UNIVERSIDADE CATÓLICA DOM BOSCO
PROGRAMA PÓS-GRADUAÇÃO *STRICTU SENSU* EM
CIÊNCIAS AMBIENTAIS E SUSTENTABILIDADE AGROPECUÁRIA


# Análise Econométrica dos Determinantes da Diversificação de Renda e de Culturas em Unidades Produtivas de Base Familiar

Autor: Gabriel Paes Herrera
Orientador: Dr. Michel Angelo Constantino de Oliveira

**UCDB**

Campo Grande
Mato Grosso do Sul
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"Dissertação apresentada, como parte das exigências para obtenção do título de MESTRE EM CIÊNCIAS AMBIENTAIS E SUSTENTABILIDADE AGROPECUÁRIA, no Programa de Pós-Graduação *Stricto Sensu* em Ciências Ambientais e Sustentabilidade Agropecuária da Universidade Católica Dom Bosco – Área de concentração: "Sustentabilidade Ambiental e Produtiva" Aplicada ao "Agronegócio e Produção Sustentável".

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# Análise Econométrica dos Determinantes da Diversificação de Renda e de Culturas em unidades produtivas de Base Familiar

**Autor**: Gabriel Paes Herrera
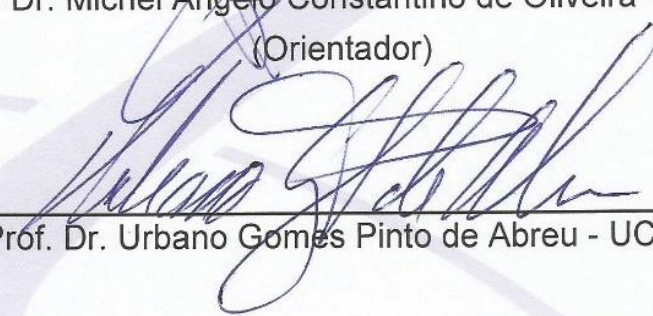**Orientador:** Prof. Dr. Michel Ângelo Constantino de Oliveira

**TITULAÇÃO:** Mestre em Ciências Ambientais e Sustentabilidade Agropecúaria
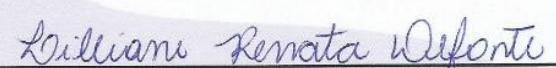**Área de concentração:** Sustentabilidade Ambiental e Produtiva

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# SUMÁRIO

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IBGE – Instituto Brasileiro de Geografia e Estatística

DAP – Declaração de Aptidão ao Pronaf

PRONAF – Programa Nacional de Fortalecimento da Agricultura Familiar

PIB – Produto Interno Bruto

FAO – Food and Agriculture Organization of the United Nations

Ha – Hectare

OECD - Organisation for Economic Co-operation and Development

PAA - Programa de aquisição de alimentos

PNAE - Programa Nacional de Alimentação Escolar

MDA – Ministério do Desenvolvimento Agrário

GPV - Gross production value

BRL – Real brasileiro

UN - United Nations

SDI - Simpson's Diversity Index

# RESUMO

A agricultura familiar é atualmente o arranjo de produção agrícola mais comum em todo o mundo. A produção advinda deste setor é extremamente importante para o abastecimento de mercados e a segurança alimentar mundial. Apesar de sua importância, a agricultura familiar carece de estudos com dados atualizados. O presente estudo analisa dados do Ministério do Desenvolvimento Agrário de 2014 de agricultores familiares em nível nacional em substituição aos dados do último Censo Agropecuário feito pelo IBGE em 2006, objetivando fornecer um retrato mais atual do setor no Brasil. O banco de dados deriva do formulário chamado "DAP – Declaração de aptidão ao Pronaf" o qual é de preenchimento obrigatório para todos os agricultores familiares que desejem ter acesso a linhas de crédito e subsídios do governo. No formulário, o produtor declara informações socioeconômicas detalhadas que passam a constituir uma poderosa fonte de dados. Conforme análise estatística descritiva pode-se afirmar que de 2006 a 2014 o número de agricultores familiares no país aumentou e mais da metade destes estão localizados na região Nordeste. A maioria possui baixo grau de escolaridade e existe uma enorme desigualdade entre as regiões do Brasil, principalmente entre o Sul e o Nordeste. Os resultados das análises econométricas apresentam os determinantes para o aumento da receita, produtividade e diversificação dos agricultores familiares. Um dos fatores mais importantes nos três casos refere-se ao produtor estar associado a uma cooperativa, fato importante visto que as análises demonstraram que apenas 5% dos agricultores familiares são associados a cooperativas. A idade do titular da DAP apresentou uma relação não-linear nos três casos e o titular ser do sexo feminino teve impacto negativo nas três análises. A assistência técnica rural demonstrou impacto negativo na receita e na produtividade, contudo esta variável é uma das que mais impacta positivamente a probabilidade de diversificação da produção.

**Palavras-chave:** agricultura familiar, pequenos produtores, segurança alimentar, econometria, políticas púbicas

# ABSTRACT

Family farming is currently the most common agricultural production arrangement in the world. Production from this sector is extremely important for supplying markets and to world's food security. Despite its importance, family farming lacks of studies and updated data. The present study analyzes data from the Ministry of Agrarian Development from 2014 of family farmers at national level, instead of utilizing data of the last Agricultural Census made by IBGE in 2006, aiming to provide a more current overview of the sector in Brazil. The database is derived from a form called "DAP - Declaration of Aptitude to Pronaf", which is mandatory for all family farmers who wish to have access to credit lines and government subsidies. In this form the producer declares detailed socioeconomic information that makes it a powerful source of data. According to a descriptive statistical analysis, it can be stated that from 2006 to 2014 the number of family farmers in the country increased and more than half of these are located in the Northeast region. Most of them have low schooling level and there is a huge inequality between the regions of Brazil, mainly between the South and Northeast. The results of the econometric analyzes present the determinants for increasing income, productivity and diversification of family farmers. One of the most important factors in the three cases is the fact of the farmer being associated to a cooperative, a matter of concern since the analyzes showed that only 5% of family farmers are cooperated. The age of the household head presented a non-linear relation in the three cases and the household head being a female had a negative impact in the three analyzes. Rural technical assistance showed to negatively impact income and productivity, however this is one of the variables that most increases the probability of production diversification.

**Key words:** family farming, smallholders, food security, econometrics, public policies.

# INTRODUÇÃO

A diversificação produtiva vem sendo objetivo de diversos estudos nos últimos anos por seus benefícios nos âmbitos econômico, social e ambiental. Os produtores que optam por este tipo de cultivo usufruem de maior estabilidade na renda, segurança alimentar, economias na manutenção da lavoura, maior qualidade do solo, maior produtividade, sustentabilidade a longo prazo, dentre outros benefícios (ALTIERI, 1999; BALOTA *et al*., 2004; LI *et al*., 2009; BARETTA *et al*., 2014).

A agricultura é um dos maiores setores na economia do Brasil e desempenha papel importante na balança comercial e na composição do PIB nacional. Segundo Guanziroli *et al*. (2012) o valor bruto da produção dos agricultores familiares em 2006 correspondeu a mais de 36% da produção agropecuária total do país, o que demonstra a força e a importância que os estabelecimentos agrícolas familiares têm para o Brasil. Os autores destacam ainda que os agricultores familiares fazem o uso mais eficiente dos fatores terra e capital, por serem itens mais escassos para este grupo que, portanto os utiliza de forma mais intensiva e cuidadosa.

A decisão de especializar ou diversificar a produção é influenciada por diversos fatores, o principal é a busca por maior rentabilidade financeira. Outros fatores incluem a mitigação de riscos financeiros e segurança alimentar, este último mais comum entre os agricultores familiares mais pobres (SAMBUICHI *et al*., 2014).

O processo de modernização da agricultura, principalmente nas últimas duas décadas, tem priorizado a mecanização e o uso intensivo de agrotóxicos e fertilizantes. Este método de cultivo, considerado tradicional atualmente, tem gerado diversos impactos ambientais e posto em risco a sustentabilidade agropecuária. Faz-se necessária a adoção de práticas sustentáveis que diminuam a degradação do solo como plantio direto e a diversificação produtiva (BALOTA *et al*., 2004; FERREIRA *et al*., 2010; KAMIYAMA *et al*., 2011).

Segundo Oliveira Filho *et al*. (2014), a identificação dos fatores que levam os agricultores familiares a optarem pela diversificação é importante pois auxilia na

formulação de políticas públicas e aponta quais ações devem ser priorizadas e adotadas visando beneficiar os produtores e a sustentabilidade ambiental.

O aumento da produtividade através da diversificação pode ser a solução para a crescente demanda mundial de alimentos, conforme exposto por Li *et al*. (2009), FAO (2014) entre outros. Considerando a importância do setor agrícola no Brasil, os estudos que avançam para desenvolver e manter a sua sustentabilidade são essenciais. As contribuições econômicas, sociais e ambientais reforçam os motivos pela qual a diversificação deve ser estimulada e amplamente utilizada.

A disponibilidade de informações precisas e atualizadas servem de base para formulação de políticas públicas que são decisivas para o desenvolvimento da agricultura familiar. Sendo assim, o presente estudo baseia-se nos dados mais atuais sobre o setor disponíveis atualmente buscando extrair informações importantes com a utilização de técnicas de estatística multivariada.

# OBJETIVOS

Contribuir com a disponibilidade de dados e análises mais atuais sobre a agricultura familiar no Brasil. Buscou-se calcular os coeficientes e analisar os fatores determinantes para o aumento da receita, produtividade e diversificação da produção de agricultores familiares no Brasil em 2014.

**Objetivos específicos**

- Realizar análise estatística descritiva do banco de dados da DAP – Declaração de Aptidão ao Pronaf de 2014.
- Calcular os coeficientes e analisar os determinantes de aumento da receita, produtividade e diversificação da produção de agricultores familiares.

# REVISÃO BIBLIOGRÁFICA

## A agricultura familiar no mundo

A agricultura familiar vem ganhando reconhecimento, especialmente nos últimos anos, por sua contribuição para produção agrícola mundial além de contribuições sociais e ambientais (BOSC *et al*., 2013). De acordo com estimativas de Graeub *et al*. (2016) e Lowder *et al*. (2014) esta é a forma prevalente de agricultura no mundo, das 570 milhões de fazendas existentes calcula-se que mais de 500 milhões sejam propriedades familiares. Ao mesmo tempo estes, que também são chamados de pequenos produtores, ocupam mais da metade de toda a área agrícola disponível no mundo e produzem pelo menos 53% dos alimentos.

Apesar de representarem quase 90% de todas as propriedades rurais a área cultivada pelos agricultores familiares em geral é pequena. Segundo Lowder *et al*. (2014) 475 milhões de pequenos agricultores possuem menos de 2 hectares de terra e cerca de 410 milhões possuem menos de 1 hectare. Conforme FAO (2014) este é um dos motivos pelo qual os agricultores familiares são mais eficientes comparado com os agricultores industriais. Os pequenos produtores têm seus recursos limitados, principalmente terra e capital, portanto o disponível é utilizado ao máximo com praticamente nenhum desperdício resultando em maior produtividade.

Não existe uma definição universal para agricultura familiar, alguns trabalhos mais antigos consideravam apenas propriedades com menos de 2 hectares, contudo está definição baseada apenas no tamanho claramente não reflete a realidade, no Brasil por exemplo a área média de um agricultor familiar é de 19 ha. Este conceito vem evoluindo e, apesar da definição variar em cada país, alguns pontos são considerados essenciais como: a área ser propriedade de uma família; predominância de mão de obra familiar e ter a maior parte da renda derivada das atividades da fazenda (BERDEGUE e FUENTEALBA, 2011; GRAEUB *et al*., 2016).

