



Assessing climate and socioeconomic effects of agricultural credit policies:

A case study of Brazil

Mandate description

This work is an output of the implementation of activity 12 of the workplan of the forum on the impact of the implementation of response measures and its Katowice Committee of Experts on the Impacts of the Implementation of Response Measures.¹

Activity 7: Facilitate the development and exchange of regional, country- and/or sector-specific case studies and approaches on (1) economic diversification and transformation and just transition of the workforce and creation of decent work and quality jobs, and (2) assessment and analysis of the impacts of the implementation of response measures with a view to understanding the positive and negative impacts

Activity 12: Develop a case study in each of the five United Nations regions in accordance with activity 7 of the workplan.

¹ As contained in annex II of decisions 4/CP.25, 4/CP.15 and 4/CMA.2.

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Abbreviation list

ABC/RenovAgro: Low-Carbon Agriculture Programme (renamed RenovAgro in 2023)

BCB: Central Bank of Brazil

CAR: Rural Environmental Registry

CMN: National Monetary Council of Brazil

CO₂e: carbon dioxide equivalent

FUNCAFÉ: programme under Plano Safra that supports the coffee sector

GHG: greenhouse gas

IBGE: Brazilian Institute of Geography and Statistics

INOVAGRO: programme under Plano Safra for the incentive of technological innovation in agriculture

KCI: Katowice Committee of Experts on the Impacts of the Implementation of Response Measures

LUC: land-use change

LULUCF: land use, land-use change and forestry

MAPBIOMAS: collaborative initiative that produces annual land use and land cover maps of Brazil using satellite images

MODERAGRO: programme under Plano Safra for modernization of agriculture and conservation of natural resources

MODERFROTA: programme under Plano Safra for the renewal of the agricultural machinery fleet

NDC: nationally determined contributions

PAM: Municipal Agricultural Survey

PCA: programme under Plano Safra for the construction of warehouses

PROCAP-AGRO: programme under Plano Safra for the strengthening of agricultural cooperatives

PRODECOOP: programme under Plano Safra for the development of agricultural cooperatives (to add value to agricultural production)

PROIRRIGA: programme under Plano Safra for irrigation and sustainable use of water resources

PRONAF: programme under Plano Safra for strengthening family agriculture

PRONAMP: programme under Plano Safra for medium-sized producers

PSI-RURAL: programme under Plano Safra for rural investment support

RECOR: Credit Operations Records System (the system that preceded SICOR, until 2012)

SEEG: Greenhouse Gas Emissions and Removals Estimation System (Brazil)

SICOR: Rural Credit Information System (from 2013 onwards)

UNFCCC: United Nations Framework Convention on Climate Change

USD: United States dollar

I. Introduction

A. Background and objectives

Achieving the goal of the Paris Agreement to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels requires the effective implementation of ambitious policies and actions to reduce GHG emissions. As governments across the world accelerate their efforts to meet this target, there is an urgent need to assess, address and report the impact (both positive and negative) of such policies from an environmental, social and economic perspective.

Within the intricate architecture of the UNFCCC and the United Nations process to negotiate and monitor multilateral action in this field, the KCI supports the assessment of climate mitigation policies, programmes and actions (understood here as ‘response measures’). This includes considering how to ensure a just transition to low-carbon economies, creating employment and quality jobs, as well as ensuring economic diversification and transformation.

Brazil and its agriculture sector constitute an important area of focus for the topics addressed by the KCI. Brazil holds a unique position in global climate change mitigation efforts as it is home to the largest tropical forest in the world, the Amazon, and it is an agricultural export powerhouse. The country’s agriculture sector presents complex yet critical questions in the context of climate change as it is a significant source of GHG emissions, but also fundamental to global food security.

Brazil is consistently among the top global GHG emitters when including land use, LULUCF.² This unfortunate position is largely attributed to deforestation, 97% of which is due to conversion for agricultural use.³ According to Brazil’s biennial update report to the UNFCCC,⁴ in 2022 emissions from agricultural activities reached 622,014 kilotons of CO₂ equivalent, accounting for 26% of the country’s total GHG emissions. The LULUCF sector contributed even more, with 1,174,326 kilotons of CO₂ equivalent, or 49% of the country’s total emissions.⁵ Figure 1 shows Brazil’s GHG emissions by sector from 2010 to 2022. The sum of emissions from the agriculture and LULUCF sectors has oscillated around 70% of total emissions, reaching a maximum of 75% in 2022.

² See <https://ourworldindata.org/greenhouse-gas-emissions>.

See also https://www.climatewatchdata.org/ghg-emissions?end_year=2022&start_year=1990.

³ See <https://brasil.mapbiomas.org/2024/05/28/matopiba-passa-a-amazonia-e-assume-a-lideranca-do-desmatamento-no-brasil/#:~:text=Em%202023%2C%20o%20Cerrado%20correspondeu,a%20expans%C3%A3o%20agropecu%C3%A1ria%20como%20vetor.>

