Can rural extension reduce income inequality in the rural areas of Brazil?

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RESUMO
A extensão rural tem apoiado os agricultores brasileiros desde os anos 50. A Política Nacional de Assistência Técnica e Extensão Rural (PNATER) remodelou este serviço nos anos 2000 e reforçou a necessidade de prestar esses serviços às pequenas e muito pequenas fazendas e, entre outras finalidades, diminuir a desigualdade de renda. Este trabalho busca identificar o efeito da extensão rural sobre a desigualdade de renda e níveis de renda nas áreas rurais brasileiras. Utilizamos a pesquisa domiciliar (PNAD) para 2014 e um método de decomposição de renda para identificar o efeito da extensão rural nos diferentes quantis de renda. Nossos resultados indicam que, embora a extensão rural aumente a renda das famílias rurais em todos os quantis de distribuição de renda, também aumenta a desigualdade de renda no Brasil rural. O acesso ao crédito rural e à educação são os fatores que mais aumentam o efeito de extensão sobre a renda.
Palavras-chave: Extensão rural, desigualdade de renda, regressão quantílica incondicional, decomposição

ABSTRACT
Rural extension has been supporting Brazilian farmers since the 1950s. The National Policy on Technical Assistance and Rural Extension (PNATER) remodeled this service in the 2000s and re-enforced the need to provide these services to very small and small farms and, subsequently, decrease income inequality. This paper seeks to identify the effect of rural extension on income and income inequality in the rural Brazil areas. We use the household survey (PNAD) for 2014 and a method of income decomposition to identify the effect of rural extension on the different income quantiles. Our findings indicate that although rural extension increases rural household income in all income distribution quantiles, it also increases income inequality in rural Brazil. Access to rural credit and education are the factors that most augment the extension effect on income.
Key words: Rural extension, income inequality, unconditional quantile regression, decomposition

JEL: Q10, Q12, Q16

1. Introduction

In developing countries, economic policies primarily target the reduction of poverty and income concentration (Chakravarty *et al.*, 2008). Food insecurity and poverty are the main obstacles to the economic growth and development of rural areas. Three out of four people living in poverty reside in rural areas and depend directly or indirectly on agricultural activity in developing countries including Brazil (World Bank, 2007). Although the Brazilian agriculture has shown a stronger performance on domestic and international markets in the last decades, this sector still faces high-income inequality. Alves *et al.* (2013) show that in 2006, 87% of the Brazilian agricultural gross income was generated by 11.4% of farms in country.

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Several public policies in Brazil that are based on income transfers and pensions have only had a modest impact on the reduction of inequality. The labor-related income (both agricultural and non-agricultural) still accounts for more than 70% of rural household income (Helfand et al., 2009). It suggests that public policies should also seek to stimulate agricultural competitiveness by increasing access to rural extension, rural credit and commodity markets. These policies could increase farmer productivity, efficiency and competitiveness, which would subsequently decrease income inequality. On the other hand, Barros et al. (2000) argues that public policies should also seek to affect areas beyond agricultural production itself to reduce income inequality.

The National Policy on Technical Assistance and Rural Extension (PNATER) is a public policy that supports the rural sector by giving farmers access to rural extension. This service can increase farmer's access to new technologies, knowledge and information (Christopolos, 2010). There have been several public policies on rural extension since the 1950s but it was the creation of PNATER in 2003 and the institutionalization of Law No. 12,188[5] on Technical Assistance and Rural Extension (ATER) in 2010 that defined the socioeconomic guidelines of these policies (Rodrigues, 1997). However, only 22% of farmers have had access to rural extension in 2006 (Brazilian Institute of Geography and Statistics – IBGE, 2017) and most of the small farmers have not accessed the services provided by rural extension (Alves *et al.*, 2013; Plata and Fernandes, 2011). This suggests that the current PNATER structure might not be achieving the goal of reducing income inequality. In order to address this problem, it is important to identify the effects of these services on income generation in the Brazilian agricultural sector.

In this paper, we focus on identifying the effect of rural extension on household income using an income decomposition proposed by Firpo *et al.* (2007) and the National Household Sample Survey (PNAD[6]). This method consists, at a first stage, in the estimation of income regressions for different unconditional quantiles of the income distribution. Then, we decomposed the income differential for the groups considered (farmers that had access to extension *versus* those that did not) to identify the main factors that explain the income gap across all analyzed quantiles.

Our results suggest that although rural extension increases rural household income, it also increases income inequality. We found that the private rural extension service has a greater effect on rural income compared to the public service provision. These findings also indicate that schooling and access to rural credit are the greatest factors contributing to the income differential between those who have had access to extension and those who have not had access to extension.

2. Related Literature

Rural extension can increase farm income in developing countries (Anderson and Feder, 2004), where the majority of the population lives in rural areas and would observe a greater impact of these policies on population welfare (Gautam, 2000). Rural extension service seeks to facilitate producers' access to new technologies, knowledge and information, and develop producer's management skills and technical practices. Access to information and knowledge can have positive impact on the environment and the family's health (Alex, Ziip and Byerlee, 2002). Access to new technologies and techniques can increase agricultural productivity and income, and reduce food insecurity, subsequently leading to a welfare gains (Alex, Ziip and Byerlee, 2002; Christopolos, 2010).

2.1. Rural Extension in Brazil

Rural extension services have taken place in Brazil since the nineteenth century (Bergarmasco, 1983), mostly performed by non-governmental institutions that sought to assist with on-farm training (Pettan, 2010). The creation of the PNATER established new dimensions (economic and socioeconomic) to the Brazilian rural extension service. PNATER structures the Brazilian rural extension as a "National

[5] According to Law No. 12,188, of January 11, 2010, technical assistance and rural extension is the informal education service, of a continuous nature, in the rural environment, which promotes processes of management, production, processing and marketing of activities and agricultural and non-agricultural services, including agroextractivist, forestry and artisanal activities (MDA, 2017).

[6] Pesquisa Nacional de Amostra em Domicílios.

Decentralized Public Extension System" and encourages the participation of nongovernmental institutions, private companies, unions and cooperatives in addition to public entities (Peixoto, 2009).

The PNATER also includes goals in developing the rural environment in a sustainable way, the adoption of ecologically based agriculture, ensuring sustainable food and nutritional security and the generation of new agricultural and non-agricultural jobs (Ministry of Agrarian Development – MDA, 2017). However, large farms and farms in more developed agricultural regions continue to obtain greater access to rural extension compared to smaller farms (Alves, 2013). It contradicts the new policy directions of focusing on vulnerable groups.

Farms in the North and Northeast regions of Brazil have been poorly provided with rural extension services compared to other regions (Kageyama, 1990). Only 15% of the farms in the Northern region have accessed these services compared to farms in the South, where 49% of them have had access. However, the implementation of the PNATER has led to an increase in resources used on rural extension, from R$ 3 million on the 2001/02 crop season to R$ 1.1 billion on the 2015/16 crop season[7] (Sistema Integrado de Administração Financeira do Governo Federal – SIAFI, 2016).

Despite the increase on resources designated to rural extension provision, several PNATER's obstacles have led to great disparities on the regional provision of extension service. For example, the PNATER system still pays low wages for extension agents and faces large costs to provide rural extension to several farms within the same municipality (Peixoto, 2014).

2.2. Income Inequality and Rural Extension

Several studies have investigated the determinants of income and income inequality in rural areas in Brazil but without explicitly considering the role of rural extension. Araújo *et al.* (2008) identified the determinants of income inequality in rural areas of the Northeast region using data from the PNAD. They calculated poverty indexes in addition to an income decomposition methodology proposed by Fei *et al.* (1978). Their findings suggested a reduction in poverty during the period 1995-2001 and that the individual educational level is the most relevant factor explaining income inequality. Mariano and Neder (2006) also examined income inequality in the rural Northeast region of Brazil using data from the PNAD for the period 1999-2001. They calculated poverty indexes and their findings suggested that agricultural income have contributed to reductions on income inequality and non-agricultural income was associated with greater inequality.

Ney and Hoffman (2009) identified the determinants of rural income focusing on the role of human and physical capital of rural properties in Brazil using the Demographic Census of 2000. They have estimated income models using the weighted least squares method and found that although physical capital has been the main determinant of rural income, individual educational levels accounts for the largest share of income inequality. They also found that human capital has a larger effect on non-agricultural income compared to agricultural income.

