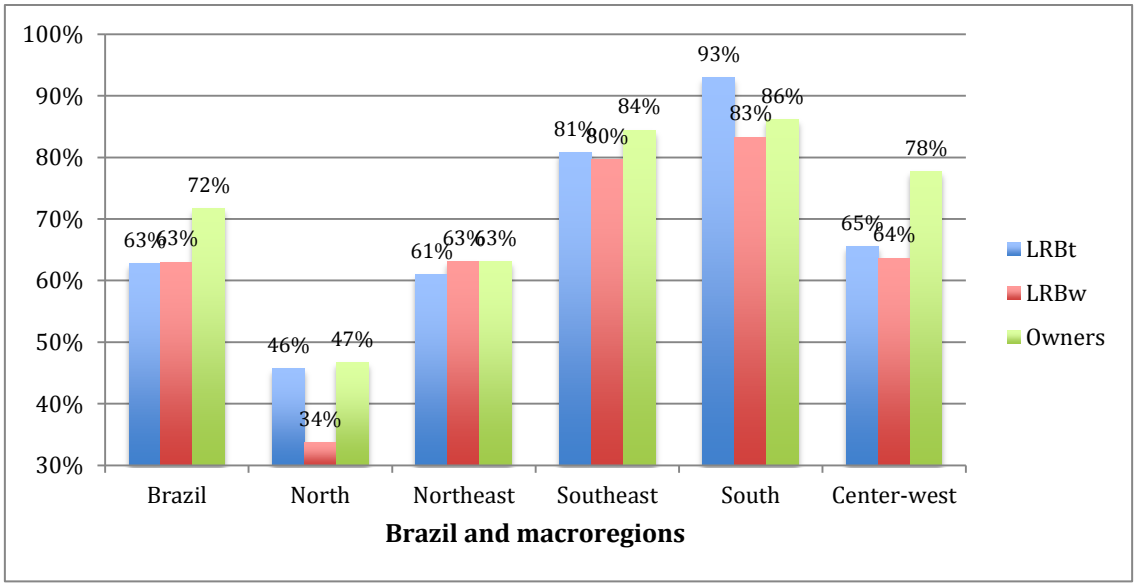
Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 3A – Participation in Unions/Associations/Social Movements

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.



Source: Author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Figure 4A – Use of Electricity by macro region

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title. Size classes are in hectares.

A.3. An alternative approach to the numbers of land reform

Marques et al. (2012) used an alternative methodology to calculate the number of land reform beneficiaries in Brazil. They combined variables from the agricultural census of 2006 and the geographical location of the settlement projects in order to construct an estimate of the universe of beneficiaries. The data from the agricultural census come from the same three questions used to make Table 4.2. They are related to (a) the origin of the establishment, (b) the condition of the farmer in relation to the land, and (c) the form of obtaining the land. The geographic location was used as follows: they crossed the perimeters of the settlements projects registered in Incra‘s files with the geographical coordinates of establishments identified by the agricultural census. Establishments inside the perimeters of a settlement were considered as land reform beneficiaries, irrespective of the answers to the questions from the census.

By combining the four variables, their universe of land reform beneficiaries consisted of establishments that met at least one of the following criteria:

a) Declared to be originated from a land reform settlement project created after 1985;

b) Was an owner who had obtained land through land reform;

c) Had land granted from a land agency, but still was without title;

d) Georeferenced point was inside the perimeters informed by Incra.

575,101 establishments met at least one of the requirements above: this can be seen as the upper limit of beneficiaries in Brazil. The sample of LRB used in this dissertation is based on (c) and (d) and has 329,860 establishments. The difference makes it important to emphasize the logic behind the choice of beneficiaries in this dissertation. The agricultural census defined LRBw only in case where the majority of the establishment‘s land was granted by a land agency but still was without title. The rule used to classify farmers as owners – which include LRBt – is not based on the most important share of land. Any producer who had even a small piece of land is classified as an owner. Because of this, some establishments could be classified like LRBt even in cases that the majority of their land had not been granted through land reform. However, the aggregated data shows that only 37,282 owners obtained land through two forms (other than both purchase and inheritance). This number includes 27 different combinations of two different forms of obtaining land and 7 of these combinations

include land reform as one of the forms. Therefore very few owners obtained land by more than one method together with land reform. LRBt and LRBw are thus considered the beneficiaries because the majority (or the totality) of their land was granted through land reform, with or without title.