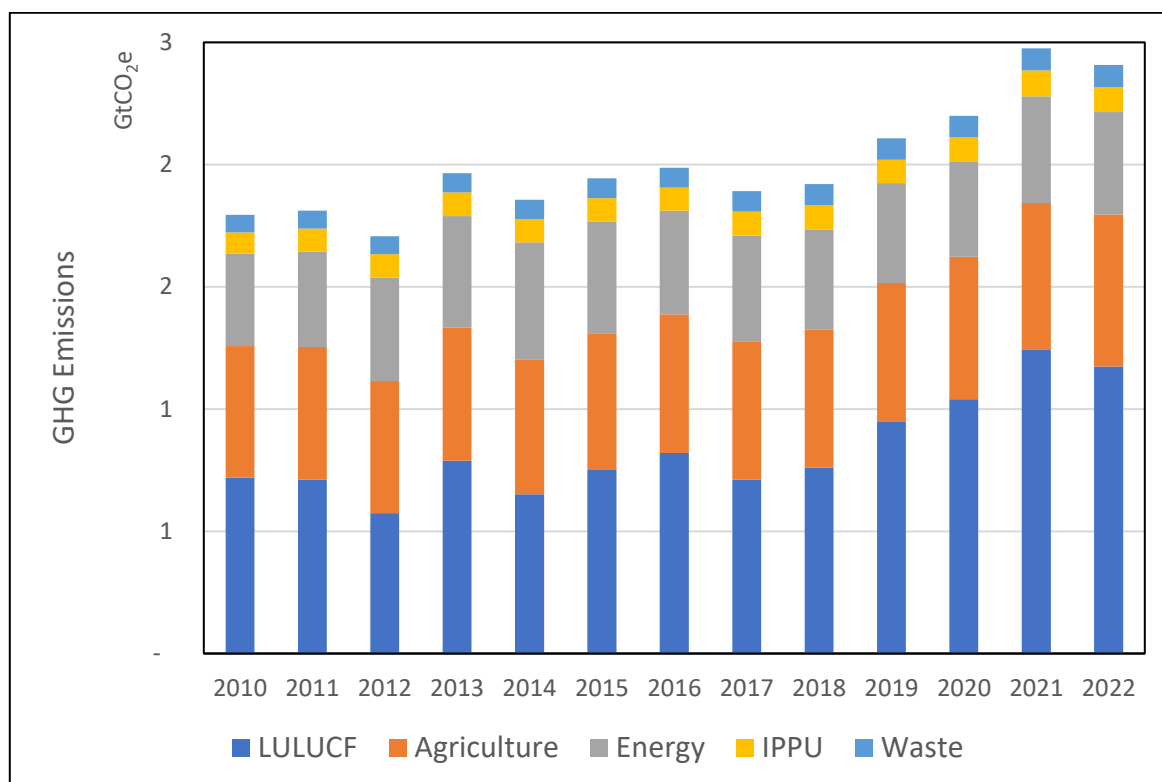
See also <https://brasil.mapbiomas.org/2024/05/28/matopiba-passa-a-amazonia-e-assume-a-lideranca-do-desmatamento-no-brasil->.

⁴ See Biennial Transparency Report of Brazil to the UNFCCC

(https://unfccc.int/sites/default/files/resource/BRA_BTR1_2024_ENG.pdf), available at <https://unfccc.int/first-biennial-transparency-reports>.

⁵ Net emissions from LULUCF were 805,694 kilotons of CO₂e, or 40% of Brazil’s net emissions in 2022.

Figure 1. Brazil's GHG emissions by sector in GtCO₂e (2010–2022)



Source: Authors' elaboration based on data from the Ministry of Science, Technology and Innovation of Brazil (MCTI).

Therefore, any meaningful progress in global climate change mitigation heavily relies on Brazil's capacity to reduce emissions from its land sector and protect its vital ecosystems. A change in the current pattern of expanding areas of agricultural production is necessary for an effective climate change mitigation policy in Brazil.

Designing sound economic policies that can simultaneously contribute to climate change mitigation, zero deforestation and food security is paramount. These policies must incentivize sustainable agricultural practices, promote technological innovation to reduce emission intensity, encourage land restoration and support a just transition for rural communities, demonstrating how economic development and environmental protection are mutually reinforcing.

Brazil's NDC,⁶ submitted under the Paris Agreement, emphasize the need to halt deforestation by 2030 and reduce GHG emissions by 37% below the 2005 level by 2025, 50% by 2030, and – the latest agreed target – between 59% and 67% by 2035. To achieve these targets, curbing deforestation and adopting sustainable agricultural practices that reduce emissions from soil management, livestock and energy use are essential. Effective policy instruments are also vital, especially considering the economic importance of agriculture and the risks of aggravating social inequities if a just transition is not being pursued.

In line with Brazil's commitments to achieving international climate goals, the Government has introduced a range of policies to reduce agricultural emissions and promote reforestation. Initiatives like Plano Safra (meaning 'Harvest Plan' in Portuguese), which has introduced financing schemes for sustainable agriculture and low-carbon practices, can play a crucial role in enabling more environmentally friendly production methods that contribute to progress towards achieving national climate goals.

Among its functions, the KCI aims to enhance the capacity of Parties to the UNFCCC to understand and manage the impacts of climate response measures. This is supported, within the workplan for 2020–2025, by the development of national, regional and sector-specific case studies such as this one.

⁶ See Brazil's Second Nationally Determined Contribution, submitted on 13 November 2024, available at <https://unfccc.int/NDCREG>.

This research project aims to contribute to the KCI objectives by providing a case study on how economic policies affect the achievement of climate objectives and discuss possible pathways to improve policy effectiveness across environmental and socioeconomic dimensions. More specifically, it focuses on the implementation of the Brazilian Agricultural Credit Programme (also known as Plano Safra). In this context, it is important to note that Brazil’s NDC explicitly proposes increased “strictness in prohibiting access to rural credit in illegally deforested areas in all biomes”.

The study consists of an econometric analysis assessing how Plano Safra has impacted the KCI’s areas of interest (mitigative capacity, economic diversification and just transition). The main research questions are:

- What have been the socio-economic and ecological impacts of Plano Safra?
- To what extent has Plano Safra promoted economic diversification, the adoption of sustainable agricultural practices and a just transition?

The final objective is to draw lessons from Brazil’s experience in implementing Plano Safra and provide guidance on the use of econometric tools to assess the impacts of climate response measures.