Além da importância para a produção agrícola mundial a agricultura familiar também desempenha importante papel social. Segundo Bosc *et al*. (2013), este setor abrange aproximadamente 2 bilhões de pessoas que dependem desta atividade para sua subsistência. É um ramo que gera e mantém empregos produtivos e renda que permite uma vida decente para bilhões de pessoas na área rural.

Somado a isto existe também a contribuição ambiental da agricultura familiar. De acordo com FAO (2014), estima-se que a população mundial chegue a 9,6 bilhões de pessoas em 2050 exigindo que a produção agrícola aumente em 60% para atender a demanda de alimentos. Toda esta produção extra colocará ainda mais pressão sob o solo, água e a biodiversidade, recursos ambientais que já sofrem com a escassez e degradação. Portanto não será suficiente apenas produzir mais, mas fazer isto com sustentabilidade. Segundo Bosc *et al*. (2013) a maior eficiência de agricultores familiares em relação a produtores industriais tem sido amplamente documentada, pequenos agricultores são capazes de atingir altos níveis de produção com o uso de mão de obra familiar em sistemas produtivos diversificados. Estes utilizam os recursos disponíveis da maneira mais produtiva possível, conservando e fazendo uso sustentável dos recursos naturais.

Por estas razões a agricultura familiar é vista como a solução para garantir a segurança alimentar mundial no longo prazo (FAO, 2014). No entanto, para isto, há a necessidade de ações que promovam o crescimento e fortaleçam este setor. Muitos países têm focado em programas de desenvolvimento agrícola voltados à intensificação da produção, monocultura e commodities, alcançando altos níveis de produtividade, porém esquecendo-se da resiliência. Existe a necessidade de reconstruir a habilidade do setor público em agir de forma eficiente para o fortalecimento dos pequenos agricultores. Pesquisa e serviços de assistência técnica são cruciais para o desenvolvimento de sistemas e práticas adaptadas as necessidades destes produtores como a agroecologia e práticas sustentáveis visando o uso mais eficiente dos recursos. Com investimento e suporte a agricultura familiar ainda tem enorme potencial para aumentar a receita e produção, principalmente em países em desenvolvimento (GRAEUB *et al*., 2016; FAO, 2014 e BOSC *et al*., 2013).

A agricultura familiar no Brasil

Assim como para o mundo a agricultura familiar também desempenha papel crucial na economia brasileira. Segundo o IBGE (2006), o setor foi responsável por 38% do valor total da produção agrícola nacional em 2006. Sendo também muito importante para a segurança alimentar do país, as propriedade rurais familiares respondem pelo fornecimento de grande parte dos alimentos consumidos no mercado interno como 83% da mandioca, 76% do feijão preto, 59% dos porcos e 58% do leite de vaca. Uma produção expressiva e essencial para o abastecimento de diversos setores e distribuição de renda no meio rural.

O Brasil está entre as dez maiores economias do mundo e tem a quinta maior área superficial. O país desempenha importante função no mercado agrícola internacional, sendo o maior fornecedor de açúcar, café e suco de laranja, além de ser um grande exportador de soja, tabaco, milho e arroz. Espera-se que o mercado agrícola continue crescendo nas próximas décadas com o aumento da população mundial, e a expectativa é de que o Brasil mantenha sua posição no topo das exportações agrícolas criando ótimas oportunidades para os agricultores familiares (OECD/FAO, 2015).

A agricultura familiar no Brasil é definida pela Lei n° 11.326 (BRASIL, 2006), tendo como pontos principais a necessidade de predominância da mão de obra familiar, limitação de área em quatro módulos fiscais (o módulo fiscal pode variar entre 5 e 110 ha dependendo da região), percentual mínimo da renda familiar originada das atividades econômicas do estabelecimento e exigência que o agricultor dirija seu estabelecimento com sua família. De acordo com IBGE (2006), dos 5,1 milhões de estabelecimentos rurais existentes no país 4,3 milhões pertencem a agricultores familiares, mais de 84%. Ainda, mais de 12 milhões de pessoas dependem deste setor para sua subsistência. Contudo está grandeza não se reflete na quantidade de terras, a agricultura familiar ocupa cerca de 80 milhões de hectares, apenas 24% de toda área agrícola disponível, fruto da elevada concentração fundiária no país.

A região Nordeste concentra pouco mais da metade dos agricultores familiares do país, bem como a população mais carente, não sendo difícil encontrar produtores que praticam a agricultura de subsistência (BERDEGUE e

FUENTEALBA, 2011). Em contrapartida, de acordo com Guilhoto *et al*. (2007), o desenvolvimento e a alta produtividade da região Sul são altamente relacionados com a forma de colonização e a cultura que se estabeleceu na região devido a imigração europeia no século dezenove.

Atualmente algumas políticas públicas importantes como o Programa Nacional de Fortalecimento da Agricultura Familiar (PRONAF) além de outras linhas de crédito, recebem críticas de diversos autores, pois são orientadas para o financiamento de itens específicos e levam os agricultores a especialização produtiva de cultivos comerciais como commodities para exportação. A falta de foco em cadeias produtivas e a ausência quase total de assistência técnica geraram resultados contrários aos esperados do PRONAF e agravou o problema de distribuição de renda entre os agricultores familiares (GRISA *et al*., 2010; GUANZIROLI *et al*., 2012; SAMBUICHI *et al*., 2014).

Outros programas incluem o Programa de aquisição de alimentos (PAA) que permite a compra da produção de agricultores familiares para doar a populações carentes sem necessidade de licitação e o Programa Nacional de Alimentação Escolar (PNAE) que torna obrigatória a aquisição de pelo menos 30% dos alimentos destinados à merenda escolar diretamente dos agricultores familiares (OECD/FAO, 2015). Estes programas, apesar de auxiliarem o setor, focam apenas na disponibilidade de crédito sendo um remédio de curto prazo. Outras medidas como pesquisa e desenvolvimento de tecnologias voltadas aos pequenos agricultores, incentivos a cooperativas e disponibilidade de assistência técnica rural de qualidade são vistas como de maior importância para garantir o futuro da agricultura familiar no longo prazo (GRAEUB *et al*., 2016).

## Diversificação produtiva

A diversificação da produção, segundo Oliveira Filho *et al*. (2014), é uma importante ferramenta de gestão de risco na qual o agricultor independe sua fonte de renda de apenas uma cultura, além disso traz também benefícios ecológicos e auxilia no controle de pragas e doenças. Também para Altieri (1999), os sistemas diversificados fornecem um meio de promover a diversidade da dieta e da renda, a estabilidade da produção, minimização do risco, redução da incidência de insetos e

doenças, o uso eficiente do trabalho, intensificação da produção com recursos limitados e maximização dos retornos com baixos níveis de tecnologia. Ainda, estima-se que os sistemas de agricultura diversificada sejam responsáveis pelo fornecimento de 15-20% da oferta de alimentos mundial.

O desafio nas próximas décadas será aumentar a produção agrícola para atender à crescente demanda mundial de alimentos, ao mesmo tempo em que o mundo sofre com as mudanças climáticas em consequência do aquecimento global e a escassez e degradação dos recursos naturais. Portanto a agricultura futura deverá ser baseada em sistemas resilientes que promovam a sustentabilidade como a diversificação da produção, integração lavoura-pecuária-floresta e agroflorestas (FAO, 2014). Vilela *et al*. (2012), apontam a utilização de sistemas de integração lavoura-pecuária-floresta como potencial solução. Este método já vem sendo utilizado em várias regiões e revela grande potencial para aumento da produção e redução da emissão de carbono, além de contribuir para a melhoria da qualidade do solo e gerar economias aos produtores.

A redução de custos para o agricultor familiar também é citada por Altieri (1999), o autor aponta que a diversificação realiza serviços ecológicos fundamentais e quando aplicada corretamente pode levar a sistemas de cultivo capazes de proporcionar sua própria fertilidade do solo, proteção das culturas e produtividade. Além disso, resulta na reciclagem de nutrientes, produção de biomassa e ativa a biota do solo, fatores que levam a produção sustentável, conservação de energia e menor dependência de insumos externos. Estas abordagens agroecológicas visam quebrar a estrutura de monocultura, aproveitando os efeitos da integração da biodiversidade vegetal e animal que aumenta as interações e sinergias complexas e otimiza as funções e processos dos ecossistemas permitindo assim que os agroecossistemas possam auto sustentar seus funcionamentos.

No Brasil, 57% dos estabelecimentos da agricultura familiar são considerados diversificados, porém os agricultores especializados possuem renda maior. Além disso, as regiões nordeste e sul são as que mais possuem propriedades agrícolas familiares com produção diversificada (SAMBUICHI *et al*., 2014). De acordo com Guanziroli *et al*. (2012), comparando o grau de diversificação obtido dos censos agropecuários feitos pelo IBGE em 1996 e 2006 pode-se concluir que houve uma tendência de especialização produtiva na agricultura familiar, certamente atribuída ao crescimento do cultivo de soja e outras commodities na última década.

A diversificação desempenha ainda importante papel social, os agricultores mais pobres obtêm neste modelo a sua segurança alimentar, para estes a policultura é uma forma de sobrevivência. O cultivo para autoconsumo pode ser visto como uma fonte de renda não monetária, a qual possibilita que as famílias economizem recursos na aquisição de alimentos nos mercados e façam frente a outras necessidades relevantes (GRISA *et al*., 2010; FRITZ FILHO *et al*., 2013)

Um estudo realizado por Grisa *et al*. (2010) pesquisou a importância da produção para o autoconsumo para os agricultores familiares do Rio Grande do Sul. Os resultados demonstraram que, na região pesquisada, as famílias deixam de gastar em média 27% da renda total anual com aquisição de alimentos nos mercados, e utilizam desta economia para fazer frente a outras demandas necessárias como luz, água e telefone.

A agricultura faz parte de um sistema complexo que interage com o meio ambiente a sua volta e, portanto não pode ser tratada como uma atividade isolada. Li *et al*. (2009), destacam que o aumento da produção de alimentos com a diversificação é muito simples e pode ser facilmente aplicada nos países em desenvolvimento, ponto muito importante face a diminuição de terras disponíveis para agricultura e o aumento da demanda de alimentos.

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# CAPÍTULO I: SMALLHOLDER FARMING IN BRAZIL: AN OVERVIEW FOR 2014

# SMALLHOLDER FARMING IN BRAZIL: AN OVERVIEW FOR 2014

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## ABSTRACT

**The goal of this paper is to provide an update on smallholder farming in Brazil. Instead of using data from the last available Agricultural Census (2006), a database from the Ministry of Agrarian Development for 2014 was used. These data are extracted from a tax form called "Declaração de Aptidão ao Pronaf-DAP" (Declaration of Aptitude to Pronaf) that is mandatory for all farmers in Brazil and is used as a source of information to screen smallholders, also called "family farmers" in Brazil, applying for special subsidized public funds available to those in this category. Therefore, the DAP is a valuable source of information regarding this sector. The results show that family farming in Brazil continues to grow and is concentrated in the Northeastern region. The South and Southeast have the highest yields per hectare, up to seven times more than the Northeast. Most of the land is in the hands of a small group concentrated in the Northeast, while most of the income is in the hands of a small group concentrated in the South.**

**Key words:** Family farm, Economy, Brazil, Agriculture.

## INTRODUCTION

The world's agricultural market is expected to continue to grow over the next decade as the world population grows at an exponential rate. Brazil is among the world's ten largest economies and has the fifth-largest surface area, and it plays an important role in agricultural exports in the international market. The country is the world's second-largest agricultural exporter and the leading supplier of sugar, orange juice and coffee; furthermore, it is a major exporter of soybeans, tobacco, maize and rice (OECD/FAO, 2015).