Even though this dissertation is not using criterion (a), Table 4.2 shows that 97,760 LRBt and 141,088 LRBw were also establishments that would be classified as beneficiary according to this criterion. Marques et al. (2012) identified 348,226 establishments as beneficiaries because they originated from a land reform project created after 1985. 68.6% (238,848) of them are part of LRB in this dissertation – either as LRBt or LRBw.

According to these numbers, LRB do not include 109,378 (348,226-238,848) establishments that were classified as beneficiaries based on criterion (a) (Table 4A). The sum of these observations with the universe of 329,860 LRB shows that Marques et al. (2012) classified approximately 135,863 establishments as beneficiaries because they were inside the perimeter of a settlement project (criterion d) even though they had not satisfied one or more of the other criteria based strictly on data available with the Agricultural Census.

Table 4A – Number of beneficiaries according to the approach by Marques et al. (2012)

Criterion	Total of establishments	
	Beneficiaries of Marques et al. (2009)	Beneficiaries in this dissertation (LRBt +LRBw)
Originated from a LR project created after 1985	348,226	238,848
Land Reform Beneficiaries waiting for the title	189,191	187,804
Land Reform Beneficiaries	290,242	290,242
Georeferenced establishments inside the perimeter of LR settlement project	403,080	?
Establishments on LR settlements		39,618
Universe of beneficiaries	575,101	329,860

Source: Marques et al. (2012) and author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: LRBt: Land reform beneficiaries with land title; LRBw: land reform beneficiaries without land title.

Some basic descriptive statistics are presented in order to compare the LRB used in this dissertation to the beneficiaries of Marques et al. (2012). Because the most important tables in their analysis consider not only establishments that met at least one of the four criteria below, but also beneficiaries of crédito fundiário, comparisons of total value of production (Table 6A), total area (Table 7A) and land productivity (Table 8A) include this category too. Tables 5A, 6A and 7A show that the data used in this dissertation represents 57% of establishments, 29% of total value of production, and 34% of total area used by Marques et al. (2012) in Brazil. According to Table 5A, the establishments in the data used in this dissertation represent only 18% of the number of beneficiaries that they count in Rondônia, 38% in Pará, 40% in Acre, and 52% in Maranhão. The average size of LRB represents 12% of average size of their beneficiaries in Rondônia, 15% in Amapá, 22% in Acre, and 28% in Pará. Average area of LRB is 34% of average area of their beneficiaries in Brazil. Table 6A shows total value of production of both groups by state. Total value of production of LRB represented only 9% of the total value of their beneficiaries in Rondônia, 10% in Amapá, 16% in Mato Grosso, and 19% in Minas Gerais.

Table 5A – Number of beneficiaries according to this dissertation approach and Marques et al. (2012)

Region	State	Marques et al. (a)	LRBt+LRBw (b)	ratio b/a
North	Rondônia	49,093	8,837	18%
	Acre	14,278	5,734	40%
	Amazonas	13,511	6,371	47%
	Roraima	5,521	2,664	48%
	Pará	58,766	22,358	38%
	Amapá	1,312	842	64%
	Tocantins	16,738	12,039	72%
Northeast	Maranhaão	53,870	28,173	52%
	Piauí	26,027	16,034	62%
	Ceará	29,798	17,909	60%
	Rio Grande do Norte	14,865	12,017	81%
	Paraíba	16,688	11,668	70%
	Pernambuco	25,918	17,075	66%
	Alagoas	10,642	7,485	70%
	Sergipe	10,298	6,477	63%
	Bahia	41,468	27,665	67%
Southeast	Minas Gerais	20,076	12,857	64%
	Espirito Santo	4,304	3,336	78%
	Rio de Janeiro	3,489	2,180	62%
	São Paulo	14,951	11,240	75%
South	Paraná	30,725	19,457	63%
	Santa Catarina	7,712	4,651	60%
	Rio Grande do Sul	15,206	10,612	70%
Center-West	Mato Grosso do Sul	21,749	18,622	86%
	Mato Grosso	49,813	29,831	60%
	Goiás	17,147	13,171	77%
	Distrito Federal	1,136	555	49%
		575,101	329,860	57%

Source: Marques et al. (2012) and author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: (a) and (b) include land reform beneficiaries with land title (LRBt) and land reform beneficiaries without land title (LRBw). All values are in reais (R$).