B. Introduction to the Plano Safra

Plano Safra is a set of government policies and financial mechanisms designed to support and promote agricultural and livestock production in Brazil. In practice, it accounts for all rural credit. It provides subsidized credit to farmers, both large commercial producers and family farmers. As seen in table 1, Plano Safra can be applied to both agricultural and livestock activities, and can be accessed by producers of all sizes for purposes including investment, operating costs, industrial processing and commercialization. They can also be divided among the various programmes under Plano Safra, which can be used for specific purposes, such as financing family farming, investments, technology adoption and modernization, or focusing on low-carbon practices. The aim is to boost production, ensure food security and foster agricultural sustainable practices.

The plan incorporates sustainability criteria, offering lower interest rates to farmers who adopt environmentally friendly practices and restricting access to those involved in illegal deforestation or other environmental abuses (for instance, by imposing safeguards that prohibit credit for properties with environmental embargoes, or that are cancelled or suspended from the rural registry CAR or intersect with undesignated public forests). A significant portion of Plano Safra is dedicated to the PRONAF, which supports family farms with finance, technical assistance and the purchase of equipment. However, Plano Safra also finances large-scale agricultural producers, and access to credit lines remains open to properties that do not fully comply with environmental legislation.⁷ Table 1 provides an outline of the credit lines available, and the amount of credit and subsidies provided through each of them.

Table 1. Contracted value and subsidies under Plano Safra between 2013 and 2024, by category

Category	Item	Contract value (USD bn)	% Total contract value	Subsidy (USD bn)	% Total subsidy	% subsidy on contracted value
Activity	Agricultural	453.0	68.1%	22.9	60.2%	5.1%
	Livestock	212.4	31.9%	15.1	39.8%	7.1%
Purpose	Commercialization	85.8	12.9%	1.1	3.0%	1.3%
	Operating costs	369.8	55.6%	10.5	27.7%	2.9%
	Industrial processing	27.4	4.1%	0.5	1.4%	1.9%
	Investment	182.3	27.4%	25.8	67.9%	14.2%

⁷ Forest Code (Law 12,651/2012) requires that all rural properties must be registered in the Rural Environmental Registry (CAR) This is necessary to access credits under *Plano Safra*; however, most properties’ records have not been analysed, by state offices, for their mandatory preservation areas.

Issuer	Large rural producer	302.3	45.4%	13.4	35.2%	4.4%
	Medium rural producer	232.6	35.0%	9.8	25.7%	4.2%
	Small rural producer	129.4	19.4%	14.7	38.8%	11.4%
	Other issuers	1.1	0.2%	0.1	0.3%	12.1%
Programme	ABC/RenovAgro	8.5	1.3%	1.2	3.1%	14.0%
	FUNCAFÉ	10.7	1.6%	0.3	0.7%	2.5%
	INOVAGRO	3.9	0.6%	0.5	1.4%	13.3%
	MODERAGRO	3.1	0.5%	0.3	0.7%	8.7%
	MODERFROTA	16.0	2.4%	1.0	2.6%	6.3%
	PCA	6.3	0.9%	1.4	3.6%	21.6%
	PROCAP-AGRO	3.5	0.5%	0.2	0.6%	6.2%
	PRODECOOP	2.8	0.4%	0.4	1.1%	14.7%
	PROIRRIGA	2.0	0.3%	0.2	0.6%	12.2%
	PRONAF	95.8	14.4%	12.6	33.1%	13.1%
	PRONAMP	82.5	12.4%	3.7	9.7%	4.5%
	PSI-RURAL	7.2	1.1%	1.8	4.7%	24.6%
	Other	423.2	63.6%	14.5	38.2%	3.4%
	Total	665.4	100.0%	38.0	100.0%	

Share of subsidy on the total contract value = 5.7%

Source: Authors' elaboration based on data from the BCB.

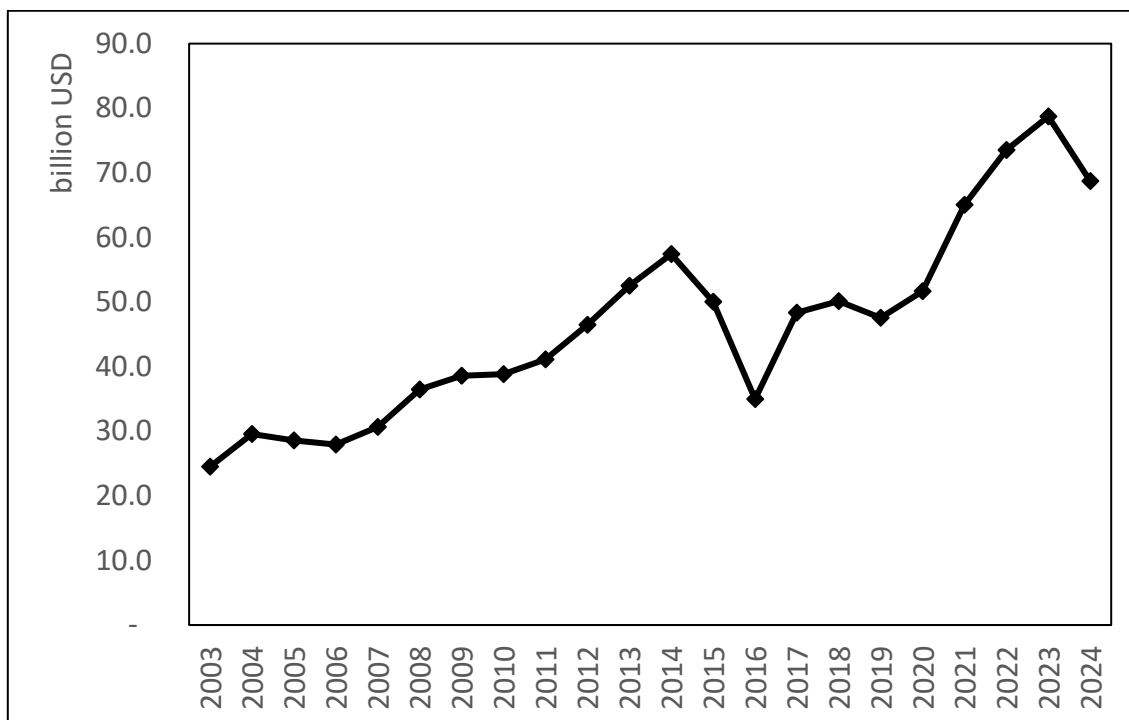
Note:

1. All the Plano Safra's contracts are associated with a single specific item in each category, so that the total sum of items in each category is equivalent. 'Other programmes' refers either to initiatives accounting for less than 0.3% of the total contracted value of Plano Safra during the period, or to special/temporary credit lines. Prices are deflated in Brazilian reais using the Brazilian consumer price index (IPCA) and converted into USD using the average exchange rate in 2024.
2. Due to rounding, the sum of the breakdown values may not equal the total in the last row.