As for literature focusing on rural areas in other countries, some studies have analyzed the effect of rural extension on income inequality. Deribew (2016) investigated the effect of rural extension on household income and income inequality using information on 734 rural households in northern Ethiopia using a decomposition of the Gini index and regressions of yield function. He identified a positive effect of rural extension on rural household income and that the rural extension policy increases agricultural income inequality and decreases non-agricultural income inequality. Akpan *et al.* (2016) identified the determinants of poverty and income inequality among 300 young rural producers selected from the state of Akwa Ibom in southern Nigeria using descriptive statistical analyzes and *Logit* regressions. They found that producers with higher levels of schooling and with access to rural extension were less likely to be below the poverty line. It implies that these factors are relevant to reduce income inequality. Akobundu *et al.* (2004) estimated income gains from participating in a rural extension program in the state of Virginia to identify the effect of rural extension on rural income. They used a two-step procedure to identify the determinants of participation and the effect of the program on income. Results suggest that a single extension agent visit was not enough to generate significant results, but income gains increase with greater participation.

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[7] A change from US$ 0.9 million to US$ 332 million in dollar of 12/28/2017 (US$ 3.31 = R$ 1.00).

These studies highlight the relevance of rural extension in enabling the development of rural families. Several other studies have investigated rural extension under a different perspective. A few papers have identified the impact of rural extension on farm technical efficiency (Helfand and Levine, 2004, Magalhães *et al.*, 2011), farm production and productivity (Baloch and Thapa, 2016; Jin and Huffman, 2016) and farm profit (Huffman and Evenson, 1989). Overall, they found that rural extension increases farm technical efficiency, productivity, production and profitability.

On the other hand, most of these studies have not focused on the effect of rural extension on rural household income. The literature lacks a study that focus in this topic and uses a suitable methodology that allows to identify the effect of rural extension on different points of the income distribution, as well as to analyze the main factors that explain the difference of income between households that had access and did not have access to extension service. This paper identifies these effects using the National Household Sample Survey (PNAD) and the income decomposition methodology proposed by Firpo *et al.* (2007).

3. The application

In this section, we present the dataset used to identify the effect of rural extension on income and the empirical methodology used to achieve this goal. We first use the unconditional quantile regression method to identify the effect of the rural extension on different income quantiles in the Brazilian rural area based on Firpo *et al.* (2007, 2009). We then identify farmers' characteristics that generate the income difference between the groups of farms based on access to rural extension.

3.1. Data

We use the 2014 National Household Sample Survey (PNAD) from the IBGE. A supplementary questionnaire was provided to the households in the 2014 PNAD, which also surveyed whether the household had access to rural extension services. In this paper, we define rural extension as what the PNATER delineates as technical assistance and rural extension. Individuals self-declared employers or self-employed as the main activity were questioned whether they have received any technical assistance during the last year. These services were split in four categories: Technical Assistance and Rural Extension Company (Empresa de Assistência Técnica e Extensão Rural – EMATER)[8]; other government agencies (federal, state or municipal); private company; or another source. We constructed three dummy variables to represent access to rural extension based on these categories: rural extension (if rural extension was carried out by any source); public rural extension (if extension was carried out by EMATER or another government agency); and private rural extension (if extension was carried out by private company).

In this paper, rural producers are those that are: 1) economically active; 2) employers or self-employed workers; and 3) those whose main enterprise activity was agriculture. Our sample also included a small portion of rural property managers residing in urban areas, which also appears in the microdata of the Agricultural Census of 2006 (IBGE, 2017). After dropping missing values and outliers, the final sample consists of 15,406 households. In our sample, 14.1% of the farmers had access to rural extension in 2014, from those, 56% had access to public extension and 44% had access to private extension. Descriptive statistics by type of access to this service and type of provision is presented in table 1.

We use monthly household income in Brazilian currency (R$ - Reais) as a proxy to farmer income as in Mariano and Neder (2006), and Ney and Hoffman (2009). Our analysis is based on monthly total household income as opposed to income solely from agricultural activities. Even though an analysis of the effect of rural extension on agricultural income could raise interesting insights, the focus of the PNATER is to provide agricultural support in addition to generate non-agricultural jobs (MDA, 2017). Therefore, we have opted to use total household income.

In addition to a variable capturing access to rural extension, we have included the following variables:

i) Gender: a dummy variable equals to 1 if the individual (head of the household) is male;
ii) Race: a dummy variable equals to 1 if the individual is black;

[8] This is a state-level company that aim to plan, coordinate and execute programs of technical assistance and rural extension, seeking to disseminate technical, economic and social knowledge to increase agricultural production and productivity and improve living conditions in rural areas.

iii) Schooling: several dummy variables for the categories “do not read and write”, “incomplete elementary school”, “complete elementary school”, “incomplete high school”, “complete high school”, “incomplete higher education” and “complete higher education”;
iv) Rural: a dummy variable equals to 1 if the individual resides in the rural area;
v) Credit: a dummy variable equals to 1 if the individual have received credit from any credit program;
vi) Land ownership: several dummy variables seeking to identify the condition of the producer in relation to the land such as whether the producer is a partner, tenant, occupant, owner or other types of ownership;
vii) Farm area: four dummy variables that represent the farm size split in very small (up to 10 hectares (ha)), small (10 to 100ha), medium (100 to 1000ha) and large (greater than 1000ha);
viii) Age: six dummies for age brackets (displayed on Table 1).

Table 1 - Mean and standard deviation of the variables used on the estimation for rural households in Brazil, for total sample and by rural extension group considered.

Variables	Brazil		No Rural Extension		Rural Extension		Public Rural Extension		Private Rural Extension	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Income	2505	3473	2252	3132	4051	4797	3200	3700	5143	5734
Gender	0.855	0.352	0.854	0.354	0.864	0.343	0.881	0.324	0.842	0.365
Race	0.0733	0.261	0.0778	0.268	0.0461	0.210	0.0739	0.262	0.0105	0.102
Years of Study	5.588	3.988	5.314	3.909	7.262	4.059	6.433	3.914	8.326	3.995
Schooling: "do not read and write"	0.00402	0.0633	0.00400	0.0631	0.00415	0.0643	0.00739	0.0857	0	0
"incomplete elementary'	0.223	0.416	0.244	0.429	0.0978	0.297	0.140	0.348	0.0432	0.203
"complete elementary"	0.518	0.500	0.519	0.500	0.507	0.500	0.524	0.500	0.486	0.500
"incomplete high school"	0.0843	0.278	0.0775	0.267	0.126	0.331	0.123	0.329	0.129	0.335
"complete high school"	0.0329	0.178	0.0322	0.176	0.0374	0.190	0.0320	0.176	0.0443	0.206
"incomp. higher education"	0.107	0.309	0.0977	0.297	0.160	0.367	0.137	0.344	0.190	0.392
"comp. higher education"	0.0317	0.175	0.0258	0.158	0.0678	0.252	0.0361	0.187	0.109	0.311
Age: Less than 25	0.0537	0.226	0.0571	0.232	0.0332	0.179	0.0255	0.158	0.0432	0.203
Between 26 and 35	0.150	0.357	0.149	0.357	0.151	0.358	0.119	0.324	0.193	0.395
Between 36 and 45	0.218	0.413	0.216	0.411	0.234	0.424	0.226	0.418	0.246	0.431
Between 46 and 55	0.261	0.439	0.256	0.436	0.295	0.456	0.291	0.455	0.300	0.459
Between 56 and 65	0.206	0.405	0.207	0.405	0.205	0.404	0.240	0.427	0.160	0.367
65 and more	0.110	0.313	0.115	0.319	0.0808	0.273	0.0985	0.298	0.0580	0.234
Reside in rural area	0.733	0.443	0.722	0.448	0.797	0.402	0.825	0.380	0.761	0.427
Access to credit	0.127	0.333	0.0766	0.266	0.434	0.496	0.408	0.492	0.467	0.499
Land ownership: Partner	0.0573	0.232	0.0581	0.234	0.0526	0.223	0.0460	0.210	0.0611	0.240
Tenant	0.0531	0.224	0.0516	0.221	0.0623	0.242	0.0378	0.191	0.0938	0.292
Occupant	0.0469	0.211	0.0486	0.215	0.0369	0.189	0.0427	0.202	0.0295	0.169
Owner	0.754	0.430	0.746	0.435	0.805	0.396	0.824	0.381	0.780	0.415
Others	0.0883	0.284	0.0956	0.294	0.0434	0.204	0.0493	0.217	0.0358	0.186
Farm size: Very small	0.600	0.490	0.622	0.485	0.468	0.499	0.539	0.499	0.377	0.485
Small	0.262	0.440	0.242	0.428	0.386	0.487	0.346	0.476	0.437	0.496
Medium	0.0704	0.256	0.0700	0.255	0.0729	0.260	0.0517	0.222	0.100	0.300
Large	0.0467	0.211	0.0450	0.207	0.0572	0.232	0.0542	0.226	0.0611	0.240
Number of Observations	**15406**		**13239**		**2167**		**1218**		**949**	

Note: SD - Standard deviation

We observe that farmers that had access to rural extension services (group A hereafter) had an average monthly income of R$ 4,051.00, while the average income of those that have not had access to rural extension (group B hereafter), on average, was R$ 2,252.00. The large standard deviation of this variable indicates great heterogeneity or a wide income distribution, which is captured by our quantile regression analysis. Farmers in group A had a higher education level, on average, 7.3 years compared to farmers on Group B that had, on average, 5.3 years. Farmers in Group A also had greater access to credit, on average, 43.4% of them had access to credit while only 7.7% of the farmer in Groups B had access.