Family farms in Brazil represent more than 80% of production units and were responsible for 38% of the gross value of agricultural production in 2006, according to the Brazilian Institute of Geography and Statistics – IBGE (2006). There is no universal definition for family farming; for example, the Brazilian definition focuses on less affluent farms, while the US definition includes farms of all sizes, from farms with low revenue to those that are multi-million dollar enterprises. It is estimated that there are more than 570 million farms in the world, and more than 500 million of these are owned by families (Lowder et al., 2014). Brazilian law's main points for defining a family farm are as follows: a farm managed by the owner and his or her family; smaller than four fiscal modules (one module may be between 5 and 110 ha depending on the locality); mostly

family rather than hired labor; and the family's main source of household income (Government of Brazil, 2006).

As reported by the OECD/FAO (2015), Brazil is projected to maintain its role as a leading supplier to international food and agriculture markets over the next decade, bringing new opportunities for family farmers. In Brazil, family agriculture has become stronger in the last few years due to the success of certain public policies implemented, which inspired other countries in Africa to adopt similar programs. One of them is The National Program for the Strengthening of family farming (PRONAF), which provides low-interest credit and whose resources reached BRL 25 billion in 2014.

To gain access to that credit and other benefits from the government, family farmers are asked to maintain a register in the Ministry of Agrarian Development (MDA). They must complete a form known as the "DAP" (Declaration of Aptitude to Pronaf), in which they provide detailed information about themselves and their properties, such as age, sex, schooling, area of the farm, number of crops produced, income of each crop, total income, number of workers and other income sources on-farm and off-farm, among others. There are approximately 5 million DAPs registered in the MDA database, which creates a plentiful source of information about family farming in Brazil. A survey with information as detailed as that obtained through the DAP is not possible even with the Agricultural Census.

Most of the studies about family farms conducted in Brazil are based on the Agricultural Census, which was last conducted in 2006. Studies using the information from the DAPs are still scarce due to the difficulty and bureaucracy involved in obtaining the data from the MDA. The Agricultural Census data, meanwhile, is easily accessed by everyone. Playing a major role in Brazil's economy and in the international market, family farms need proper attention. This article aims to generate a portrait of family farming in Brazil in 2014 using the information declared by the farmers on the DAP to offer an analysis with a new perspective and more updated and complete data.

## MATERIALS AND METHODS

This article is based on information declared by family farmers on the DAP form obtained through the Ministry of Agrarian Development (MDA) from October 2014. Family farmers from every state in the country can fill in their declaration forms on authorized organizations and, after its correct completion, the form is immediately sent electronically to the MDA system. Subsequently, the DAP is checked to identify any mistakes or false information. The farmers must communicate any changes related to their properties and are not allowed to go for more than three years without updating their DAPs. Therefore, the data extracted from the system database contains information that may have been inserted on the same day or as far back   as three years ago.

The method used to analyze the data was exploratory, with the purpose of verifying the behavior of family farming in 2014. To carry out the analysis, the database was refined by removing cases with missing values or very distorted values (outliers) to minimize errors in the results. Approximately 133 thousand DAPs were excluded, and the final database used for this study contained approximately 4.7 million cases.

The database analyses were conducted using the statistical software R, given its capacity to process large amounts of data.

**RESULTS AND DISCUSSION**

First, it is important to highlight that Brazil's size means that it contains many different climates, biomes and cultures, which affects agribusiness throughout the country. Therefore, it would not be correct to analyze the data and assume that the average values reflect the reality of the whole country. There are five main regions in Brazil, and each has its own importance, particular characteristics and productive structures. Thus, it is interesting to conduct analyses on a national level as well as on a regional level to develop a more micro perspective and better understand the reality of family farming in Brazil.

Going through the profile of the DAP owners, there are approximately 2.9 million males, representing 62.8%, and more than 1.7 million females, forming 37.2% of farmers. Studies conducted in Ghana, Kenya and Cotê D'ivoire demonstrated a higher number of male smallholder heads: 70%, 80.6% and 85.2% respectively (Martey et al., 2012; Kiplimo et al., 2015; Lawin and Zongo, 2016). The age distribution is very wide-ranging, from 18 – the age of majority in Brazil - to 100 years old. Figure 1 indicates that most family farmers are between 20 and 55 years old. These results are similar to the mean age between 31 and 50 found by Kiplino et al. (2015) in a study conducted with 600 family farmers in Kenya.
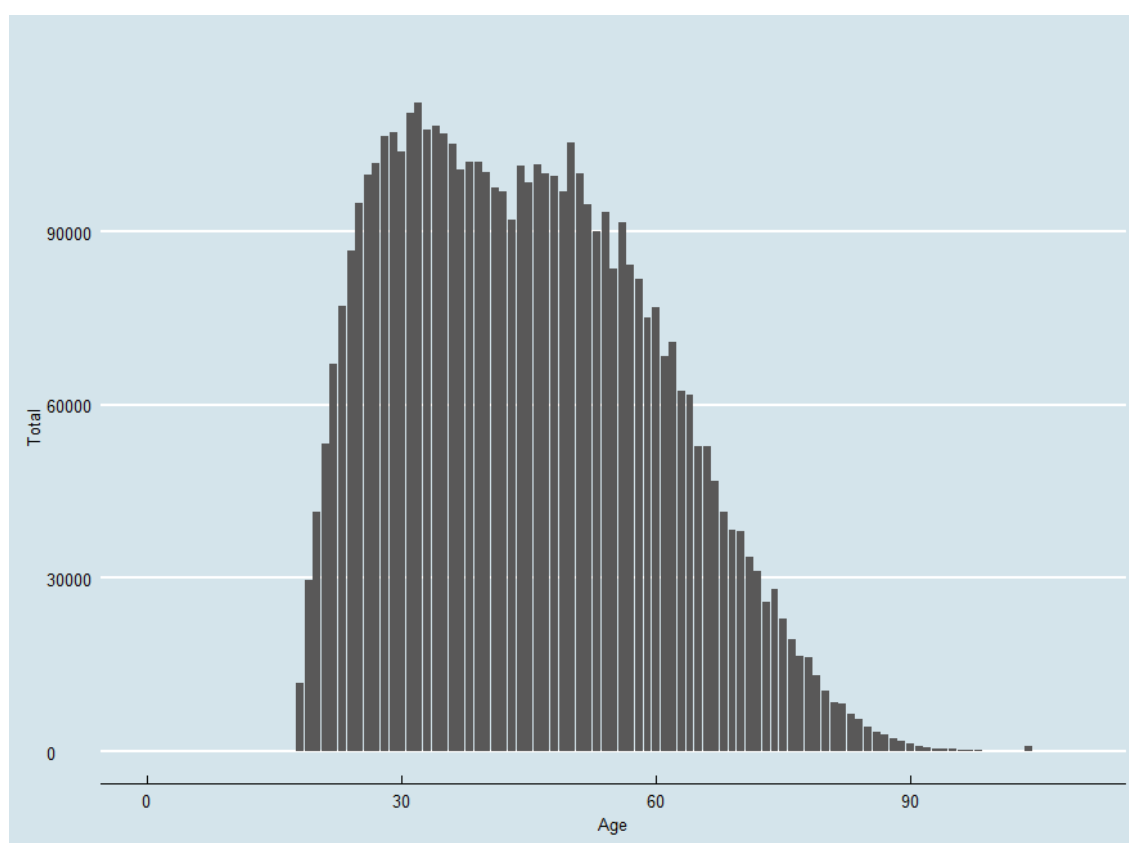


**Figure 01.** Age distribution of smallholder heads based on the Declaration of Aptitude to Pronaf (DAP).

Schooling levels draw attention to the fact that most smallholders have a low level of education, ranging from having completed elementary school to literate, according to Figure 2. This scenario is true for all regions of the country, as none of them stands out with high levels of education. According to Lawin and Zongo (2016), most of agricultural household heads in Cotê D'Ivoire have not been to school and, as in Brazil, the level of education of family farmers is in general very low.

The results also show a low number of family farmers who are members of agricultural cooperatives, only 5%. Those who seek technical assistance or for formal education make up only 7.6%, and these numbers are similar to the ones found by Guanziroli et al. (2012). Partnership arrangements are considered to be the reason for the strengthening and resilience of smallholders in regions as eastern Spain and it is also regarded as a very important factor for family farmers in Ghana which mostly belong to a farmer association (Moreno-Perez et al., 2011; Martey et al., 2012). The results present evidence of the continuity of the profile of family farmers in Brazil already described in the IBGE 2006 Agricultural Census.
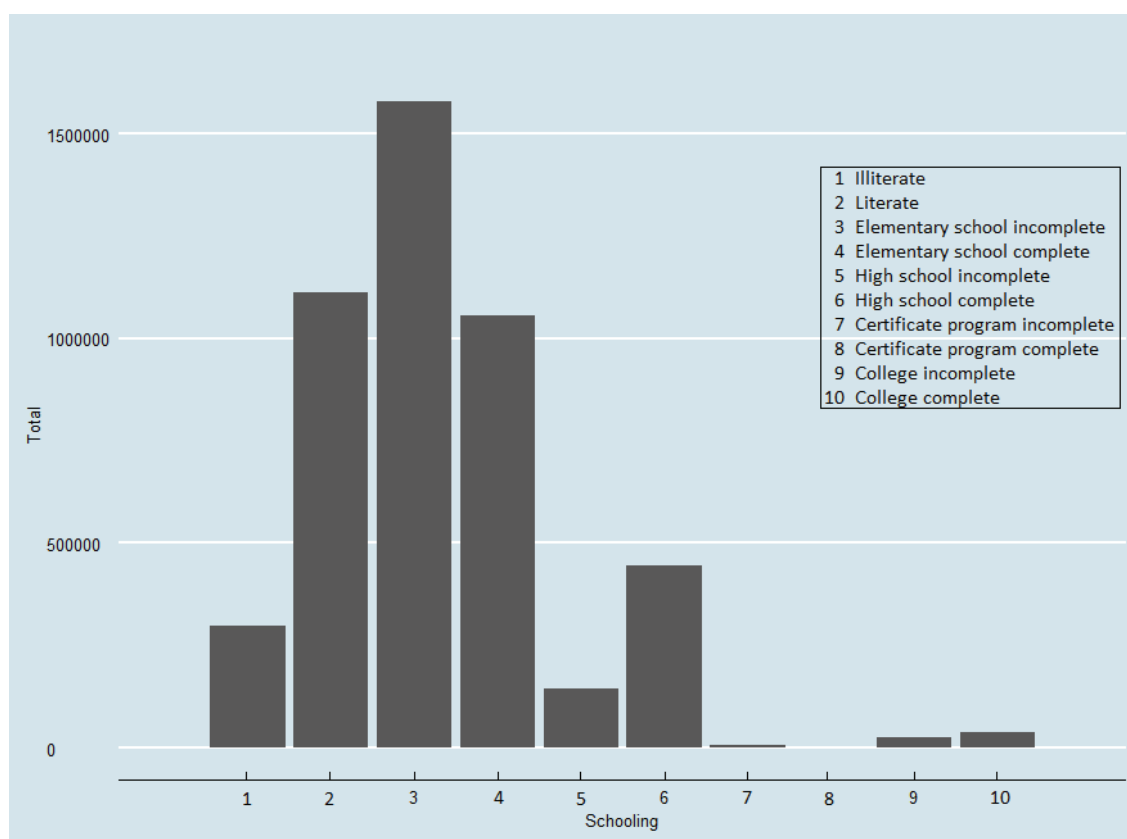


**Figure 02.** Schooling levels of smallholder heads.

The average size of smallholder's farms in Brazil is 19.06 ha, however there are major differences between the five main regions. The Central-West and North have the biggest averages, 41.07 ha and 39.67 ha respectively. Whereas the Southeast, Northeast and South have an average size of 17.08 ha, 16.02 ha and 15.51 ha respectively. Those results suggest that the average size of smallholder's farms in Brazil are bigger than those in other regions such as eastern Spain (5 ha), central-east Kenya

(2 ha), Republic of Macedonia (1.7 ha) and Malawi (0.4 ha) (Moreno-Perez et al., 2011; Kikulwe et al., 2015; Angelovska and Ackovska, 2012; Denning et al., 2009).