Since its inception in 2003, Plano Safra has served as a cornerstone of Brazil's agricultural policy framework. Its goals are to stimulate investments in rural areas, support production costs and the commercialization of agricultural commodities, improve the living standards of rural populations, protect soil, preserve the environment, enable land acquisition and legal registration of land tenure, and develop forestry and fishing activities. Plano Safra is a government programme that supports the provision of rural credit for all activities related to crop farming and livestock farming. Currently, nearly two thirds of funds available under Plano Safra consist of subsidized rural credit and one third consists of private resources operated by financial institutions (though these resources also benefit from some degree of implicit subsidy, since they are exempt from income tax).

Over the years, Plano Safra has become increasingly relevant, with annual rural credit surpassing 60% of gross domestic product (GDP) from agriculture. Rural credit has grown steadily in the 22 years since the plan's inception, with a real growth rate higher than 9% in several years (figure 2). Currently, Plano Safra provides nearly USD 70 billion to Brazil's agriculture sector annually.

Figure 2. Rural credit concessions (2003–2024)



Source: Authors' elaboration based on data from the BCB.

Note: Prices are deflated in Brazilian reais using the Brazilian consumer price index (IPCA) and converted into USD using the average exchange rate of 2024.

Rural credit provided through the Plano Safra finances current operational expenses, investment, as well as the commercialization and industrialization of agricultural production within rural properties or in cooperatives. Credit for operational expenses traditionally represents the lion's share of the total of rural credit under Plano Safra, reaching 56% in 2013–2024. Credit for investment (e.g. credit for the acquisition of machinery and equipment) is also important, amounting to 27% of the total in the same period (own estimation using data from the BCB and SICOR). The same proportions were observed in the most recent year covered by the analysis (i.e. 2024).

Plano Safra is an important policy for providing credit to farms of all sizes. One of its significant features is the provision of credit at subsidised rates. Table 1 shows that subsidies are greater for certain types of rural credit, such as credit aimed at family farming (PRONAF), investment, and adoption of new technologies and low-carbon production. Complementing this, table 2, which displays the financial conditions for the credit in 2024–2025,⁸ shows that interest rates are much lower than the market rate. For reference, the basic interest rate in Brazil jumped from 10.55% in July 2024 to 14.75% as of May 2025.

Table 2. Interest rates for Plano Safra programmes

Plano Safra programmes	Interest rates (2024–25)
PRONAMP	8%
ABC/RenovAgro and PCA	8.5%
PCA up to 6K tons	7%
Business operational cost	12%
MODERFROTA	11.5%
Environmental RenovAgro and Pasture Recovery/Conversion	7%

⁸ Plano Safra's yearly cycle is normally launched in July and is valid until June of the next year.

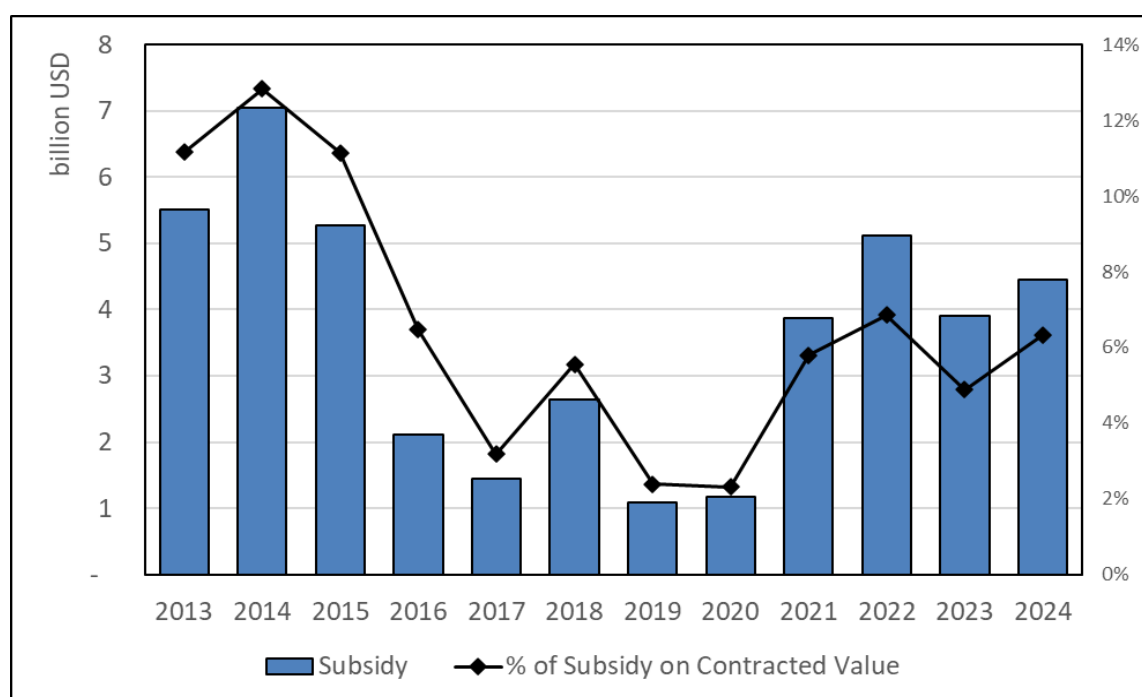
MODERAGRO, PROIRRIGA and Business Investment	10.5%
PRODECOOP and PROCAP-AGRO	11.5%
MODERFROTA and PRONAMP	10.5%
PRONAF	0.6–3%

Source: Ministry of Agriculture and Livestock of Brazil (MAPA)⁹

Note: The programme acronyms are explained in the glossary on page 3.