We do not observe a substantial difference of farmer's age between groups, 85% of the sample is male, 73% of sample resides in rural areas, and 75% of them own the farm. On average, the monthly household income reported by farmers that had access to private rural extension (R$ 5,143) is 60% higher than the average income of farms that had access to public rural extension service (R$ 3,200). Farmers that had access to private rural extension services had a higher level of education and had greater access to credit.

3.2 The unconditional quantile regression approach

To identify the effects of rural extension on rural income and income inequality we use the unconditional quantile regression approach proposed by Firpo *et al.* (2009) and the concept of *Recentered Influence Function* (RIF). The influence function[9] allows us to identify the relative effect (the influence) of an individual observation on a statistic of interest (Silva and França, 2016). That is, for a statistic distribution $v(F_y)$, the influence of each observation on $v(F_y)$ is given by the influence function $IF(y; v, F_y)$. The incorporation of the statistic $v(F_y)$ in the influence function results in the so-called Recentered Influence Function, $RIF(y; v) = v(y) + IF(y; v)$. It allows us to analyze the effects of individual covariates on the statistical distribution of interest. We are interested on the distribution of the quantiles but this approach can also be applied to different statistical distributions such as Gini coefficient, variance, or others that can represent income inequality[10].

We define the τ-*th* quantile (q_τ) of the income distribution *Y* as $q_\tau = \upsilon_\tau(F_y) = \inf_q \{q : F_y(q) \geq \tau\}$, and its influence function $IF(y; q_\tau, F_y)$ as:

$$IF(y; q_\tau, F_y) = \frac{\tau - 1\{y \leq q_\tau(F_y)\}}{f_y(q_\tau(F_y))} \tag{1}$$

where $1\{y \leq q_\tau(F_y)\}$ is an indicator function, which shows whether the variable *Y* (monthly household income) is less than or equal to the quantile q_τ, and $f_y\left(q_\tau(F_y)\right)$ represents the marginal density function of the distribution of *Y* evaluated in q_τ.

The Recentered Influence Function, which will replace the dependent variable *Y* in the unconditional quantile analysis, is defined by the sum of the distribution statistics and their respective influence function, $RIF(y; v, F_y) = v(F_y) + IF(y; v, F_y)$. Thus, adapting the expression to the τ - *th* quantile (q_τ), the RIF for each income quantile is given by:

$$RIF(y; q_\tau, F_y) = q_\tau + \frac{\tau - 1\{y \leq q_\tau(F_y)\}}{f_y(q_\tau(F_y))} \tag{2}$$

where the conditional expectation is $v(F_y)$ (Firpo *et al.*, 2009; Silva and França, 2016) as in

$$E[RIF(y; v, F_y)] = v(F_y) \tag{3}$$

[9] The influence function method provides a linear approximation for a nonlinear function of a statistical distribution of interest, such as quantiles, variance or others, allowing us to estimate the effect of one or more covariates on the distribution of the statistics of interest (Chi andLee, 2008). For more details, see Chi and Lee (2008) and Firpo *et al.* (2009).

[10] For an average, e.g. $\mu(F_y)$, the influence function - IF, would be given by $IF(y; \mu(F_y)) = y - \mu(F_y)$, with the RIF specified as: $RIF(y; \mu) = IF(y; \mu) + \mu$. Firpo *et al.* (2007) present the RIF regressions for the case of the variance and Gini coefficient.

We first obtain the sample quantile $\hat{q}_\tau$ (Firpo *et al.*, 2009; Koenker and Basset, 1978) and then the marginal density function $\hat{f}_y(\hat{q}_\tau)$ using Kernel functions. After obtaining these estimates, they are incorporated in (2).

Assume a covariate vector X and the conditional expectation of the RIF as a function of X; i.e. $E[RIF(y; v, F_y)|X = x]$. Then, it can be represented as a linear regression in function of X, $RIF(y; v, F_y) = X\beta + \varepsilon$. Assuming $E[\varepsilon|X] = 0$ and applying the Law of Iterated Expectations, we have the unconditional quantile regression

$$v(F_y) = E_X\left[E\left[\,RIF(y; v, F_y)\right]\right] = E[X].\beta \quad (4)$$

where y represents the monthly rural household income; $RIF(y; v, F_y)$ is the Recentered Influence Function, which replaces the observed y in each observation; X is the vector of explanatory variables; and β are the coefficients of interest, which capture the effect of changing the distribution of a variable on the unconditional quantile of y or the unconditional quantile partial effect (Firpo *et al.*, 2009). We can use *Ordinary Least Squares* or another linear estimator to estimate these coefficients[11].

3.3. Decomposition of the income differentials

We use an income decomposition procedure proposed by Firpo *et al.* (2007)[12] to estimate the income differentials between groups. It consists of estimating the RIF regression along with a re-weighting scheme proposed by DiNardo *et al.* (1996). It is an adaptation of the Oaxaca-Blinder[13] decomposition approach, which allows us to expand the decomposition to other statistics of interest such as quantiles, variance and Gini coefficient.

Assume two groups of households: *A* (farmers that had access to rural extension) and *B* (farmers that had not had access to rural extension); an outcome variable *Y* (logarithm of household incomes); and a group of covariates that represents individual's characteristics. The decomposition seeks to identify the difference in the income distributions of the two groups based on some statistics of these distributions as opposed to only analyzing the mean. It is represented as

$$\Delta^v = v(F_{yA}) - v(F_{yB}) \quad (5)$$

where $v(F_{yt})$ represents a statistic of the income distribution (income quantiles on this paper), for two groups $t = A, B$.

The term Δ^v is then divided in two components: difference in the observable individual's characteristics (*Composition Effect*); and difference in coefficients between the two groups (*Return Effect*). To implement this decomposition, first a counterfactual distribution (F_{yC}) has to be obtained in addition to its statistics of interest, $v(F_{yC})$, such as in (10). It allows us to simulate an income distribution with characteristics of group *A* and the returns (coefficients) to the characteristics of group *B*. We can insert F_{yc} in (5) to obtain

$$\Delta^v = \left[v(F_{yB}) - v(F_{yC})\right] + \left[v(F_{yC}) - v(F_{yA})\right] \quad (6)$$
$$\Delta^v = \Delta_R^v + \Delta_X^v$$

where the total income differential is decomposed into two terms: Δ_R^v, which represents the portion of the differential resulting from the differences in the returns (coefficients) of the characteristics (*return effect*); and Δ_X^v, which represents the portion of the differential associated with the differences in the distributions of the characteristics (*composition effect*).

To obtain (6) we re-estimate the RIF regressions for each of the groups and obtain the conditional expectation. This allows us to obtain the expected value of the RIF for the observed distributions $v(F_{yt})$ and the counterfactual distribution $v(F_{yC})$ in a linear specification

[11]Firpo *et al.* (2009) present three possibilities of estimators: ordinary least squares, logistic estimator, and a non-parametric estimator. However, the results presented by the three methods were very close, and the advantage of one estimator over other cannot be tested.

[12]This method has been used in other studies such as in Machado and Mata (2005).

[13] The traditional Oaxaca-Blinder decomposition approach (Blinder, 1973; Oaxaca, 1973) consists of decomposing the mean income differences (or other outcome variable) of two groups of individuals into two components: one associated with the observed characteristics and the other related to the return of such characteristics, allowing also to identify the contribution of each explanatory variable over the total estimated difference. For more details, see Jann (2008).

$$v(F_{yt}) = E[RIF(y_t; v_t)|X, T = t] = X_t\beta_t \quad (7)$$
$$v(F_{yC}) = E[RIF(y_A; v_C)|X, T = B] = X_C\beta_C \quad (8)$$
for t = A, B. To obtain the parameters of interest β, Firpo *et al.* (2007) uses a reweighting technique based on the study of DiNardo *et al.* (1996). The reweighting factors for each group are obtained by the probability that a farmer had access to rural extension given the characteristics vector X and may be estimated using a probability model such as *Logit* or *Probit* (Chi and Li, 2008). Then, the weighted RIF regressions can be estimated by OLS to obtain the parameters $\hat{\beta}$ for each group.