According to the database, more than half (61.4%) of Brazilian family farmers are located in the Northeast region, as shown in Figure 3. On the Agricultural Census (2006) this amount was approximately 50.1%. Following in second place is the South region followed by the Southeast, North and Central-West, respectively. The Central-West region is known as an area of large industrial farms and for its focus on producing commodities for exportation, with little space for family farmers.



**Figure 03.** Distribution of family farms by main regions in Brazil.

Notably, even though the large majority of family farmers are located in the Northeast, the region is not the leader in gross production value (GPV). Instead, the South region is responsible for the largest proportion of the GPV, approximately 38.6%. The GPV analyzed considers all on-farm income sources that include agriculture and livestock production, agro-industry, handicraft and agrotourism. This reveals greater production efficiency in the South, which can be seen on Figure 4. The difference between the regions in Brazil are impressive: while the South has an average productivity of BRL 3,225.55/ha, that of the Northeast region is BRL 410.57/ha. According to Guilhoto et al. (2007), the structure observed in the South is strongly related to the form of colonization of the region and to the culture that settled there due to the European immigration to Brazil.

Furthermore, the South, Southeast and Central-West regions are areas with a higher rainfall rate, better soil fertility and, consequently, more expensive land. On the

other hand, the Northeast region is an area that experiences long dry periods and is less developed, with high levels of social inequality. The productivity increase in this region is strongly related to investments in irrigation.



**Figure 04.** Relationships between farm area and Gross Production Value (GPV) by main regions in Brazil.

Unfortunately, inequality is a constant problem in Brazil and is also present in family farming. The database shows that only 10.6% of family farmers own farms with an area greater than or equal to 50 hectares and they occupy 52.8% of the total area owned by family farmers in Brazil. Most of these are located in the Northeast region, as shown on Table 1. It was found, however, that 9.4% of family farmers have 53.3% of the total annual GPV and the large majority of them are in the South and Southeast regions. Again, the superior capacity of production per hectare of the South and Southeast regions can be verified. Moreover, these figure draw attention to the fact that perhaps millions of hectares in the Northeast are not being used to their fullest capacity. Angelovska and Ackovska (2012) found a similar problem of uncultivated lands in the Republic of Macedonia, there, among other reasons, this problem is related to the lack of cooperativism amidst family farmers. This may also be the reason for the low productivity in large areas in the Northeast region, however further studies need to be conducted in order to diagnose the causes of this problem in the region.

A study conducted by Guanziroli et al. (2012) also found a small group of 400,000 family farmers that were responsible for 69.5% of the total production and concentrated

most of the revenue, but this study did not specify where in Brazil this group was located.

**Table 01.** Distribution of larger properties and bigger incomes.

| | Area more or equal to 50 ha | | | | Income more or equal to BRL 50K | | | |
|---|---|---|---|---|---|---|---|---|
| | Quant. | %* | Area ha | %* | Quant. | %* | GPV | %* |
| **North** | 131,320 | 2.8 | 13,160,219 | 14.7 | 33,617 | 0.7 | 2,748,977,336 | 3.2 |
| **Northeast** | 254,536 | 5.4 | 24,536,925 | 27.4 | 34,062 | 0.7 | 2,863,856,517 | 3.3 |
| **Southeast** | 44,173 | 0.9 | 3,652,725 | 4.1 | 135,131 | 2.9 | 12,907,695,540 | 14.9 |
| **South** | 29,587 | 0.6 | 1,946,875 | 2.2 | 200,104 | 4.3 | 23,583,617,590 | 27.3 |
| **Central-West** | 38,823 | 0.8 | 4,004,729 | 4.5 | 39,820 | 0.8 | 3,993,244,645 | 4.6 |
| **Total** | **499,439** | **10.6** | **47,301,473** | **52.8** | **442,734** | **9.4** | **46,097,391,628** | **53.3** |

* Percentage in relation to the total of family farmers analyzed.

Although we cannot confirm that all family farmers in Brazil are registered on MDA and have a DAP, the number of DAPs analyzed in this article (4.7 million) is greater than the total number of family farmers found by the 2006 Agricultural Census (4.3 million). It is possible to assume from these figures that the number of family farmers has been increasing in Brazil. More than half of them are located in the Northeast, which has the largest properties; however, this region has one of the lowest revenues, which clearly demonstrates a problem of inequality that has also been identified by other authors and still persists.

The huge productivity gap between regions needs to be carefully assessed. Brazil is expected to remain one of the largest agricultural exporters in the world and will therefore need to rely on family farm production, which has already proved to be voluminous and important for the country. One of the solutions may be investing in and encouraging the education of family farmers. Although the low level of schooling is prevalent in all states and some states have high levels of productivity per hectare despite low education levels, the promotion of education would be beneficial for the entire sector.

The problem of income concentration by a small portion of family farmers has already been described by Guanziroli et al. (2012), who attribute it to the fact that there are subgroups of family farmers: industrial, non-industrial and peasant. Industrial family farmers seem to have access to the most lines of credit. Therefore, it is necessary to adjust the public policies for strengthening family farming that are actually creating inequity and strengthening a small group rather than all.

## Conclusions

The analyses show that family farming continues to grow and plays an important role in Brazilian agricultural production. The existence of a disproportional distribution of family farmers, which are highly concentrated in the Northeast region, was observed. Another main point is the low level of schooling found for the vast majority of family farmers in all regions of Brazil. In addition, the data revealed an enormous inequality in the distribution of land and income. Among Brazilian family farmers, 10.6%, mostly from the Northeast, own 52.8% of the land. In contrast, 9.4% of family farmers, mostly in the South, concentrate 53.3% of the total income of the sector.

Further studies are necessary to diagnose the causes of low productivity in the Northeast region, this may be a key point for increasing agricultural production of family farmers in Brazil. In addition, it is important that new studies continue updating the data of the sector rather than analyzing information from the Agricultural Census of 2006.

## Conflict of Interests

The authors have not declared any conflicts of interest.

## ACKNOWLEDGEMENTS

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CAPÍTULO II: ECONOMETRIC ANALYSIS OF INCOME, PRODUCTIVITY AND DIVERSIFICATION AMONG SMALLHOLDERS IN BRAZIL

# ECONOMETRIC ANALYSIS OF INCOME, PRODUCTIVITY AND DIVERSIFICATION AMONG SMALLHOLDERS IN BRAZIL

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## ABSTRACT

Family farming plays important roles in agricultural production and the world's food security. This paper provides an econometric analysis of income, productivity and diversification of Brazilian smallholders. Using the most updated data from the Ministry of Agrarian Development (MDA) enables a more precise analysis than traditional agri-

census data. The database contains approximately 4.7 million family farmers from all regions of the country. We used linear and tobit regression to untangle useful information behind these large datasets. The results demonstrated that the smallholders that are part of an agricultural cooperative or a member of a farmer's association positively affect income, productivity and diversification. The age of household heads is shown to have a non-linear relationship in the three cases, while the household head being female presented a negative effect in all regressions. Although recent technical assistance showed negative impacts on income and productivity, farmer's assistance positively affected the likelihood of a smallholder diversifying their production and, therefore, becoming less subject to price imbalances. The results support current views in the field of smallholder farming while presenting marked regional differences of a continental country, enabling policy makers to make better, more informed decisions.

**Key words:** Agricultural Economics; Smallholder; Brazil; Econometric Analysis.

## 1. Introduction

The importance of smallholder agriculture has become more evident for food production in the past few years, where smallholders are mainly composed of family farmers. This group has been recognized as extremely important for global food security, particularly after the 2014 United Nations' (UN) Year of Family Farming. Because of growing concerns in food security, some important measures to strengthen smallholder's agriculture can already be seen, such as in the development of public policies and increasing investments targeting this sector (Bosc et al., 2013). The

important contribution of family farmers to the world's agricultural production is evident. Therefore, this contribution must be encouraged and enhanced.

There is no universal definition of a family farm. Formerly, only properties with less than two hectares were considered smallholders. However, this definition is based only on property size and does not represent the reality. This concept has evolved and, despite definitions varying between countries, some issues are considered essential; for example, there needs to be a property held by a family with only or mostly family labor, and that labor should produce a large share of their income. According to this definition, smallholding is the prevalent form of farming globally; approximately 90% of all farms in the world are considered family farms and are responsible for producing most of the world's food (Berdegue and Fuentealba, 2011; Graeub et al., 2016).

According to the Food and Agriculture Organization (FAO) of the United Nations - FAO (2014), there are at least 500 million family farms in the world that support almost 2 billion people who depend on these farms for their livelihood. The large majority of these farms are very small; 72% are less than one hectare and only 1% are bigger than 50 ha. In Brazil, there are approximately 4.7 million family farmers who own a total of 89 million hectares and support 17 million people (Bosc et al., 2013; Herrera et al., 2017). As in other countries, smallholders in Brazil are essential not only for their production, which in 2006 accounted for 38% of the gross value of agriculture, but also because they help the country to ensure the supply for the domestic market and maintain its position as a dominant agricultural exporter, according to the Brazilian Institute of Geography and Statistics – IBGE (2006).

There are increasing concerns about the growing global demand for food in the next few decades, particularly in the face of climate change. Closing this food shortage

gap will place additional stress on land, water and biodiversity, which are already scarce or are showing signs of degradation in several countries (FAO, 2014). Market requirements are showing that it is not enough to produce more food, but that the production needs to be done with an emphasis on sustainability. The efficiency of smallholder farming relative to larger farms has been widely documented (Bosc et al., 2013); smallholders can achieve high production levels using family labor in diversified production systems. Therefore, these 500 million family farmers are the key to ensuring the world's food security and environmental sustainability (FAO, 2014).

In line with the size and importance of family farming to the world, this sector needs to be constantly monitored. As stated by Bosc et al. (2013), up-to-date information on the smallholder sector is important for the purpose of strategic investments and to strengthen this group. To contribute to those goals, this study analyzes family farming in Brazil using the most current data available. Most of the studies of this sector in Brazil are based on the Agricultural Census, which was last conducted by the IBGE in 2006. However, our approach uses the Ministry of Agrarian Development (MDA) cadaster from 2014. Studies using data from the MDA are scarce since there is a restrictive bureaucracy involved in obtaining these data compared to the Agricultural Census, from which data are easily accessed.

By focusing on income, productivity and diversification, this paper aims to better understand the determinants of these three key points for family farmers and the world's future. Actions to empower and increase smallholder's income are key in reducing high poverty rates and gender inequalities in rural areas. Improvements in productivity are crucial to attending to the growing demand for food. While diversification is important for family farmer's income security, the practice enhances sustainability in agriculture, since

diversification can value rare seeds and form seed cooperatives, enlarging the diversity of cultivated species (Bosc et al., 2013; FAO, 2014). Our paper is organized as follows. The next section presents the data source and describes the methodology. The econometric techniques and the variables considered. Then, the empirical results are presented and the findings are discussed. The final section provides conclusions and recommendations for future research.

## 2. Materials and methods

### 2.1. Data source

The data analyzed in this article were obtained through the MDA in October 2014 and are from a dataset form known as the "DAP" (Declaration of Aptitude to Pronaf), which is mandatory for all family farmers in Brazil who wish to have access to public financing, special subsidies and other policies available to those in this category. Smallholders from every state in the country can fill in their declaration forms on authorized organizations, and after its correct completion, the form is immediately sent electronically to the MDA system. Subsequently, the DAP is checked to identify any mistakes or misleading information. The farmers must communicate any changes related to their properties and are not allowed to go more than three years without updating their DAPs. Therefore, the data extracted from the database contain information that may have been inserted on the same day or as far back as three years ago. This is a useful timeframe for agricultural cycles.

