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Public food procurement and food security: an assessment of the impacts of the PAA on family farming in Brazil

Compras públicas de alimentos e segurança alimentar: uma avaliação dos impactos do PAA na agricultura familiar no Brasil

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ABSTRACT: Public Food Procurement (PFP) can be used as an important social intervention tool to promote food security for specific groups, foster rural development, and drive local and regional food economies towards more sustainable paths. The Food Acquisition Program (PAA) is a Brazilian government program created to encourage family farming and combat food insecurity and nutritional risks among socially vulnerable people. This study aimed to estimate the impact on gross agricultural income and production diversity for family farmers who delivered products for the main modality of this program: Simultaneous Purchase and Donation (CDS). We utilized an empirical difference-in-differences strategy, using microdata from government administrative records that cover all PAA-CDS purchase amounts in the country, as well as information on about two million family farming production units for the period between 2009 and 2017. Our findings indicate that PAA-CDS contributed to an average increase of 24.2% in farmers' gross income from production. The poorest benefited the most, with an increase of 45.9% for farmers in the 10th percentile of gross income. Regarding the diversity of production, we estimated a significant positive impact of the program on the diversity index and the number of products, as well as a reduction in the specialization of gross income. These results suggest that the program's design can be effective for its primary purposes.

Keywords: family farming; gross income; production diversity.

RESUMO: As compras públicas de alimentos podem ser utilizadas como uma importante ferramenta de intervenção social para promover a segurança alimentar de grupos específicos, fomentar o desenvolvimento rural e impulsionar as economias alimentares locais e regionais para caminhos mais sustentáveis. O Programa de Aquisição de Alimentos (PAA) é um programa do governo brasileiro criado para incentivar a agricultura familiar e combater a insegurança alimentar e nutricional de pessoas em situação de vulnerabilidade social. Este estudo teve como objetivo estimar o impacto do PAA na renda bruta agrícola e na diversidade da produção de agricultores familiares que acessaram à principal modalidade deste programa: Compra com Doação Simultânea (CDS). Utilizamos uma estratégia empírica de diferenças em diferenças, utilizando microdados de registros administrativos do governo que cobrem todos os valores de compra do PAA-CDS no país, bem como informações sobre cerca de dois milhões de unidades produtivas da agricultura familiar no período de 2009 a 2017. Nossos resultados indicam que o PAA-CDS contribuiu para um aumento médio de 24,2% do valor bruto da produção dos agricultores. Os mais pobres foram os mais beneficiados, com aumento de 45,9% para os agricultores do percentil 10 da renda bruta. Em relação à diversidade da produção, estimou-se um impacto positivo significativo do programa no índice de diversidade e no número de produtos, bem como uma redução na especialização da renda bruta. Esses resultados sugerem que o desenho do programa pode ser eficaz para seus objetivos.

Palavras-chaves: agricultura familiar; renda bruta agrícola; diversidade da produção.

1. Introduction

Public Food Procurement (PFP) programs have shown promise in various countries as a promising social policy tool that can achieve multiple objectives and benefit different groups, including promoting Food Security and Nutritional Outcomes (FSNO) for vulnerable groups, and encouraging the production and consumption of healthy foods. In implementing these programs, it is possible to adopt regulations that not only prioritize the economic aspects of purchasing, but also consider other important aspects such as the quality of the food offered, coherence with local food culture, and food production methods that respect labor rights, human dignity, and the environment. Thus, these governmental acquisitions can effectively support the development of a more sustainable food system (Stefani *et al*., 2017; Swensson & Tartanac, 2020; Swensson *et al*., 2021; Gaitán-Cremaschi *et al*., 2022).

In Brazil, an innovative experience of PFP began in 2003 with the Food Acquisition Program (Programa de Aquisição de Alimentos – PAA). This program was created as part of an integrated package of actions aimed at combating hunger, which also included the demand for food to meet the population in a situation of Food Insecurity and Nutritional Risk (FINR). The innovation of PAA was to use PFP as a rural development instrument by purchasing food directly and exclusively from family farmers and their organizations. It was evident that small farmers had difficulties in accessing the traditional instruments of agricultural policy, demanding specific instruments adapted to meet their needs. Therefore, the idea of creating PAA aimed to unite the objective of social intervention focused on FSNO with the strategies of agricultural policy oriented towards rural development, using the power of PFP to support family farming (Sabourin & Grisa, 2018; Sambuichi *et al*., 2019).

The PAA inspired the implementation of several other PFP initiatives for family farms in Brazil and other countries. Its positive results formed the basis for the Brazilian National School Food Program (PNAE) to establish a minimum percentage of 30% for purchases from family farming through law in 2009. This program has also become an international reference, inspiring similar programs in Latin American countries, the Caribbean, and Africa, particularly for school food (FAO, 2017; Swensson & Klug, 2017; Sabourin & Grisa, 2018; Gaitán-Cremaschi *et al*., 2022).

The experience of the PAA and PNAE also served as a reference for the formulation of other public procurement programs at the state and municipal levels, such as the São Paulo Program for Agriculture of Social Interest (PPAIS), the State Food Acquisition Program of Rondônia, the Policy for the Acquisition of Family Farming Food of the State of Ceará, the Federal District Program for the Acquisition of Agricultural Production (PAPA/DF), the State Food Acquisition Program of Santa Catarina (PAA-SC), among others (Grisa, Ávila & Cabral, 2021).

Internationally, the Brazilian PFP programs aimed at family farming exported their execution mechanisms to countries in Latin America and the Caribbean. In Colombia, for example, the School Feeding Program (PAE) mandates the procurement of at least 20% of the total monthly public purchases of food, goods, and services from local sources, with a preference for peasant organizations. In Paraguay, a "Simplified Process for the Acquisition of Agricultural Products from Family Farming" was created, which facilitates the procurement of food for this sector. In Haiti, in addition to building structures for local purchases from family farmer associations, such as the Facilitating Unit for the Purchase of Local Products (UFAPAL), there are also policies at the municipal level, as is the case in Petite Riviere de Nippes. Similar examples can also be observed in Bolivia, Chile, Honduras, and Guatemala (Sabourin & Grisa, 2018).

International studies indicate that local purchases from family farms not only provide access to food, but also control food prices in the domestic market, stimulate the increase and diversification of production, and promote the consumption of food based on regional cultural habits. Furthermore, the high point in terms of impacts of family farming PFP programs, especially those that allocate their food to schools, lies in combating FINR and generating income for the beneficiary supplier (Maiellaro, 2022).

Throughout its history, PAA has been the subject of hundreds of empirical studies, mainly case studies, which demonstrate regional or local trends using predominantly qualitative methodologies. Sambuichi *et al*. (2019) and Perin et al. (2021) have conducted systematic literature reviews of case studies on the benefits and challenges of the program. The main benefits of PAA in promoting FSNO included improvements in the access, quantity, quality, and regularity of food, not only for consumer beneficiaries but also for supplier farmers. Additionally, the program's donations have introduced new types of food to menus in schools, day care centers, nursing homes, hospitals, and other entities in the social assistance network, encouraging diversification and improvement of eating habits, as well as the consumption of healthy foods that value local food culture (Sambuichi *et al*., 2019; Perin *et al*., 2021).

Regarding the goal of strengthening family agriculture, most case studies demonstrated that the PAA contributed to increasing the income of farmers and the diversity of their production. This was due to the guarantee of commercialization, which encouraged family farmers to invest in the acquisition of goods and in the improvement of their production units. It also motivated crop diversification, increased employment opportunities in rural communities, and promoted local and regional development (Sambuichi *et al*., 2019; Perin *et al.,* 2021). There are also studies that evaluated and problematized the theme in a regional or even local context, analysing the socio-territorial changes observed as a result of the implementation of the PAA, showing the diversity of relationships and dynamics in territories that potentiate the emancipation of family farmers (Brasil, 2014; Silva, 2019).