Thus, the decomposition presented in (11) can be obtained as
$$\Delta^v = [\bar{X}_B.\hat{\beta}_B - \bar{X}_C.\hat{\beta}_C] + [\bar{X}_C.\hat{\beta}_C - \bar{X}_A.\hat{\beta}_A] \quad (9)$$
$$\hat{\Delta}^v = \hat{\Delta}^v_R + \hat{\Delta}^v_X$$
We can also identify the contribution of each covariate X_k, where k = 1, ..., K, on each of the effects obtained in (15) as in
$$\hat{\Delta}^v_X = \sum_{k=1}^{K}(\bar{X}_{Ck} - \bar{X}_{Ak})\hat{\beta}_A \quad (10)$$
$$\hat{\Delta}^v_R = (\hat{\beta}_{B1} - \hat{\beta}_{C1}) + \sum_{k=2}^{K}\bar{X}_{Bk}(\hat{\beta}_{Bk} - \hat{\beta}_{Ck}) \quad (11)$$
where in (11) the first term (difference in the returns of the covariate k = 1) represents the difference in the intercepts of the regressions of groups A and B, and the second term represents the contribution of the return of each covariate in the total return effect. Thus, a positive result for a given covariate, for example schooling, in (10) would indicate that farmer's higher schooling level augment the rural extension effect on the income differential between farmers that had access to the extension service and those that had not. A positive result in (11) would indicate that the increase in the income differential is explained by the higher return (coefficient) of schooling by farmers with rural extension[14].

4. Results and discussion

We first present the results of the unconditional quantile regression[15] and then the results of the income decomposition. Our results suggest that rural extension increases both rural income and income inequality. Results of the income differential decomposition have shown that higher schooling level and access to rural credit augment the effect of rural extension on rural income but also contribute to the aggravation of the income inequality.

4.1. Effect of rural extension in rural income

The results of the RIF regressions for the unconditional income distribution quantiles of the logarithm of monthly household income using Ordinary Least Squares (OLS) are displayed in Table 2. The estimated coefficients have shown variation along the income distribution quantiles when compared to the estimated coefficients obtained for the mean (OLS). It implies that rural extension and individual's characteristics affect household income differently in each of the income quantiles and it re-enforces the need to use the unconditional quantile regression approach.

[14] Fortin *et al.* (2011) argue that one of the main shortcomings of this method is that the feedback effect is sensitive to the choice of the base group, although they also indicate that there still no way of correcting this limitation. On the other hand, this method is path independent, which means that the order in which the different elements of the detailed decomposition are calculated does not affect the results of the decomposition (Oliveira and Silveira Neto, 2015).
[15] A possible endogeneity issue related to the adoption of rural extension might affect the outcome of the unconditional quantile regression. We did not address this issue given the absence of adequate instrumental variables.

Table 2 – Estimates of unconditional quantile regression and OLS for the income function for households in rural area of Brazil in 2014.

$Ln(Y_i)$	OLS	q10	q20	q30	q40	q50	q60	q70	q80	q90
Rural Extension	0.426***	0.285***	0.339***	0.394***	0.469***	0.361***	0.411***	0.523***	0.581***	0.601***
	(0.0208)	(0.0301)	(0.0264)	(0.0273)	(0.0292)	(0.0240)	(0.0249)	(0.0318)	(0.0411)	(0.0583)
Gender	-0.0339*	-0.0492 NS	-0.132***	-0.156***	-0.0605**	-0.00654 NS	-0.0286 NS	-0.0115 NS	0.0312 NS	0.0481 NS
	(0.0189)	(0.0434)	(0.0314)	(0.0298)	(0.0301)	(0.0233)	(0.0221)	(0.0249)	(0.0279)	(0.0359)
Race	-0.168***	-0.0135 NS	-0.0808*	-0.171***	-0.212***	-0.232***	-0.192***	-0.247***	-0.253***	-0.192***
	(0.0270)	(0.0629)	(0.0464)	(0.0438)	(0.0415)	(0.0307)	(0.0283)	(0.0298)	(0.0292)	(0.0361)
Schooling: "Incomplete Elementary"	0.0311 NS	0.482 NS	0.585**	0.115 NS	-0.288 NS	-0.223 NS	-0.310**	-0.191 NS	-0.385**	0.0378 NS
	(0.120)	(0.343)	(0.228)	(0.195)	(0.183)	(0.143)	(0.132)	(0.141)	(0.159)	(0.0650)
"Complete Elementary"	0.287**	0.674**	0.791***	0.318 NS	-0.0140 NS	0.00729 NS	-0.0501 NS	0.114 NS	-0.0539 NS	0.356***
	(0.119)	(0.342)	(0.228)	(0.194)	(0.182)	(0.143)	(0.131)	(0.140)	(0.159)	(0.0643)
"Incomplete High School"	0.480***	0.893***	0.971***	0.470**	0.187 NS	0.183 NS	0.0833 NS	0.344**	0.188 NS	0.600***
	(0.121)	(0.344)	(0.230)	(0.197)	(0.185)	(0.145)	(0.134)	(0.144)	(0.164)	(0.0828)
"Comp. High School"	0.504***	0.850**	0.959***	0.599***	0.156 NS	0.172 NS	0.0951 NS	0.323**	0.323*	0.777***
	(0.125)	(0.352)	(0.236)	(0.203)	(0.191)	(0.149)	(0.138)	(0.149)	(0.171)	(0.112)
"Incomp. Higher education"	0.691***	0.890***	1.154***	0.718***	0.448**	0.388***	0.350***	0.578***	0.416**	0.894***
	(0.121)	(0.344)	(0.229)	(0.196)	(0.184)	(0.144)	(0.133)	(0.144)	(0.163)	(0.0834)
"Comp. Higher education"	1.289***	1.035***	1.223***	0.826***	0.631***	0.629***	0.633***	1.077***	1.384***	2.306***
	(0.126)	(0.343)	(0.229)	(0.198)	(0.186)	(0.146)	(0.136)	(0.149)	(0.174)	(0.145)
Age: Less than 26	-0.0312 NS	-0.0106	-0.0970 NS	-0.180***	-0.156***	-0.114***	-0.0471 NS	-0.0748*	-0.0989**	0.0409 NS
	(0.0340)	(0.0922)	(0.0664)	(0.0599)	(0.0568)	(0.0420)	(0.0363)	(0.0413)	(0.0479)	(0.0616)
Between 36 and 45	0.138***	0.252***	0.197***	0.0910 NS	0.0782 NS	0.0160 NS	0.102***	0.0530 NS	-0.00802 NS	0.133**
	(0.0329)	(0.0867)	(0.0629)	(0.0576)	(0.0552)	(0.0410)	(0.0357)	(0.0408)	(0.0473)	(0.0609)
Between 46 and 55	0.197***	0.153*	0.245***	0.186***	0.157***	0.105**	0.208***	0.165***	0.0838*	0.193***
	(0.0328)	(0.0874)	(0.0624)	(0.0574)	(0.0552)	(0.0411)	(0.0360)	(0.0413)	(0.0480)	(0.0625)
Between 56 and 65	0.476***	0.513***	0.677***	0.638***	0.590***	0.405***	0.411***	0.329***	0.234***	0.337***
	(0.0341)	(0.0871)	(0.0627)	(0.0586)	(0.0572)	(0.0430)	(0.0381)	(0.0433)	(0.0500)	(0.0649)
65 and more	0.786***	0.845***	1.053***	1.062***	1.165***	0.844***	0.644***	0.509***	0.364***	0.466***
	(0.0372)	(0.0862)	(0.0616)	(0.0585)	(0.0578)	(0.0455)	(0.0424)	(0.0489)	(0.0563)	(0.0724)
Reside in rural area	-0.246***	-0.178***	-0.209***	-0.210***	-0.232***	-0.201***	-0.225***	-0.304***	-0.283***	-0.312***
	(0.0158)	(0.0317)	(0.0244)	(0.0242)	(0.0245)	(0.0190)	(0.0186)	(0.0221)	(0.0256)	(0.0344)
Access to Credit	0.257***	0.204***	0.166***	0.251***	0.241***	0.235***	0.259***	0.318***	0.407***	0.303***