The BCB/SICOR database allows for the comparison of market interest rates with the average rates applied to Plano Safra’s loans. Considering the financial conditions of Plano Safra’s contracts (interest rate, date of approval and maturity), it is possible to calculate the present value of the difference in interest payments.¹⁰ According to estimates in table 1, the implicit subsidy resulting from rural credit contracts since 2013 totals approximately USD 38 billion, which corresponds to about 5.7% of the Plano Safra programme over that period.¹¹ This is the size of the implicit subsidy referred to in this report.¹² Figure 3 shows the absolute subsidies level from rural credit contracts throughout the years, as well as their relative value as a share of the total credit granted under Plano Safra.

Figure 3. Implicit subsidy under Plano Safra (2013–2024)



Source: Authors’ elaboration based on SICOR microdata.

⁸ See <https://www.gov.br/agricultura/pt-br/assuntos/noticias/governo-federal-lanca-plano-safra-24-25-com-r-400-59-bilhoes-para-agricultura-empresarial>

¹⁰ The present value is an estimate of the current worth of a future sum of money or stream of cash flows, discounted by the interest rate, to reflect the time value of money. The idea is that money available today is worth more than the same amount in the future due to its potential to earn interest or returns. In the case of the Plano Safra, the use of interest rates below market value means a transfer of resources to the benefiting rural producers, which is financed with public funds, and the exercise aims to estimate this subsidy.

¹¹ The Central Bank of Brazil provides the microdata with every contract of rural credit with subvention. See <https://www.bcb.gov.br/estabilidadefinanceira/tabelas-credito-rural-proagro>.

¹² See Annex A for more information on the calculation methodology and more specific results.

The value of the subsidy is substantial as it never fell below USD 1 billion in 2013–2024. The amount varies according to the difference in interest rates and the total credit granted. In 2023 and 2024, subsidies averaged USD 4.2 billion, or 5.6% of the total rural credit value in the same period.¹³

This implies an important distribution of public resources, with unequal effects: 38.5% of the subsidy in 2024 (35.5% when considering the period 2013–2024) was appropriated by large landholders. Looking at the distribution of rural credit by programme,¹⁴ PRONAF, which targets family farmers, accounts for only 17% of the total in the period 2023–2024, despite the fact that family farms tend to be more credit-constrained than large farms. Plano Safra has evolved over the years to strengthen its sustainability components. For instance, the introduction of ABC/RenovAgro (a federal government programme aimed at promoting low-carbon agriculture, formerly known as Programa ABC and renamed RenovAgro in 2023) in 2012 marked a pivotal effort to promote environmentally sustainable practices, such as crop rotation, agroforestry, integrated pest management and soil conservation, in an effort to reduce GHG emissions from agriculture.

The ABC/RenovAgro programme aims to provide financial resources and technical assistance to farmers who adopt sustainable agricultural technologies and practices. These practices are intended to mitigate climate change by reducing emissions from production processes, increasing carbon sequestration in soils and forests, and improving resource use efficiency. Nevertheless, ABC/RenovAgro has not yet managed to achieve sufficient scale as it has never surpassed 4% of total rural credit concessions, and it currently amounts to USD 2 billion.

Recognizing the need to stimulate change through incentives for sustainability in all credit operations (and not just in the ABC/RenovAgro), in 2023 new criteria were introduced to promote greener practices. These include:

- A 0.5 percentage point reduction in interest rates for credits concerning operational expenses for properties that have a Rural Environmental Registry (CAR). The CAR is a mandatory electronic registry gathering environmental information to determine whether the rural property complies with the Forest Code.
- Preferential interest rates for PRONAF, including an annual interest rate of 2% for socio-biodiversity products (to finance operational expenses), as well as agroecological and organic farming, and 3% for investment.
- Safeguards that prohibit credit for properties with environmental embargoes, a cancelled or suspended CAR, or that intersect with undesignated public forests (undesignated public forests are often at risk of land grabbing).
- A ban, from January 2026, on credit to properties where deforestation has occurred after July 2019, unless the property owners provide an Authorization of Suppression (CMN Resolution 5193/2024).

Such policy developments demonstrate Brazil's growing recognition of the important role that financial instruments play in promoting sustainability. These measures reflect a practical approach that links fiscal policy with environmental goals directing the implicit subsidies of Plano Safra towards more sustainable activities.

Nevertheless, while there is a general acceptance of the introduction of incentives towards more sustainable practices, more binding restrictions to curb deforestation and other unsustainable practices often encounter resistance within the agriculture sector. This leads to a situation where new incentives are designed in an attempt to enhance sustainability, but restrictions are not effectively applied to reduce rural credit available to those not complying with environmental law, especially the Forest Code.

In this regard, Plano Safra demonstrates the potential of financial instruments to support more sustainable agricultural practices. Initiatives such as the ABC/RenovAgro highlight opportunities to expand low-carbon production, and ongoing efforts to direct rural credit toward sustainable agricultural practices can further align financial support with environmental objectives, thereby promoting sustainability across the sector. At the

¹³ This implies a subsidy under Plano Safra that represents 12% of *Bolsa Família* - a large cash-transfer programme directed to the poorest households in Brazil.