However, few published studies have used quantitative methods to analyse the effects of the PAA on its beneficiaries, and there is still a lack of research demonstrating the impact of the program on the income and production of Brazilian family farmers (Perin *et al.,* 2021). Moreover, most of these studies had a very limited scope, with few observations, leading to a lack of more comprehensive quantitative studies published on the topic, which makes it difficult to extrapolate the results, especially considering the vast geographical expanse of the country and the heterogeneity of local situations. There are already some national-level quantitative studies conducted (Santos *et al.,* 2015; Salgado *et al.,* 2017), but these only analysed the spatial concentration and focus of the program, and not its effects on the beneficiaries.

Conducting quantitative impact assessments of large-scale programs, such as the PAA, presents significant challenges due to the vast territory of the country, the diversity of local realities, and the high cost associated with creating data collection infrastructure and logistics. Assessing public policies can be particularly arduous, given that many programs lack experimental designs, which impairs the ability to infer their impacts. Nevertheless, despite these challenges, policy evaluations must be conducted, given their crucial role in assisting policymakers in identifying future priorities and/or necessary adjustments to public programs (Gertler *et al.,* 2016). Moreover, in the specific case of the PAA, there is an additional challenge imposed by the program's complexity, which involves different modalities of procurement, operators, and beneficiaries.

However, there are also databases that are still largely unexplored and that can be utilized for evaluative research, namely, government administrative records. By cross-referencing these databases, which were obtained during the implementation of public policies, it is possible to develop quantitative analyses capable of providing answers to some questions related to the effects and efficacy of the programs.

In this study, we used administrative records of PAA, cross-referenced with other databases, to verify the production characteristics of farmers and assess the program's impact on them. The hypothesis under analysis in our study is that access to the PAA would allow farmers, especially the poorest, to increase their gross agricultural income and diversify their production. The difference-in-differences method was applied to analyse the effects of the program's main procurement modality on its supplier beneficiaries. This method allows for the comparison of the production of farmers who have and have not accessed the program, before and after access, controlling for various observable characteristics at the farmer and municipal levels. To do this, we identified farmers who delivered and did not deliver products to the program throughout Brazil from 2009 to 2017, covering over two million units of family farm production. Based on these results and existing literature, we examine whether the PAA is fulfilling its objectives of strengthening family farming and promoting FSNO identify characteristics of the program that may have contributed to its results, and highlight the main lessons derived from the program's experience.

2. Literature review

2.1. Characterization of the PAA

The PAA was established by Article 19 of Law 10.696/2003 with the primary objectives of encouraging family farming and combating FINR among people in socially vulnerable situations. To achieve this, the program innovatively allowed the federal government to purchase products directly from family farmers without the need for public bidding. The change established by this law simplified bureaucratic requirements for farmers to access this marketing channel and introduced the possibility of creating a market reserve aimed at this audience, in accordance with their specificities and their own rules (Sambuichi *et al.* 2019).

The creation of the PAA occurred in a context where the political agenda was focused on fighting hunger, with the program being one of the structural components of the Zero Hunger strategy. Subsequently, with the institutionalization of the National System of Food Security and Nutritional Outcomes (SISAN) in 2006, and the National Policy of Food Security and Nutritional Outcomes (PNSAN) in 2010, along with the inclusion of the Right to Adequate Food (DHAA) in Article 6 of the Federal Constitution as a social right in the same year, there was a boost in actions aimed at combating FINR. Investments were made in PFP, especially in the PAA, which combined two mechanisms of action: while aiming to directly combat hunger through the donation of food to people in situations of food insecurity, it also used the government's purchasing power to encourage family farming, creating a safe marketing channel that generated income and had positive effects on the productive matrix, promoting inclusive rural development through the local acquisition and distribution of food (Sambuichi *et al*. 2019; Perin *et al.* 2021).

PAA is a complex program that includes several purchasing modalities. Although they all have the general objective of promoting family farming, their methods of operation differ significantly. Therefore, analysing the effects of the program as a whole is inappropriate. Instead, it is necessary to analyse the effects of each modality separately. For this research, we chose to evaluate the effects of Simultaneous Purchase and Donation (*Compra com Doação Simultânea* – CDS), which is the main and most characteristic modality of PAA, responsible for approximately 70% of the resources applied in the program throughout the period (Sambuichi *et al*., 2019).

The CDS purchases food directly from family farmers, or their organizations, and immediately donating it to charitable entities, schools, popular restaurants, food banks, community kitchens, public hospitals, and prisons. The resources for this modality come from the federal government, and the purchases are executed by the National Supply Company (CONAB) or by state and municipal governments (Nehring & McKay, 2013).

The PAA-CDS has two main types of beneficiaries:

i) suppliers, represented by family farmers benefiting from Law 11.326/2006; and

ii) consumers, people served by social assistance entities, food and nutrition public equipment, public education and healthcare units, and individuals in correctional facilities.

To achieve these objectives, the PAA-CDS also has two main types of interventions:

i) food purchases, aimed at the supplier beneficiaries; and

ii) food donations, aimed at consumer beneficiaries (Sambuichi *et al.*, 2019).

The suppliers' mode of access to the PAA-CDS varies depending on the type of operator (Figure 1). In purchases operated by CONAB, the farmer needs to be affiliated with an organization, such as a cooperative or association. When financial resources are available for acquisitions, CONAB disseminates this information to farmers' organizations, setting a deadline for them to submit their proposals for product delivery. If the proposal is selected, farmers can sell their products to the program, and payment is made to organizations after proof of product delivery to the receiving entities (Nehring & McKay, 2013).

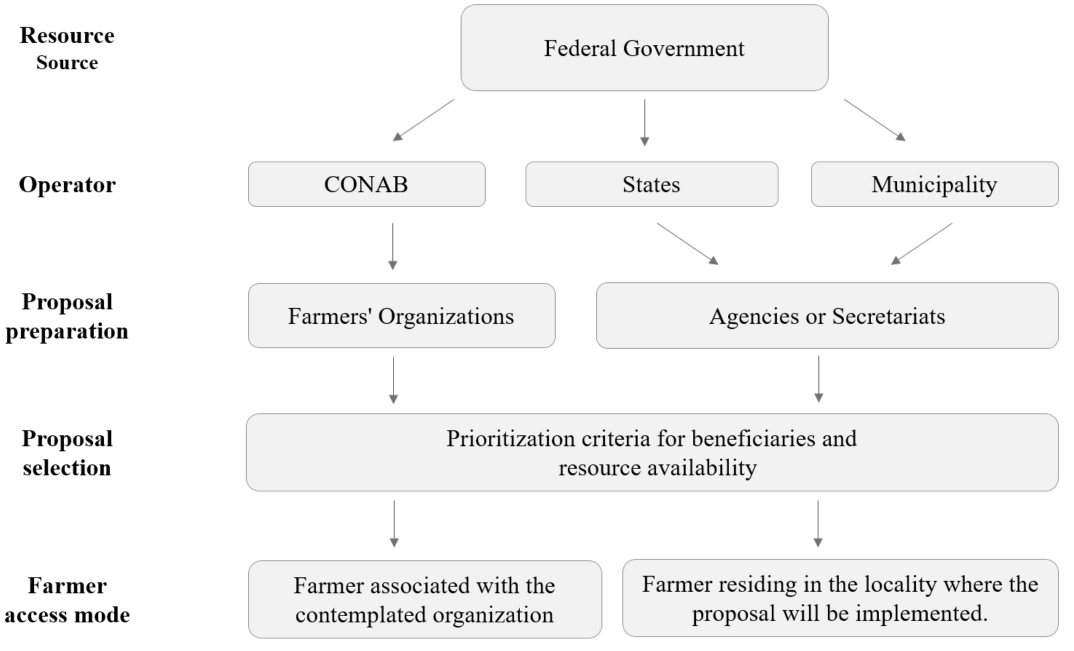

FIGURE 1 – Operational mode and access of supplier beneficiaries to PAA-CDS.
SOURCE: elaborated by the authors.