The information provided by the farms in the DAP form is very detailed and includes social and technical variables, such as age, gender, schooling, area of the

farm, number of crops produced and total income, among others. To carry out the analysis, we refined the database, removing cases with missing or distorted values (outliers) in order to minimize type 1 and type 2 errors. Approximately 3% (133,000 DAPs) were excluded, and the final database used for this study contained approximately 4.7 million cases. Therefore, it creates a plentiful source of information about family farming in Brazil (a description of all variables can be found in Table 01).

**Table 01.** Variables description and summary statistics.

| Variable | Description | Mean | Std. Dev. |
|---|---|---|---|
| Land owner | Dummy (0, 1) | 0.6243 | 0.4842 |
| Gender | HH Dummy (1 male, 2 female) | 1.3720 | 0.4833 |
| Age | HH Age in years | 44.8358 | 15.2110 |
| Area | Total area of the farm in hectares | 19.0604 | 33.3236 |
| Income | Total on-farm income in BRL | 18404.13 | 37667.88 |
| Diversification | Simpson index value | 0.3529 | 0.2821 |
| Cooperative | Dummy (0, 1) | 0.0497 | 0.2175 |
| Rural assistance | Dummy (0, 1) | 0.0768 | 0.2663 |
| Region 1 | North dummy (0, 1) | 0.0945 | 0.2925 |
| Region 2 | Northeast dummy (0, 1) | 0.6144 | 0.4867 |
| Region 3 | Southeast dummy (0, 1) | 0.1188 | 0.3235 |
| Region 4 | South dummy (0, 1) | 0.1421 | 0.3492 |
| Region 5 | Central-west dummy (0, 1) | 0.0300 | 0.1706 |
| Income social benefits | Income from social benefits in BRL | 861.1216 | 3666.725 |
| Income off-farm | Total off-farm income in BRL | 376.4161 | 2749.629 |
| Age² | Age squared | 2241.631 | 1474.818 |
| Hired work force | Number of hired work force in days/man | 3.6980 | 1.7514 |

| Schooling 1 | HH schooling. Literate dummy (0, 1) | 0.0631 | 0.2432 |
| Schooling 2 | HH schooling. Elementary school completed dummy (0, 1) | 0.8600 | 0.3469 |
| Schooling 3 | HH schooling. High school completed dummy (0, 1) | 0.1898 | 0.3921 |
| Schooling 4 | HH schooling. College completed dummy (0, 1) | 0.0764 | 0.2657 |
| Productivity | Productivity BRL/ha | 8345.119 | 334852.2 |

*HH (Household head)

## 2.2. Linear regressions

We applied two linear regressions in order to identify determinants of income and productivity, considering that these two dependent variables have continuous values. According to Wooldridge (2015), regression techniques allow us to explore and infer the relation between a dependent variable and specific independent variables. The basic equation is given by the formula:

$$y = c + \beta x + \varepsilon \qquad \text{(eq. 1)}$$

where $x$ is the explanatory variable (independent), $y$ is the explained or dependent variable and $\varepsilon$ is the error that corresponds to the deviation between the real value and the approximate value of $y$ and $c$ is the constant that represents the value of $y$ when $x$ is equal to zero. The coefficients $\beta$ and $c$ are obtained by the least squares method using the following formulas:

$$\beta = \frac{n.\sum_{i=1}^{n} XiYi - \sum_{i=1}^{n} Xi \sum_{i=1}^{n} Yi}{n.\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} Xi\right)^2} \qquad \text{(eq. 2)}$$

$$C = \frac{\sum_{i=1}^{n} Yi - \beta \sum_{i=1}^{n} Xi}{n} \qquad \text{(eq. 3)}$$

The quality and adjustments of the values obtained in the regression are measured with the $R^2$ index. The dependent variables "income" and "productivity" were used in logarithmic form, following the current literature as outlined by Salazar et al. (2016), Meraner et al. (2015), Olwande et al. (2015) and Benoit (2001).

## 2.3. Tobit regression

The third objective of this study is to analyze determinants of income diversification. The measurement of income diversity was done using Simpson's Diversity Index - SDI (Simpson, 1949). The Simpson Index is one of the most meaningful and robust diversity measures available (Magurran, 2004). This index considers all varieties of income sources and their proportional contribution to the total income diversification. The analysis, based on smallholder's income inside the farm (on-farm), includes agriculture and livestock production, agro-industry, handicraft and agrotourism. While completing the DAP form, farmers must specify their income with each crop, and thus the index also considers the diversity of species cultivated in the farm. Simpson's Index was calculated through the formula:

$$Simpson's Diversity\ Index = 1 - \sum_{i=1}^{N} \left(\frac{X_i}{\sum_{i=1}^{N} X_i}\right)^2 \qquad \text{(eq. 4)}$$

$X_i$, gross value of each product or crop

$N$, number of products and crops

The index varies from 0 to 1, where 0 represents a very specialized farmer and 1 a very diversified farmer. For study purposes, four classes of diversity degree were established, following the one adopted by Sambuichi et al. (2016):

- Very specialized: SDI = 0;

- Specialized: SDI > 0.0 and ≤ 0.35;

- Diversified: SDI > 0.35 and ≤ 0.65;

- Very diversified: SDI > 0.65.

We used the Tobit (Tobin, 1958) estimation model, since a common problem in regression analysis occurs when the dependent variables are censored. Here, the dependent variable (SDI) is restricted between 0 and 1 and follows a normal distribution $N(\mu, \sigma^2)$. In this case, $Y$ has a truncated normal distribution, $Y \geq 0$ or $Y \leq 1$. The regression model in which the dependent variable has a truncated normal distribution is known as the Tobit model. Following Verbeek (2008), the theoretical model was utilized:

$$X_i = \beta' \mathbf{Z_i} + \varepsilon_i$$

$$Y = X, se \; X \geq 0$$

$$Y = 0, se \; X < 0$$

Where $\beta_i$ is a vector of specific parameters associated with the vector $Z_i$, which contains the observable farm's and farmers characteristics. The error term $\varepsilon_i$ is normally distributed and assumed to be multivariate with a mean of zero. The estimation is made through the following likelihood function:

$$logL = -\frac{n}{2}\log(2\pi) - \frac{n}{2}log\sigma^2 - \Sigma\left(\frac{X_i - \beta'Z_i}{\sigma}\right)^2 + \Sigma log\left[1 - \Phi\left(\frac{\beta'Z_i}{\sigma}\right)\right] \quad \text{(eq. 5)}$$

where $n$ is the sample size, and $\Phi$ ( ) is the cumulative density of the normal distribution of the latent variable. This is the common likelihood function of a truncated distribution. In this analysis, the dependent variable has the following density function of probability: $f(X|X > 0) = \frac{f(X)}{Prob(X>0)}$, according to the definition of a conditional probability. However, $Prob(X > 0) = 1 - \Phi\left(\frac{0 - \beta'Z_i}{\sigma}\right)$. Thus, the first three terms of the likelihood function refer to the normal distribution of the latent variable (conditional probability numerator), and the last term refers to the probability that the latent variable is greater than zero, that is, having some degree of diversification (denominator of conditional probability).

We measured the regression quality using the McFadden pseudo-$R^2$, which is equivalent to the unit minus the ratio between the likelihoods of the complete model and the model with only the intercept. The pseudo-$R^2$ is analogous to conventional $R^2$ in order to capture the adjustment in relation to the predictive capacity of the model, although it has a different interpretation.

## 3. Results and Discussion

Brazil is a country of great proportions and many contrasts, and the difference of the agribusiness of each region is clear. Figure 01 shows the average of the variables income, productivity and diversification for each Brazilian state. The highest incomes are in the Central and Southern regions, while the highest productivities are in the Federal District (capital of the country) and in some Southern states. However, productivity in smallholdings are generally low. The most diversified states are in the Northeast and South of the country. Production diversification in the Northeast is associated with subsistence and food security of families, as this region is concentrated with the country's poorest populations (Simões et al., 2010; Berdegue and Fuentealba, 2011). The diversified production and high productivity of smallholders in the South are strongly related to the form of colonization of the region and to the culture that settled there, due to the European immigration to Brazil in the nineteenth century (Guilhoto et al., 2007; Fernandes and Woodhouse, 2008).

**Figure 01**. Average income, productivity and diversification of each state.
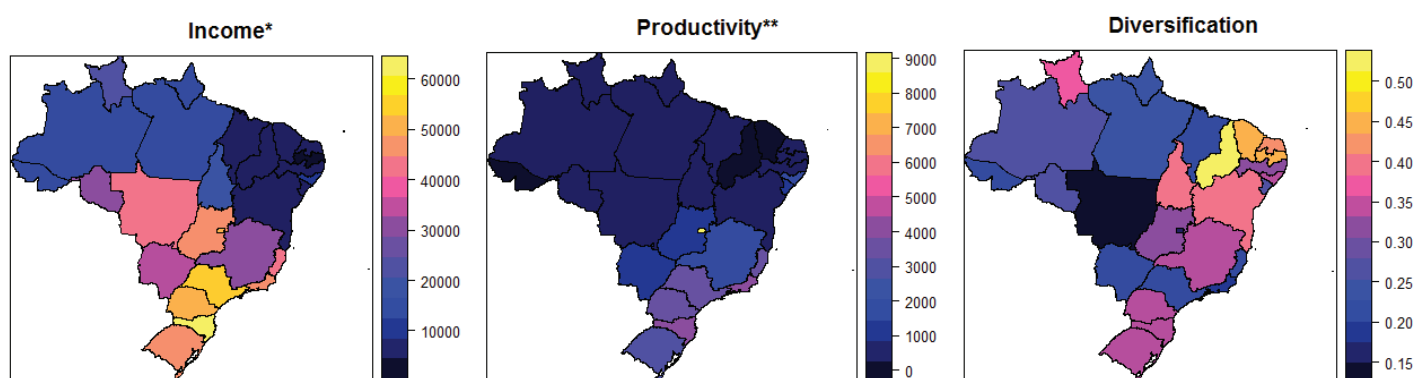


*Annual income in BRL; **BRL/ha/annual. Data from October 2014.

The regression results are presented in Table 02, where all coefficients are significant (p<0.01). The variables "Region 5" and "Schooling 4" were omitted because of multicollinearity. According to the results, family farmer's income is more positively affected in cases where the farmer belongs to a cooperative or a farmer's association. As reported by FAO (2014), cooperatives play a very important role in smallholder's production and access to markets. A study conducted in China by Ito et al. (2012) also highlights that the agricultural cooperative system is an important avenue for farmers to improve their income. However, despite the importance and benefits, only 5% of family farmers are associated with cooperatives in Brazil (Herrera et al., 2017).

The fact of the farmer being the owner of the land, instead of having a leasing or any other type of contract, is the second most positively impacting factor on smallholder's income. Production diversification also has a positive impact on income, as well as increased property size and the farmer having an off-farm source of income, although the latter variable presents a very low coefficient value. Family farmers being from the North, Northeast and Southeast are negatively affected compared to those from the Central-West, while farmers from the South region are positively impacted.

A sign of gender inequality can also be derived from data, where female smallholder head is negatively related to household income. Similarly, having had recent access to rural technical assistance, having a hired work force and receiving income from social benefits were also negatively related to income. With respect to schooling, being only literate has a positive impact on income, while having elementary or high school completed have negative effects compared to having college completed. These results can be explained by the fact that farmers with higher levels of education are

more likely to secure a non-farm job and settle down in cities, according to Yue et al. (2010) and Greiner and Sakdapolrak (2013). Thus, smallholders seeking formal education tend to reduce agricultural production until the point they migrate to the city, leaving less educated workforce in the rural areas.