¹⁴ Plano Safra is divided into several programmes that have different objectives and, therefore, different financial conditions.

same time, these initiatives currently represent only a small share of total rural credit, leaving room for production activities associated with deforestation and carbon-intensive practices.¹⁵

C. Why use econometrics for policy evaluation

Policy decisions involve the use of public resources and can affect millions of people. It is, therefore, essential to have a good understanding of whether a policy is meeting its goals and, if not, what is hindering its success. It is also fundamental to understand how well a policy works, for whom and under what circumstances. Econometrics helps answer these questions.

Econometrics can be a powerful tool for evaluating public policies drawing from real-world experience and examples. It helps decision makers understand how rigorous data analysis can improve the design, targeting and impact of government interventions.

Econometrics is the use of statistics and mathematics to analyse economic data. It goes beyond simple averages and trends, as it helps to isolate cause-and-effect relationships. Moreover, it allows the researcher to understand the underlying mechanisms that make some relationships causal. This matters because without proper analysis, there is a risk of drawing the wrong conclusions – and designing the wrong policies. Econometrics is, therefore, a tool to shed light on the “intended but unrealised effects” of a policy, as stated by Albert Hirschman (Hirschmann, 1977, p.131). As Amartya Sen asserts, compared to the more common approach of looking at unintended consequences of an action, “the failure of those intended effects to be realized is a real departure from what was hoped, and is thus much more interesting” (Sen, 1996, p. xviii).

In order to understand whether the results of some policy evaluations are causal, it is important to know how to separate correlation from causation. Since the beginning of this century, the literature on causal inference in econometrics has surged. For instance, the 2021 Nobel Prize in Economics was awarded to Joshua Angrist and Guido Imbens for their methodological contributions to the analysis of causal relationships (jointly to David Card for his contributions to labor economics using causal methods).

The use of econometrics to understand causal analysis inspired by scientific methodologies mainly involves identifying a suitable control group to compare with a group receiving an intervention (the ‘treatment’ group). The control group is essential. For instance, if a policy or programme (e.g. a cash benefit) is provided to an individual, and its impact on a particular outcome, such as food consumption, needs to be measured, with access to the individual’s consumption data, it is possible to compare food expenditure before and after the benefit is received, attributing any observed change solely to the programme. However, concurrently with receiving the benefit, the individual could also make efforts to increase the labour income or could experience a health issue requiring more food intake, thereby allocating a larger portion of income to food. How can it be determined if the increase in food consumption was caused by the benefit, the increase in labour income or the increase in food intake?

The idea of econometrics is to isolate the impact of the benefit from the other factors measuring what would have happened with food consumption if the person had not received the benefit. The problem is that it is impossible to directly observe this scenario – referred to in the literature as the ‘counterfactual’ – after the benefit has been disbursed.

If a group of individuals received the benefit, a similar group who did not receive the benefit (called the ‘control group’) is needed as a comparison to observe what would have happened with food consumption in that situation. The problem is how to find this control group. There are few main tools used in the literature, some of which can be found in appendix B.

These tools help reduce bias and increase confidence in the findings, producing analysis that can support the improvement of the policy design and the identification of the most impacted groups. Using appropriate econometric techniques, policymakers can, for instance, obtain reliable evidence on the effectiveness of Plano Safra in advancing just transitions — balancing environmental sustainability with socio-economic development.

¹³ Souza et al (2024) show that there is still a significant amount of subsidized credit going to properties that deforest. For more details, see: <https://www.climatepolicyinitiative.org/pt-br/publication/car-a-car-as-instituicoes-financeiras-e-o-credito-para-propriedades-com-desmatamento/>

In the context of this report, the goal was to find suitable control groups for the municipalities receiving rural credit or receiving more rural credit than others. To do so, the fixed effects model was used to separate the impacts of Plano Safra from other factors such as macroeconomic trends and specific characteristics of each municipality.

The fixed effect model relies on a few key major assumptions to ensure the validity of results. First, regressors (such as Plano Safra’s credit) must be exogenous, meaning they should not correlate with unobserved shocks affecting the outcome. Second, the model assumes that relevant time-varying confounders are either controlled for or do not bias the treatment variable. Finally, the model assumes that the effect of the treatment is roughly the same across different units and over time. If these assumptions are violated, the estimated impact may reflect unobserved factors rather than the causal effect of interest.

Econometric models are a useful tool for understanding causal relationships, but they also have limitations. For example, fixed effects models can account for factors that do not change over time, but they cannot capture variables or shocks that do vary over time and affect outcomes. Simple models may also miss differences across contexts. Thus, limitations must be recognized alongside checks for robustness or complementary processes to strengthen the credibility of findings.

II. Main results

This chapter presents the main results of the econometric analysis assessing the impact of Plano Safra on the three dimensions: climate change mitigation, economic diversification (including a discussion on food security) and just transition. The main results show the impact of a hypothetical 50% reduction in the volume of rural credit available under Plano Safra on various outcomes. In other words, the main results show how many variables such as the value of agricultural production could change if Plano Safra were reduced by half.¹⁶ Furthermore, appendix A also presents the coefficients of the econometric models, which indicate the average impact of a 10% increase in rural credit on the same outcomes. Table 3 summarizes these indicators: the first indicator corresponds to the independent variable driving the econometric model, while the others represent dependent variables affected by rural credit.