Regarding the operations conducted by states and municipalities, the proposals are drafted by their respective secretariats or agencies, without requiring farmers to be affiliated with any farmer's organization to participate. The process begins with a formal expression of interest from the state or municipal entity in participating in the program. After the selection and execution of the proposals, the Federal Government remunerates the farmers who demonstrated proof of their product delivery to entities, with payment made directly to them (Nehring & Mckay, 2013).

To operate effectively, the PAA requires the involvement of a network of actors who operate at the local level. This network may include technical assistance organizations, community groups, government agencies, NGOs, and other stakeholders who work to promote the existence of the program and provide support to actors to navigate bureaucratic processes and adapt their production to meet the program's requirements. In addition, effective coordination, and communication between PAA managers at the Federal level, CONAB operators, state and municipal governments, and local agents are crucial for building trust and addressing any challenges that arise in adaptation.

2.2. Program trajectory

Throughout its trajectory, the PAA underwent different periods, as shown by the study conducted by Perin et al. (2021). After the initial years of the program implementation, during which there was a concern with the organization and adaptation of procedures, both at the managerial and local levels, the PAA established itself as an important PFP program, applying resources above BRL 1 billion in 2011 and 2012 (Equivalent to USD 302 million, considering that in December 2017 the exchange rate was BRL 3.31).

In 2013, operation Agro-Fantasma launched by the Federal Police investigated alleged diversions related to the execution of the PAA by CONAB, involving supplier farmers, presidents of associations and cooperatives, and CONAB operators. Despite the absolving outcome, the operation ultimately weakened the networks created by the program by integrating different groups in its implementation, leading to a demotivation of family farmers to continue participating in the PAA, harming various suppliers and entities of the social assistance network, as there were interruptions in food deliveries in the locations where the operation was launched (Triches & Grisa, 2015; Barth-Teixeira *et al.* 2017). From then on, control agencies requested a series of adjustments in the procedures and operational norms of the projects, resulting in increased bureaucracy and difficulties for farmers' organizations to access the program. Because of this operation, there was a weakening of the PAA operated by CONAB, as well as a significant reduction in the resources invested in the PAA, jeopardizing the continuity of the public policy (Perin *et al*. 2021; Sambuichi *et al*. 2019).

After a slight recovery in the funds invested in the PAA in 2014, a continuous reduction in the amounts applied to purchases was noted, along with a loss of CONAB leading role in the program's operationalization, giving way for the states and municipalities to stand out in the execution of operations carried out through terms of adherence. Contextually, from 2016, there was a change in the government's political and institutional agenda, followed by a progressive dismantling of the institutional structures built to support family agriculture and promote FSNO in the country. There was the extinction of the Ministry of Agrarian Development (MDA), followed by the reduction of the role of the secretariats and bodies responsible for the implementation and management of various ongoing policies to promote family agriculture, which also led to the disorganization of technical teams that worked in the implementation of local actions and culminated in a drastic reduction of budgetary and financial transfers, under the narrative of cost containment aligned with a neoliberal policy (Perin *et al*., 2021).

Since then, PAA, which had lost its reach due to budget cuts, has been given a lifeline in the Covid-19 pandemic by being promoted as a possible strategy to counteract the negative social impacts (Sambuichi *et al.* 2020). However, considering the current government agenda that did not prioritize FSNO policies, although the program was operational, many adjacent structures were dismantled, hindering its full implementation, such as technical assistance services and the National Council for Food Security and Nutritional Outcomes (Consea). In 2021, still amidst the economic and health crisis caused by the pandemic, the PAA was replaced by the "Programa Alimenta Brasil". Although it preserved most of the modalities and purposes of the PAA, the new program was severely affected by a lack of resources, becoming mainly dependent on parliamentary amendments (Perin *et al*., 2021).

In analysing the dismantling and challenges for the reconstruction of public policies on sovereignty and food security in Brazil, Delgado, and Zimmermann (2022) highlight the prominence of strategies aimed at ensuring access to and availability of food in this rescue process. Among them, the PAA and the PNAE stand out both as income-generating policies for family agriculture through market reservations, contributing to the dimension of access, and as guarantors of greater domestic food production in terms of availability. In 2023, with the new change in government, there is a return to the centrality of anti-hunger policies in the governmental agenda, and with it, the reactivation of the Consea and the PNSAN, and the recreation of the PAA itself through Law No. 14.628, of July 2023.

2.3. Quantitative studies that evaluated the program's impacts

Doretto & Michellon (2007) conducted one of the first quantitative studies on the impacts of the PAA, involving 123 farmers in three municipalities of the state of Paraná. The study showed a significant increase of approximately 25% to 43% in the income of participating suppliers. The authors also observed that the greatest difference in income was seen among the poorest family farmers, who typically faced more difficulties in accessing other public support programs, such as agricultural credit. This study also concluded that approximately 30% of the beneficiary farmers increased their cultivation area after joining the program, and more than 60% of them invested in technological advancements to improve crop management and increase production. Sobreira *et al*. (2019) also identified this effect in another study conducted with 110 beekeepers in eight municipalities of the state of Ceará. Using a logistic regression model, the study demonstrated a correlation between access to the PAA and the adoption of management practices based on more advanced technology.

The study conducted by Libânio & Cirino (2020), which was carried out in a municipality in the state of Minas Gerais, used the propensity score matching method on a sample of 95 farmers. The results indicate that the PAA had an impact on farmers' demand for labor in agricultural production. Family farmers had to increase their production to meet the program's demand and, as a result, had to involve more people in their activity. Additionally, the study found that the PAA offered more attractive prices compared to other markets, which was a decisive factor for farmers to continue participating after the first year of access. The study also discovered that PAA beneficiaries reported a higher average monthly income compared to non-beneficiaries. However, no statistical significance was found in the income difference between the groups of farmers who accessed and did not access the program, which could have been due to the small sample size used.

The study conducted by Bosetti (2021), using simple linear correlation and linear regression techniques, analysed the regional distribution of financial resources of the PAA (Food Acquisition Program) in the state of Santa Catarina, covering the years 2009 to 2018. The research particularly observed the role of associations and cooperatives in the process of production and commercialization of family farm products within the scope of the PAA. Among the findings, the research indicates that the PAA is strongly related to the number of cooperatives/associations present in the location where the Program is implemented. This is because the study showed a significant correlation between the variables "number of associated or cooperative farmers" and the "volume of program resources". This data indicates that "the greater mobilization of resources by the PAA in the period 2009-2018 was conditioned on the organizational capacity of local agents in associative and cooperative entities" (p. 114). From this, it is inferred that the public policy of institutional markets is strongly related to social capital and the capacity for organization and mobilization of family farmers, which in many contexts, is stimulated by public policy.

Is his analyses Bosetti (2021) also demonstrated a correlation between the presence of rural settlements and the execution of the PAA. This indicates a coherence of the program with the social, productive, territorial, and associative characteristics of the locations where the public policy is implemented, leading to greater effectiveness in generating income, increasing, and diversifying the production of family farmers linked to social movements for agrarian reform.

3. Methods

3.1. Data

The main database used in this study is the microdata from the Declaration of Aptitude to Pronaf (DAP) register. We used this database to obtain general information about family farmers and their production in different years and cross-check with the database of farmers who accessed the PAA-CDS. The DAP register enables farmers to access federal public policies aimed at this segment, including PAA. This instrument is used to identify and qualify the Family Unit of Agrarian Production (UFPA) on family farming, functioning as an identification document containing personal data of landowners, territorial and productive data of the farm, and family income. Another important characteristic of this registry is that each family unit must have only one main DAP. In the case of a stable union, the register must identify the couple responsible for maintaining the family unit, registered as the first and second holders. Finally, the DAP will be linked to the municipality of permanent residence of the family farmer and UFPA.