Table 6A – Total value of production of land reform beneficiaries according to this dissertation approach and Marques et al. (2012)

Macroregion	State/ macroregion	Value of production		
		Marques et al. (a)	LRBt+LRBw +CFB (b)	Ratio b/a
North	Rondônia	681,113,149	64,200,000	9%
	Acre	202,373,581	54,600,000	27%
	Amazonas	148,830,109	43,300,000	29%
	Roraima	35,527,616	11,000,000	31%
	Pará	853,949,789	210,000,000	25%
	Amapá	60,034,375	5,889,759	10%
	Tocantins	143,955,558	61,100,000	42%
Northeast	Maranhaão	526,590,111	225,000,000	43%
	Piauí	77,144,924	46,500,000	60%
	Ceará	327,680,996	119,000,000	36%
	Rio Grande do Norte	99,245,130	50,400,000	51%
	Paraíba	164,947,548	59,400,000	36%
	Pernambuco	502,469,579	177,000,000	35%
	Alagoas	110,260,384	39,500,000	36%
	Sergipe	67,044,005	26,800,000	40%
	Bahia	541,613,359	130,000,000	24%
Southeast	Minas Gerais	586,527,326	114,000,000	19%
	Espiríto Santo	42,138,336	18,600,000	44%
	Rio de Janeiro	63,170,077	43,500,000	69%
	São Paulo	763,497,906	128,000,000	17%
South	Paraná	635,803,958	224,000,000	35%
	Santa Catarina	334,316,777	168,000,000	50%
	Rio Grande do Sul	600,272,162	231,000,000	38%
Center-West	Mato Grosso do Sul	231,360,269	107,000,000	46%
	Mato Grosso	1,213,241,782	195,000,000	16%
	Goiás	330,107,935	84,400,000	26%
	Distrito Federal	103,441,340	56,900,000	55%
	North	2,125,784,177	450,089,759	21%
	Northeast	2,416,996,036	873,600,000	36%
	Southeast	1,455,333,645	304,100,000	21%
	South	1,570,392,897	623,000,000	40%
	Center-West	1,878,151,326	443,300,000	24%
	Brazil	9,446,658,081	2,694,089,759	29%

Source: Marques et al. (2012) and author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: (a) and (b) include land reform beneficiaries with land title (LRBt), land reform beneficiaries without land title (LRBw), and beneficiaries of crédito fundiário (CFB). All values are in reais (R$).

Table 7A – Total area of land reform beneficiaries according to this dissertation approach and Marques et al. (2012)

Region	State/ Region	Total Area		
		Marques et al. (a)	LRBt+LRBw +CFB (b)	Ratio b/a
North	Rondônia	3,708,245	459,151	12%
	Acre	1,458,465	323,761	22%
	Amazonas	896,451	281,674	31%
	Roraima	480,374	174,225	36%
	Pará	4,790,259	1,324,330	28%
	Amapá	356,692	53,712	15%
	Tocantins	1,111,429	523,247	47%
Northeast	Maranhaão	1,748,290	714,306	41%
	Piauí	574,050	320,520	56%
	Ceará	729,449	368,014	50%
	Rio Grande do Norte	328,590	199,338	61%
	Paraíba	206,170	127,467	62%
	Pernambuco	387,280	161,205	42%
	Alagoas	133,667	63,073	47%
	Sergipe	137,345	67,758	49%
	Bahia	1,538,594	593,229	39%
Southeast	Minas Gerais	1,228,940	355,224	29%
	Espiríto Santo	54,592	26,181	48%
	Rio de Janeiro	42,787	18,401	43%
	São Paulo	571,887	166,540	29%
South	Paraná	1,204,343	664,474	55%
	Santa Catarina	247,802	110,725	45%
	Rio Grande do Sul	721,164	264,514	37%
Center-West	Mato Grosso do Sul	688,871	473,217	69%
	Mato Grosso	4,925,362	1,669,584	34%
	Goiás	1,165,955	411,635	35%
	Distrito Federal	37,336	28,197	76%
	North	12,801,915	3,140,100	25%
	Northeast	5,783,435	2,614,909	45%
	Southeast	1,898,206	566,346	30%
	South	2,173,309	1,039,713	48%
	Center-West	6,817,524	2,582,633	38%
	Brazil	29,474,389	9,943,700	34%

