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Agri-Food Policies and Family Farms' Commercialization: Insights from Brazil

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Abstract: Brazil is one of the main agricultural producers in the world, and its agri-food system has been experiencing concentration and intensification. Since the beginning of the 1990s, the Brazilian government has implemented different interventions to support family agriculture, such as the National Programme for Strengthening Family Farming (PRONAF), the Technical Assistance and Rural Extension Programme (ATER), and different seed distribution programs. Despite the social and economic relevance of these programs, there is a lack of quantitative studies investigating their impact on the resilience of family farms, primarily the promotion of commercialization. We aim to fill this gap by applying propensity score matching techniques to household-level data from the 2014 Brazilian National Household Sample Survey. Only this survey has recorded this type of information to date. We compare the commercialization behavior of policy recipients with that of non-recipients, accounting for interaction effects between different policies. Our results show that PRONAF has had a significant positive impact on family farmers' propensity to engage in commercialization, and the effect increases if they also have access to technical assistance. Technical assistance alone has a positive effect, while seed distribution appears not to make a significant difference. Our results suggest that an appropriate policy mix can increase the resilience of family farms in emerging countries.

Keywords: family agriculture; market integration; policy mix; impact analysis; propensity score matching

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1. Introduction

At the beginning of the 21st century, family farming was still considered part of the problem of food insecurity [1]. This assumption was related to the idea that family farmers need to cope with poverty-related issues [2] and thus are not particularly keen on improving productivity. In recent years, this perception has completely changed: nowadays, family farming is recognized as fundamental in promoting endogenous rural development [3,4], achieving environmental sustainability [3,5–7], and reducing food insecurity and poverty [8,9]. Family farms are instrumental in developing territorialized agrifood systems that preserve genetic and land use diversity, in contrast to mainstream agro-industrial systems that favor monocultures and intensive land use [3,10,11].

However, the consolidation of family farming systems depends on their market potential [3,12]. The pursuit of sustainable practices in the absence of commercialization eventually leads to loss of income and discouragement of farmers to the benefit of large agro-industrial actors [12]. According to [8] (p. 12), family farmers' "marketed production can not only help stabilize local markets prices, providing improved incentives for investment, but also create opportunities for households to generate cash surpluses which, when spent or reinvested within the rural economy, can generate significant multiplier effects". Thus, scholars and international institutions stress the importance of output markets for family farms. At the same time, they point out that the different configurations of these markets—in terms of size, dynamics, institutional arrangements, and social and power relationships—can influence family farmers' initiatives [4,9,13].

In the last 20 years, Brazilian policymakers have implemented different programs for strengthening food security and improving the living conditions of family farmers [14,15]. This represents a deviation from traditional government policies in Latin America, which have promoted a development model based on industrial monoculture [3]. In particular, Brazilian family farmers have benefited from three policy interventions: the National Program for Strengthening Family Farming (*Programa Nacional de Fortalecimento da Agricultura Familiar*, PRONAF), which provides credit on favorable conditions; the Technical Assistance and Rural Extension Programme (*Assistência Técnica e Extensão Rural*, ATER); and a set of seed distribution programs (SEEDS). PRONAF, ATER, and SEEDS are structured in different sub-programs, also depending on the geographical level of application (federal or state level). In the following, we identify all sub-programs with the same acronym.

PRONAF was the first program exclusively dedicated to supporting family farmers in Brazil, and several studies have analyzed its benefits and drawbacks (e.g., [16,17]). Likewise, ATER and SEEDS have been particularly important for Brazilian rural development [18–21]. These programs all have different goals, but they share a common focus on supporting productivity and the integration of family farmers into market dynamics. Nevertheless, there is a lack of research on the effect of these three programs on family farmers' propensity to commercialize their production, which, as highlighted above, generates clear benefits in terms of socioeconomic and environmental sustainability.

Furthermore, no empirical work has investigated the combined effect of these policies on commercialization using a quantitative, counterfactual approach. Indeed, policies tackling multi-dimensional issues related to individuals, households, and communities are often implemented simultaneously, generating impacts beyond their explicit goals [22]. In some cases, such policy mixes support farmers' autonomy by encouraging diversification strategies and promoting sustainability; in other cases, they foster specialization and conventional agricultural systems, undermining this autonomy [23–25]. Existing research in this area examines specific combinations of policies, namely, the impact of PRONAF, ATER, and SEEDS in shaping the productive profiles of family farms and enhancing productivity [18,26]; of PRONAF and ATER in fostering production and generating income [27–29]; of ATER and SEEDS in promoting agrobiodiversity conservation and sustainability [30,31]; and of PRONAF and SEEDS in stimulating production and supporting diverse production models [32,33].

Many empirical studies on the impact of policy mix(es) have focused on environmental aspects, for instance, the impact of different policy instruments on farmers' adaptation to climate change [20], their social vulnerability [34], or the optimal structure they should adopt for achieving positive results in terms of ecosystem conservation [35]. In doing so, they have neglected to consider that socioeconomic sustainability is key for family farmers to survive and successfully address environmental challenges. When it comes to small farmers who are mainly producing for their own consumption, socioeconomic sustainability relates to their strategic decision to commercialize or not commercialize their production. Given the multidimensional benefits of family farms' commercialization for poverty reduction and thus rural development, it is important to assess the combined effects of agri-food policies on this indicator, regardless of whether this was their explicit target.

We aim to address this research gap by investigating whether the above policy programs (individually or jointly) encouraged family farmers to commercialize their production. We focus specifically on family farmers, rather than large corporate farmers, because of their role in ensuring a fair income distribution in rural areas and thus sustainable rural development. Our Research Questions (RQ) are as follows:

RQ1: *Did the participation of Brazilian family farms in specific agricultural programs (PRONAF, ATER, and SEEDS) result in increased propensity to commercialize their production?*

RQ2: *Did simultaneous participation in more than one program result in an increased propensity to commercialize?*

To answer these questions, we use data from the 2014 National Household Sample Survey (*Pesquisa Nacional por Amostra de Domicílios*, PNAD) of the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE) [36]. This survey contains information on households' socio-demographic characteristics, employment, income, and participation in different programs supporting family agriculture. It also identifies the households who allocated part of their agricultural production to commercialization. Given that participation in the above programs could be endogenous to market orientation, to answer our RQs we adopt a propensity score matching (PSM) approach.

The paper is structured as follows. In Section 2, we review the literature on family farms' commercialization. Then, Section 3 describes the programs considered in this study. In Section 4, we present our data, illustrate how we defined the units of observation (family farmers), and describe the method of analysis. Section 5 illustrates and discusses the results, and Section 6 concludes the paper.

2. Family Farms and Commercialization

The commercialization of agri-food products from family farms in emerging countries has been extensively discussed in the literature (e.g., [37,38]). International development institutions such as the World Bank and the FAO consider commercialization an effective strategy to address rural poverty. Indeed, it increases productivity, raises rural incomes, and improves food security [13,39,40].

While commercialization is assumed to be a desirable outcome, market dynamics alone are not always successful in promoting it among small actors [41], and a blend of public and private interventions have been used to promote it [42]. Public policies have focused either on increasing farm productivity and thus sellable production or on facilitating farmers' access to new markets [43]. Regulating input and output markets, improving communications and transport infrastructure, providing extension services, securing property rights, and improving access to credit are among the tools used for enabling commercialization [41]. Credit can be provided in collaboration with the banking system, through ad hoc institutions, or informally [44]. Non-repayable loans and in-kind support are also options [45,46]. For example, agricultural extension services may be responsible for distributing seeds and fertilizers [47].

One branch of the literature on agricultural commercialization focuses on structural and cultural drivers and barriers. Structural elements include, among others, farm characteristics [48], rural infrastructures [49], and capital markets [50]. Cultural elements concern the value systems affecting farmer intentions, such as the level of risk aversion [51]; market orientation [52]; preference for food security over cash income [53]; livelihoods goals [54]; or the will to reduce external dependence, which could result in disengagement from formal markets [55]. Focusing on Brazil specifically, [56] argues that the attempts to integrate family farmers in regulated markets have generated heterogeneous responses, since the rationale behind family farmers' decisions is the search for autonomy in a context of vulnerability. A second branch of the literature analyzes the impact of commercialization on farmers' income and poverty levels (e.g., [57,58]). A third one highlights the social and ecological benefits generated by semi-subsistence farming, with some authors calling for their recognition by means of policy incentives, for example, those of the EU Common Agricultural Policy [59]. Finally, the critical development literature has analyzed the impact on rural communities of different typologies of agricultural markets [60], underlining themes such as food sovereignty and resilience [39].

Despite the large number of studies focusing on drivers of and barriers to commercialization, research assessing the joint impact of policy interventions on this indicator is limited. This is also due to the challenge of defining "commercialization" and "commercial farmers". The former is usually understood as the proportion of agricultural output sold in the market to the total value of output [41], while the latter are generally defined as farmers selling over half of their output [61].

Among the studies linking policy interventions to commercialization levels, ref. [62] found that social grants reduce small farmers' propensity to commercialize in South Africa. In turn, ref. [63] argues that improved infrastructures (namely, irrigation systems) increase the commercialization of peri-urban agriculture in Kenya. Ref. [42] reviews the Ethiopian policies to promote cereal intensification and commercialization, finding that these have generated lower than expected payoffs. Thus, outcomes are very much context-dependent, and policy measures that have worked well in a certain region or period are not perfectly reproducible elsewhere or in a different time. Notably, the extant literature focuses mainly on Africa, while Latin America, which presents very a different agri-food system, is mostly neglected.

Few studies have adopted a quantitative approach to investigate whether credit and service provision promote commercial agriculture or whether these resources are internalized by means of increased self-consumption [49]. Among them, ref. [46] found a positive effect of fertilizer subsidization on the commercialization of maize but no effect of family farmers' self-sufficiency in Malawi. Moving to a transition country, ref. [64] observed that direct payments to farmers in Kosovo have a positive effect on commercialization of some products (fruits and vegetables, cereals, and oilseeds), but not others (livestock products). However, these studies tested the impacts of a single policy, without considering interaction effects between policies. We add to this debate by analyzing the impact of the interaction among three different policy programs, focusing on Brazil as a case study.

3. The Brazilian Context

Large export-oriented farms have always dominated the Brazilian agri-food context [65]. Although family farms represent 77% of the total number of Brazilian establishments [66], they did not receive much attention in the Brazilian policymaking process until the 1990s. Starting from that decade, the pressure exerted by social movements, international non-governmental organizations, and the scientific community has prompted the Federal Government to introduce dedicated programs for family farmers [14,67].