The age variable presented a positive impact in all three regressions, although the age squared variable showed a negative impact in all three cases. This demonstrates a non-linear relationship corresponding to theories of household life cycles; in other words, after a certain age threshold, it no longer has a positive impact and starts to have negative effects, corroborating the studies of Jayne et al. (2003), Fischer and Qaim (2012) and Abdulai and CroleRees (2001).

**Table 02.** Effect of the variables on income, productivity and diversification.

| | Dependent Variable | | |
|---|---|---|---|
| | **Income log** | **Productivity log** | **SDI** |
| Land owner | 0.409*** | 0.441*** | -0.069*** |
| | (0.0001) | (0.001) | (0.0004) |
| Gender | -0.494*** | -0.251*** | -0.027*** |
| | (0.001) | (0.001) | (0.0004) |
| Age | 0.013*** | 0.005*** | 0.008*** |
| | (0.0002) | (0.0002) | (0.00007) |
| Area | 0.006*** | -0.026*** | 0.001*** |
| | (0.00002) | (0.00002) | (0.00000) |
| Income | ——— | ——— | -0.00000009*** |
| | | | (0.00000) |
| Diversification | 0.145*** | -0.451*** | ——— |

| | | | |
|---|---|---|---|
| | (0.002) | (0.002) | |
| Cooperative | 0.506*** | 0.265*** | 0.011*** |
| | (0.003) | (0.003) | (0.0009) |
| Rural assistance | -0.279*** | -0.259*** | 0.054*** |
| | (0.002) | (0.002) | (0.0007) |
| Region 1 | -0.685*** | -0.538*** | 0.099*** |
| | (0.004) | (0.004) | (0.001) |
| Region 2 | -1.544*** | -1.049*** | 0.277*** |
| | (0.003) | (0.004) | (0.001) |
| Region 3 | -0.079*** | 0.078*** | 0.155*** |
| | (0.003) | (0.004) | (0.001) |
| Region 4 | 0.271*** | 0.207*** | 0.238*** |
| | (0.003) | (0.004) | (0.001) |
| Region 5 | ———— | ———— | ———— |
| Income social benefits | -0.00001*** | -0.00001*** | 0.000005*** |
| | (0.00000) | (0.00000) | (0.00000) |
| Income off-farm | 0.00003*** | 0.00002*** | 0.000002*** |
| | (0.00000) | (0.00000) | (0.00000) |
| Age² | -0.0001*** | -0.0001*** | -0.00006*** |
| | (0.00000) | (0.00000) | (0.00000) |
| Hired work force | -0.008*** | -0.002*** | 0.004*** |
| | (0.0003) | (0.0004) | (0.0001) |
| Schooling 1 | 0.177*** | 0.166*** | -0.0706*** |
| | (0.005) | (0.006) | (0.001) |
| Schooling 2 | -0.829*** | -0.528*** | 0.033*** |
| | (0.005) | (0.006) | (0.001) |
| Schooling 3 | -0.574*** | -0.335*** | 0.058*** |

|  | (0.005) | (0.006) | (0.001) |
|---|---|---|---|
| Schooling 4 | _____ | _____ | _____ |
| Productivity | _____ | _____ | 0.00000003*** |
|  |  |  | (0.00000) |
| Constant | 10.451*** | 8.783*** | -0.198*** |
|  | (0.007) | (0.009) | (0.002) |
| Observations | 4,699,422 | 4,699,422 | 4,699,422 |
| $R^2$ | 0.440 | 0.376 | _____ |
| Pseudo $R^2$ | _____ | _____ | 0.0406 |

Note: *p<0.1; **p<0.05; ***p<0.01

Standard error in parentheses

Regarding the determinants of productivity, the smallholder being the owner of the land is the variable that most positively impacted production, followed by the farmer being part of a cooperative. Having an off-farm source of income also positively impacted productivity, despite having a low value coefficient. Although Latin America has the second highest land productivity globally (Bosc et al., 2013), the productivity of smallholders in Brazil is generally low.

The diversification of production was the variable that most negatively affected productivity, in contrast to the positive impact that it causes on family farmer's income. Contrary to what might be expected, farmer receipts of technical assistance had negative impacts on productivity, and income. This contrasts with other studies, such as Fernandes and Woodhouse (2008) and Marenya and Barrett (2006), which reported this variable is important for improving production and productivity. The smallholder head being a female also presented a negative impact on productivity, reinforcing the signs of

gender inequality. Greater property size, having a hired work force and receiving income from social benefits showed negative effects as well. However, these three last variables had low value coefficients.

According to the results, the smallholder being from the South and Southeast regions positively impacted productivity, while being from the Northeast or North negatively affected productivity when compared to those from the Central-West region. For income, schooling level showed the same results, in what being only literate has a positive impact while having elementary or high school completed have negative impacts, compared to smallholders with college completed.

Analyzing the determinants for production diversification, family farmers who recently received rural technical assistance or belong to a cooperative or a farmer's association were shown to be more diversified. A study conducted by Herath and Takeya (2003) with smallholders in Sri Lanka showed that contact with extension agents also had positive effects on the intention of farmers' intercropping cultures. This is an important variable to be encouraged by public policies, as diversification is considered an essential tool for risk management, cost reduction and sustainability increases, according to Fernandes and Woodhouse (2008), Meraner et al. (2015), Abdulai and CroleRees (2001) and Barrett et al. (2001). Farmers that have a hired work force or greater property size are also positively associated with diversification. The positive relationship between large farms and diversification is also reported in the Netherlands and in Sothern Mali by Meraner et al. (2015) and Abdulai and CroleRess (2001). Further, the probability of diversification also increases if the smallholder receives income from social benefits or has an off-farm income source, with these last two having very low coefficients.

In cases where the farmer is the landowner or the household head is a female, the chances of production diversification are lower. The probability also decreases in cases of greater income or productivity, although these coefficients are very low. The chances of a smallholder diversifying production are higher in all regions compared to those from the Central-West region. Regarding the smallholder schooling level, being only literate decreases the probability of diversification, while having elementary or high school completed increases the chances compared to those with college completed.

## 4. Conclusions

Public policy has large impacts on the success of family farms and food security and is simultaneously crucial for the economic and social wellbeing of smallholders. The adoption of fast and robust actions by governments can provide assertive impacts on gender inequality and the effectiveness of technical assistance towards social, economic and environmental sustainability. Selecting appropriate data sources can make a difference in the success or failure of an entire agricultural sector. Our results demonstrated that one of the most important factors to increasing income, productivity and diversification is the participation of family farmers in agricultural cooperatives or farmer's associations. Therefore, governmental actions should facilitate participation in these organizations.

It was also possible to observe a non-linear disposition in the household head age, corresponding to theories of household life cycles in which age has a positive impact until a certain age when it begins to have a negative impact.

On the issue of gender, the negative household results on female-led farms and their impact on productivity, income and diversification deserves special attention. This suggests the need for catered actions to empower and strengthen women in rural areas and better metrics to reflect other impacts of their participation in the family farm activities.

There is also the fact that a farmer receiving recent rural technical assistance had a negative impact on income and productivity, whereas this same factor is the one which most positively impacts the probability of a smallholder diversify the production. This needs careful analysis, since the quality of rural technical assistance is responsible for improving production and productivity in other countries and can be particularly decisive in enhancing resilience and reducing crop related risks.

Despite higher level of education having a negative effect on income and productivity, these results can be explained by the fact that smallholders with higher schooling degree tend to seek non-farm jobs and move to cities. Thus, public policies need to approach the deeper causes of rural-urban migration flows, including communication, wage and land concentration.

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**Conflicts of Interest:** none.

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# CONSIDERAÇÕES FINAIS

As análises apresentadas neste estudo fornecem informações importantes quanto a agricultura familiar no Brasil. Apesar de não se poder afirmar que todos os agricultores familiares possuem uma DAP, o número de agricultores familiares analisados no banco de dados obtido junto ao MDA é superior ao número registrado pelo Censo Agropecuário realizado pelo IBGE em 2006. Sendo possível afirmar que a agricultura familiar vem crescendo no Brasil.

Observou-se também a grande concentração destes produtores na região Nordeste, mais de 60%. E esta mesma região demonstrou ter a menor produtividade do país, que chega a ser sete vezes menor quando comparada a produtividade da região Sul. Os resultados demonstraram um retrato da desigualdade na distribuição de terras e de receita entre os agricultores familiares. Pouco mais de dez por cento destes produtores concentram mais da metade da área agrícola ocupada pelos agricultores familiares, sendo a maioria da região Nordeste. Em contrapartida, quase dez por cento destes agricultores concentram mais da metade da receita de todos os agricultores familiares do país, sendo a maioria da região Sul.

De acordo com as análises, o cooperativismo é uma das variáveis que mais afeta positivamente a receita, a produtividade e a diversificação. Fator preocupante visto que os resultados também demonstram que apenas cinco por cento dos agricultores familiares no Brasil fazem parte de cooperativas. Este é um ponto chave que precisa receber atenção dos governantes.

Ainda, o fato de o agricultor familiar ser do sexo feminino demonstrou ter impacto negativo na receita, produtividade e diversificação. Mais um fator alarmante que demonstrando a existência de desigualdade de gênero no setor. Faz-se necessário, portanto, a adoção de políticas públicas e medidas que apoiem as mulheres que praticam a agricultura familiar no nosso país.

Este estudo contribui para geração de informações importantes e atualizadas sobre a agricultura familiar no Brasil. No entanto, limita-se a fornecer uma perspectiva de quais variáveis impactam de forma positiva e quais impactam de forma negativa o agronegócio familiar, sem revelar porém a razão para este impacto. Portanto, os resultados sugerem caminhos para novos estudos que possam apresentar os motivos pelos quais cada variável impacta positiva ou negativamente os agricultores familiares no Brasil.

Importante também ressaltar a necessidade de estudos que abordem o fluxo migratório campo-cidade, e que principalmente busquem soluções para que agricultores familiares que buscam a educação formal não abandonem suas atividades agrícolas.

APÊNDICE

*Full Length Research Paper*

# Smallholder farming in Brazil: An overview for 2014

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The goal of this paper is to provide an update on smallholder farming in Brazil. Instead of using data from the last available Agricultural Census (2006), a database from the Ministry of Agrarian Development for 2014 was used. These data are extracted from a tax form called "Declaração de Aptidão ao Pronaf-DAP" (Declaration of Aptitude to Pronaf) that is mandatory for all farmers in Brazil and is used as a source of information to screen smallholders, also called "family farmers" in Brazil, applying for special subsidized public funds available to those in this category. Therefore, the DAP is a valuable source of information regarding this sector. The results show that family farming in Brazil continues to grow and is concentrated in the Northeastern region. The South and Southeast have the highest yields per hectare, up to seven times more than the Northeast. Most of the land is in the hands of a small group concentrated in the Northeast, while most of the income is in the hands of a small group concentrated in the South.

**Key words:** Family farm, economy, Brazil, agriculture.

## INTRODUCTION

The world's agricultural market is expected to continue to grow over the next decade as the world population grows at an exponential rate. Brazil is among the world's ten largest economies and has the fifth-largest surface area, and it plays an important role in agricultural exports in the international market. The country is the world's second-largest agricultural exporter and the leading supplier of sugar, orange juice and coffee; furthermore, it is a major exporter of soybeans, tobacco, maize and rice (OECD/FAO, 2015).