The Ministry of Agrarian Development provided a database with microdata on all active or expired DAPs registered until December 2017. This database was cross-checked with the PAA-CDS suppliers database, which was made available for this research by the Ministry of Social Development and the National Supply Company (CONAB) from the period of 2009 to 2017. The crossing of the bases was done by the Social Security Number (*Cadastro de Pessoas Físicas* – CPF), an identification variable that was available in both databases, for the first and second holders registered in the DAP. The final dataset contains information on family farmers and UPFA production, supplemented with municipal-level data from other databases. Additional data sources used include the Brazilian Central Bank (BCB), National Education Development Fund (FNDE), Brazilian Institue of Geography and Statistics (IBGE), Integrated Natural Disaster Information System (S2ID), National Institute of Meteorology (INMET), Ministry of Infrastructure (MI), and Special Secretariat of the Brazilian Federal Revenue Service (RFB) (Table 1).

The program was evaluated using the following variables:

i) gross income from production,
ii) number of products,
iii) diversity index, and
iv) gross income specialization index.

The first variable encompasses the impact of gross income derived from agricultural activities, which is determined by the gross value of family production. The remaining variables assess the effect of the program on production diversity. The second variable reflects the impact on the range of distinct items produced. The third variable is the overall diversity index of production, measured by the Shannon index (equation 1), which evaluates the complexity of the systems, and was chosen because it presents a better balance between the diversity components (DeJong, 1975). The fourth variable is the gross income specialization index (equation 2), which quantifies the extent to which the gross income from family production relies on a single product, used to indicate the UFPA's tendency to monoculture.

The Shannon diversity index is calculated using the following formula:

$$H = -\sum(wi * log\,(wi)) \qquad (1)$$

where $wi = (vi/VT)$; vi represents the production value of product i, and VT is the total production value. Subsequently, a min–max normalization scale was applied, using the equation: $(x - min)/(max - min)$, where min is the minimum value of variable H and max is the maximum value of variable H. Normalization is necessary to ensure that the index varies between zero and one.

The gross income specialization index is derived from the following equation:

$$wmax = (vp/VT) \qquad (2)$$

where vp is the production value of the main product and VT is the total production value of the family unit. This index ranges from 0 to 1, with the maximum value achieved when the gross income from production is derived from only one product.

As covariates, we incorporated information related to family background, farm characteristics, and labor used in production, as well as data at the municipal level (Table 1). These variables were selected because they are available in the databases and could have some influence on the decision of farmers to access the program or on the dependent variables tested.

Although the PAA was established in mid-2003, our sample only covers the period between 2009 and 2017 due to data availability constraints. Regarding the limitations of the data, it is important

TABLE 1 – Description of the main variables used and their respective sources.

Variables	Description	Source
Family Background		
Education	Dummy variables for education level of DAP holders, including Illiterate, Elementary, High School, Technical Education, and Higher Education	DAP
Gender	Dummy variable indicating gender of both DAP primary and secondary holders	DAP
Age Range	Dummy variables indicating age range of primary DAP holder, including categories such as 16|─|20; 21|─|30; 31|─|40; 41|─|50; 51|─|60; 61|─|70	DAP
Marital status	Dummy variable indicating marital status of primary DAP holder, with value 1 for married and 0 for other	DAP
Members of the family	Number of family members	DAP
NIS	Dummy variable indicating whether the primary or secondary DAP holder has a Social Identification Number (NIS) required for accessing government social programs for low-income individuals	DAP
Social Income	Income from sources other than the UFPA, such as social programs and social security	DAP
Farm, Production, and Labor		
Farm Area	Farm area size	DAP
Farm Exceeds 4 Modules	A dummy variable indicating whether the farm has more than 4 fiscal modules. In agricultural contexts, a fiscal module is a unit of land area used for tax purposes	DAP
Explored Farms	Number of farms explored	DAP
Permanent Employees	Number of permanent employees	DAP
Eventual Strength	Variable indicating if the farmer has temporary employees	DAP
Diversity of Agricultural Production	Index that measures the diversity of agricultural production	DAP

Gross Income Specialization	Index that quantifies the level of gross income dependence on a single product	DAP
Number of Products	Variable indicating the number of different items produced	DAP
Rural Credit	Dummy variable indicating if the primary or secondary DAP holder has previously obtained government program credit	DAP
Gross Income from Production	Gross income from food production	DAP
Municipal Covariates		
Meteorological Variables	Set of meteorological variables indicating the total annual rainfall and average temperature for each season, including winter, spring, summer, and autumn	INMET
Natural Disasters	Number of reported natural disasters	S2iD
Municipal Rural Credit	The total amount of rural credit granted for investments, funding, and marketing by the municipal level	BCB
Agricultural Participation	The proportion of the gross value added in agriculture to the total gross value added of the municipality (Agricultural GVA / Total GVA)	IBGE
PNAE	The total amount allocated to the Municipal National School Feeding Program (PNAE)	FNDE
Fleet Trucks	Number of trucks in the municipal's fleet	MI
Tractor Fleet	Number of tractors in the municipal's flee	MI
ITR	Rural land property tax (ITR)	RFB

SOURCE: prepared by the authors.

NOTES: All variables denominated in monetary units have been adjusted for inflation using the National Broad Consumer Price Index (IPCA) to reflect constant values as of December 2017.

to highlight that the observations in our sample were subject to a filtering process. We removed inconsistent values and outliers and selected each UFPA that appeared for at least two periods and had not participated in another mode of the program[1]. Considering that the validity of the DAP is two or more years and annual renewal of registration is not mandatory, our information forms an unbalanced panel of data. Additionally, since our sample only covers the period between 2009 and 2017, we do not know whether some UFPA that did not access the PAA during this period had accessed it in earlier years. Also, the analysis did not include consumer beneficiaries because there is no microdata identified by CPF about the people who consumed the food, making it impossible to carry out this type of analysis. Lastly, it is worth noting that in this study we are comparing only farmers registered in the DAP, who may or may not have had access to government programs. We have no information

[1] The information that contained typing errors, such as farmers without an official document number or with incorrect or missing digits, was excluded. Furthermore, outlier elimination was carried out, which involved excluding extreme values from both ends of the distribution. As a result, 1% of the lowest and 1% of the highest values were removed.

about other family farmers who do not have DAP and are not covered by federal public policies.

3.2. *Empirical strategy*

To assess the effects of PAA-CDS on the variables of interest, the difference-in-differences (DID) method was used. This choice was made because a simple comparison between participating and non-participating family farmers in PAA may present issues of selection bias, as the farmers tend to self-select to participate in the program. The DID approach is a commonly used technique for evaluating the impact of public policies. With this technique, it is possible to estimate the impact of PAA-CDS by comparing the changes over time in the variables of interest between the UFPA that participated in the program and those that did not, while controlling for observable and unobservable characteristics over time. This allows for a more accurate estimation of the program's impact compared to other evaluation methods.

Recently, several important publications have emerged regarding the DID method, demonstrating that common estimates of DID with Two-Way fixed effects (TWFE) are imprecise in specifications with multiple periods, when there is heterogeneity in treatment effects and variation in treatment timing across units (Roth *et al.*, 2023).

In our study, there is heterogeneity in the effect of participation in the PAA, as the remuneration of farmers varies according to the products sold to the PAA, and there is also variation in the exposure time of UFPA to the program. Therefore, the use of the difference-in-differences (DID) approach with the Two-Way fixed effects (TWFE) estimator may lead to biased estimates.

Alternative and more robust estimators have been proposed to deal with heterogeneity in treatment effects and variation in treatment timing across units. We used the estimator proposed by Sun & Abraham (2021), called the Interaction-weighted estimator (IW). This estimator provides an estimate of the $CATT_{e,\ell}$ which represents the average treatment effect over ℓ periods of the initial treatment for the cohort of units that were first treated in period e. The IW estimator coincides with the average time and group effect proposed by Callaway & Sant'Anna (2021). Additionally, the IW estimator package in the R language, called fixes, is computationally more efficient.