The establishment of a rural credit program targeting family farms dates back to 1995, when the Federal Government introduced PRONAF [68]. This program provides credit on favorable conditions for family farmers to finance agricultural activities and purchase new equipment. Because of its longevity, PRONAF has been remodeled several times during its history. In the first period (1995–2002), its focus was on improving credit facilities and on defining a set of regulations for integrating in the system those farmers who had historically been excluded from the benefits of Brazilian agricultural policy [69]. In the second period (2003–2014), more resources from the federal budget were allocated to the program, and access rules were modified and the funding system simplified to enlarge the number of beneficiaries [70]. The third period, started in 2014, has seen a reduction in the quantity of resources allocated and in the number of beneficiaries because of the 2008 economic crisis and the changing national political landscape [71]. The data we analyze are from the time when the program was still in its "golden age".

The services offered by ATER were formally introduced in 1975 with the creation of the Brazilian Enterprise for Technical Assistance and Rural Extension (*Empresa Brasileira de Assistência Técnica e Extensão Rural*, EMBRATER). This federal agency was aimed at facilitating the diffusion of new technologies in agriculture [72]. EMBRATER was dismissed in 1992, and its activities were transferred to the State Governments [73]. According to [19] (p. 108), "since the beginning of the 1990 s, for almost fifteen years, the Federal Government's investments in technical assistance and rural extension were negligible, until their resumption with the first Government of Luís Inácio Lula da Silva (2003–2006)" (our translation from the original text in Portuguese). ATER assists family farmers in the adoption and implementation of different production technologies and in the development of social innovation for increased productivity.

Seed distribution (SEEDS) has always been implemented by the State Governments through the acquisition and distribution of seed stocks at prices lower than the market price. While the overarching goal of this program and its sub-programs has always been the same (reducing input costs), the priorities have varied between states. For example, Paraíba has promoted the use of creole seeds to strengthen traditional food production for self-consumption [21]. In contrast, Rio Grande do Sul conceived the program as a tool to promote farm specialization [74].

While not formally related, these policy instruments were designed to address similar needs of a specific socioeconomic group (i.e., family farmers) and to achieve multiple goals, namely, an increase in agricultural productivity and better integration of family farmers into the market. This led to an interaction (and sometimes an overlap) between these programs, which can be considered a type of policy mix according to the classification proposed by [22]: a combination of multiple policy instruments, with multiple goals, implemented by multiple governments. Policy mixes emerge when different policy instruments with different goals are implemented for addressing a specific issue [25,75]. In this context, we observe three programs that were originally designed with different scopes and were not supposed to be combined but concretely targeted the same population group and shared a common objective: a production increase.

4. Data and Methods

4.1. Data: The Brazilian National Household Sample Survey (PNAD)

This paper uses data from the PNAD, which is conducted yearly by the IBGE and provides information on the socioeconomic characteristics of Brazilian households. The PNAD sample is representative of the Brazilian population at different levels of aggregation [36]. We use the 2014 wave (362,627 observations) because it is the only one released to date that contains information on the recipients of PRONAF, ATER, and SEEDS. We focus primarily on the survey sections that explore the material conditions of the household units, their socio-demographic characteristics, and their working activities and earnings (salaries and rents).

According to Brazilian Federal Law 11,326 of 24 July 2006, to be recognized as a "family farmer", it is necessary for a farm to meet three criteria: (1) its area must be less than four *módulos fiscais* (a unit of measurement in hectares); (2) it must use mainly family labor for conducting farm activities; (3) it must derive a minimum share of the household's income from these activities. In operational terms, Brazilian policies use the definition of the National Register for Family Farming (*Cadastro Nacional da Agricultura Familiar*), which details the above criteria by specifying that at least 50% of the workforce dedicated to farming must come from household members, and at least 50% of the household income should derive from these activities. For PRONAF, there is also a fourth criterion, i.e., a ceiling for the annual household gross income of BRL 360,000 (for 2018).

The PNAD does not include explicit information on whether the households sampled are considered family farms according to the law. Therefore, we filtered them according to the following criteria:

(1) Farm size: owning or leasing less than a certain area of land, with the thresholds based on the state where the farm is located (this choice introduces some inaccuracy because the National Registry sets the threshold at municipal level; unfortunately, the PNAD does not include a variable for the municipality);
(2) Labor: being an entrepreneur and (a) hiring no labor, (b) employing a maximum of two individuals (a criterion for accessing PRONAF until the early 2000s) or (c) being employed without remuneration (it was not possible to directly assess the engagement of sample households in farm activities);
(3) Income: earning more than 50% of the gross household income from farming;
(4) Income ceiling: earning less than BRL 360,000 of gross household income a year.

We retained the households that met these four criteria simultaneously, thus obtaining a dataset of "family farms" with 9209 observations.

4.2. Method: Propensity Score Matching

We are interested in whether the family farmer engaged in commercialization of farm production in the agricultural year 2013–2014. The 2014 PNAD includes the following question: "*During the period from 28 September 2013 to 27 September 2014, have you sold any part of the main production of this activity*?". We used this question to generate a binary variable equal to 1 if the farmer engaged in commercialization, 0 otherwise. Because of the dichotomous nature of this variable, our outcome is the proportion (or percentage) of farmers who engaged in commercialization. We focus on the difference in this proportion between recipients of each policy or policy mix and non-recipients (as in [76]). The farmers who did not answer the question had to be excluded from the analysis.

The PNAD detects commercialization through different channels, and information about the main purchaser is also provided. In Section 5, we discuss this aspect in further detail. Indeed, although the World Bank promotes integration into formal markets rather than informal sales, the latter practice has a positive and possibly even larger impact on the incomes and food security of the rural population in Brazil [56] and other regions [61].

Our treatments are represented by the farmer's participation in PRONAF, ATER, and SEEDS, detected through specific questions.

Evaluating a policy intervention in a non-experimental context requires the policy impact on each unit (the "treatment effect") to be independent of the impacts on other units [77]. This condition is key to assess the average effects on a treated population [78]. Furthermore, treated and untreated actors, i.e., those who benefited from a policy intervention and those who did not, must be identifiable. However, the impact of a policy on the treated is represented by the difference in the outcome variable with and without the treatment (i.e., the counterfactual), which is technically impossible to estimate, because an actor cannot be both treated and untreated in a cross-sectional dataset.

Because participation in our programs is not randomized, it is important to consider the presence of selection bias [79]. Indeed, the group of family farms that have benefited from one or more policies is self-selected and can be inherently different from those who have not. To address this issue, we use propensity score matching (PSM). This method makes it possible to create a control group from independent untreated observations sharing similar characteristics with the treated [80]. For each observation, an index called the propensity score (PS) is estimated, which represents the probability of being treated given a set of covariates. Alternative methods such as difference-in-differences or regression discontinuity design were not applicable in our case due to the cross-sectional nature of the data.

The computation of the PS is based on the following model:

$$p(X_i) = Prob(T_i = 1|X_i) \quad (1)$$

where X_i is the set of covariates characterizing family farm i, while T_i is the assignment of family farm i to the treatment.

Using PSM, we can estimate the average treatment effect on the treated (ATT). In addition to the ATT, we can estimate the average treatment effect (ATE), i.e., the average treatment effect on the population under consideration. Herein, since we are interested in the differential impact of the policies for the farmers receiving them, we present our results in terms of ATT, while tables with the results in terms of ATE are provided as Supplementary Materials. The ATT is defined as follows [81]:

$$ATT = E(Y(1)|T = 1) - E(Y(0)|T = 1) \quad (2)$$

where $E(Y(1)|T = 1)$ corresponds to the outcome for the family farms who benefited from a policy and $E(Y(0)|T = 1)$ is the outcome for the same family farms if they would have not benefited from it. Only the first term of the right side of Equation (2), $E(Y(1)|T = 1)$, is observable, while the counterfactual term $E(Y(0)|T = 1)$ does not exist. A solution consists of creating a counterfactual using the untreated family farms [76,82]. In order to estimate the ATT, two conditions need to be met: conditional independence, i.e., family farms must be assigned to the treatment independent of the observed outcome and conditionally on a set of covariates X_i, and common support, i.e., farms with similar covariates must have a positive probability of being both treated and untreated [81]. If both conditions hold, it is possible to produce unbiased estimates of the ATT, and Equation (2) becomes the following:

$$ATT = E(Y(1)|T = 1,\ p(X_i)) - E(Y(0)|T = 1,\ p(X_i)) \quad (3)$$

where $p(X_i)$ is the PS given the set of covariates X_i.

The literature identified a set of characteristics that influence the probability of family farms both participating in policy programs and engaging in commercialization: age, gender, farm size, race, education, household size, assets, farm and off-farm incomes, and geographical location [83,84]. The PNAD dataset includes variables for each of the above elements. For race, we create a binary variable indicating whether the respondent identified as "white". For assets, we consider the ownership of a mobile phone, of a means of transport, and access to the Internet. Farm and off-farm incomes are included separately. Finally, for the location, we use indicators of Brazilian macro-regions.

Another issue specifically related to this study is that the same family farm may have accessed different policy interventions. The combination of these interventions, deliberate or not, may have led to synergies or conflicts influencing the outcome [85,86]. Hence, we must isolate interactions that can lead to biased results. To address this issue, we follow the approach proposed by [76]. Their methodology is suitable for this study because of the cross-sectional nature of their dataset as well as ours.

First, by identifying the potential intersections between policies, we define ten treatments, which are illustrated by the sets in Figure 1:

1. PRONAF (total): set 1 (treated) vs. set ~1 (untreated).
2. ATER (total): 2 vs. ~2.
3. SEEDS (total): 3 vs. ~3.
4. PRONAF only: 4 vs. no policy.
5. ATER only: 5 vs. no policy.
6. SEEDS only: 6 vs. no policy.
7. PRONAF and ATER: 7 ($1 \cap 2$) vs. no policy.
8. PRONAF and SEEDS: 8 ($1 \cap 3$) vs. no policy.
9. ATER and SEEDS: 9 ($2 \cap 3$) vs. no policy.
10. All policies: 10 ($1 \cap 2 \cap 3$) vs. no policy.