Source: Marques et al. (2012) and author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: (a) and (b) include land reform beneficiaries with land title (LRBt), land reform beneficiaries without land title (LRBw), and beneficiaries of crédito fundiário (CFB). All values are in hectares.

Finally, Table 8A shows that land productivity of LRB in this dissertation represented 86% of the average calculated by Marques et al. (2012) in Brazil. The

greatest difference occurred in Mato Grosso, where land productivity of beneficiaries in this dissertation represented 48% of their productivity. On the other hand, land productivity in Amazonas was more similar; it represented 96% of their value.

Table 8A – Land productivity of land reform beneficiaries according to this dissertation approach and Marques et al. (2012)

Region	State/ Region	Land productivity		
		Marques et al. (a)	LRBt+LRBw +CFB (b)	Ratio b/a
North	Rondônia	183.68	144.68	79%
	Acre	138.76	169.12	122%
	Amazonas	166.02	160.15	96%
	Roraima	73.96	63.18	85%
	Pará	178.27	160.35	90%
	Amapá	168.31	109.65	65%
	Tocantins	129.52	118.76	92%
Northeast	Maranhaão	301.20	320.10	106%
	Piauí	134.39	145.97	109%
	Ceará	449.22	332.75	74%
	Rio Grande do Norte	302.03	255.55	85%
	Paraíba	800.06	467.31	58%
	Pernambuco	1297.43	1104.93	85%
	Alagoas	824.89	626.02	76%
	Sergipe	488.14	396.44	81%
	Bahia	352.02	229.57	65%
Southeast	Minas Gerais	477.26	324.45	68%
	Espiríto Santo	771.88	723.49	94%
	Rio de Janeiro	1476.38	2410.68	163%
	São Paulo	1335.05	769.31	58%
South	Paraná	527.93	337.96	64%
	Santa Catarina	1349.13	1526.06	113%
	Rio Grande do Sul	832.37	879.45	106%
Center-West	Mato Grosso do Sul	335.85	230.58	69%
	Mato Grosso	246.33	118.48	48%
	Goiás	283.12	207.44	73%
	Distrito Federal	2770.55	2017.93	73%
	North	166.05	145.73	88%
	Northeast	417.92	341.11	82%
	Southeast	766.69	541.27	71%
	South	722.58	601.90	83%
	Center-West	275.49	174.26	63%
	Brazil	320.50	275.19	86%

Source: Marques et al. (2012) and author‘s calculation with 2006 Agricultural Census (IBGE), aggregated data.

Notes: (a) and (b) include land reform beneficiaries with land title (LRBt), land reform beneficiaries without land title (LRBw), and beneficiaries of crédito fundiário (CFB). All values are in Reais per hectares (R$/hectare).

These Tables show that the beneficiaries that are in their universe, but are not part of the group of LRB used in this dissertation, tend to be considerably larger. These establishments are either inside the perimeter of a settlement project or originated from a land reform project after 1985. However, the majority of their land does not appear to have been granted through land reform, either to owners who obtained their land through LR or to beneficiaries waiting for title. If it were, these establishments would have been classified as LRBt or LRBw. In spite of these differences, the comparison also shows that average land productivity is quite similar across studies. Since this dissertation focuses on the performance of LRB, especially in terms of land productivity, the differences in how LR beneficiaries are defined might be less important than the total number, or total area, of the beneficiaries based on one definition or another.