	(0.0215)	(0.0316)	(0.0285)	(0.0286)	(0.0309)	(0.0249)	(0.0258)	(0.0326)	(0.0421)	(0.0579)
Land ownership: Partner	-0.0374 ^{NS}	0.0368 ^{NS}	0.0414 ^{NS}	-0.0171 ^{NS}	-0.0765 ^{NS}	-0.128***	-0.0644**	-0.0898**	-0.120***	-0.0880*
	(0.0290)	(0.0666)	(0.0519)	(0.0485)	(0.0466)	(0.0347)	(0.0327)	(0.0365)	(0.0414)	(0.0525)
Tenant	0.000632 ^{NS}	-0.0608 ^{NS}	-0.0159 ^{NS}	0.0151 ^{NS}	0.0567 ^{NS}	0.0331 ^{NS}	0.0368 ^{NS}	0.0177 ^{NS}	-0.0741 ^{NS}	0.00342 ^{NS}
	(0.0287)	(0.0673)	(0.0501)	(0.0467)	(0.0462)	(0.0355)	(0.0356)	(0.0411)	(0.0458)	(0.0627)
Ocupant	-0.0989***	0.0409 ^{NS}	-0.0637 ^{NS}	-0.130**	-0.211***	-0.129***	-0.100***	-0.157***	-0.125***	-0.143***
	(0.0356)	(0.0820)	(0.0650)	(0.0609)	(0.0572)	(0.0411)	(0.0368)	(0.0355)	(0.0357)	(0.0346)
Other_condition	-0.261***	-0.450***	-0.235***	-0.258***	-0.260***	-0.225***	-0.268***	-0.296***	-0.265***	-0.138***
	(0.0242)	(0.0694)	(0.0468)	(0.0422)	(0.0399)	(0.0292)	(0.0252)	(0.0265)	(0.0272)	(0.0362)
Farm size: Small	0.257***	0.268***	0.266***	0.219***	0.240***	0.202***	0.224***	0.276***	0.346***	0.296***
	(0.0164)	(0.0302)	(0.0239)	(0.0243)	(0.0249)	(0.0197)	(0.0195)	(0.0231)	(0.0279)	(0.0360)
Medium	0.370***	0.183***	0.186***	0.158***	0.167***	0.196***	0.305***	0.445***	0.541***	0.881***
	(0.0291)	(0.0479)	(0.0387)	(0.0389)	(0.0401)	(0.0315)	(0.0317)	(0.0386)	(0.0492)	(0.0771)
Large	0.334***	0.339***	0.320***	0.329***	0.375***	0.247***	0.252***	0.266***	0.331***	0.427***
	(0.0335)	(0.0529)	(0.0452)	(0.0468)	(0.0485)	(0.0406)	(0.0396)	(0.0474)	(0.0576)	(0.0824)
Intercept	6.811***	5.218***	5.525***	6.392***	6.928***	7.207***	7.449***	7.556***	7.964***	7.832***
	(0.124)	(0.353)	(0.235)	(0.202)	(0.190)	(0.149)	(0.137)	(0.148)	(0.169)	(0.0916)
F	233.93	42.84	107.09	129.21	169	189.47	205.42	198.2	147.52	64.51

Note: RE – Rural Extension; *** significant at 1%, **significant at 5%, * significant at 10%, NS - non significant; Standard errors in parentheses; **q10** represents the income quantile considered, in this case the bottom 10% It goes up to **q90**, the upper 90%.

Our results indicate a statistically positive effect of rural extension service on rural income. This effect increases as we evaluate higher income quantiles of the distribution. Farmers in group A face a higher income compared to farmers in group B in the bottom two income quantiles, 28.5% and 33.9% respectively (q10 and q20). The distance between the two immediate quantiles decreases as we evaluate higher quantiles; i.e. for q80 and q90, the increase on income are 58.1% and 60.1%, respectively. These results imply that these services raise monthly household income and, on the other hand, increase income inequality in rural Brazil. These results contradict one of the main objectives of this service, to increase rural income through the dissemination of new technologies and reduction of the negative effects caused by market imperfections (Alves *et al.*, 2013). The greater access to this service by large and more profitable farms re-enforces the maintenance of income inequality in rural areas. Deribew (2016) found a similar result for Ethiopian farmers in which results suggest a positive effect of rural extension on the rural income and an increase on income inequality in the agricultural activity[16].

Individual's characteristics such as *gender* and *race* have not shown a great discriminatory effect throughout the income distribution. Households headed by *females* have shown greater income compared to *male headed households* only at the bottom of the income distribution. We also find that black individuals faced lower income compared to non-black individuals but there is no clear pattern along the income distribution.

Our results indicate that a higher level of *education* such as "complete elementary school", "high school" and "higher education" is associated with a greater income compared to the base variable, "people who cannot read or write". Duarte *et al.* (2003), Oliveira and Silveira Neto (2015), and Reis *et al.* (2017) have also identified positive effects of investments in human capital on income for Brazil. Our results show that education can decrease income inequality. We observe a great income return to "high school" level in the bottom quantiles of the distribution. On the other hand, "higher education" increases inequality, but, note that, only 3.2% of the sample had access to high education. As Ney and Hoffman (2009) suggested, these results show the significant role of human capital on explaining rural income inequalities.

Farmer's *experience*, in this paper represented by age, has a stronger effect at the bottom of income distribution; i.e. older individuals are related to higher income level compared to those younger than 25 years of age (base category). It implies that experience contributes to the reduction of rural income inequality. Our results also suggest that *access to rural credit* increases income, which is probably associated to improvements on farm productive capacity through acquisition of inputs and new technologies. This factor increases income by at least 17% at the bottom of the distribution and up to 41% at the top of the distribution.

Farm ownership increases income. We found that *land ownership* of the types *partners*, *occupant* and *other classifications* face lower income compared to farm owners (base category) in all quantiles of the income distribution. Farm owners have a greater incentive to invest in innovations and in other long-term technology, which increase rural income. These properties also have greater access to credit and other services since farmers can use their land as a tangible guarantee for the fulfillment of financial obligations (Besley, 1995). Farmers that *reside in rural areas* are associated with lower income in all quantiles of the income distribution. Farmers' residence in urban areas might grant them greater access to information about markets, banking institutions and other services.

In Table 3, we display the effect of rural extension on income by source of this service. Figure 1 shows the effect of rural extension, both aggregate and disaggregate by source, on income. Our findings indicate that private rural extension has a greater effect on rural income compared to public service. Private service has a larger effect on income on the top part of the income distribution (q90) compared to the public service. This service increases rural income in 88.7% compared to non-adopters while the public service increases income in 35.5%. This result is probably associated with resource restriction that small and low-income farmers face, which limits the effect of rural extension on income. Additionally, large farmers have greater access to a more specialized private extension service. It explains the increasing income gap between the sources of extension as higher income quantiles are considered.

[16]However, when considering different sources of income from livestock and other non-agricultural sources, Deribew (2016) finds a negative effect of rural extension on income inequality.

Table 3– Estimates of unconditional quantile regression – Public and Private Rural Extension, for rural households in Brazil in 2014.