Treatments 1–3 capture the impact of each policy in turn without disentangling the policy mix effects. As such, they represent a baseline to be compared to the impact of the same policies in isolation, measured by treatments 4–6 [76]. Treatments 7–10 correspond to the different policy mixes.

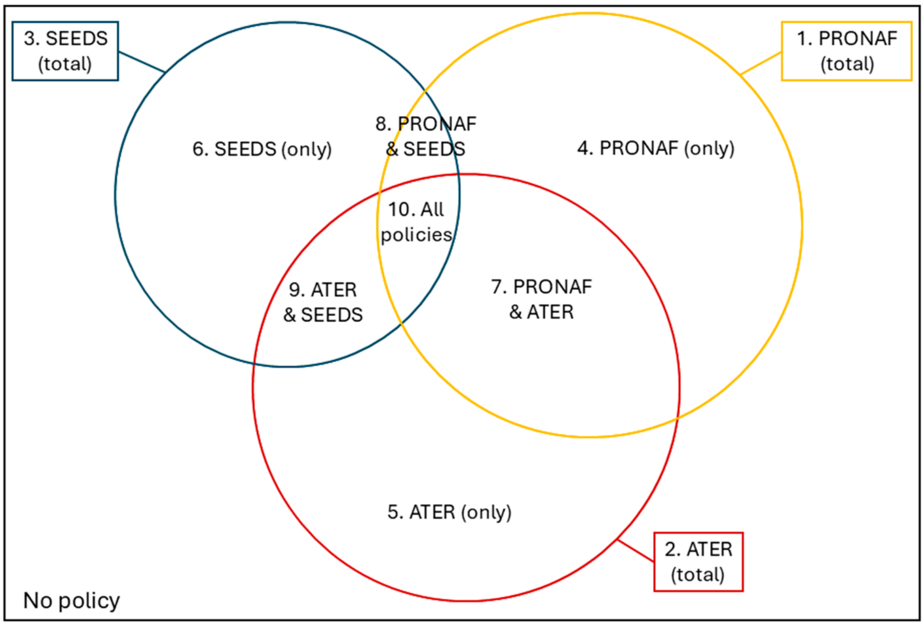

Figure 1. Illustration of the intersections between policy programs and policy mixes. Notes: The sizes of the circles and intersections are proportional to the number of family farmers who accessed each program or mix of programs in the sample. However, the size of the rectangle is not to scale, since only 19.4% of the farms accessed at least one policy, resulting in much smaller circles.

As already mentioned, family farmers' participation in the three policies is identified through questions inquiring whether they received farm credit, technical assistance, or seeds. However, we are interested in the impact of public policies—not similar types of services obtained from the private sector. Considering the farm credit or technical assistance obtained from private enterprises as additional treatments would increase the number of treatments greatly due to the additional policy mixes, thus fragmenting the sample; in contrast, ignoring them would result in omitted variables and related confounding effects. For these reasons, we exclude from the analysis the family farms that received agricultural credit not from PRONAF or technical assistance from private enterprises, resulting in a sample size of 4170 units.

The above procedure for estimating the ATT can only be applied to treatments 1–3, where the same farm can be considered "treated" with more than one policy and the control groups are represented by the farms that did not receive that specific treatment. For treatments 4–10, which isolate the cases of simultaneous participation in more than one policy, the treatments are mutually exclusive, and the control is always represented by the farms that did not benefit from any of the policies (the gray area in Figure 1).

Following [76], for treatments 4–10, Equation (2) becomes the following:

$$ATT = E(Y(m)|T = m) - E(Y(l)|T = m) \quad (4)$$

where m is the treatment of interest, l its absence. This multivariate context has been explored by [87,88], whose authors developed the generalized PS to address the identification problem arising in this situation. This is defined as the "conditional probability of receiving a particular level of treatment given the pre-treatment characteristics" [76] (p. 731).

To estimate the different PSs, we use different models: for treatments 1–3, three logistic regressions where the dependent variable takes a value of $T = 1$ in the presence of treatment and $T = 0$ otherwise; for treatments 4–10, a multinomial logistic model where the dependent variable can assume eight different values: a baseline outcome for the non-treated condition (i.e., $T = 0$, for the farmers who did not benefit from any policy) and seven additional levels corresponding to the mutually-exclusive treatments 4–10. Given the nonordered nature of the dependent variable, the multinomial logistic model is appropriate, as it compares the probability of each treatment outcome to the baseline.

The logistic and multinomial logistic models, whose full estimates are provided as Supplementary Materials, show that participation in different programs is related (positively or negatively) to provenience from the Northeast and South macro-regions, age, gender, availability of a means of transport, and, above all, farm size and incomes. Race, level of education, ownership of a mobile phone, and access to the Internet have a significant impact in some instances. The model for PRONAF performs best, with a pseudo-R-squared of 0.113, followed by the multinomial logistic model with 0.095, ATER with 0.082, and SEEDS with 0.056.

After calculating the PSs, we match the observations using three different algorithms: kernel, nearest neighbor, and radius. The kernel estimator matches each treated farm to all untreated farms, assigning larger weights to the farms that are less distant in terms of PS. The nearest-neighbor estimator matches each treated farm with the n closest untreated farms in terms of PS. Following [89], we adopt nearest-neighbor matching with replacement, i.e., we allow the same untreated farm to be matched to more than one treated farm, which lowers the bias but increases the variance. We set n = 2, which is the maximum number of neighbors recommended by [90] for most research settings. Finally, the radius estimator matches each treated farm with all the untreated farms closer than the length of the radius; we use a radius of 0.01, corresponding to a total width between 3.2% of the range of the PS in treatments 4–10 and 5.7% in treatment 3. The radius may result in each treated farm being matched to many untreated farms, especially in the regions where the density of the PS values is high. However, compared to nearest neighbor, it avoids matching them with very distant farms where the density is low. The plots of the PS distributions, reported in Figure 2 as well as in the Supplementary Materials, show that there is good overlapping and no evident mismatch in terms of density peaks between the different treatments and their counterfactuals. Partial exceptions are represented by treatments 8, 9, and 10, for which the sample includes very few observations and whose results must thus be considered with care.

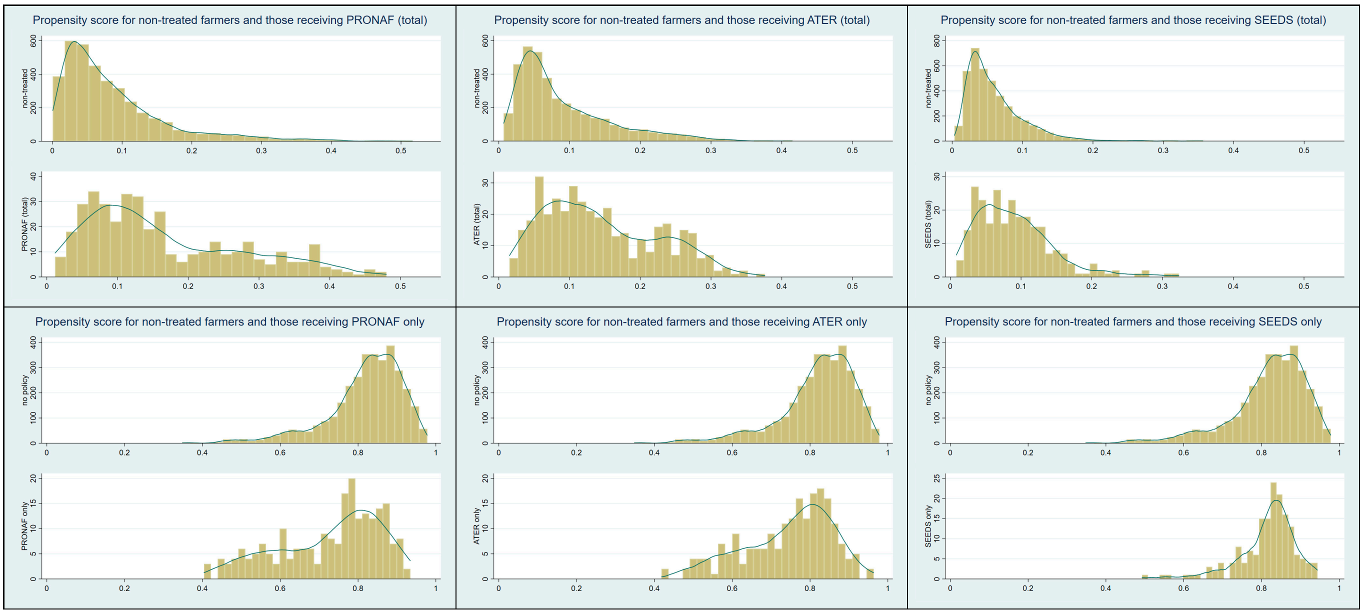

Figure 2. *Cont.*

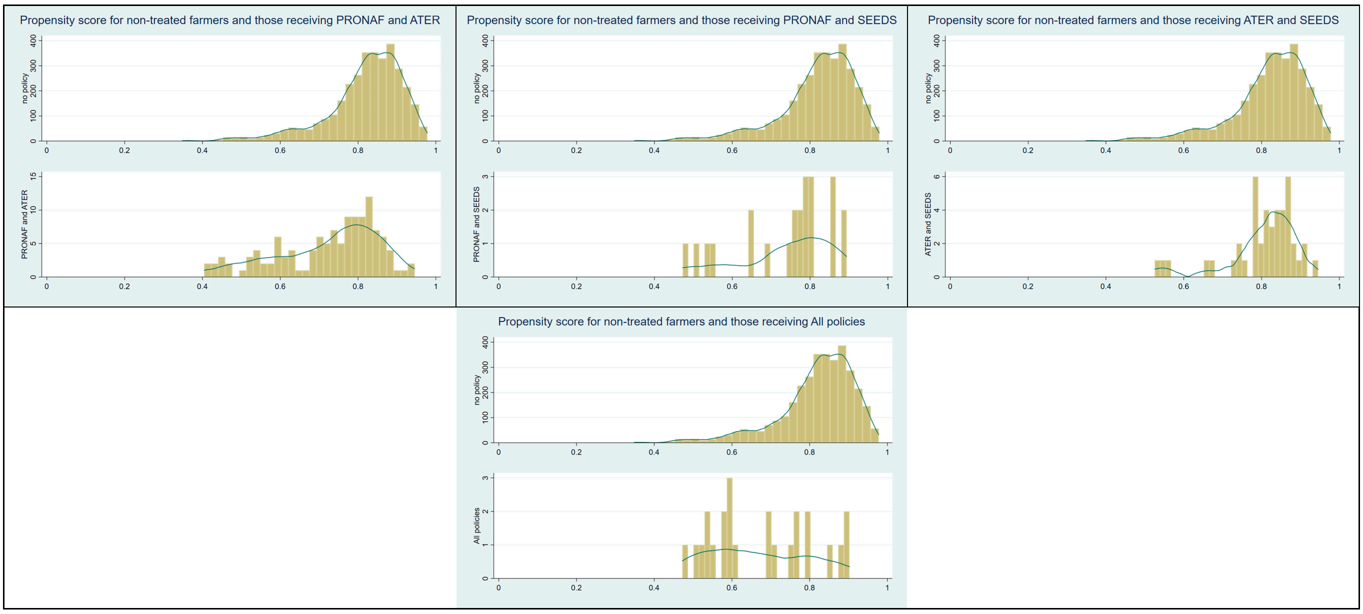

Figure 2. Overlapping plots of the PS values for different treatments and their counterfactuals.