By using the interaction-weighted (IW) estimator, it is possible to use both the untreated UFPAs and the last treated cohort as the comparison group. Additionally, the assumption of "parallel trends" can be conditional or unconditional on covariates, including the assumption of no anticipatory behavior. The dynamic specification of the estimator proposed by Sun & Abraham (2021) can be formally represented as follows (equation 3):

$$\mathrm{Y}_{g,t} = \hat{\gamma}_g + \hat{\lambda}_t + \sum_{-K,\ell\neq-1}^{L} \hat{\beta}_\ell 1\{\mathrm{F}_g = t - \ell\} + \varepsilon_{g,t} \quad (3)$$

The strategy consists of regressing the outcome $\mathrm{Y}_{g,t}$ on fixed effects for group $\hat{\gamma}_g$ and period $\hat{\lambda}_t$, as well as on relative-time indicators, represented by $1\{\mathrm{F}_g = t - \ell\}$, which take a value of 1 if group g started participating in the PAA ℓ periods ago. The estimated coefficient $\hat{\beta}_\ell$, for $\ell \geq 0$, aims to capture the cumulative effect of $\ell + 1$ periods of program participation. On the other hand, for $\ell \leq -2$, the estimated coefficient $\widehat{\beta}_\ell$ is used as a placebo to test the parallel trends assumption, by comparing the outcome trends between groups that will and will not participate in the program in $|\ell|$ periods. Additionally, $\varepsilon_{g,t}$ represents the error term.

Finally, the study employed the DID strategy together with the Unconditional Quantile Regression (UQR) estimator to estimate the program's effect on different quantiles of gross income from production. The UQR method allows for a more detailed analysis of the relationship between variables, going beyond the average effect (Rios-Avila & Maroto, 2022). To do so, we used the statistical approach of Recentered Influence Functions (RIFs), popularized by Firpo *et al.* (2009). This approach allows for partial effects of explanatory variables at any unconditional quantile of gross income from production (Rios-Avila & Maroto, 2022).

It is important to note that the unconditional quantile regression estimator was only used to estimate the impact of the PAA on gross income from production. For the metrics of production diversity, new samples were generated based on the quantiles of gross income from production, using the 10th, 25th, 50th, 75th, and 90th percentiles. Then, the relationship between the variables (Number of Products, Agricultural Production Diversity, and Gross Income Specialization) will be evaluated at each percentile of interest.

3.3. Descriptive statistics

The final sample consists of 2,097,170 UFPAs, of which 43,819 delivered products to the PAA-CDS while 2,053,351 did not. To understand of the coverage of our sample, it is worth noting that the 2017 Brazilian Agricultural Census recorded a total of 3,897,408 family farm establishments in Brazil.

Table 2 presents descriptive statistics divided into two groups: those who delivered products to the PAA and those who did not. These statistics showed that there are many differences between the average characteristics of the UFPAs that did and did not access the program, including family background, farm characteristics, and municipality covariates.

TABLE 2 – Descriptive statistics for the UFPAs that accessed and did not access the PAA.

Variable Name	**Accessed PAA (n=43,819)**				**Not Access PAA (n =2,053,351)**			
	Mean	**Sd**	**Min**	**Max**	**Mean**	**Sd**	**Min**	**Max**
Illiterate (1st)	0.024	0.153	0	1	0.053	0.224	0	1
Illiterate (2nd)	0.022	0.148	0	1	0.043	0.202	0	1
Complete Primary Educ (1st)	0.356	0.479	0	1	0.272	0.445	0	1
Complete Primary Educ (2nd)	0.261	0.439	0	1	0.188	0.391	0	1
Complete High School (1nd)	0.133	0.339	0	1	0.094	0.292	0	1
Complete High School (2nd)	0.085	0.279	0	1	0.056	0.230	0	1

Complete Technical Educ (1st)	0.003	0.056	0	1	0.001	0.036	0	1
Complete Technical Educ (2nd)	0.001	0.035	0	1	0.000	0.022	0	1
Complete Higher Educ (1st)	0.013	0.112	0	1	0.007	0.083	0	1
Complete Higher Educ (2nd)	0.015	0.123	0	1	0.010	0.098	0	1
Man (1st)	0.682	0.466	0	1	0.643	0.479	0	1
Woman (2nd)	0.143	0.350	0	1	0.162	0.368	0	1
Age Range 16|—|20 (1st)	0.007	0.084	0	1	0.022	0.147	0	1
Age Range 21|—|30 (1st)	0.128	0.334	0	1	0.180	0.384	0	1
Age Range 31|—|40 (1st)	0.227	0.419	0	1	0.232	0.422	0	1
Age Range 41|—|50 (1st)	0.258	0.437	0	1	0.239	0.426	0	1
Age Range 51|—|60 (1st)	0.233	0.422	0	1	0.198	0.398	0	1
Age Range 61|—|70 (1st)	0.111	0.314	0	1	0.095	0.293	0	1
Married (1st)	0.707	0.455	0	1	0.691	0.462	0	1
ln(Members of the Family)	1.450	0.348	0.693	3.932	1.455	0.352	0.693	3.932
NIS (1st)	0.644	0.479	0.0	1.0	0.680	0.467	0	1
NIS (2nd)	0.444	0.497	0.0	1.0	0.353	0.478	0	1
ln(Social Income)	1.259	3.194	0.000	12.350	1.482	3.386	0.000	15.172
ln(Farm Area)	2.210	1.166	0.000	8.125	2.238	1.244	0.000	12.782
ln(Explored Farms)	0.720	0.153	0.000	3.045	0.724	0.159	0.000	3.045
ln(Permanent Employees)	0.031	0.148	0.000	2.197	0.066	0.205	0.000	2.398
ln(Eventual Strength)	0.097	0.640	0.000	7.802	0.107	0.654	0.000	10.309
Rural Credit (1st. 2nd)	0.003	0.055	0.0	1.0	0.002	0.045	0.000	1
Farm Exceeds 4 Modules	1.000	0.018	0.000	1.000	1.000	0.009	0.000	1.000
ln(Spring Temperature)	3.229	0.109	2.700	3.451	3.239	0.117	2.588	3.451
ln(Summer Temperature)	3.238	0.061	2.872	3.383	3.247	0.066	2.793	3.383
ln(Autumn Temperature)	3.156	0.142	2.536	3.379	3.165	0.151	2.470	3.412
ln(Winter Temperature)	3.123	0.168	2.360	3.384	3.129	0.186	2.292	3.404
ln(Spring Precipitation)	5.322	0.963	1.661	6.990	5.092	0.949	1.661	7.066
ln(Summer Precipitation)	5.934	0.578	3.747	7.277	5.787	0.534	3.665	7.364
ln(Autumn Precipitation)	5.597	0.589	2.728	7.259	5.628	0.579	2.728	7.600

ln(Winter Precipitation)	4.519	1.039	0.466	6.959	4.500	1.010	0.466	6.959
ln(Natural Disasters)	0.310	0.462	0.000	2.833	0.455	0.485	0.000	2.833
ln(Total Credit for Costing)	14.287	3.851	0.000	20.926	13.600	3.882	0.000	21.411
ln(Total Credit for Investments)	15.167	2.106	0.000	19.828	15.058	1.626	0.000	21.174
ln(Total Credit for Commerce)	4.051	6.849	0.000	21.789	2.849	5.888	0.000	22.139
Agricultural Participation	0.174	0.154	0.000	0.886	0.181	0.131	-0.323	0.908
ln(PNAE)	17.772	1.495	0.000	24.166	17.454	1.245	0.000	24.242
ln(Fleet Trucks)	0.012	0.009	0.000	0.091	0.010	0.010	0.000	0.405
ln(Tractor Fleet)	0.002	0.004	0.000	0.074	0.001	0.004	0.000	0.111
ln(ITR)	10.022	2.239	0.000	15.924	9.306	1.764	0.000	15.973
ln(Gross income from production)	9.607	1.246	5.791	12.143	9.024	1.476	5.787	12.143
Diversity of Agricultural Production	0.203	0.170	0.000	0.799	0.204	0.157	0.000	0.912
Income Specialization	0.702	0.248	0.116	1.000	0.688	0.237	0.068	1.000

SOURCE: prepared by the authors.