A.4. Difference-in-difference results

Table 9A – Effects of land reform on land productivity in Brazil: difference-in-differences with binary treatment

Variable	(1)	(2)	(3)	(4)
Time x LRB	-7.66*	20.43*	-20.51*	-51.11*
	(34.77)	(30.51)	(29.61)	(26.71)
Time	236.60	260.29	240.08	-16.42*
	(31.61)	(27.71)	(26.87)	(33.65)
LRB	-226.17	-54.51	-54.92	19.22*
	(22.40)	(20.79)	(20.21)	(18.00)
Farm Size (relative to 0-5)				
5-10			-150.40*	306.81
			(121.65)	(107.58)
10-20			576.11	169.87*
			(112.69)	(100.27)
20-50			-716.17	-785.32
			(87.60)	(77.08)
50-100			-908.10	-807.98
			(149.88)	(131.93)
100-500			-628.07	-748.73
			(111.79)	(98.57)
500-			-972.61	-1107.04
			195.34	179.01
Access to institutions/public goods				
Credit				-167.89
				(58.96)
Electricity				213.02
				(31.43)
Technical Assistance				334.80
				(45.41)
Cooperatives				303.23
				(39.23)
Technology and inputs				
Average value of machines				0.00
				(0.00)
Irrigation				352.98
				(53.27)
Fertilization				467.90
				(32.35)
Limestone				800.32
				(51.13)
Pesticide				126.45
				(27.81)
Agricultural practices				104.36
				(28.95)
Constant	563.00	408.66	702.25	59.23*
	(20.43)	(31.17)	(34.83)	(37.09)
State Fixed effects	No	Yes	Yes	Yes
Adjusted R2	0.06	0.28	0.32	0.48
Observations (Municipalities)	4087	4087	4087	4081

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 10A – Effects of land reform on land productivity in Brazil: difference-in-differences with intensity measured by % of LRB

Variable	(1)	(2)	(3)	(4)
Time	236.60	260.44	240.35	-17.30*
	(31.51)	(27.69)	(26.88)	(33.66)
LRB	-226.17	-56.72	-55.36	19.16*
	(22.32)	(20.79)	(20.22)	(18.01)
% of LRB (relative to no LRB)				
LRB 0-10%	39.56*	-13.70*	-11.09*	-46.31*
	(35.23)	(31.03)	(30.12)	(27.14)
LRB 10-20%	-131.17	-88.16*	-33.71*	-40.46*
	(44.81)	(39.52)	(38.45)	(34.46)
LRB 20-30%	-193.76	-134.50	-65.17*	-92.67
	(60.64)	(53.56)	(52.19)	(46.03)
LRB 30-40%	-259.64	-165.52	-63.65*	-97.59*
	(80.04)	(70.78)	(69.31)	(61.20)
LRB>40%	-136.42*	-96.24*	-100.63*	-105.22
	(68.73)	(61.47)	(60.57)	(53.22)
Farm Size (relative to 0-5)				
5-10			-150.00*	307.22
			(121.69)	(107.63)
10-20			593.21	183.28*
			(113.12)	(100.78)
20-50			-687.97	-765.17
			(88.86)	(78.20)
50-100			-917.07	-813.26
			(149.96)	(132.00)
100-500			-633.76	-755.41
			(111.89)	(98.65)
500-			-947.71	-1096.44
			(195.93)	(179.41)
Access to institutions/public goods				
Credit				-175.12
				(59.22)
Electricity				213.05
				(31.45)
Technical Assistance				341.62
				(45.61)
Cooperatives				301.42
				(39.25)
Technology and inputs				
Average value of machines				0.00
				(0.00)
Irrigation				355.38
				(53.32)
Fertilization				468.05
				(32.37)
Limestone				797.44
				(51.22)
Pesticide				124.72
				(27.83)
Agricultural practices				103.68
				(28.99)
Constant	563.00	422.02	693.66	54.99
	(20.37)	(22.88)	(35.10)	(37.24)
State Fixed effects	No	Yes	Yes	Yes
Adjusted R2	0.06	0.28	0.32	0.48
Observations (Municipalities)	4087	4087	4087	4081

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 11A – Effects of land reform on land productivity in Brazil: difference-in differences with intensity measured by average time of existence of settlements