Using three different estimators enables us to compare different results as a robustness check [91]. Furthermore, to compute the variance of the ATT and thus its standard error, we run 1000 bootstrap replicates for each treatment.

PSM controls for observed differences between treated and untreated units but cannot address unobservable differences. This can be a challenge especially in emerging and developing economies, whose farmers are characterized by inseparability of production and consumption choices and thus endogeneity of decisions, including market and policy participation [92]. Following [93], we assess the robustness of our results to the influence of unobserved variables by running the test developed by [94]. This test assumes that two farms with the same observed characteristics may differ in the odds of participating in a policy by at most a factor of Γ (unobserved bias), beyond which the estimated ATT becomes non-significant. In the next section, we report the critical levels of Γ for attaining a 5% significance level.

5. Empirical Results

Out of 4170 family farms, 393 accessed financial support from PRONAF, 396 benefited from technical assistance (ATER), and 258 accessed seed distribution (SEEDS). Table 1 illustrates the characteristics of different groups in terms of the matching variables. The farms differ depending on the policy received as well as compared to the group of farms that did not benefit from any policy. While the age of the farmers is similar across groups, the farms accessing PRONAF and ATER are more often managed by a white male; those accessing SEEDS have a larger share of female and non-white managers. The farmers benefiting from SEEDS show lower levels of education and have larger households. The ownership of a mobile phone or of a means of transport and access to the Internet follow similar patterns, being more common among the farmers who benefited from PRONAF or ATER. A relevant difference is observed in the average farm income, which is more than double for the households benefiting from either PRONAF or ATER compared to those benefiting from SEEDS. The latter earn less than those receiving no policy support. A similar gap is observed for non-farm incomes, although in this case the groups differ by a factor of 1.5 at most. In turn, the farms that benefited from SEEDS manage a larger farm area, which could be related to lower land quality. Indeed, while the productive Southern macro-region is overrepresented among the farms receiving PRONAF and ATER, a majority of those participating in SEEDS come from the poorer Northeast. These results suggest that direct estimates without matching would be highly biased.

Table 1. Socioeconomic characteristics of family farms by public policy accessed.

Variables	Total		PRONAF		ATER		SEEDS		No Policy	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Age (years)	46.15	12.73	47.72	11.60	48.58	12.08	46.34	10.78	45.84	12.97
Gender (male, %)	90.48		95.17		89.39		86.05		90.51	
Farm area (ha)	1.37	5.25	1.82	7.11	1.28	1.04	2.02	10.68	1.33	5.02
Race (white, %)	40.00		59.29		57.32		41.09		36.92	
Education (years)	5.86	3.96	6.66	3.69	6.77	3.71	5.65	4.03	5.73	3.98
Household size	3.55	1.70	3.31	1.29	3.44	1.58	4.08	2.08	3.54	1.72
Mobile phone (%)	78.49		89.31		90.15		82.95		76.29	
Internet (%)	21.65		34.35		32.32		23.64		19.58	
Means of transport (%)	71.06		88.80		83.84		67.83		68.67	
Farm income (BRL/month)	1152.77	1675.08	1789.33	1907.08	1591.54	1732.32	812.32	871.66	1091.79	1676.13
Other incomes (BRL/month)	1035.75	1723.51	1120.13	1265.94	1264.51	1424.16	840.03	973.36	1018.82	1810.97
Macro-region North (%)	27.82		17.05		24.24		18.22		29.63	
Northeast (%)	33.79		21.12		15.91		53.88		35.20	
Central-West (%)	7.39		8.40		4.80		3.10		7.74	
Southeast (%)	15.28		17.30		20.20		9.30		14.97	
South (%)	15.73		36.13		34.85		15.50		12.47	
Number of obs.	4170		393		396		258		3361	

Notes: The three policies and "No policy" sum up to more than the total number of observations because some farms have benefited of more than one policy, i.e., they are counted in more columns. Number of input observations: 9 for mobile phone, Internet, and means of transport; 36 for other incomes.

Table 2 shows the distribution of the farms by policy or policy mix received, the percentage that engage in commercialization in each group, and the difference compared to the control group before matching. Overall, 73.9% of the farms in the sample sell part of their production, but this figure ranges from 91.3% of those receiving both PRONAF and SEEDS to 70.7% of those benefiting from SEEDS only. The percentage of farms commercializing some production is significantly higher among those receiving policy support than among those receiving no support, with the exception of those participating in SEEDS. The number of farms benefiting from PRONAF and ATER is similar, accounting for around one-tenth of the total in both cases; instead, the number of farms receiving SEEDS is smaller (6.2% of the total). The most common policy mix is between PRONAF and ATER—around one-third of the farms benefited from either of the two.

Table 2. Number and share of farms engaging in commercialization (%), by policy or policy mix.

Policy/Policy Mix	All Farms		
	Number	Market (%)	Difference [1]
No policies	3361	71.73%	
1. PRONAF (total)	393	87.79%	15.29% ***
2. ATER (total)	396	85.35%	12.62% ***
3. SEEDS (total)	258	76.74%	3.00%
4. PRONAF only	223	87.44%	15.71% ***
5. ATER only	205	83.41%	11.68% ***
6. SEEDS only	167	70.66%	1.08%
7. PRONAF and ATER	123	87.80%	16.07% ***
8. PRONAF and SEEDS	23	91.30%	19.60% **
9. ATER and SEEDS	44	86.36%	14.63% **
10. All policies	24	87.50%	15.77% **
Total	4170	73.93%	

Notes: [1] Compared to the farms not receiving that policy for treatments 1–3 and to "No policy" for treatments 4–10. Significance level: ** 5%; *** 1%.

Before illustrating the PSM results, it must be noted that the kernel algorithm produces the weakest matching. Indeed, the variance ratio for the treated and control groups is outside the required range of [0.5; 2] for all the treatments, meaning that the covariates are not well balanced between these groups. In turn, radius is the most robust matching algorithm, producing reliable results for all the treatments except "All policies". Finally, nearest-neighbor matching balances the covariates effectively for the treatments consisting of a single program but not for those indicating a policy mix. The full balancing tables for all the treatments and matching algorithms are provided as Supplementary Materials.

As a first step, we assess the impact on commercialization of the single policies in turn, both regardless of whether the farms benefited simultaneously from other policies—treatments PRONAF (total) (1), ATER (total) (2), and SEEDS (total) (3)—and by isolating them from other policies—treatments PRONAF only (4), ATER only (5), and SEEDS only (6). Table 3 illustrates the results for the first group of treatments using the three different matching algorithms, Table 4 the results for treatments 4–6.

Table 3. Increase in the percentage of commercial farms among policy recipients, regardless of policy interactions (treatments 1–3).

Interaction	Treated	Controls	Matching Algorithm	ATT (Common Support)					Magnitude of Γ
				Coeff.	St. Err.	Z	*p*-Value	%	
1. PRONAF (total)	393	3777	Kernel	*0.129*	*0.019*	*6.64*	*0.000 ****	*12.9%*	*2.025*
			Nearest neighbor (n = 2)	0.081	0.032	2.52	0.012 **	8.1%	1.425
			Radius caliper (0.01)	0.116	0.021	5.44	0.000 ***	11.6%	2.025
2. ATER (total)	396	3774	Kernel	*0.099*	*0.019*	*5.14*	*0.000 ****	*9.9%*	*1.650*
			Nearest neighbor (n = 2)	0.095	0.032	2.96	0.003 ***	9.5%	1.450
			Radius caliper (0.01)	0.085	0.020	4.26	0.000 ***	8.5%	1.625
3. SEEDS (total)	258	3912	Kernel	*0.040*	*0.026*	*1.51*	*0.130*	*4.0%*	*1.000*
			Nearest neighbor (n = 2)	0.064	0.044	1.45	0.147	6.4%	1.000
			Radius caliper (0.01)	0.070	0.027	2.58	0.010 **	7.0%	1.000

Notes: Significance level: ** 5%; *** 1%. Matching results for which the variance ratio is outside [0.5; 2] are in *italics*.

Table 4. Increase in the percentage of commercial farms among the recipients of a single policy (treatments 4–6).

Interaction	Treated	Controls	Matching Algorithm	ATT (Common Support)					Magnitude of Γ
				Coeff.	St. Err.	Z	*p*-Value	%	
4. PRONAF only	223	3361	Kernel	*0.135*	*0.024*	*5.57*	*0.000 ****	*13.5%*	*1.825*
			Nearest neighbor (n = 2)	0.117	0.042	2.77	0.006 ***	11.7%	1.425
			Radius caliper (0.01)	0.125	0.027	4.69	0.000 ***	12.5%	1.850
5. ATER only	205	3361	Kernel	*0.088*	*0.027*	*3.23*	*0.001 ****	*8.8%*	*1.325*
			Nearest neighbor (n = 2)	0.095	0.046	2.05	0.040 **	9.3%	1.225
			Radius caliper (0.01)	0.080	0.028	2.83	0.005 ***	8.0%	1.325
6. SEEDS only	167	3361	Kernel	*0.011*	*0.035*	*0.30*	*0.763*	*1.1%*	*1.000*
			Nearest neighbor (n = 2)	0.036	0.056	0.64	0.521	3.6%	1.000
			Radius caliper (0.01)	0.050	0.037	1.36	0.173	5.0%	1.000

Notes: Significance level: ** 5%; *** 1%. Matching results for which the variance ratio is outside [0.5; 2] are in *italics*.