Ln(Y_ii)	**OLS**	**q10**	**q20**	**q30**	**q40**	**q50**	**q60**	**q70**	**q80**	**q90**
Public RE	0.268***	0.205***	0.216***	0.264***	0.324***	0.246***	0.249***	0.346***	0.417***	0.355***
	(0.0263)	(0.0421)	(0.0362)	(0.0364)	(0.0377)	(0.0306)	(0.0319)	(0.0403)	(0.0512)	(0.0696)
Private RE	0.610***	0.378***	0.481***	0.545***	0.637***	0.495***	0.599***	0.729***	0.771***	0.887***
	(0.0280)	(0.0311)	(0.0279)	(0.0316)	(0.0358)	(0.0308)	(0.0315)	(0.0422)	(0.0577)	(0.0879)
Gender	-0.0297 NS	-0.0470 NS	-0.129***	-0.153***	-0.0566*	-0.00344 NS	-0.0243 NS	-0.00676 NS	0.0356 NS	0.0548 NS
	(0.0188)	(0.0435)	(0.0314)	(0.0298)	(0.0300)	(0.0233)	(0.0221)	(0.0249)	(0.0280)	(0.0357)
Race	-0.160***	-0.00918 NS	-0.0741 NS	-0.164***	-0.204***	-0.226***	-0.183***	-0.237***	-0.244***	-0.179***
	(0.0270)	(0.0630)	(0.0464)	(0.0438)	(0.0414)	(0.0306)	(0.0283)	(0.0298)	(0.0292)	(0.0362)
Schooling: "Incomplete Elementary"	0.00789 NS	0.470 NS	0.567**	0.0962 NS	-0.309*	-0.240*	-0.334**	-0.217 NS	-0.409***	0.00173 NS
	(0.120)	(0.341)	(0.226)	(0.193)	(0.180)	(0.142)	(0.130)	(0.140)	(0.158)	(0.0614)
"Complete Elementary"	0.263**	0.662*	0.773***	0.298 NS	-0.0361 NS	-0.0104 NS	-0.0749 NS	0.0865 NS	-0.0790 NS	0.318***
	(0.119)	(0.340)	(0.226)	(0.192)	(0.179)	(0.142)	(0.130)	(0.139)	(0.158)	(0.0608)
"Incomplete High School"	0.456***	0.881***	0.952***	0.451**	0.165 NS	0.166 NS	0.0592 NS	0.318**	0.164 NS	0.564***
	(0.121)	(0.341)	(0.228)	(0.195)	(0.182)	(0.144)	(0.133)	(0.143)	(0.163)	(0.0798)
"Comp. High School"	0.475***	0.836**	0.937***	0.575***	0.129 NS	0.150 NS	0.0651 NS	0.290*	0.293*	0.732***
	(0.125)	(0.349)	(0.234)	(0.201)	(0.188)	(0.149)	(0.137)	(0.149)	(0.171)	(0.110)
"Incomp. Higher education"	0.662***	0.876**	1.131***	0.694***	0.421**	0.367**	0.321**	0.545***	0.386**	0.849***
	(0.121)	(0.341)	(0.227)	(0.194)	(0.181)	(0.144)	(0.132)	(0.143)	(0.163)	(0.0808)
"Comp. Higher education"	1.243***	1.012***	1.187***	0.788***	0.589***	0.596***	0.585***	1.025***	1.336***	2.234***
	(0.125)	(0.340)	(0.227)	(0.196)	(0.183)	(0.146)	(0.135)	(0.148)	(0.174)	(0.144)
Age: Less than 26	-0.0293 NS	-0.00960 NS	-0.0955 NS	-0.179***	-0.154***	-0.112***	-0.0451 NS	-0.0727*	-0.0969**	0.0440 NS
	(0.0339)	(0.0921)	(0.0663)	(0.0598)	(0.0568)	(0.0420)	(0.0362)	(0.0413)	(0.0481)	(0.0617)
Between 36 and 45	0.143***	0.255***	0.201***	0.0953*	0.0830 NS	0.0198 NS	0.108***	0.0589 NS	-0.00262	0.141**
	(0.0328)	(0.0867)	(0.0629)	(0.0575)	(0.0551)	(0.0410)	(0.0357)	(0.0409)	(0.0475)	(0.0612)
Between 46 and 55	0.201***	0.155*	0.249***	0.189***	0.161***	0.109***	0.213***	0.170***	0.0885*	0.200***
	(0.0327)	(0.0874)	(0.0624)	(0.0573)	(0.0551)	(0.0411)	(0.0360)	(0.0413)	(0.0482)	(0.0628)
Between 56 and 65	0.486***	0.518***	0.685***	0.646***	0.599***	0.412***	0.422***	0.340***	0.245***	0.353***
	(0.0340)	(0.0871)	(0.0627)	(0.0586)	(0.0571)	(0.0430)	(0.0380)	(0.0433)	(0.0502)	(0.0651)
65 and more	0.796***	0.851***	1.061***	1.070***	1.175***	0.852***	0.655***	0.520***	0.375***	0.482***
	(0.0371)	(0.0863)	(0.0616)	(0.0585)	(0.0579)	(0.0455)	(0.0424)	(0.0489)	(0.0564)	(0.0727)
Reside in rural area	-0.245***	-0.178***	-0.208***	-0.209***	-0.230***	-0.200***	-0.224***	-0.302***	-0.282***	-0.310***
	(0.0157)	(0.0317)	(0.0244)	(0.0242)	(0.0245)	(0.0191)	(0.0186)	(0.0221)	(0.0256)	(0.0344)

Access to Credit		0.255***	0.204***	0.165***	0.250***	0.240***	0.234***	0.257***	0.317***	0.406***	0.301***
		(0.0215)	(0.0315)	(0.0285)	(0.0285)	(0.0308)	(0.0249)	(0.0257)	(0.0324)	(0.0420)	(0.0578)
Land ownership:	*Partner*	-0.0409 NS	0.0350 NS	0.0386 NS	-0.0200 NS	-0.0797*	-0.131***	-0.0680**	-0.0937**	-0.123***	-0.0935*
		(0.0289)	(0.0666)	(0.0519)	(0.0484)	(0.0465)	(0.0347)	(0.0328)	(0.0367)	(0.0416)	(0.0526)
Tenant		-0.00811 NS	-0.0653 NS	-0.0227 NS	0.00787 NS	0.0487 NS	0.0268 NS	0.0279 NS	0.00788 NS	-0.0832*	-0.0102 NS
		(0.0286)	(0.0673)	(0.0501)	(0.0468)	(0.0463)	(0.0356)	(0.0355)	(0.0410)	(0.0457)	(0.0625)
Ocupant		-0.0970***	0.0419 NS	-0.0622 NS	-0.129**	-0.209***	-0.127***	-0.0982***	-0.155***	-0.123***	-0.140***
		(0.0354)	(0.0819)	(0.0649)	(0.0608)	(0.0570)	(0.0410)	(0.0368)	(0.0356)	(0.0357)	(0.0344)
Other_condition		-0.261***	-0.450***	-0.235***	-0.258***	-0.260***	-0.225***	-0.268***	-0.295***	-0.265***	-0.137***
		(0.0241)	(0.0694)	(0.0467)	(0.0422)	(0.0398)	(0.0292)	(0.0251)	(0.0266)	(0.0273)	(0.0365)
Farm size: Small		0.248***	0.263***	0.259***	0.211***	0.232***	0.195***	0.215***	0.266***	0.336***	0.281***
		(0.0164)	(0.0303)	(0.0239)	(0.0243)	(0.0249)	(0.0197)	(0.0195)	(0.0231)	(0.0278)	(0.0357)
Medium		0.361***	0.178***	0.179***	0.150***	0.159***	0.189***	0.296***	0.434***	0.531***	0.866***
		(0.0290)	(0.0480)	(0.0388)	(0.0389)	(0.0402)	(0.0316)	(0.0318)	(0.0386)	(0.0491)	(0.0770)
Large		0.327***	0.336***	0.315***	0.324***	0.369***	0.242***	0.245***	0.258***	0.324***	0.416***
		(0.0334)	(0.0530)	(0.0454)	(0.0469)	(0.0486)	(0.0407)	(0.0395)	(0.0473)	(0.0577)	(0.0819)
Intercept		6.828***	5.227***	5.539***	6.407***	6.944***	7.220***	7.467***	7.575***	7.982***	7.860***
		(0.124)	(0.350)	(0.233)	(0.200)	(0.187)	(0.148)	(0.136)	(0.148)	(0.169)	(0.0890)
F		229.54	41.86	103.7	125.8	163.17	183.73	207.31	197.13	143.85	62.81

Note: RE – Rural Extension; *** significant at 1%, **significant at 5%, * significant at 10%, NS - non significant; Standard errors in parentheses; **q10** represents the income quantile considered, in this case the bottom 10% It goes up to **q90**, the upper 90%.

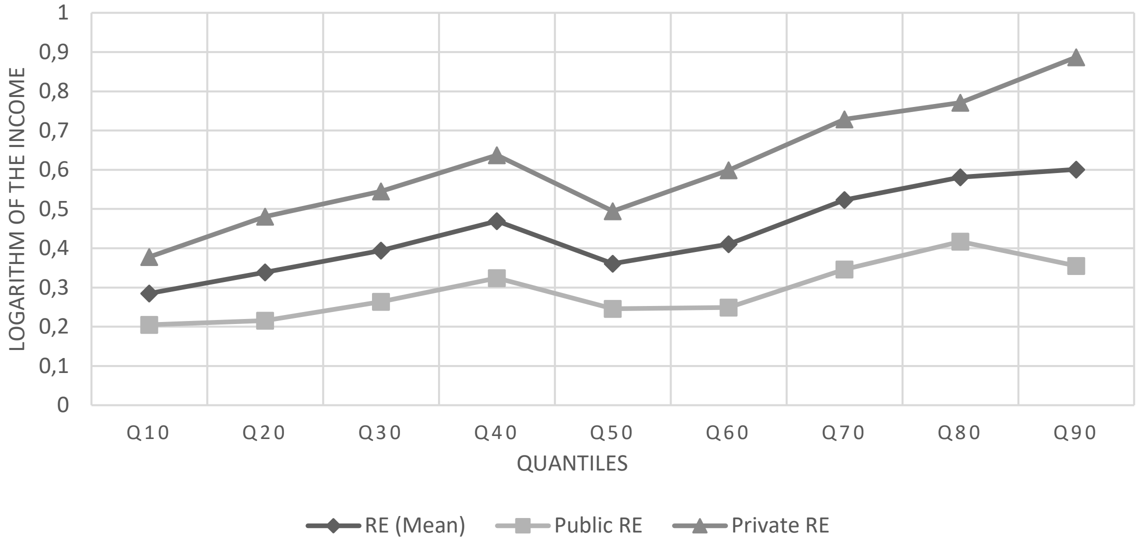

Figure 1 - Effects of rural extension on the income quantiles oh rural households in rural areas of Brazil, 2014.
Note: RE: Rural Extension.