Family farms in Brazil represent more than 80% of production units and were responsible for 38% of the gross value of agricultural production in 2006, according to the Brazilian Institute of Geography and Statistics – IBGE (2006). There is no universal definition for family farming; for example, the Brazilian definition focuses on less affluent farms, while the US definition includes farms of all sizes, from farms with low revenue to those that are multi-million dollar enterprises. It is estimated that there are more than 570 million farms in the world, and more than 500 million of these are owned by families (Lowder et al., 2014). Brazilian law's main points for defining a family farm are as follows: a farm managed by the owner and his or her family; smaller than four fiscal modules

(one module may be between 5 and 110 ha depending on the locality); mostly family rather than hired labor; and the family's main source of household income (Government of Brazil, 2006).

As reported by the OECD/FAO (2015), Brazil is projected to maintain its role as a leading supplier to international food and agriculture markets over the next decade, bringing new opportunities for family farmers. In Brazil, family agriculture has become stronger in the last few years due to the success of certain public policies implemented, which inspired other countries in Africa to adopt similar programs. One of them is The National Program for the Strengthening of family farming (PRONAF), which provides low-interest credit and whose resources reached BRL 25 billion in 2014.

To gain access to that credit and other benefits from the government, family farmers are asked to maintain a register in the Ministry of Agrarian Development (MDA). They must complete a form known as the "DAP" (Declaration of Aptitude to Pronaf), in which they provide detailed information about themselves and their properties, such as age, sex, schooling, area of the farm, number of crops produced, income of each crop, total income, number of workers and other income sources on-farm and off-farm, among others. There are approximately 5 million DAPs registered in the MDA database, which creates a plentiful source of information about family farming in Brazil. A survey with information as detailed as that obtained through the DAP is not possible even with the Agricultural Census.

Most of the studies about family farms conducted in Brazil are based on the Agricultural Census, which was last conducted in 2006. Studies using the information from the DAPs are still scarce due to the difficulty and bureaucracy involved in obtaining the data from the MDA. The Agricultural Census data, meanwhile, is easily accessed by everyone. Playing a major role in Brazil's economy and in the international market, family farms need proper attention. This article aims to generate a portrait of family farming in Brazil in 2014 using the information declared by the farmers on the DAP to offer an analysis with a new perspective and more updated and complete data.

## MATERIALS AND METHODS

This article is based on information declared by family farmers on the DAP form obtained through the Ministry of Agrarian Development (MDA) from October 2014. Family farmers from every state in the country can fill in their declaration forms on authorized organizations and, after its correct completion, the form is immediately sent electronically to the MDA system. Subsequently, the DAP is checked to identify any mistakes or false information. The farmers must communicate any changes related to their properties and are not allowed to go for more than three years without updating their DAPs. Therefore, the data extracted from the system database contains information that may have been inserted on the same day or as far back as three years ago.

The method used to analyze the data was exploratory, with the purpose of verifying the behavior of family farming in 2014. To carry out the analysis, the database was refined by removing cases with missing values or very distorted values (outliers) to minimize errors in the results. Approximately 133 thousand DAPs were excluded, and the final database used for this study contained approximately 4.7 million cases.

The database analyses were conducted using the statistical software R (R Core Team, 2017), given its capacity to process large amounts of data.

## RESULTS AND DISCUSSION

First, it is important to highlight that Brazil's size means that it contains many different climates, biomes and cultures, which affects agribusiness throughout the country. Therefore, it would not be correct to analyze the data and assume that the average values reflect the reality of the whole country. There are five main regions in Brazil, and each has its own importance, particular characteristics and productive structures. Thus, it is interesting to conduct analyses on a national level as well as on a regional level to develop a more micro perspective and better understand the reality of family farming in Brazil.

Going through the profile of the DAP owners, there are approximately 2.9 million males, representing 62.8%, and more than 1.7 million females, forming 37.2% of farmers. Studies conducted in Ghana, Kenya and Cotê D'ivoire demonstrated a higher number of male smallholder heads: 70, 80.6 and 85.2% respectively (Martey et al., 2012; Kiplimo et al., 2015; Lawin and Zongo, 2016). The age distribution is very wide-ranging, from 18 – the age of majority in Brazil - to 100 years old. Figure 1 indicates that most family farmers are between 20 and 55 years old. These results are similar to the mean age between 31 and 50 found by Kiplimo et al. (2015) in a study conducted with 600 family farmers in Kenya.

Schooling levels draw attention to the fact that most smallholders have a low level of education, ranging from having completed elementary school to literate, according to Figure 2. This scenario is true for all regions of the country, as none of them stands out with high levels of education. According to Lawin and Zongo (2016), most agricultural household heads in Cotê D'Ivoire have not been to school and, as in Brazil, the level of education of family farmers is in general very low.

The results also show a low number of family farmers who are members of agricultural cooperatives, only 5%. Those who seek technical assistance or for formal education make up only 7.6%, and these numbers are similar to the ones found by Guanziroli et al. (2012). Partnership arrangements are considered to be the reason for the strengthening and resilience of smallholders in regions as eastern Spain and it is also regarded as a very important factor for family farmers in Ghana which mostly belong to a farmer association (Moreno-Perez et al., 2011; Martey et al., 2012). The results present evidence of the continuity of the profile of
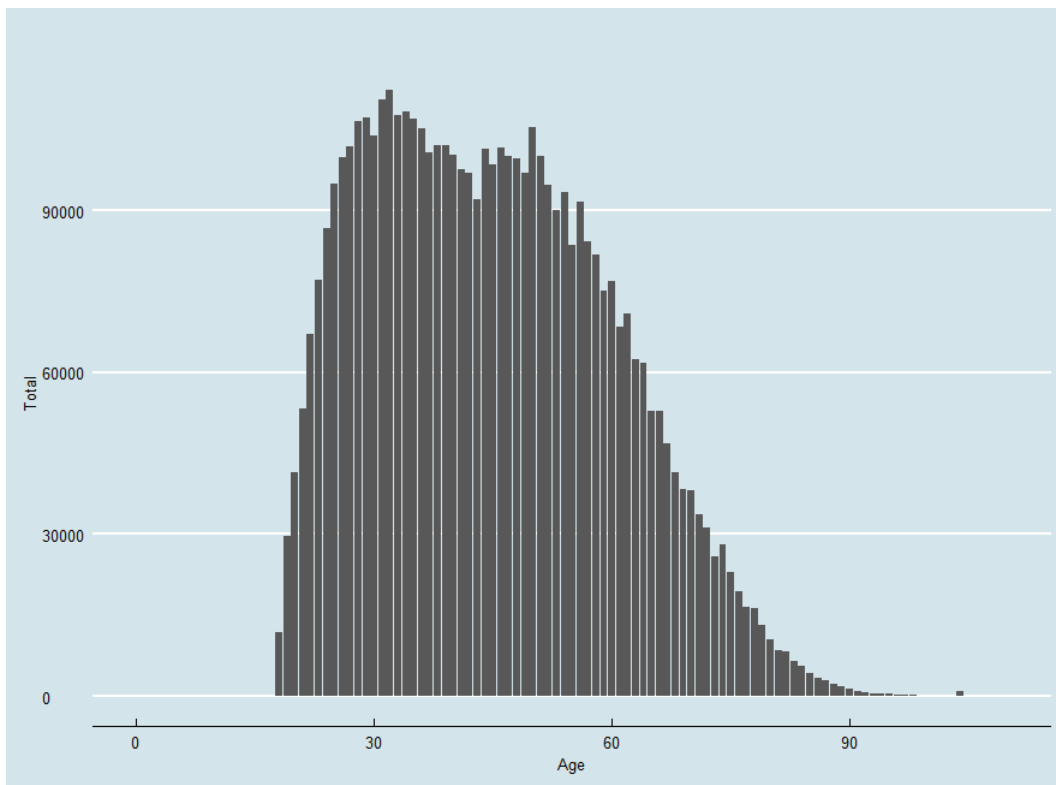
**Figure 1.** Age distribution of smallholder heads based on the Declaration of Aptitude to Pronaf (DAP).
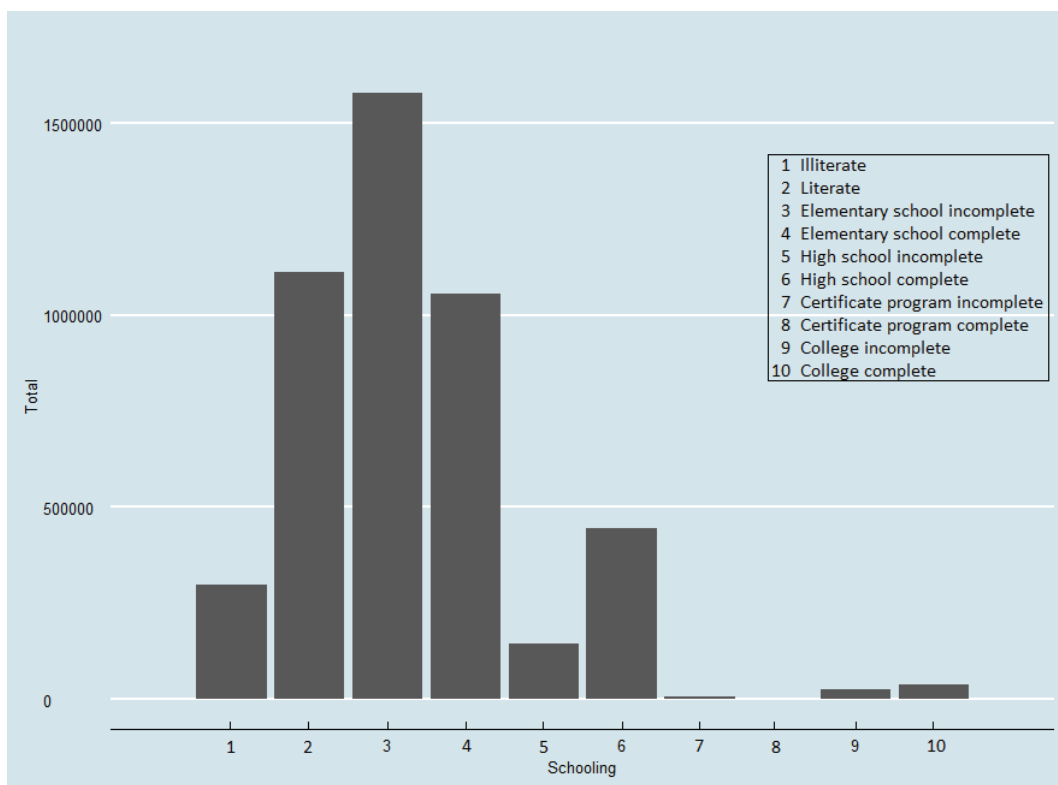