The estimated ATTs are positive for all three programs, meaning that the percentage of family farms engaging in commercialization never decreases due to receiving public policy support. However, in the case of SEEDS, the difference is only significant with radius matching when the interactions with other policies are not disentangled (Table 3) and becomes non-significant if the policy is analyzed separately (Table 4). Furthermore, the magnitude of Γ indicates that the results are not robust to unobserved differences. A prior study [93] suggests that a magnitude of 1.4 indicates sufficient robustness, with it being unlikely that unobservable characteristics would influence the odds of joining a policy for two farmers with similar observable characteristics to such an extent. These figures suggest that the increase in commercialization may rather be due to the other programs from which some farms benefited in addition to SEEDS. The strongest impact on commercialization is generated by PRONAF. The results for treatment 1 indicate that the probability that family farms commercialize their output increases by between 8.1% and 12.9% if they receive

PRONAF, depending on the matching method. A slightly larger increase is observed for treatment 4—between 11.7% and 13.1%. The farms receiving support from ATER show a probability of commercialization that is between 8.5% and 9.9% higher than the control group, and between 8.0% and 9.3% if the effect is isolated from other policies.

Overall, the impact of the policies in isolation (Table 4) is similar to the impact measured when the farmers receiving more than one policy are included among the treated (Table 3). This suggests that the policy mixes generate limited synergies; furthermore, the direction of the effect is unclear. For PRONAF, it seems that farmers accessing this policy alone are more likely to commercialize, while for ATER the mix has a slight boosting effect, as discussed in the following. Finally, the results of the test developed by [94] indicate that the estimates for PRONAF are the most robust to unobserved factors, followed by those for ATER, and that those obtained with kernel or radius matching are more robust than those obtained with nearest-neighbor matching.

Despite facilitated credit conditions (in terms of interest rates and payment terms), PRONAF loan agreements usually require commercialization of part of the production. Second, loans are only approved for economically and environmentally viable crops and livestock activities in their respective territories [71]. Third, PRONAF may end up increasing commercialization because failure to repay the credits would result in indebtedness, with negative implications for the family. Producing for the market is the main strategy used by family farms to repay the loan. These elements indicate that PRONAF is a market-oriented policy, and our results add empirical evidence that this policy is effective in supporting the commercialization of family farms.

The family farms benefiting from ATER only are slightly less likely to commercialize their production than those accessing PRONAF only. In general, ATER targets a large range of agri-food activities, aiming to improve or promote better integration as well as sustainable practices, including vegetable gardens, orchards, commercial and non-commercial crops (e.g., potatoes, cassava, beans, and peanuts), small-scale breeding (such as poultry, goats, and pigs), production for self-consumption, and environmental preservation [95]. In contrast to PRONAF, it does not target commercialization directly. Therefore, its significant impact on commercialization represents an interesting result from a policy evaluation perspective.

As for SEEDS, the absence of a significant impact on commercialization may be due to four main reasons: (i) its profile as a policy addressing the needs of "poor farmers"; (ii) the larger presence, among its recipients, of female farmers, who are central for the preservation and valorization of production for self-consumption [95]; (iii) its structural characteristics, since participants receive a pay-off in seeds instead of money; (iv) the profile of the SEEDS programs in the Northeast region, mainly oriented toward subsistence production and self-consumption. Although we also match the farms based on gender and macro-region, there may be additional unobservable factors related to these characteristics.

As a second step, we investigate the impact of the policy mixes (treatments 7–10). Overall, 123 farms in the sample benefited from PRONAF and ATER, 23 from PRONAF and SEEDS, 44 from ATER and SEEDS, and 24 from all policies together. Due to these small numbers, our results must be considered carefully, as also suggested by a value of Γ often equal or close to one and by the poorer overlap of the PS plots in Figure 2, which results in a poor match.

The impact of the policy mixes on commercialization is reported in Table 5. The estimated ATTs are all positive, meaning that the percentage of farms engaging in commercialization never decreases and, in most cases, is statistically significant (especially with kernel and radius matching). However, the magnitude of Γ is only acceptable (larger than 1.4) for the PRONAF–ATER mix, and the matching is only robust for radius matching for treatments 7 to 9. The PRONAF–ATER mix boosts commercialization by between 13.4% and 16.3%. Surprisingly, the largest effect is generated by the PRONAF–SEEDS mix (16.5% to 23.9%). The ATER–SEEDS mix, where significant and properly matched, generates a 14.6% effect. The increases in commercialization thanks to the policy mixes are larger than the effects of the policies separately (Table 4) but smaller than their sum. Therefore, while the policy mixes generate positive synergies, these are not very strong, suggesting that the decision whether to commercialize is generally made as a result of a single policy. In most cases, this is PRONAF, given the characteristics of this policy and of its pool of recipients, as already detailed in the text.

Table 5. Increase in the percent of commercial farms among policy mix recipients (treatments 7–10).

Interaction	Treated	Controls	Matching Algorithm	ATT (Common Support)					Magnitude of Γ
				Coeff.	St. Err.	Z	*p*-Value	%	
7. PRONAF and ATER	123	3361	Kernel	*0.142*	*0.032*	*4.40*	*0.000 ****	*14.2%*	*1.675*
			Nearest neighbor (n = 2)	*0.163*	*0.059*	*2.92*	*0.005 ****	*16.3%*	*1.675*
			Radius caliper (0.01)	0.134	0.035	3.82	0.000 ***	13.4%	1.650
8. PRONAF and SEEDS	23	3361	Kernel	*0.192*	*0.065*	*2.98*	*0.003 ****	*19.2%*	*1.125*
			Nearest neighbor (n = 2)	*0.239*	*0.132*	*1.82*	*0.069 **	*23.9%*	*1.250*
			Radius caliper (0.01)	0.165	0.074	2.24	0.025 **	16.5%	1.125
9. ATER and SEEDS	44	3361	Kernel	*0.146*	*0.055*	*2.68*	*0.007 ****	*14.6%*	*1.150*
			Nearest neighbor (n = 2)	*0.102*	*0.095*	*1.08*	*0.279*	*10.2%*	*1.000*
			Radius caliper (0.01)	0.146	0.055	2.65	0.008 ***	14.6%	1.150
10. All policies	24	3361	Kernel	*0.125*	*0.069*	*1.80*	*0.071 **	*12.5%*	*1.000*
			Nearest neighbor (n = 2)	*0.229*	*0.127*	*1.80*	*0.072 **	*22.9%*	*1.050*
			Radius caliper (0.01)	*0.140*	*0.083*	*1.68*	*0.092 **	*14.0%*	*1.000*

Notes: Significance level: * 10%; ** 5%; *** 1%. Matching results for which the variance ratio is outside [0.5; 2] are in *italics*.

One aspect that may help in understanding our results is the commercialization channels mobilized by family farmers, illustrated in Table 6. Different market configurations produce different results in terms of social reproduction of the family farm. In the case of the farmers who accessed PRONAF (alone or together with ATER and SEEDS), the main commercialization channels were companies (40.3%), middlemen (23.8%), and cooperatives (19.1%). Previous studies found that 70% of PRONAF resources go to just three products (soybean, corn, and coffee), which are generally commercialized through the above channels [71,96,97].

Table 6. Main purchasers of farm production during the last year: percentage of farms that indicated each purchaser, by type of policy or policy mix received.

Policy [1]	Company	Cooperative	Government	Owner of the Good Used	Middleman	Consumer	Other
No policies	20.07%	6.39%	0.58%	0.54%	37.08%	34.59%	0.75%
1. PRONAF (total)	40.29% ***	19.13% ***	2.03% **	1.16%	23.77% ***	12.46% ***	1.16%
2. ATER (total)	38.17% ***	16.86% ***	2.96% ***	0.89%	27.51% ***	12.72% ***	0.89%
3. SEEDS (total)	15.66% **	12.62% **	3.03% ***	1.01%	29.80%	36.87% *	1.01%
4. PRONAF only	42.56% ***	16.41% ***	1.54%	0.51%	24.62% ***	13.33% ***	1.03%
5. ATER only	41.52% ***	12.28% ***	2.34% ***	0.58%	30.99%	11.70% ***	0.58%
6. SEEDS only	8.47% ***	7.63%	3.39% ***	0.00%	33.05%	46.61% ***	0.85%
7. PRONAF and ATER	38.89% ***	21.30% ***	3.70% ***	0.93%	24.07% ***	10.19% ***	0.93%
8. PRONAF and SEEDS	23.81%	14.29%	0.00%	4.76% **	28.57%	28.57%	0.00%
9. ATER and SEEDS	18.42%	13.16% *	5.26% ***	0.00%	31.58%	31.58%	0.00%
10. All policies	42.86% ***	38.10% ***	0.00%	4.76% **	9.52% ***	0.00% ***	4.76% **
Total	23.06%	8.27%	1.01%	0.58%	35.03%	31.27%	0.78%

Notes: [1] Significance of the difference compared to the farmers who did not receive that policy for Treatments 1–3 and to "No policy" for Treatments 4–10. Significance level: * 10%; ** 5%; *** 1%.

The dynamics generated by ATER are more diverse. Initially, ATER was strongly focused on the modernization of agriculture and thus supported actions directed towards conventional products and markets. However, in recent years, ATER professionals have started promoting alternative agroecological practices and participatory methods. Since 2010, federal resources have been allocated to ATER for promoting diversification, sustainability, agroecology, and food and nutritional security, often by stimulating production for self-consumption and the establishment of alternative agri-food networks [98]. Nevertheless, the commercialization channels are not very different from PRONAF. PNAD data indicate that the farmers benefiting from ATER (only) were selling mainly to companies (38.2%) and middlemen (27.5%); only 12.7% were selling directly to consumers. In turn, 46.6% of the farmers who accessed SEEDS (only) were selling mainly to consumers, while under 10% were selling mainly to private companies. SEED recipients were mostly from the Northeast, where there are many initiatives focused on the production of traditional foods, whether for self-consumption or for local markets [18].

It is worth emphasizing that compared to other policies, PRONAF exerts a stronger influence on the commercialization channels even when mixed with the other programs. Instead, ATER seems to be a flexible policy that relates to different production systems and marketing strategies. For instance, family farmers accessing both PRONAF and ATER chose mostly private companies as their main commercialization channels, while those accessing ATER and SEEDS but not PRONAF sell predominantly to consumers.