4.2. Decomposition of income differentials

The data indicates that farmer's characteristics are different between farms in groups A and B and our findings presented in the previous subsection indicate that rural extension increases rural income and income inequality. Therefore, we use the income decomposition method along with the RIF regressions to evaluate how much of the income differences between the farm groups is attributed to the *composition effect* and to the *return effect*. The former effect represents the differences in the distribution of the individual's characteristics and the latter effect represents the differences in the returns of these characteristics. It allows us to identify the contribution of each variable to these effects, presented in the Tables A1 and A2 in the Appendix, and Figures 2, 3, 4 and 5.

Figure 2 displays the decomposition of the income differential between groups A and B in the *composition effect* and *return effect*. Farmers that had access to rural extension are associated with a greater income in all quantiles compared to farmers that had not accessed this service. The *composition effect* increases along with the quantiles; i.e. the differences in the individual characteristics such as schooling level and access to rural credit explain almost the entire income gap between such groups in the top tier of the income distribution. However, the *return effect* represents most of the total effect on income. It implies that the high returns to the explanatory variables explains most of the income differential.

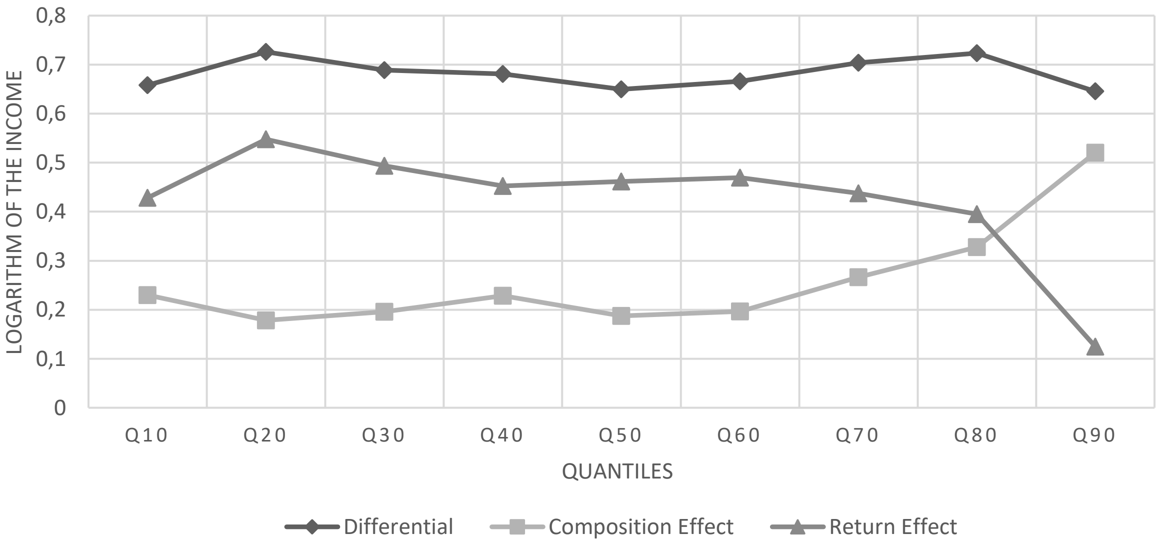

Figure 2 - Decomposition of the household income differential between groups A and B in rural areas of Brazil, 2014.

Figure 3 displays the detailed decomposition of the *composition effect*. Schooling and access to rural credit are the main factors explaining greater income for farmers that had access to rural extension (group A) compared to farmers in group B. Farmer's experience affects income negatively. It is an important contributing factor to household income for farmers that had not had access to rural extension service. Farmers that had access to rural extension take advantage of the extension agent suggestions to manage their production rather than relying only on their (farmer's) experience. Characteristics such as gender and race (included in *Others* in Figure 3) contribute to the reduction of the income differential between the two groups.

The returns to extension service might be restricted among the low-income farmers due to their restricted access to education and credit. Higher education levels facilitate their interaction with the extension agents allowing them to absorb information and implement the technical recommendations more precisely. Alves *et al.* (2013) also indicate that larger farmers have greater access to rural credit, which allows them to invest in modern inputs and adopt technologies that are more productive. It implies that the current structure of the national rural extension policy is reinforcing social inequalities.

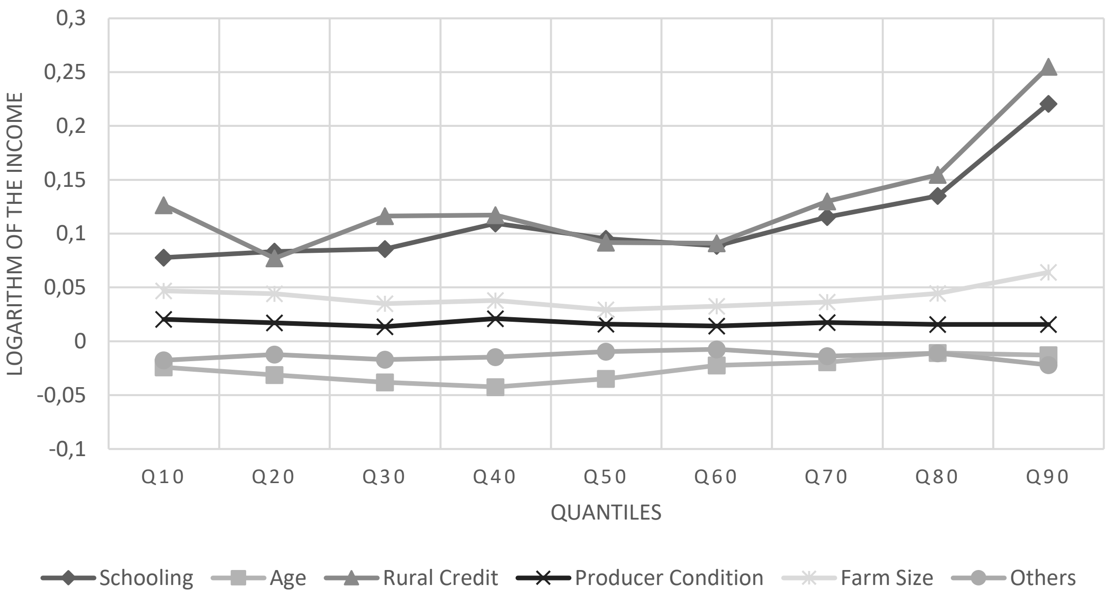

Figure 3 - Detailed decomposition of the *composition effect* of the household income differential in rural areas of Brazil, 2014.

Figure 4 displays the *return effect* for each group of farmers. Although we observe a decreasing effect of schooling on rural income, this variable contributes considerably to the increase of income in the first two income quantiles. For the first quantile, 2.8% of the farmers had a complete high school degree while for the last quantile, 5.0% completed high school. It implies that lower schooling levels have a higher return (marginal effect) in lower quantiles. Public policies that seek to incentivize the conclusion of high school (or school attendance) among low-income farmers would benefit them since it would boost the rural extension effect on their income.

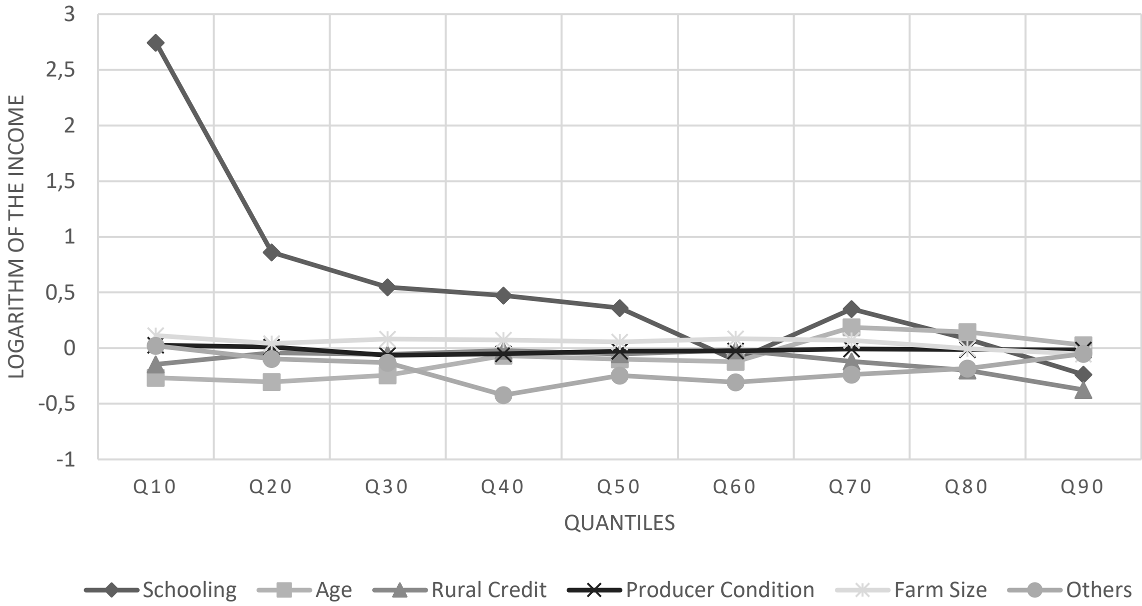

Figure 4 - Detailed decomposition of the *return effect* of the household income differential in rural areas of Brazil, 2014.