Table 3. Summary of indicators

Type of indicator	Description	Source
Total credit	Total amount in USD of credit granted. This information is also disaggregated by type of credit programme (e.g. the family farm strengthening programme, PRONAF, the Low-Carbon Agriculture Programme (ABC/RenovAgro) and others).	SICOR (2013–2024) and RECOR (2001–2012)
Production value	Total amount of crops produced in USD by the municipality, also calculated by crop (soybeans, rice, beans, corn, wheat, cassava).	PAM
Productivity	Total production value divided by the area used for agricultural production, also calculated by crop (soybeans, rice, beans, corn, wheat, cassava).	PAM
Land use area	Total area of different land uses such as forested area, pasture area, temporary crops, perennial crops area, also as available by crop (soybeans, sugarcane, rice, cotton).	MapBiomass
GHG emissions	Total municipality GHG emissions in tonnes of carbon dioxide equivalent (tCO ₂ e). The variable exists also by Intergovernmental Panel on Climate Change (IPCC) sector (mainly agriculture, energy and land use change).	SEEG
Production value from family agriculture	Total amount of USD received for production in family agricultural households. This serves as a proxy of households’ income, especially for family farms.	Agricultural Census

¹⁶ The 50% figure was chosen arbitrarily to represent a counterfactual scenario in which Plano Safra would continue to exist, at a much smaller scale. Thus, the estimate presents a more intuitive picture of the policy’s relevance.

Pesticide use	Number of agricultural households using pesticides by municipality.
Organic agriculture	Number of agricultural households with organic agriculture by municipality.
No-till plantation	Number of agricultural households with no-till plantation by municipality.

Note: the list of indicators does not exactly represent the list of variables, but rather summarizes specific groups of variables that aim to answer questions related to climate mitigation, economic diversification and the just transition.

A. Climate change mitigation

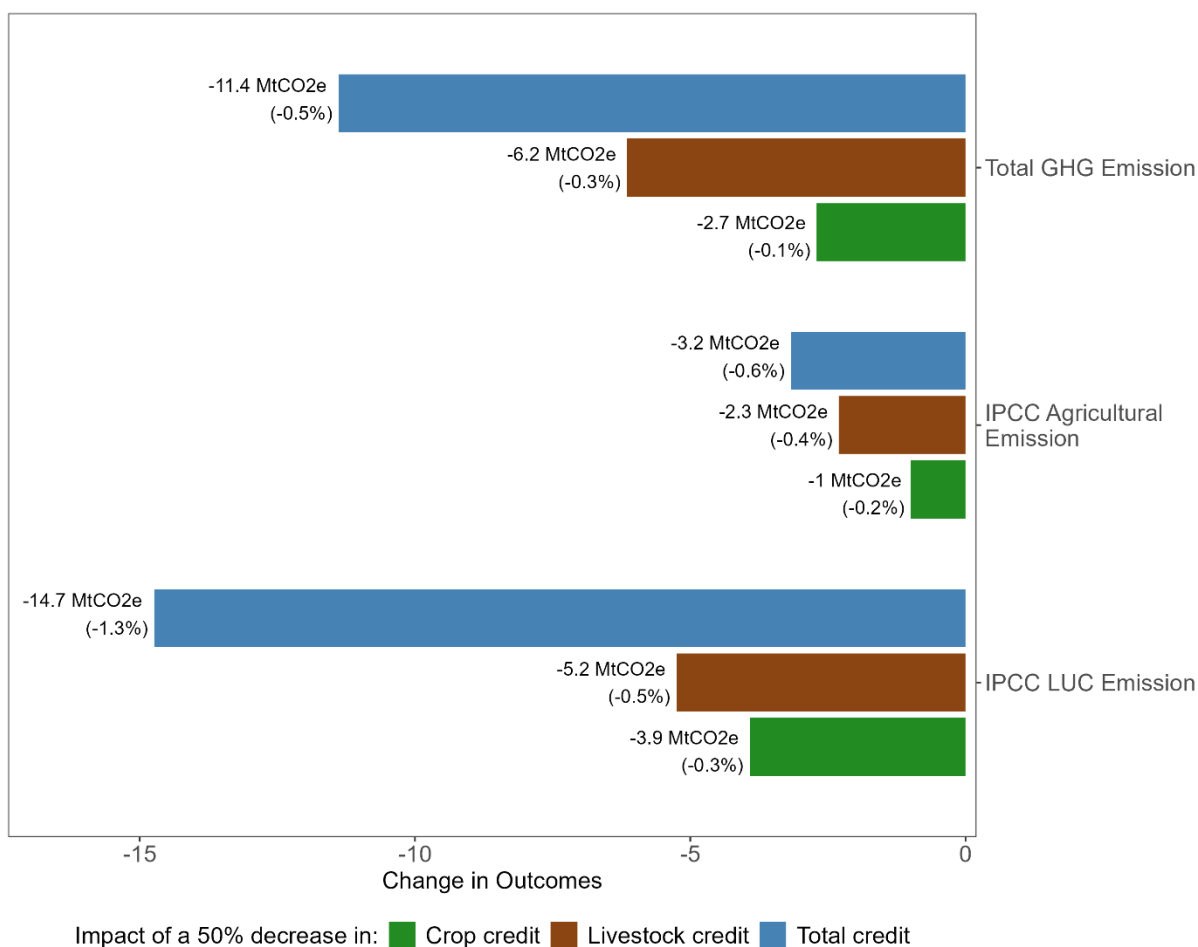
As discussed, the main goal of Plano Safra is to support agricultural production in Brazil. However, while the government has been progressively raising its environmental targets for the agriculture sector, incentives for sustainable agricultural production remain relatively limited.

In such context, this section analyses the relationship between rural credit and variables linked to climate mitigation. More specifically, the impacts of the Brazilian rural credit policy under Plano Safra on climate mitigation are assessed using the following indicators:

- (i) municipal total GHG emissions;
- (ii) municipal GHG emissions from LULUCF;
- (iii) municipal GHG emissions from agriculture;
- (iv) municipal change in forest cover.