Variable	(1)	(2)	(3)	(4)
	(16.09)	(14.38)	(14.02)	(26.54)
LRB	-171.27	-41.57	-42.16	4.19*
	(17.60)	(16.79)	(16.33)	(14.46)
Years of existence				
0-5 years	-348.99	-210.19	-184.14	-131.87
	(30.83)	(27.51)	(26.77)	(23.70)
6-10 years	-234.27	-122.93	-80.00	-43.84
	(25.91)	(23.15)	(22.63)	(20.10)
11-15 years	-229.77	-170.93	-139.09	-60.24*
	(42.38)	(37.77)	(36.80)	(32.43)
>15 years	-7.84*	31.31*	53.64*	26.20*
	(69.57)	(62.13)	(60.35)	(53.02)
5-10			-143.53*	303.32
			(121.37)	(107.64)
10-20			608.24	179.63*
			(112.43)	(100.40)
20-50			-688.83	-779.13
			(87.52)	(77.29)
50-100			-898.95	-792.62
			(149.47)	(132.01)
100-500			-619.53	-730.59
			(111.44)	(98.62)
500-			-912.86	-882.79
			(194.95)	(174.90)
Credit				-178.05
				(59.07)
Electricity				212.17
				(31.46)
Technical Assistance				360.89
				(45.22)
Cooperatives				325.21
				(39.09)
Technology and inputs				
Average value of machines				0.00
				(0.00)
Irrigation				366.17
				(88.75)
Fertilization				366.17
				(32.25)
Limestone				804.91
				(51.08)
Pesticide				113.80
				(27.71)
Agricultural practices				120.92
				(28.98)
Constant	517.27	406.21	671.76	64.25*
	(16.83)	(20.48)	(33.59)	(35.42)
State Fixed effects	No	Yes	Yes	Yes
Adjusted R2	0.08	0.28	0.33	0.48
Observations (Municipalities)	4087	4087	4087	4081

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data, and INCRA data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 12A – Effects of land reform on land productivity in the South: difference-in differences with intensity measured by average time of existence of settlements

Variable	(1)	(2)	(3)	(4)
Time	541.04	536.77	567.52	434.38
	(35.37)	(34.68)	(30.58)	(59.98)
LRB	-24.940*	16.62*	2.77*	8.40*
	(40.89)	(40.44)	(35.59)	(32.22)
Years of existence				
0-5 years	-395.30	-415.59	-307.89	-245.27
	134.23	131.66	115.23	103.00
6-10 years	-456.32	-410.78	-287.26	-193.28
	(70.66)	(69.52)	(61.73)	(55.98)
11-15 years	-219.31	-255.38	-363.60	-260.95
	(104.94)	(103.24)	(92.70)	(83.10)
>15 years	-380.24	-454.17	-441.48	-348.79
	(196.51)	(193.00)	(168.65)	(149.29)
Farm Size (relative to 0-5)				
5-10			1532.28	509.43*
			(411.20)	(387.09)
10-20			2898.14	1061.88
			(271.28)	(267.34)
20-50			117.47*	-752.10
			(331.71)	(300.56)
50-100			88.80*	-1760.69
			(855.76)	(784.77)
100-500			-1278.19	-1556.79
			(645.35)	(575.91)
500-			1628.74	1302.66*
			(956.23)	(868.84)
Access to institutions/public goods				
Credit				-90.29*
				(110.20)
Electricity				119.50*
				(79.55)
Technical Assistance				295.12
				(77.48)
Cooperatives				298.85
				(63.12)
Technology and inputs				
Average value of machines				0.00
				0.00
Irrigation				279.95*
				(166.21)
Fertilization				489.52
				(103.45)
Limestone				-261.42
				(105.04)
Pesticide				429.30
				(95.64)
Agricultural practices				249.45
				(81.29)
Constant	711.40	617.49	-435.14	-490.08
	(38.68)	(42.63)	(152.09)	(149.54)
State Fixed effects	No	Yes	Yes	Yes
Adjusted R2	0.13	0.17	0.37	0.51
Observations (Municipalities)	753	753	753	753

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data, and INCRA data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 13A – Effects of land reform on land productivity of small farms in Brazil – difference-in-differences with intensity measured by % of LRB