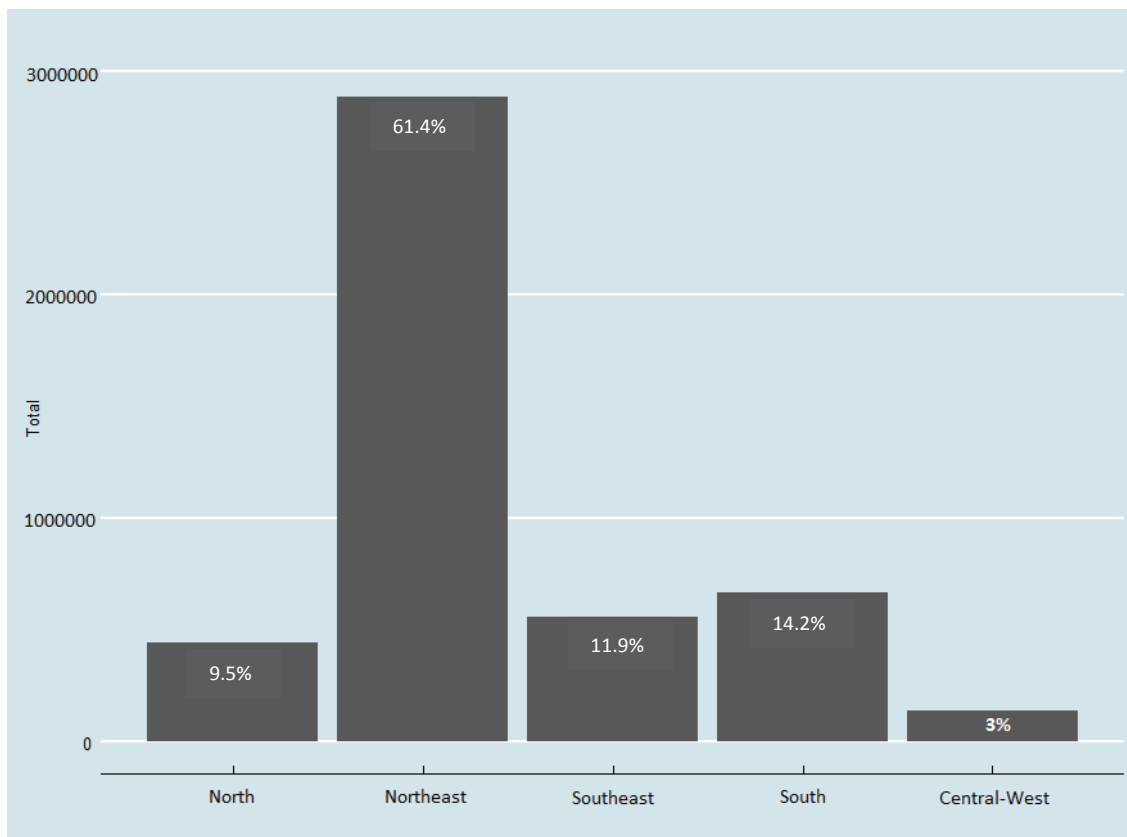**Figure 2.** Schooling levels of smallholder heads.

**Figure 3.** Distribution of family farms by main regions in Brazil.

family farmers in Brazil already described in the IBGE 2006 Agricultural Census.

The average size of smallholder's farms in Brazil is 19.06 ha, however there are major differences between the five main regions. The Central-West and North have the biggest averages, 41.07 ha and 39.67 ha respectively. Whereas the Southeast, Northeast and South have an average size of 17.08 ha, 16.02 ha and 15.51 ha respectively. Those results suggest that the average size of smallholder's farms in Brazil are bigger than those in other regions such as eastern Spain (5 ha), central-east Kenya (2 ha), Republic of Macedonia (1.7 ha) and Malawi (0.4 ha) (Moreno-Perez et al., 2011; Kikulwe et al., 2015; Angelovska and Ackovska, 2012; Denning et al., 2009).

According to the database, more than half (61.4%) of Brazilian family farmers are located in the Northeast region, as shown in Figure 3. On the Agricultural Census (2006) this amount was approximately 50.1%. Following in second place is the South region followed by the Southeast, North and Central-West, respectively. The Central-West region is known as an area of large industrial farms and for its focus on producing commodities for exportation, with little space for family farmers.

Notably, even though the large majority of family

farmers are located in the Northeast, the region is not the leader in gross production value (GPV). Instead, the South region is responsible for the largest proportion of the GPV, approximately 38.6%. The GPV analyzed considers all on-farm income sources that include agriculture and livestock production, agro-industry, handicraft and agrotourism. This reveals greater production efficiency in the South, which can be seen on Figure 4. The difference between the regions in Brazil are impressive: while the South has an average productivity of BRL 3,225.55/ha, that of the Northeast region is BRL 410.57/ha. According to Guilhoto et al. (2007), the structure observed in the South is strongly related to the form of colonization of the region and to the culture that settled there due to the European immigration to Brazil.

Furthermore, the South, Southeast and Central-West regions are areas with a higher rainfall rate, better soil fertility and, consequently, more expensive land. On the other hand, the Northeast region is an area that experiences long dry periods and is less developed, with high levels of social inequality. The productivity increase in this region is strongly related to investments in irrigation.

Unfortunately, inequality is a constant problem in Brazil and is also present in family farming. The database shows that only 10.6% of family farmers own farms with
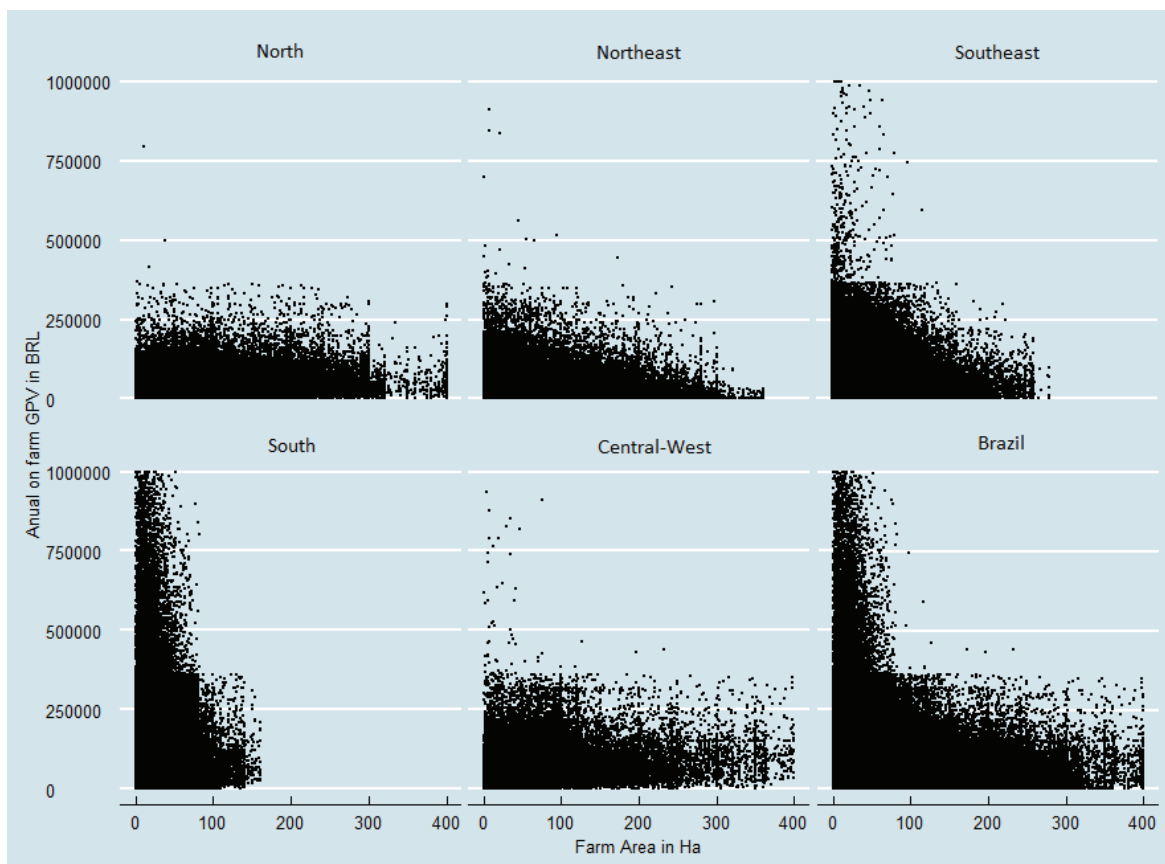
**Figure 4.** Relationships between farm area and gross production value (GPV) by main regions in Brazil.

**Table 1.** Distribution of large properties and bigger incomes.

| Region | Area more or equal to 50 ha | | | | Income more or equal to BRL 50K | | | |
|---|---|---|---|---|---|---|---|---|
| | Quantity | %* | Area ha | %* | Quantity | %* | GPV | %* |
| North | 131,320 | 2.8 | 13,160,219 | 14.7 | 33,617 | 0.7 | 2,748,977,336 | 3.2 |
| Northeast | 254,536 | 5.4 | 24,536,925 | 27.4 | 34,062 | 0.7 | 2,863,856,517 | 3.3 |
| Southeast | 44,173 | 0.9 | 3,652,725 | 4.1 | 135,131 | 2.9 | 12,907,695,540 | 14.9 |
| South | 29,587 | 0.6 | 1,946,875 | 2.2 | 200,104 | 4.3 | 23,583,617,590 | 27.3 |
| Central-West | 38,823 | 0.8 | 4,004,729 | 4.5 | 39,820 | 0.8 | 3,993,244,645 | 4.6 |
| **Total** | **499,439** | **10.6** | **47,301,473** | **52.8** | **442,734** | **9.4** | **46,097,391,628** | **53.3** |

* Percentage in relation to the total of family farmers analyzed.

an area greater than or equal to 50 ha and they occupy 52.8% of the total area owned by family farmers in Brazil. Most of these are located in the Northeast region, as shown on Table 1. It was found, however, that 9.4% of family farmers have 53.3% of the total annual GPV and the large majority of them are in the South and Southeast regions. Again, the superior capacity of production per hectare of the South and Southeast regions can be verified. Moreover, these figure draw attention to the fact that perhaps millions of hectares in the Northeast are not

being used to their fullest capacity. Angelovska and Ackovska (2012) found a similar problem of uncultivated lands in the Republic of Macedonia, there, among other reasons; this problem is related to the lack of cooperativism amidst family farmers. This may also be the reason for the low productivity in large areas in the Northeast region, however further studies need to be conducted in order to diagnose the causes of this problem in the region.

A study conducted by Guanziroli et al. (2012) also

found a small group of 400,000 family farmers that were responsible for 69.5% of the total production and concentrated most of the revenue, but this study did not specify where in Brazil this group was located.

Although we cannot confirm that all family farmers in Brazil are registered on MDA and have a DAP, the number of DAPs analyzed in this article (4.7 million) is greater than the total number of family farmers found by the 2006 Agricultural Census (4.3 million). It is possible to assume from these figures that the number of family farmers has been increasing in Brazil. More than half of them are located in the Northeast, which has the largest properties; however, this region has one of the lowest revenues, which clearly demonstrates a problem of inequality that has also been identified by other authors and still persists.

The huge productivity gap between regions needs to be carefully assessed. Brazil is expected to remain one of the largest agricultural exporters in the world and will therefore need to rely on family farm production, which has already proved to be voluminous and important for the country. One of the solutions may be investing in and encouraging the education of family farmers. Although the low level of schooling is prevalent in all states and some states have high levels of productivity per hectare despite low education levels, the promotion of education would be beneficial for the entire sector.

The problem of income concentration by a small portion of family farmers has already been described by Guanziroli et al. (2012), who attribute it to the fact that there are subgroups of family farmers: industrial, non-industrial and peasant. Industrial family farmers seem to have access to the most lines of credit. Therefore, it is necessary to adjust the public policies for strengthening family farming that are actually creating inequity and strengthening a small group rather than all.

## Conclusions

The analyses show that family farming continues to grow and plays an important role in Brazilian agricultural production. The existence of a disproportional distribution of family farmers, which are highly concentrated in the Northeast region, was observed. Another main point is the low level of schooling found for the vast majority of family farmers in all regions of Brazil. In addition, the data revealed an enormous inequality in the distribution of land and income. Among Brazilian family farmers, 10.6%, mostly from the Northeast, own 52.8% of the land. In contrast, 9.4% of family farmers, mostly in the South, concentrate 53.3% of the total income of the sector.

Further studies are necessary to diagnose the causes of low productivity in the Northeast region, this may be a key point for increasing agricultural production of family farmers in Brazil. In addition, it is important that new studies continue updating the data of the sector rather than analyzing information from the Agricultural Census of 2006.

## CONFLICT OF INTERESTS

The authors have not declared any conflicts of interest.

## ACKNOWLEDGEMENTS

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