In summary, the three programs analyzed (PRONAF, ATER, and SEEDS) play a crucial role in promoting agricultural production by offering financial resources under favorable conditions and enabling the purchase of inputs and machinery essential for production and commercialization. Additionally, they provide seeds for the cultivation of certain varieties and deliver specialized technical assistance. These measures significantly support the livelihoods and sustainability of family farmers, bridging the gaps created by the lack of personal financial resources and granting access to vital products and services. Furthermore, these programs are found to positively impact commercialization, though the degree of this impact varies depending on the programs and their combinations. Importantly, this does not necessarily result in the elimination of production for self-consumption. Given these complex dynamics, it is imperative that policies aimed at family farming in developing and emerging countries not only focus on their individual effects but also prioritize their interactions and the synergies with other public instruments. The overarching objective should be to strengthen autonomy and resilience within this socioeconomic group, advancing productive, economic, and market-access strategies that support their social reproduction in the contemporary context.

6. Discussions and Policy Implications

Family farming is increasingly recognized as essential for promoting rural development, reducing poverty, and achieving environmental sustainability [5–9]. Its important role in emerging countries such as Brazil is confirmed by the large number of family farms. In the last decades, these have been targeted by federal and state policies with the objectives of both stimulating production for commercialization and strengthening food security. In this paper, we focused on three different policies—PRONAF, ATER, and SEEDS—to investigate their impact on family farmers' decision to commercialize their production.

Although the impact of some policies and policy mixes are non-significant, in no case do we observe a reduced propensity towards commercialization among policy recipients. All the estimated ATTs are positive, regardless of whether commercialization is an explicit goal of the policies considered. PRONAF is associated with the highest increase in the probability of engaging in commercialization. This effect is visible both when farmers participate in this program only, and when they benefit from a combination of PRONAF and other policies. Such findings are corroborated by qualitative studies highlighting the productivity-focused approach of PRONAF [97,99]. On the other hand, accessing SEEDS alone is least likely to stimulate commercialization. Nevertheless, when this policy is combined with either PRONAF or ATER, we observe a marginal increase in the effect of the latter, suggesting some positive synergies. The effect of ATER is positive yet smaller than that of PRONAF, and their combined impact (13.4%) is the largest among those that are statistically significant and is robust to unobserved variables.

By mapping the types of markets mobilized, we show that PRONAF is associated with production for private companies, while the family farmers benefiting from SEEDS target mostly consumers in local markets. ATER encourages more diverse commercialization strategies, which are key in shaping more sustainable production models [4].

This study draws attention to a crucial aspect for policymaking: evaluating policy mixes. As shown, public policies produce different results depending on whether they act individually or jointly; ignoring potential complementarities or conflicts between policies might impact their efficiency, causing mismanagement of public funds and undermining rural development processes. Furthermore, we showed that different policies mobilize different markets, with differential impacts on the social reproduction of agriculture: further research on this aspect is needed. Our results also suggest that policy mixes can lead to unexpected results, in line with [25]. They can generate positive outcomes such as an increase in commercialization but can also foster unintended behaviors. For instance, SEEDS was used by some Brazilian states for supporting farmers' self-consumption [83], meaning that commercialization would be a "by-product" of the policy mixes. Neglecting potential behavioral shifts in farmers benefiting from different policies can be risky from a policy design perspective. Adjusting the current policy framework may be an option, but coordination between multiple actors (at the federal, state, and municipal levels) is required. A new governance architecture for agri-food policies aiming to increase agricultural production while preserving the environment is probably needed. As highlighted by [100], policy mixes whereby policy instruments are interrelated and not overlapping, and where there is coordination between public authorities at different institutional levels, can be the optimal strategy in cases of governance complexity.

In terms of recommendations for public policies, the article highlights the following: (i) their importance for promoting family farmers' integration into markets and ensuring their social reproduction, though it is also important to promote other non-market strategies and consider the quality of the markets in ensuring autonomy and sustainability; (ii) the importance of monitoring mechanisms and of the analysis of data on public policies in Brazil to assess their individual effects over time—something that is still rare.

Our analysis presents some limitations, mainly due to data constraints, but may also inspire new studies. First, the PNAD dataset does not report information on the quantity and value of the food produced and marketed by family farmers; therefore, we were unable to assess the impact of PRONAF, ATER, and SEEDS in this sense. Another limitation is related to the cross-sectional nature of the PNAD dataset. Longitudinal data would have enabled us to understand long-term policy impacts by observing farmers' decisions to continue producing for the market in the long run, including after the cessation of the financial incentives. Sustainability beyond the funding period is a key indicator of success of public policies, as it suggests that the latter were able to change the underlying motivations of stakeholders, but is also a challenge. Equally, a panel dataset would have allowed us to assess causality, rather than correlation, thus increasing the robustness of the recommendations derived. This phenomenon might be investigated in further research, for instance, once the next wave of the PNAD survey is published. Despite these shortcomings, PNAD remains the richest available dataset on this matter to date.

Commercialization does not necessarily mean increased food and nutritional security or sustainability of farm production practices. A prior report [41] highlights that commercialization generate first-, second-, and third-order impacts. First-order impact include income and employment benefits, second-order ones pertain to health and nutrition, and third- or higher-order ones concern environmental and macro-economic outcomes beyond the farming household. While we argued that the resilience of family farms is key to preserving a more sustainable, territorialized food system, the environmental impacts of commercialization can be mixed. An appropriate policy mix that, alongside promoting commercialization, also protects property rights and regulates the use of water and chemical fertilizers is needed [101,102]. Further research should be dedicated to investigating these aspects, i.e., how the market integration of Brazilian family farmers relates to food security and sustainable practices and whether there are trade-offs. This will require the measurement of indicators such as the intensity of water and fertilizer use, average farm sizes, and nutritional outcomes, for instance through the Household Dietary Diversity Score (HDDS) [103], as well as the assessment of how these vary with commercialization levels. In this regard, it would be interesting to focus on other programs that can be accessed by Brazilian family farms, such as the Food Acquisition Program (PAA) and the National School Feeding Program (PNAE) [9]. Equally, while we have seen that the SEEDS program has the largest impact in the Northeast region of Brazil and is crucial for promoting food and nutritional security, it would be important to conduct further studies on this program in different states separately (which was not possible using the PNAD dataset). This would allow identification of policy profiles that are more production-oriented in order to reach more precise conclusions about the impacts of this program on the commercialization of family farming.

Supplementary Materials: Supporting information (tables with the logistic and multinomial logistic regressions used to calculate the PSs, the results of the matching procedure, and the ATE values; figures with the overlapping plots) can be downloaded at: https://www.mdpi.com/article/10.3390/su162411102/s1.

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References

1. FAO. Agricultura Familiar en América Latina y el Caribe: Recomendaciones de Política. 2014. Available online: http://www.fao.org/3/i3788s/i3788s.pdf (accessed on 5 November 2024).
2. Ellis, F. Household strategies and rural livelihood diversification. *J. Dev. Stud.* **1998**, *35*, 1–38. [CrossRef]
3. González, F.; León, Y.; López-Estébanez, N. Family farming as a key element of the multifunctional and territorialized agrifood systems as witnessed in the South Pacific Region of Costa Rica. *Land* **2022**, *11*, 447. [CrossRef]
4. De Souza-Amaral, L.; De Jesus-Santos, C.; De Souza, C.R.; Penha, T.A.M.; De Araújo, J.P. O papel das Cadeias Curtas de Comercialização na construção de um modelo de desenvolvimento rural sustentável no semiárido nordestino: O caso da Central de Comercialização da Agricultura Familiar do Rio Grande do Norte (CECAFES). *Desenvolv. Meio Ambiente* **2020**, *55*, 494–516.
5. FAO. Agricultura Familiar y Sistemas Alimentarios Inclusivos Para el Desarrollo Rural Sostenible. 2016. Available online: https://openknowledge.fao.org/server/api/core/bitstreams/b6878549-2af0-4d6b-a52c-9b4a5e95777f/content (accessed on 17 December 2024).