NOTES: ln( ) represents the use of the natural logarithm.

This shows the importance of controlling for these variables. For example, mean of education variables is higher in the group that accessed the PAA compared to the group that did not, particularly regarding the number of individuals who completed elementary and high school. Additionally, the proportion of men is higher in the group that accessed the PAA, while the proportion of women is higher in the group that did not.

4. Results and discussion

4.1. Average impacts of the PAA on suppliers' gross income and production diversity

The regression results indicate that access to the PAA-CDS had a statistically significant impact on the four dependent variables that were tested. Specifically, there was a positive impact on gross income from production, the number of products, and the diversity of the production index, while there was a negative impact on the specialization index. These effects were observed to be statistically significant in both specifications tested, without controls (1) and with controls (2) (Table 3). We will focus our discussion main on the results from specification (2) as they are considered more robust, given that observable characteristics are also controlled for. Furthermore, the comparison group used consists solely of UFPA's that have never participated in the program during the analysed period.

Estimates from model (2), which considers controls, indicate that the PAA-CDS modality had an impact of 0.217 on the gross income of the

TABLE 3 – Estimated impact of access to the PAA-CDS on supplier farmers.

Dependent variables / Specifications	(1)	(2)
Gross Income from Production	**0.233 *****	**0.217 *****
	(0.025)	(0.025)
N	4.786.720	4.786.720
Number of Products	**0.028 *****	**0.032 *****
	(0.010)	(0.010)
N	4.786.720	4.786.720
Diversity of Agricultural Production	**0.011 *****	**0.011 *****
	(0.004)	(0.004)
N	4.784.994	4.784.994
Gross Income Specialization	**-0.014 *****	**-0.013 *****
	(0.006)	(0.006)
N	4.784.994	4.784.994
Fixed Effects		
UFPA	Yes	Yes
Year	Yes	Yes
Covariates	No	Yes

SOURCE: prepared by the authors.

NOTES: The significance levels are indicated by asterisks as follows: *** p<0.01, ** p<0.05, * p<0.10. The value in parentheses represents the clustered standard error at the municipality level. The average annual gross income from production for UFPA's that participated in the PAA-CDS program is BRL 29,045.00, while for those that did not participate, it is BRL 22,927.00. As of December 2017, the exchange rate of the US dollar to the Brazilian real was BRL 3.31, and the monthly minimum wage was BRL 937.00. For additional information, please refer to: http://www.ipeadata.gov.br/ExibeSerie.aspx?serid=31924.

family farmers (Table 3). This corresponds to an annual average increase of 24.23% on the gross value of production of the UFPAs participated by the program, representing in monetary terms, approximately BRL 7.038,00 or USD 2.126,00 yearly. It is important to note that gross value measured here includes marketed food items and those used for self-consumption.

Table 4 presents the results of the dynamic specification of event studies, using lags and leads of the treatment variable to assess the impact of the PAA over time. During the pre-treatment periods (lags -2 to -5), none of the specifications presented statistically significant coefficients. This provides suggestive evidence of the validity of the parallel trends assumption, as this assumption cannot be tested (Roth et al., 2023).

TABLE 4 – Event study PAA-CDS.

Time relatives	Gross Income from Production	Number of Products	Diversity of Agricultural Production	Gross Income Specialization
- 5	-0.021	-0.009	-0.009	0.016
	(0.044)	(0.017)	(0.007)	(0.010)
- 4	-0.034	0.009	0.0002	0.002
	(0.039)	(0.014)	(0.006)	(0.009)
- 3	0.049	0.006	0.0009	-0.0005
	(0.035)	(0.014)	(0.005)	(0.008)
- 2	0.012	-0.006	-0.006	0.011
	(0.030)	(0.011)	(0.004)	(0.007)
0	**0.191 *****	**0.033 *****	**0.011 *****	**-0.014 ****
	(0.026)	(0.010)	(0.004)	(0.006)
1	**0.382 *****	**0.043 ****	**0.014 ***	-0.017
	(0.042)	(0.018)	(0.007)	(0.011)
2	**0.466 *****	0.034	0.009	-0.010
	(0.049)	(0.024)	(0.009)	(0.014)
3	**0.319 *****	0.011	0.007	-0.011
	(0.051)	(0.022)	(0.008)	(0.012)
4	**0.400 *****	0.025	0.015	-0.023
	(0.080)	(0.029)	(0.011)	(0.016)
5	**0.403 *****	0.021	0.002	0.003
	(0.070)	(0.031)	(0.012)	(0.021)
6	**0.155 ****	0.027	0.010	-0.008
	(0.062)	(0.032)	(0.012)	(0.018)
7	0.300	0.034	0.009	-0.006
	(0.199)	(0.066)	(0.028)	(0.045)
N	4.786.720	4.786.720	4.784.994	4.784.994

Fixed Effects				
UFPA	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes

NOTES: The significance levels are indicated by asterisks as follows: *** p<0.01, ** p<0.05, * p<0.10. The value in parentheses represents the clustered standard error at the municipality level.

SOURCE: Prepared by the authors.

tories to those of family farmers who did not join the PAA, i.e., income only increased for the group of family farmers who joined the PAA.

Additionally, the statistically significant coefficients indicate that the program has a positive effect on the gross production income of family farmers, especially for those who participate more than once, with the most significant effect observed in the third period (lead 2) of program participation. Regarding production diversity metrics, it is observed that increases in diversity mainly occur in the first two periods following program entry.

The indication that there is a positive impact on gross income from access to the PAA corroborates the findings of Doretto & Michellon (2007) in municipalities of the state of Paraná and of Modenese & Sant'Ana (2019) in the municipality of Mirandópolis, São Paulo. It also confirms the observations of various empirical qualitative studies conducted in several regions of the country, where beneficiaries reported an increase in income resulting from access to the program (Perin *et al.,* 2021).

The increase in the gross value of production can be a result of two different effects: an increase in the quantity of food produced and/or an increase in the price of products. As shown by Perin *et al.* (2021), both effects were reported in qualitative case studies conducted in different regions of the country. (Resque *et al.,* 2019; Perin *et al.,* 2021). The prices paid for purchases are determined based on monthly surveys regularly conducted by CONAB, using the prices paid in local or regional wholesale markets as a reference. Therefore, the method used is not intended to have a direct impact on product prices, although this can be observed indirectly.

Analysing from the perspective of the theory of change, Sambuichi *et al*. (2019) developed the logical model of operation for the PAA-CDS, projecting the expected results for each intervention carried out by the program. They showed that one of the immediate expected outcomes is an increase in production. The authors demonstrated that the food acquisitions made by the PAA are expected to raise the production of farmers by opening a secure channel for selling their products, which encourages them to invest and improve their production units to meet the demand.

Furthermore, another mechanism through which the program can stimulate an increase in production is by encouraging the organization of farmers, especially in the case of the PAA operated by CONAB, which purchases food only from organizations (Sambuichi *et al.,* 2019). As demonstrated by Bosetti's study (2021), there is a strong correlation between the volume of resources executed by this program and the number of associated or cooperative farmers. The increased organization of farmers tends to lead to improvements in production structure and marketing capacity, allowing farmers greater access to the PAA itself and to other markets. This creates a virtuous cycle that leads to an increase in the income of beneficiaries (Sambuichi *et al*., 2019).

Therefore, it depends on the ability of organizations and institutions to stimulate innovations, changes, and engagements in the realm of public policy (Gaitán-Cremaschi *et al*., 2022). By constituting a relevant instrument for stimulating mobilization, participation, and organization of family farmers for the formation of marketing circuits, the PAA results in the increase of income and production levels, or the introduction of new products into the productive system, enhancing market diversification opportunities, such as in the case of free markets and local markets (Rambo *et al*., 2023), and also contributing to the transition to sustainable food systems (Gaitán-Cremaschi *et al.,* 2022).