Our findings have indicated a distinct return to rural extension by source of provision. To decouple this effect, we decompose these income differentials by source of provision in the two *effects* described previously. Figure 5 displays the returns to private provision of extension services compared to public provision (base).

The total income differential between the groups of farmers (farmers that had access to private and public rural extension services) has a U-shape format. The *return effect* explains most of the income differential. It implies that the returns to the individual's characteristics such as schooling and access to rural credit explains most of the observed greater income obtained by farmers that had access to private rural extension service.

Schooling has played a significant role on augmenting the effect of rural extension on household income. Public policies that incentivize farmer's school attendance would have a spillover effect given that it would also increase their benefits from accessing rural extension. These results also suggest that rural households might benefit from the alignment of public policies on provision of rural credit and rural extension. Already in place, the National Policy of Family Agriculture and Rural Family Enterprises (PRONAF) seeks to provide credit to small farms. In 2017, this policy has provided credit to 1.1 million farmers for a total close R$ 21 million[17] (Banco Central do Brasil - BACEN, 2018).

[17] US$ 6.3 million in dollar of 12/28/2017 (US$ 3.31 = R$ 1.00).

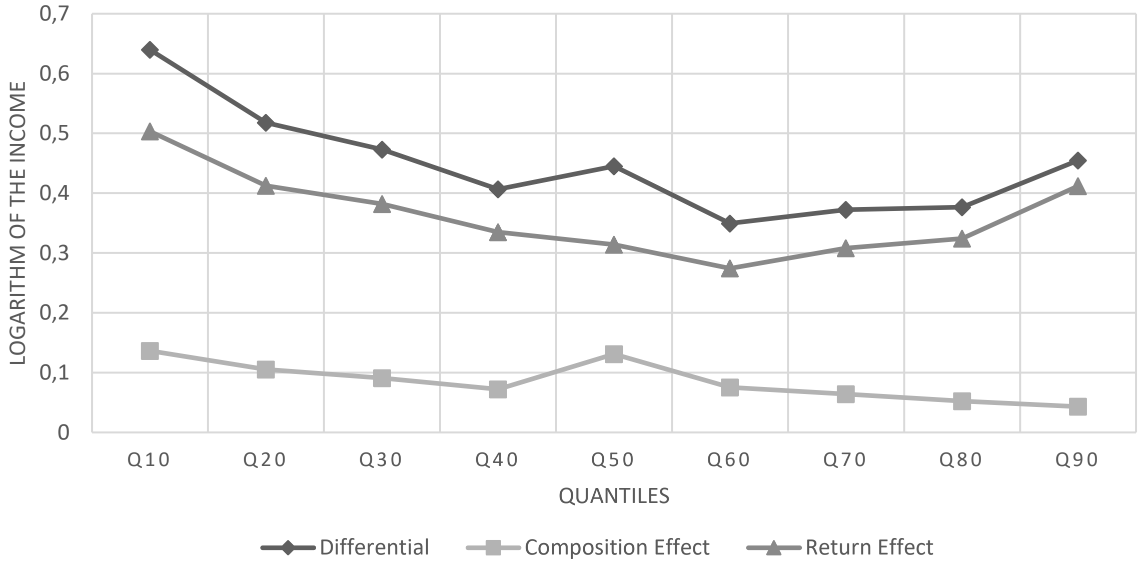

Figure 5 - Decomposition of the income differential between farmers that had access to private rural extension compared to those that had access to public rural extension (base) in rural areas of Brazil, 2014.

Our findings suggest that although public provision of extension service increases rural household income, the private service is more efficient in achieving greater income. It implies that there is room for improvements on the public provision. Lower-income farmers (see Figure 5) would benefit from efficiency improvements on the provision of public extension, which would increase household income.

5. Conclusions

Although Brazilian rural areas still rely on agricultural activities to generate income, agricultural production is mainly produced by large farmers. Access to rural extension could be a tool to increase income and decrease inequality in these areas. In this paper, we use household survey and a method of income decomposition to test whether access to rural extension increases income and decreases inequality.

Our results indicate that rural extension increases rural household income and income inequality, failing to achieve one of the goals of this service, which is to reduce inequality (Alves *et al.*, 2013). Access to private rural extension has a stronger effect on rural income compared to public extension. Wealthier farmers, at the top portion of the income distribution, observe a stronger effect of rural extension on income compared to the low-income farmers at the lower portion of the income distribution. Larger farmers and farm owners also have greater access to rural credit, as confirmed by Alves *et al.* (2013), since these farmers can use the land as a tangible guarantee for the fulfillment of their financial obligations (Besley, 1995).

Individual's characteristics explains great part of the income differential between the groups of farmers. A greater level of schooling and access to rural credit augment the effect of rural extension on rural income but also contribute to the aggravation of the income inequality. It confirms the relevance of the effect of human capital on income, as also found by Duarte *et al.* (2003), Oliveira and Silveira Neto (2015), and Reis *et al.* (2017) for Brazil.

These findings suggest that access to rural extension alone is not enough to raise social welfare of the low-income farmers. These farmers are constrained by the limited access to credit and schooling. The design and implementation of a joint public policy that incorporates components of rural extension provision, of access to rural credit and of the promotion of the human capital would help to achieve the goal of reducing income inequality. In Brazil, some public policies already deal separately with these components. The PRONAF seeks to provide credit to small farms while the Food Acquisition Program (PAA) seeks to reduce hunger and poverty.

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Appendix

Table A1 – Decomposition of the income differentials: With Rural Extension – Without Rural Extension (2014).

	q10	q20	q30	q40	q50	q60	q70	q80	q90
Differential (LnYi)	0.65838	0.72606	0.68896	0.68119	0.64949	0.66605	0.70397	0.7232	0.64546
Composition Effect	0.22971	0.17838	0.19562	0.22875	0.18752	0.19684	0.26651	0.32788	0.52055
Return Effect	0.42867	0.54768	0.49333	0.45244	0.46197	0.46922	0.43746	0.39532	0.12491
Composition Effect Detailed									
Schooling	0.07781	0.08334	0.0859	0.10951	0.09517	0.0888	0.11548	0.13494	0.22071
Age	-0.0241	-0.0312	-0.0382	-0.0424	-0.035	-0.0223	-0.0193	-0.0108	-0.013
Access to credit	0.12649	0.07709	0.11634	0.11724	0.09168	0.09108	0.13014	0.15469	0.25497
Land ownership	0.02033	0.01712	0.01365	0.02111	0.01599	0.01415	0.01735	0.01556	0.01576
Farm Size	0.04675	0.04433	0.03494	0.03802	0.02927	0.0325	0.03644	0.04444	0.06406
Others	-0.0176	-0.0123	-0.017	-0.0147	-0.0096	-0.0074	-0.0136	-0.0109	-0.022
Return Effect Detailed									
Schooling	2.74381	0.85986	0.54795	0.47161	0.35943	-0.1123	0.35136	0.0825	-0.2374
Age	-0.2661	-0.3043	-0.2422	-0.0683	-0.0983	-0.1226	0.18654	0.14499	0.02634
Access to credit	-0.1449	-0.0422	-0.0564	-0.0212	-0.0523	-0.018	-0.1203	-0.2001	-0.3743
Land ownership	0.02589	0.0086	-0.0648	-0.0501	-0.0283	-0.026	-0.009	-0.0145	-0.0172
Farm Size	0.11253	0.04192	0.08047	0.07246	0.05576	0.08304	0.07112	-0.0041	-0.0532
Others	0.02019	-0.0966	-0.1317	-0.4223	-0.2448	-0.3058	-0.2381	-0.1825	-0.0506

Source: Own elaboration.

Table A2 – Decomposition of the income differential: Private Rural Extension – Public Rural Extension (2014).

	q10	q20	q30	q40	q50	q60	q70	q80	q90
Differential (LnYi)	0.63968	0.51764	0.47284	0.40674	0.44489	0.34952	0.37236	0.37637	0.45494
Composition Effect	0.13639	0.10524	0.09107	0.07197	0.13094	0.0753	0.06423	0.05223	0.04312
Return Effect	0.50329	0.4124	0.38177	0.33477	0.31394	0.27423	0.30813	0.32414	0.41182

Fonte: Own elaboration.