6. Ortiz, W.; Vilsmaier, U.; Acevedo Osorio, Á. The diffusion of sustainable family farming practices in Colombia: An emerging sociotechnical niche? *Sustain. Sci.* **2018**, *13*, 829–847. [CrossRef]
7. Suess-Reyes, J.; Fuetsch, E. The future of family farming: A literature review on innovative, sustainable and succession-oriented strategies. *J. Rural. Stud.* **2016**, *47*, 117–140. [CrossRef]
8. Graeub, B.E.; Chappell, M.J.; Wittman, H.; Ledermann, S.; Kerr, R.B.; Gemmill-Herren, B. The State of Family Farms in the World. *World Dev.* **2021**, *87*, 1–15. [CrossRef]
9. HLPE. Investing in Smallholder Agriculture for Food Security. A Report by the High Level Panel of Experts on Food Security and Nutrition. 2013. Available online: http://www.fao.org/3/a-i2953e.pdf (accessed on 4 November 2024).
10. Zimmerer, K.S. The compatibility of agricultural intensification in a global hotspot of smallholder agrobiodiversity (Bolivia). *Proc. Natl. Acad. Sci. USA* **2013**, *110*, 2769–2774. [CrossRef] [PubMed]
11. Shaver, I.; Chain-Guadarrama, A.; Cleary, K.; Sanfiorenzo, A.; Santiago-García, R.; Finegan, B.; Hormel, L.; Sibelet, N.; Vierling, L.A.; Bosque-Pérez, N.-A. Coupled Social, Economic and Ecological Outcomes of Agricultural Intensification in Costa Rica and the Future of Biodiversity Conservation in Tropical Agricultural Regions. *Glob. Environ. Chang.* **2015**, *32*, 74–86. [CrossRef]
12. Bosa, J.A.; Rover, O.J. Desafios e aprendizados para a transição agroecológica do café orgânico: O caso da agricultura familiar do Leste de Minas Gerais. *Desenvolv. Meio Ambiente* **2021**, *58*, 404–425. [CrossRef]
13. Arias, P.; Hallam, D.; Krivonos, E.; Morrison, J. *Smallholder Integration in Changing Food Markets*; FAO: Rome, Italy, 2013; Available online: https://www.fao.org/3/i3292e/i3292e.pdf (accessed on 4 November 2024).
14. Grisa, C.; Schneider, S. *Políticas Públicas de Desenvolvimento Rural no Brasil*; UFRGS: Porto Alegre, Brazil, 2015.
15. Niederle, P.; Wesz Junior, V.J. *Agrifood System Transitions in Brazil*; Routledge: London, UK, 2020.
16. Guanziroli, C.E.; Basco, C.A. Construction of agrarian policies in Brazil: The case of the National Program to Strengthen Family Farming (Pronaf). *Comun. Mag.* **2010**, *5*, 44–63.
17. Maia, A.G.; Eusébio, G.; Silveira, R.L.F. Can credit help small family farming? Evidence from Brazil. *Agric. Financ. Rev.* **2019**, *80*, 212–230. [CrossRef]
18. Cunha, F.L. Sementes da Paixão e as Políticas Públicas de Distribução de Sementes na Paraíba. Ph.D. Thesis, UFRRJ, Rio de Janeiro, Brazil, 2013.
19. Diesel, V.; Mina Dias, M.; Neumann, P.S. Pnater (2004–2014): Da concepção à materialização. In *Políticas Públicas de Desenvolvimento Rural no Brasil*; Grisa, C., Schneider, S., Eds.; UFRGS: Porto Alegre, Brazil, 2015; pp. 107–128.
20. Miná Dias, M. As mudanças de direcionamento da Política Nacional de Assistência Técnica e Extensão Rural (PNATER) face ao difusionismo. *Rev. Oikos* **2007**, *18*, 11–21.
21. Petersen, P.; Silveira, L.; Dias, E.; Curado, F.; Santos, A. Sementes ou grãos. Lutas para desconstrução de uma falsa dicotomia. *Agriculturas* **2013**, *10*, 36–45.
22. Del Rio, P.; Howlett, M. Beyond the 'Tinbergen rule' in policy design: Matching tools and goals in policy portfolios. *Annu. Rev. Policy Des.* **2013**, *1*, 1–16. [CrossRef]
23. Buchenrieder, G. *Conceptual Framework for Analysing Structural Change in Agriculture and Rural Livelihoods*; Discussion Paper; Leibniz Institute of Agricultural Development in Central and Eastern Europe (IAMO): Halle (Saale), Germany, 2007; Volume 113.
24. Dumangane, M.; Freo, M.; Granato, S.; Lapatinas, A.; Mazzarella, G. *An Evaluation of the CAP Impact: A Discrete Policy Mix Analysis*; Publications Office of the European Union: Luxembourg, 2021.
25. Milhorance, C.; Le Coq, J.-F.; Sabourin, E.; Andrieu, N.; Mesquita, P.; Cavalcante, L.; Nogueira, D. A policy mix approach for assessing rural household resilience to climate shocks: Insights from Northeast Brazil. *Int. J. Agric. Sustain.* **2021**, *20*, 675–691. [CrossRef]
26. Londres, F. *As Sementes da Paixão e as Políticas de Distribuição de Sementes na Paraíba*; AS-PTA: Rio de Janeiro, Brazil, 2014.
27. Damasceno, F.C. *Avaliação dos Serviços de Assistência Técnica e Extensão Rural em Assentamentos do Município de Lagoa Grande-PE*; Monograph; Instituto Federal de Educação, Ciência e Tecnologia do Sertão Pernambucano: Petrolina, Brazil, 2016.
28. Garcia, M.O.; Castro, E.R.; Teixeira, E.C. Eficácia do Pronaf-crédito no município de São Miguel do Anta/MG. *Rev. Bras. Gestão Desenvolv. Reg.* **2008**, *4*, 154–173.
29. Cruz, N.B.D.; Jesus, J.G.D.; Bacha, C.J.C.; Costa, E.M. Acesso da agricultura familiar ao crédito e à assistência técnica no Brasil. *Rev. Econ. Sociol. Rural.* **2020**, *59*, e226850. [CrossRef]
30. Balensifer, P.H.d.M. Redes territoriais de sementes crioulas: Um novo olhar dos serviços de assistência técnica e extensão rural (Ater) em Pernambuco. *Braz. J. Agroecol. Sustain.* **2019**, *1*, 1–22. [CrossRef]
31. Fonseca, M.T.D. O Renascimento dos Guardiões de Sementes sob a luz da Legislação e das Políticas Públicas: Uma Análise Multidimensional da Agrobiodiversidade e da Sustentabilidade. Master's Thesis, Universidade Federal de Santa Maria, Santa Maria, Brazil, 2024.
32. Lima, M.N.D. *Agricultura Familiar e os Programas de Incentivo à Produção no Município de Cuité/PB*; Monograph; Universidade Federal de Campina Grande: Campina Grande, Brazil, 2019.
33. Menegoni, C.D.C. *Sementes Crioulas: O Caso do Programa de Produção de Sementes Desenvolvido Pela União das Associações Comunitárias do Interior de Canguçu*; Monograph; Universidade Federal do Rio Grande do Sul: São Lourenço do Sul, Brazil, 2011.
34. Milhorance, C.; Sabourin, E.; Le Coq, J.F.; Mendes, P. Unpacking the policy mix of adaptation to climate change in Brazil's semiarid region: Enabling instruments and coordination mechanisms. *Clim. Policy* **2020**, *20*, 593–608. [CrossRef]

35. Niemeyer, J.; Vale, M.M. Obstacles and opportunities for implementing a policy-mix for ecosystem-based adaptation to climate change in Brazil's Caatinga. *Land Use Policy* **2022**, *122*, 106385. [CrossRef]
36. IBGE. *Pesquisa Nacional por Amostra de Domicilios Anual 2014. Downloads | Estatisticas*. 2017. Available online: https://ftp.ibge.gov.br/Trabalho_e_Rendimento/Pesquisa_Nacional_por_Amostra_de_Domicilios_anual/microdados/2014/ (accessed on 11 November 2024).
37. Blanc, J. Family farmers and major retail chains in the Brazilian organic sector: Assessing new development pathways. A case study in a peri-urban district of São Paulo. *J. Rural. Stud.* **2009**, *25*, 322–332. [CrossRef]
38. Tipraqsa, P.; Schreinemachers, P. Agricultural commercialization of Karen Hill tribes in northern Thailand. *Agric. Econ.* **2009**, *40*, 43–53. [CrossRef]
39. Jiren, T.S.; Dorresteijn, I.; Hanspach, J.; Schultner, J.; Bergsten, A.; Manlosa, A.; Jager, N.; Senbeta, F.; Fischer, J. Alternative discourses around the governance of food security: A case study from Ethiopia. *Glob. Food Secur.* **2020**, *24*, 100338. [CrossRef]
40. World Bank. *World Development Report 2008: Agriculture for Development*; World Bank: Washington, DC, USA, 2007.
41. Jaleta, M.; Gebremedhin, B.; Hoekstra, D. *Smallholder Commercialisation: Processes, Determinants and Impacts*; Discussion Paper; ILRI: Nairobi, Kenya, 2009; Volume 18.
42. Spielman, D.J.; Byerlee, D.; Alemu, D.; Kelemework, D. Policies to promote cereal intensification in Ethiopia: The search for appropriate public and private roles. *Food Policy* **2010**, *35*, 185–194. [CrossRef]
43. Wiggins, S.; Argwings-Kodhek, G.; Leavy, J.; Poulton, C. *Small Farm Commercialisation in Africa: Reviewing the Issues*; Research Paper; Future Agricultures Consortium: Brighton, UK, 2011; Volume 23.
44. Awunyo-Vitor, D. Informal financial market in Ghana: Factors influencing participation by maize farmers. *Sav. Dev.* **2015**, *39*, 37–58.
45. Obayelu, A.E. Cross-country comparison of voucher-based input schemes in sub-Sahara Africa agricultural transformation: Lessons learned and policy implications. *Agric. Conspec. Sci.* **2016**, *81*, 251–267.
46. Sibande, L.; Bailey, A.; Davidova, S. The impact of farm input subsidies on maize marketing in Malawi. *Food Policy* **2017**, *69*, 190–206. [CrossRef]
47. Kilelu, C.W.; Klerkx, L.; Leeuwis, C. How dynamics of learning are linked to innovation support services: Insights from a smallholder commercialization project in Kenya. *J. Agric. Educ. Ext.* **2014**, *20*, 213–232. [CrossRef]
48. Bobojonov, I.; Teuber, R.; Hasanov, S.; Urutyan, V.; Glauben, T. Farmers' export market participation decisions in transition economies: A comparative study between Armenia and Uzbekistan. *Dev. Stud. Res.* **2016**, *3*, 25–35. [CrossRef]
49. Hepp, C.M.; Bruun, T.B.; Neergaard, A. Transitioning towards commercial upland agriculture: A comparative study in Northern Lao PDR. *NJAS-Wagening. J. Life Sci.* **2019**, *88*, 57–65. [CrossRef]
50. Vasco, C.; Tamayo, G.; Griess, V. The drivers of market integration among indigenous peoples: Evidence from the Ecuadorian Amazon. *Soc. Nat. Resour.* **2017**, *30*, 1212–1228. [CrossRef]
51. Muriithi, B.W.; Matz, J.A. Welfare effects of vegetable commercialization: Evidence from smallholder producers in Kenya. *Food Policy* **2015**, *50*, 80–91. [CrossRef]
52. Abafita, J.; Atkinson, J.; Kim, C.S. Smallholder commercialization in Ethiopia: Market orientation and participation. *Int. Food Res. J.* **2016**, *23*, 1797.
53. Poole, N.D.; Chitundu, M.; Msoni, R. Commercialisation: A meta-approach for agricultural development among smallholder farmers in Africa? *Food Policy* **2013**, *41*, 155–165. [CrossRef]
54. Alexander, K.S.; Parry, L.; Thammavong, P.; Sacklokham, S.; Pasouvang, S.; Connell, J.G.; Jovanovic, T.; Moglia, M.; Larson, S.; Case, P. Rice farming systems in Southern Lao PDR: Interpreting farmers' agricultural production decisions using Q methodology. *Agric. Syst.* **2018**, *160*, 1–10. [CrossRef]
55. Varga, M. Resistant to change? Smallholder response to World Bank-sponsored "commercialisation" in Romania and Ukraine. *Can. J. Dev. Stud.* **2019**, *40*, 528–545. [CrossRef]
56. Schneider, S.; Niederle, P.A. Resistance strategies and diversification of rural livelihoods: The construction of autonomy among Brazilian family farmers. *J. Peasant. Stud.* **2010**, *37*, 379–405. [CrossRef]
57. Mariyono, J. Stepping up to market participation of smallholder agriculture in rural areas of Indonesia. *Agric. Financ. Rev.* **2019**, *79*, 255–270. [CrossRef]
58. Schure, J.; Levang, P.; Wiersum, K.F. Producing woodfuel for urban centers in the Democratic Republic of Congo: A path out of poverty for rural households? *World Dev.* **2014**, *64*, 80–90. [CrossRef]
59. Davidova, S. Semi-subsistence farming: An elusive concept posing thorny policy questions. *J. Agric. Econ.* **2011**, *62*, 503–524. [CrossRef]
60. Matenga, C.R.; Hichaambwa, M. Impacts of land and agricultural commercialisation on local livelihoods in Zambia: Evidence from three models. *J. Peasant. Stud.* **2017**, *44*, 574–593. [CrossRef]
61. Varga, M. Poverty reduction through land transfers? The World Bank's titling reforms and the making of "subsistence" agriculture. *World Dev.* **2020**, *135*, 105058. [CrossRef]
62. Sinyolo, S.; Mudhara, M.; Wale, E. The role of social grants on commercialization among smallholder farmers in South Africa: Evidence from a continuous treatment approach. *Agribusiness* **2019**, *35*, 457–470. [CrossRef]
63. Mwangi, J.K.; Crewett, W. The impact of irrigation on small-scale African indigenous vegetable growers' market access in peri-urban Kenya. *Agric. Water Manag.* **2019**, *212*, 295–305. [CrossRef]