This finding is not isolated or exclusive to the Brazilian scenario and can also be observed in a case study that analysed public food procurement from family agriculture in Uruguay. The research suggests that innovation in the process of public food procurement from family agriculture is related to the "maturity of the networks and their actors". It depends, therefore, on the ability of organizations and institutions to stimulate innovations, changes, and engagements in the realm of public policies (Gaitán-Cremaschi *et al.,* 2022).

Regarding the diversity of production, the results presented in Table 3 indicate that access to PAA-CDS had a statistically significant positive effect on the two aspects that make up diversity:

i) richness, which in our study is represented by the number of different items produced; and

ii) evenness, which, in this case, represents how well income is distributed among products.

Thus, we observed that the PAA acts to promote diversification in UFPAs, both increasing the number of items produced and decreasing the concentration of production value in a few products.

Our results corroborate the effects observed in various case studies conducted in different regions of Brazil, which demonstrated the effectiveness of the PAA (Food Acquisition Program) in encouraging diversification in family farming. Agapto *et al.* (2012) analysed the PAA in Campina do Monte Alegre, São Paulo, and observed that farmers who traditionally grew grains began planting vegetables and greens after joining the PAA. These studies provide examples of situations where the program fostered the cultivation of new products and cases where it enabled the commercialization of items previously produced only for self-consumption, promoting the diversification of income for the beneficiary supplier (Sambuichi *et al*., 2019; Perin *et al*., 2021).

Analysing the theoretical model of the program's intervention, some characteristics of the operation mode of the PAA-CDS can explain this phenomenon (Sambuichi *et al.,* 2019). In the case of operations carried out by CONAB, as the purchase proposals are prepared by the farmers' own organizations, this grants more autonomy to the suppliers to decide how to plan their production, thus allowing them to opt for the advantages of polyculture. In the case of proposals prepared by state or municipal public bodies, there is also an advantage in making a diversified proposal, as this encourages the production of various foods to reinforce local supply. Generally, before preparing the proposals, both the farmers' organizations and the secretariats or governmental bodies consult with the farmers to find out what they can produce to deliver to the program, seeking to cover the diversity of local production (Nehring & McKay, 2013).

Since the entities in the social assistance network demand and accept donations of a wide variety of products, this also encourages the formulation of diverse purchasing proposals. This operational mechanism also allows the program to absorb the diversity of items from the productive backyards of farmers, which are generally used only for their own consumption, as farmers do not always find a suitable market to sell them (Sambuichi *et al*. 2019).

It is important to note that the two components of diversity are associated with a range of benefits for the food security of producers. The increase in the number of products has been associated with dietary diversification, contributing to improved food security through self-consumption and increased income (Pellegrini & Tasciotti, 2014; Makate *et al.,* 2016; Sanju *et al.,* 2019; Gbenga *et al*., 2020). In addition, it allows a better distribution of production and workforce throughout the year, given the seasonality of most crops. It is also associated with the promotion of polyculture in consortia or rotational systems, which allows a more environmentally sustainable mode of production, with greater stability and less use of pesticides and inputs in general and is widely used in ecological-based agriculture and organic production (Frison, 2016).

On the other hand, income diversification corresponds to the expansion of financial sources, a strategy widely used by small farmers to deal with the risks inherent in agricultural production. It should be noted that this type of production is particularly vulnerable to risks, as well as price and marketing variations common to all production sectors. It also suffers from climatic instabilities and the incidence of pests and diseases that can strongly affect the gains of the producer. For this reason, having an income well distributed in a diversified portfolio of products gives more security to always have some return with production, which is very important, mainly for the poorest and least capitalized farmers (Ellis, 1998; Di Falco & Perrings, 2005; Feliciano, 2019).

4.2. Impacts by gross income quantiles

We found a significant positive impact of the program on the gross production income of UFPAs across all income quantiles (Table 5). Specifically, the access to PAA-CDS was associated to a noteworthy 45.94% increase in gross income for the 10th percentile (equivalent to BRL 1,234.00 or USD 372.00), 42.19% in the 25th percentile (BRL 2,634.00 or USD 796.00), 29.05% in the 50th percentile (BRL 5,080.00 or USD 1,535.00), 21.65% in the 75th percentile (BRL 8,212.00 or USD 2,481.00), and 22.51% in the 90th percentile (BRL 16,724.00 or USD 5,053.00) on an annual basis. These results suggest that the program has had a pronounced impact on the farmers who belong to the lowest gross income groups, by enabling them to add value that accounts for a relatively substantial proportion of their earnings.

These results are in line with the conclusions of other studies carried out in various locations in Brazil that identified a positive effect of the program, especially on low-income farmers (Sambuichi

TABLE 5 – Quantile regressions of PAA-CDS effects on supplier farmers.

Specifications /Quantities	(1) Q.10	(2) Q.25	(3) Q.50	(4) Q.75	(5) Q.90
Gross Income from Production	**0.378 *****	**0.352 *****	**0.255 *****	**0.196 *****	**0.203 *****
	(0.067)	(0.049)	(0.052)	(0.042)	(0.041)
N	4.786.721	4.786.721	4.786.721	4.786.721	4.786.721
Number of Products	-0.009	0.017	**0.030 *****	**0.032 ****	0.018
	(0.017)	(0.014)	(0.011)	(0.014)	(0.022)
N	2.273.637	3.153.182	4.352.723	2.111.334	1.038.478
Diversity of Agricultural Production	-0.004	0.008	**0.011 *****	**0.010 ***	0.005
	(0.007)	(0.006)	(0.004)	(0.005)	(0.008)
N	2.272.463	3.151.715	4.351.190	2.110.901	1.038.321
Gross Income Specialization	0.009	-0.011	**-0.013 ****	-0.011	-0.006
	(0.011)	(0.009)	(0.006)	(0.008)	(0.013)
N	2.272.463	3.151.715	4.351.190	2.110.901	1.038.321
Fixed Effects					
UFPA	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes

SOURCE: prepared by the authors.

NOTES: Prepared by the authors. Significance levels are represented by *** p<0.01, ** p<0.05, * p<0.10; the value in parentheses represents the clustered standard error at the municipality. The incomes of the quantile treaties are Q.10 = BRL 2.686,00; Q.25 = BRL 6.243,00; Q.50 = BRL 17.488,00; Q.75 = BRL 37.929,00; Q.90 = BRL 74.308,00. The dollar exchange rate against the Brazilian real in December 2017 was BRL 3.31, and the monthly minimum wage was BRL 937.00.

et al., 2019; Perin *et al*., 2021). In Mirandópolis, São Paulo, the study by Modenese & Sant'Ana (2019) found that, for 20% of the PAA supplier beneficiaries interviewed, the monetary income generated by the program exceeded 70% of the total family income. Doretto & Michellon (2007), in the municipality of Cerro Azul in the state of Paraná, for example, found that farmers participating in the PAA showed an 87.8% increase in average income compared to non-beneficiary farmers in the group with incomes of up to a minimum wage.

With regards to production diversity metrics, a statistically significant increase was observed in the production diversity of suppliers for the Q.50 and Q.75 percentiles. These results are noteworthy because they demonstrate that the effect of promoting diversification occurs mainly for UFPAs with a medium to high socioeconomic profile. One potential explanation for these findings is that lower-income farmers may exhibit greater production diversity due to their tendency to produce more for subsistence and rely on their own production for self-consumption. Additionally, for these farmers, depending on a sole source of income entails a heightened level of risk (Ellis, 1998; Di Falco & Perrings, 2005; Feliciano, 2019).