Variable	(1)	(2)	(3)	(4)
Time	322.26	353.71	409.71	-190.48
	(43.34)	(39.16)	(40.38)	(51.01)
LRB	-212.23	-70.08	-79.08	8.97*
	(30.94)	(29.48)	(28.73)	(25.53)
% of LRB (relative to no LRB)				
LRB 0-10%	127.49	100.55	64.46*	27.82*
	(48.78)	(44.16)	(43.26)	(38.85)
LRB 10-20%	75.36*	118.21	161.66	160.60
	(63.04)	(57.09)	(55.82)	(49.78)
LRB 20-30%	-125.34*	-49.66*	65.49*	78.40*
	(85.37)	(77.54)	(75.82)	(67.13)
LRB 30-40%	-169.76*	-100.27 *	65.99*	102.84*
	(115.60)	(104.89)	(102.35)	(89.78)
LRB>40%	-350.50	-265.18	-52.42*	20.89*
	(82.46)	(76.15)	(75.98)	(67.20)
Farm Size (relative to 0-5)				
5-10			-586.88	-101.31*
			(153.38)	(135.64)
10-20			-371.89	-812.63
			-(1299.39)	(126.09)
20-50			-1642.44	-1290.25
			(90.68)	(80.38)
50-100			-697.17	-576.28
			(143.51)	(126.99)
Access to institutions/public goods				
Credit				-299.21
				(86.70)
Electricity				551.42
				(49.36)
Technical Assistance				126.50*
				(68.86)
Cooperatives				200.95
				(59.78)
Technology and inputs				
Average value of machines				0.03
				(0.00)
Irrigation				1168.85
				(77.26)
Fertilization				536.14
				(46.52)
Limestone				615.56
				(81.84)
Pesticide				196.71
				(40.25)
Agricultural practices				234.65
				(44.38)
Constant	769.35	548.23	1137.37	366.99
	(28.11)	(34.03)	(49.75)	(52.34)
State Fixed effects	No	Yes	Yes	Yes
Adjusted R2	0.06	0.24	0.28	0.45
Observations (Municipalities)	4080	4080	4080	4080

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%

Table 14A – Effects of land reform on land productivity in small farms in the South – difference-in-differences with intensity measured by % of LRB

Variable	(1)	(2)	(3)	(4)
Time	597.78	580.92	634.26	224.74 *
	(80.01)	(77.91)	(73.55)	(88.65)
LRB	-87.34*	-46.12*	-79.59*	27.20*
	(52.98)	(51.87)	(49.06)	(42.33)
% of LRB (relative to no LRB)				
LRB 0-10%	133.02*	146.65*	111.14*	20.99*
	(89.44)	(87.10)	(82.16)	(71.13)
LRB 10-20%	-463.13*	-442.10	-434.92	-155.60*
	(135.25)	(131.82)	(125.64)	(107.36)
LRB 20-30%	-570.36	-536.12	-738.04	-278.05*
	(209.54)	(204.38)	(195.71)	(165.77)
LRB>30%	-438.01	-434.99	-688.28	-114.94*
	(184.55)	(179.66)	(176.95)	(150.80)
Farm Size (relative to 0-5)				
5-10			1178.38	624.87*
			(431.48)	(386.60)
10-20			2789.11	314.24*
			(248.71)	(250.94)
20-50			-716.91	-1533.48
			(238.53)	(214.34)
Access to institutions/public goods				
				(118.32)
Electricity				359.31
				(84.43)
Technical Assistance				(232.68)
				(85.17)
Cooperatives				70.04*
				(69.09)
Technology and inputs				
Average value of machines				0.03
				(0.00)
Irrigation				-139.18*
				(203.93)
Fertilization				585.11
				(109.29)
Limestone				-529.27
				(119.26)
Pesticide				(392.22)
				(106.49)
Agricultural practices				154.93
				(87.84)
Constant	943.31	788.56	-118.28*	-205.51
	(47.51)	(50.63)	(158.74)	(150.28)
State Fixed effects	No	Yes	Yes	Yes
Adjusted R2	0.21	0.25	0.33	0.53
Observations (Municipalities)	752	752	752	752

Source: Author‘s calculation with 1985 and 2006 Agricultural Censuses (IBGE), aggregated data.

Notes: Robust standard errors in parenthesis. * Not significant at 5%