64. Kostov, P.; Davidova, S.; Bailey, A.; Gjokaj, E.; Halimi, K. Can direct payments facilitate agricultural commercialisation: Evidence from a transition country. *J. Agric. Econ.* **2020**, *72*, 72–96. [CrossRef]
65. Rada, N.; Helfand, S.; Magalhães, M. Agricultural productivity growth in Brazil: Large and small farms excel. *Food Policy* **2019**, *84*, 176–185. [CrossRef]
66. IBGE. Estatísticas. 2020. Available online: https://sidra.ibge.gov.br/ (accessed on 4 November 2024).
67. Cecconello, E.R.F.; Moro, L.D.; Foguesatto, C.R.; Breichtenbach, R.; Neckel, A.; Spanhol, C.P.; Vieira-Filho, J.E.R.; Mores, G.D.V. Challenges and Potentialities of Sustainability in the Institutional Food Market of Family Farming. *Sustainability* **2023**, *15*, 15796. [CrossRef]
68. Ghinoi, S.; Wesz Junior, V.J.; Piras, S. Political debates and agricultural policies: Discourse coalitions behind the creation of Brazil's Pronaf. *Land Use Policy* **2018**, *76*, 68–80. [CrossRef]
69. Schneider, S. *A Diversidade da Agricultura Familiar*; UFRGS: Porto Alegre, Brazil, 2006.
70. Mattei, L. A reforma agrária brasileira: Evolução do número de famílias assentadas no período pós-redemocratização do país. *Estud. Soc. Agric.* **2012**, *20*, 301–325.
71. Wesz Junior, V.J. O Pronaf pós-2014: Intensificando a sua seletividade? *Rev. Grifos* **2021**, *30*, 89–113. [CrossRef]
72. Silva, P.M. Assistência Técnica e Extensão Rural no Brasil: Um pouco de sua história. *Análises Indicadores Agronegócio* **2016**, *11*, 1–6.
73. Sette, C.; Ekboir, J.M. *An Overview of Rural Extension in Brazil: The Current Situation*; ILAC Working Paper No. 14.; ILAC: Rome, Italy, 2013.
74. Silva, P.M.; Gomes, M.C.; Corrêa, L.V. Racionalidade e inovação tecnológica: O agricultor familiar diversificado face ao processo de decisão da escolha da cultivar de milho. *Rev. Fac. Agron.* **2013**, *112*, 35–43.
75. Lesnikowski, A.; Ford, J.D.; Biesbroek, R.; Berrang-Ford, L. A policy mixes approach to conceptualizing and measuring climate change adaptation policy. *Clim. Chang.* **2019**, *156*, 447–469. [CrossRef]
76. Guerzoni, M.; Raiteri, E. Demand-side vs. supply-side technology policies: Hidden treatment and new empirical evidence on the policy mix. *Res. Policy* **2015**, *44*, 726–747. [CrossRef]
77. Blundell, R.; Costa Dias, M. Evaluation Methods for Non-Experimental Data. *Fisc. Stud.* **2000**, *21*, 427–468. [CrossRef]
78. Rubin, D.B. Randomization analysis of experimental data: The Fisher randomization test comment. *J. Am. Stat. Assoc.* **1980**, *75*, 591–593. [CrossRef]
79. Heckman, J.J.; Ichimura, H.; Smith, J.; Todd, P. Sources of selection bias in evaluating social programs: An interpretation of conventional measures and evidence on the effectiveness of matching as a program evaluation method. *Proc. Natl. Acad. Sci. USA* **1996**, *93*, 13416–13420. [CrossRef] [PubMed]
80. Rosenbaum, P.R.; Rubin, D.B. The central role of the propensity score in observational studies for causal effects. *Biometrika* **1983**, *70*, 41–55. [CrossRef]
81. Caliendo, M.; Kopeinig, S. Some practical guidance for the implementation of propensity score matching. *J. Econ. Surv.* **2008**, *22*, 31–72. [CrossRef]
82. Dehejia, R.; Wahba, S. Propensity score-matching methods for non-experimental causal studies. *Rev. Econ. Stat.* **2002**, *84*, 151–161. [CrossRef]
83. Fitz, D. Evaluating the impact of market-assisted land reform in Brazil. *World Dev.* **2018**, *103*, 255–267. [CrossRef]
84. Luan, D.X.; Bauer, S. Does credit access affect household income homogeneously across different groups of credit recipients? Evidence from rural Vietnam. *J. Rural. Stud.* **2016**, *47*, 186–203. [CrossRef]
85. Cunningham, P.; Edler, J.; Flanagan, K.; Larédo, P. The Innovation Policy Mix. In *Handbook of Innovation Policy Impact*; Edler, J., Cunningham, P., Gök, A., Shapira, P., Eds.; Edward Elgar Publishing: Cheltenham, UK, 2016; pp. 505–542.
86. Howlett, M.; Rayner, J. Patching vs packaging in policy formulation: Complementary effects, goodness of fit, degrees of freedom, and feasibility in policy portfolio design. *Annu. Rev. Policy Des.* **2013**, *1*, 1–19.
87. Imbens, G.W. The role of the propensity score in estimating dose–response functions? *Biometrika* **2000**, *87*, 706–710. [CrossRef]
88. Lechner, M. *Identification and Estimation of Causal Effects of Multiple Treatments Under the Conditional Independence Assumption*; Springer: Berlin/Heidelberg, Germany, 2001.
89. Abadie, A.; Drukker, D.; Herr, J.L.; Imbens, G.W. Implementing matching estimators for average treatment effects in Stata. *Stata J.* **2004**, *4*, 290–311. [CrossRef]
90. Austin, P.C. Statistical criteria for selecting the optimal number of untreated subjects matched to each treated subject when using many-to-one matching on the propensity score. *Am. J. Epidemiol.* **2010**, *172*, 1092–1097. [CrossRef]
91. Ogutu, S.O.; Okello, J.J.; Otieno, D.J. Impact of information and communication technology-based market information services on smallholder farm input use and productivity: The case of Kenya. *World Dev.* **2014**, *64*, 311–321. [CrossRef]
92. Singh, I.; Squire, L.; Strauss, J. *Agricultural Household Models: Extensions, Applications, and Policy*; The Johns Hopkins University Press: Baltimore, MD, USA, 1986.
93. Kuhfuss, L.; Subervie, J. Do European agri-environment measures help reduce herbicide use? Evidence from viticulture in France. *Ecol. Econ.* **2018**, *149*, 202–211. [CrossRef]
94. DiPrete, T.A.; Gangl, M. Assessing bias in the estimation of causal effects: Rosenbaum bounds on matching estimators and instrumental variables estimation with imperfect instruments. *Sociol. Methodol.* **2004**, *34*, 271–310. [CrossRef]
95. Grisa, C.; Gazolla, M.; Schneider, S. A 'produção invisível' na agricultura familiar: Autoconsumo, segurança alimentar e políticas públicas de desenvolvimento rural. *Agroalimentaria* **2010**, *16*, 65–79.

96. Conterato, M.A.; Bráz, C.A.; Rodrigues, S.R. A commoditização do Pronaf e os desafios da agricultura familiar no Rio Grande do Sul. *Rev. Grifos* **2021**, *30*, 190–211. [CrossRef]
97. Grisa, C.; Wesz Junior, V.J.; Buchweitz, V.D. Revisitando o Pronaf: Velhos questionamentos, novas interpretações. *Rev. Econ. Sociol. Rural.* **2014**, *52*, 323–346. [CrossRef]
98. Caporal, F.R.; Dambrós, O. Extensão rural agroecológica: Experiências e limites. *Redes-Rev. Desenvolv. Reg.* **2017**, *22*, 275–297.
99. Aquino, J.; Schneider, S. 12 anos da política de crédito do PRONAF no Brasil (1996–2008): Uma reflexão crítica. *Rev. Extensão Estud. Rurais* **2011**, *1*, 309–347.
100. Pacheco-Vega, R. Environmental regulation, governance, and policy instruments, 20 years after the stick, carrot, and sermon typology. *J. Environ. Policy Plan.* **2020**, *22*, 620–635. [CrossRef]
101. Pingali, P.L.; Rosegrant, M.W. Agricultural commercialization and diversification: Processes and policies. *Food Policy* **1995**, *20*, 171–185. [CrossRef]
102. Pingali, P.; Khwaja, Y.; Meijer, M. *Commercializing Small Farms: Reducing Transaction Cost*; ESA Working Paper No. 05–08; FAO: Rome, Italy, 2005; Available online: https://ageconsearch.umn.edu/record/289070/?v=pdf (accessed on 9 December 2024).
103. Kennedy, G.; Ballard, T.; Dop, M. *Guidelines for Measuring Household and Individual Dietary Diversity*; FAO: Rome, Italy, 2011; Available online: https://openknowledge.fao.org/server/api/core/bitstreams/86ee19ca-4fab-4547-b837-44cf2a7d6927/content (accessed on 9 December 2024).