Sambuichi *et a*l. (2014), utilizing 2012 data from the DAP registry, assessed the degree of production diversity amongst family farmers across various income ranges in Brazil. The study observed that 68% of farmers in the lower income group (earning BRL 20,000 or less, equivalent to USD 10,256 annually) were classified as diversified or highly diversified, whereas 62% of farmers in the highest income range (earning BRL 200,000 or more, equivalent to USD 102,564 annually) were categorized as specialized or highly specialized.

In the same study, the authors discussed the advantages and disadvantages of productive diversification and highlighted its significance in promoting the sustainability of family agricultural production. They also warned that farmers who achieve greater success in producing for the market tend to become more specialized (Sambuichi *et al.,* 2014). This finding is reinforced by Guanziroli *et al*. (2012), comparison of data from the 1996 and 2006 Brazilian agricultural censuses, which showed an increase in the percentage of specialized family farmers during this period, particularly in the higher-income brackets.

The trend towards specialization can be attributed to various factors, including the influence of agricultural modernization, which has increased access to technologies that mainly support monoculture. Moreover, the expansion of bank credit opportunities generally favors financing specific items produced in monoculture systems, further promoting specialization. Another factor that contributes to farmers choosing to specialize is the greater availability of agricultural insurance policies, which decreases the production risks associated with monoculture (Di Falco & Perrings, 2005). However, a significant factor influencing the decision to specialize is the difficulty of accessing adequate markets that can absorb diversified production (Lamers *et al*., 2016).

Intermediate- or higher-income farmers are frequently those who specialize in production to meet market requirements and, in doing so, have forfeited the other benefits provided by polyculture. This is because agricultural markets generally tend to favour production systems that specialize in a few crops and utilize high-yield varieties that are more uniform in terms of quality and shape. A significant portion of agricultural diversity has low market value and limited outlets, and there are often only a few products that attract demand from large consumer groups and generate higher revenue for farmers (Lamers *et al.*, 2016).

Therefore, the empirical results obtained in this research corroborate the expected results in the logical model of the program, according to which: by offering a marketing channel capable of absorbing a high diversity of products, the PAA stimulates productive diversity and provides farmers with the opportunity to balance income, thus enabling more sustainable production from economic (income), social (food security), and environmental (greater biodiversity and lower environmental impact) perspectives (Sambuichi *et al*., 2019).

4.3. Key lessons from the PAA experience

As previously mentioned, the PAA has served as a model for other PFP policies in various countries. However, it is important to note that the success of these initiatives and any potential future programs will depend on how well they incorporate the unique characteristics of the PAA-CDS model into their designs. These characteristics are fundamental for achieving similar results and adapting them to the local context.

As discussed by Swensson et al. (2021), PFP programs represent a distinctive intersectoral tool that can be customized to a wide range of contexts, including economies with low to high-income levels. The effectiveness of this instrument depends on the decision-making process and the ability of local, regional, and national governments to tailor their purchases to diverse social intervention goals, within their policy and regulatory frameworks. This includes determining which foods will be procured, from whom they will be acquired, and the type of production system that will be utilized.

The primary characteristic of the PAA is its capacity to integrate the goals of strengthening family farming and combating FINR of vulnerable people. Among the main features of the program that may have contributed to its results, we highlight:

The market reserve for family farming: This is the main strategy that characterizes the mode of intervention of PAA as a program aimed at promoting FSNO. This assumes that the lack of adequate market access is a bottleneck for the growth of such farmers' production, and without market support, family farmers have difficulties competing with large producers and companies to access the PFP.

Dispensation from bidding and simplification of bureaucratic requirements for procurement: This is an important aspect to explain the results obtained by the program, since prior to such relaxation, family farmers faced difficulties in meeting bureaucratic requirements to participate in bidding processes and access the public procurement market (Sambuichi *et al.,* 2019).

Local food procurement and distribution: This strategy allows the program to promote local development and supply chains, contributing to the sustainability of the agri-food system. As explained by Stefani et al. (2017), location requirements for contractual suppliers are a discriminating factor in relation to the impact of PFP programs. When suppliers are required to be local, interventions create a structured demand within the local economy that facilitates the access of family agriculture to markets. This makes it easier, less costly, and less risky for family farmers to produce their goods.

Decentralization in the drafting and implementation of program proposals: This is a very important and unique feature of this program that explains its success in encouraging family farming and promoting the diversification of production in various regions of the country. Decentralized elaboration gives more autonomy to farmers and local governments to define what will be produced, how it will be produced, and how it will be delivered. This allows them to adapt to meet the specific needs of each region.

Another important point to consider in the PAA experience is the considerable investment of financial resources required for the implementation and improvement of the operating structure. This investment included the expansion of CONAB's physical, personnel, and technological structures to meet the program's needs, as well as the creation of a network of actors who participated in its operation at the local level. There was also a strengthening of the articulation between federal, state, and municipal governments to implement the program.

It should be noted that this articulation is crucial for the program to achieve its objectives. For example, issues such as inadequate prices or delayed payments have hindered PAA actions in some locations. These problems occur in other PFP initiatives as well. As showed by Upton & Lentz (2017), the local procurement by the United Nations World Food Program is hampered by slow payment to farmers and complicated bidding. In the case of the PAA, managers have made efforts to overcome these problems by improving regulations and the program's mode of operation. For this, it was important to articulate the federal government and local operators to detect these problems and find solutions adapted to each reality (Perin *et al.,* 2021).

Another contributing factor to the results of PAA is that it was created as part of a broader public policy agenda that included a set of programs and actions aimed at food security and rural development. These programs and actions supported and complemented each other, leading to better outcomes. Several case studies conducted in different regions have shown that the results obtained by PAA also depend on the existence of other supporting policies, such as technical assistance programs, credit, improvement of transport and storage infrastructure, support for cooperatives, and community mobilization (Resque *et al.,* 2019; Perin *et al*., 2021).

It's important to emphasize that, for the program to continue achieving its goals of increasing income and diversifying the production of family farmers, it's crucial to invest resources in its acquisitions. During the study period from 2009 to 2017, approximately BRL 6.7 billion or USD 2 billion was invested in purchases, allowing the program to serve beneficiaries across all regions and states of Brazil (Sambuichi *et al*., 2019). However, in recent years, there has been a sharp decrease in the budgetary resources allocated for PAA acquisitions. This reduction not only limits the program's geographical scope and number of beneficiaries but also threatens the governance structure created for its implementation (Perin *et al.*, 2021). Without access to resources, local agents may be demobilized, resulting in a significant loss, as the program's effectiveness and reach depend heavily on the coordination and engagement of these actors. The recreation of the program in 2023 and the investment of new resources ignite hopes that this public policy may regain the importance it had in its most active periods.

In conclusion, we emphasize the importance of continuing studies on the program and its contribution to the promotion of FSNO and rural development in the country, analysing it in the light of change theory to understand the underlying mechanisms of its operation and impacts on the territories. For this, more in-depth and regionalized quantitative studies will be necessary, given the vast geographical extent of the country and the diversity of realities in which the PAA operates.

5. Conclusions

Our estimates showed that access to the PAA-CDS was associated with an increase in the gross production value of farmers. The most significant impact was observed among the poorest, who experienced a 45.9% increase in the 10th percentile of gross income. The program was also associated with the diversification of farmers' product portfolios. This effect was more pronounced in family units with middle to higher gross income profiles, in the 50th and 75th percentiles.

These results demonstrate the positive effects of the PAA-CDS on gross income and production diversity among its suppliers. This indicates that the program is achieving its main objective of encouraging family farming. Additionally, it contributed to promoting food security and reducing rural poverty, as it had a significant impact on the gross income of the poorest farmers.

Finally, we highlight the following features of the program's design that may have contributed to its results:

i) market reservation for family agriculture;

ii) exemption from bidding and simplification of bureaucratic requirements for purchases;

iii) local acquisition and distribution of food; and

iv) decentralization in the development and execution of proposals.

We emphasize the importance of considering these features when replicating the model for other PFP initiatives aimed at promoting family farming, adapting them to the specific needs of each local context.

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