The estimated coefficients (figure A1) suggest that rural credit is associated with an increase in GHG emissions, whether in total emission values or in subsectors, such as agricultural production and LUC. More specifically, a 10% increase in rural credit leads to a 0.076% increase in GHG emissions, and similarly a 10% decrease in rural credit leads to a 0.076% decrease in GHG emissions. To illustrate the relevance of Plano Safra in terms of its relationship with GHG emissions, figure 4 shows the impact of a 50% reduction in credit volume of Plano Safra on GHG emissions—estimated around USD 19 billion—based on the average level of Plano Safra between 2013 and 2024. A reduction of Plano Safra of this scale would lead to a decrease in GHG emissions of 14.7 MtCO_{2e} and 3.2 MtCO_{2e} in the LUC and agricultural production sectors respectively. The total effect on GHG emissions is slightly lower due to indirect effects in other emitting sectors, such as energy.

Figure 4. Annual effect of a 50% reduction in rural credit on GHG emissions



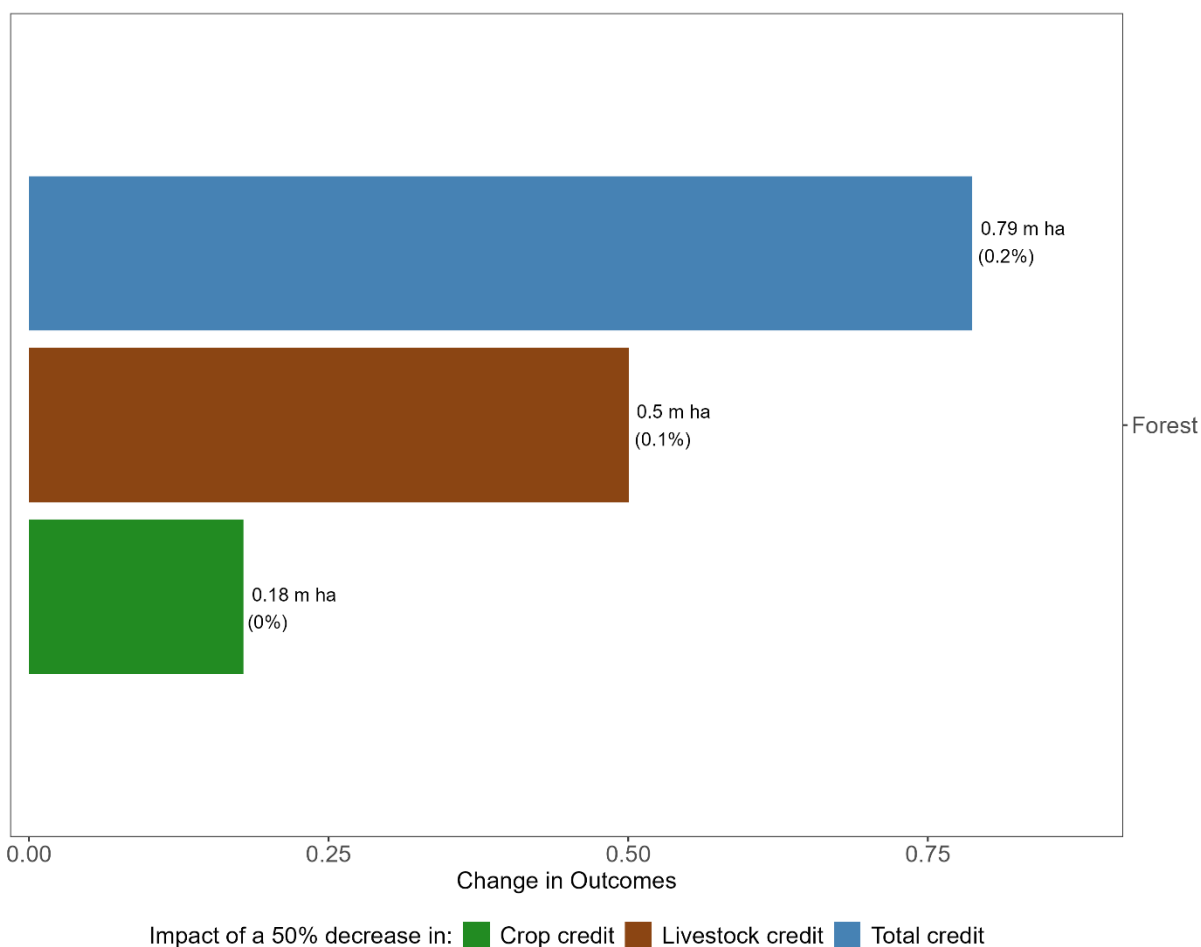
Source: Authors' elaboration based on SEEG (2024) and BCB (2025a).

Notes: These results were estimated using the coefficients in figure A1, with reference to the average annual values of GHG emissions and rural credit from 2013 to 2024.

By examining the activities more closely, it is clear that credit to livestock has a greater impact on GHG emissions and deforestation than credit to crop production. This is not surprising as 75% of agricultural emissions are from cattle raising, which is also the main cause of deforestation in Brazil (SEEG, 2024).

The results of rural credit on GHG emissions in the LUC sector are especially linked to the deforestation in frontier areas - that is, deforestation occurring at the frontier between agricultural expansion and large areas of forest and natural vegetation. Figure 5 displays the estimated impact of a 50% decrease in Plano Safra on rural credit and forest cover – based on the estimated coefficients in table A1, which shows that a 10% increase/decrease in rural credit is associated with a 0.022% decrease/increase in forest cover. In this sense, a reduction of this scale in rural credit would result in a 0.8 million hectare increase in forest area (due to avoided deforestation). Again, a proportionally greater effect would be observed if this reduction were in livestock credit.

Figure 5. Annual effect of a 50% cut in rural credit on forest area



Source: Authors' elaboration based on MapBiomias (2025) and BCB (2025a).

Notes: These results were estimated using the coefficients in figure A1, with reference to the average forest cover and rural credit from 2013 to 2024.

B. Economic diversification

Another important dimension for the assessment of Plano Safra is economic diversification. In this regard, the report considers the association between Plano Safra and:

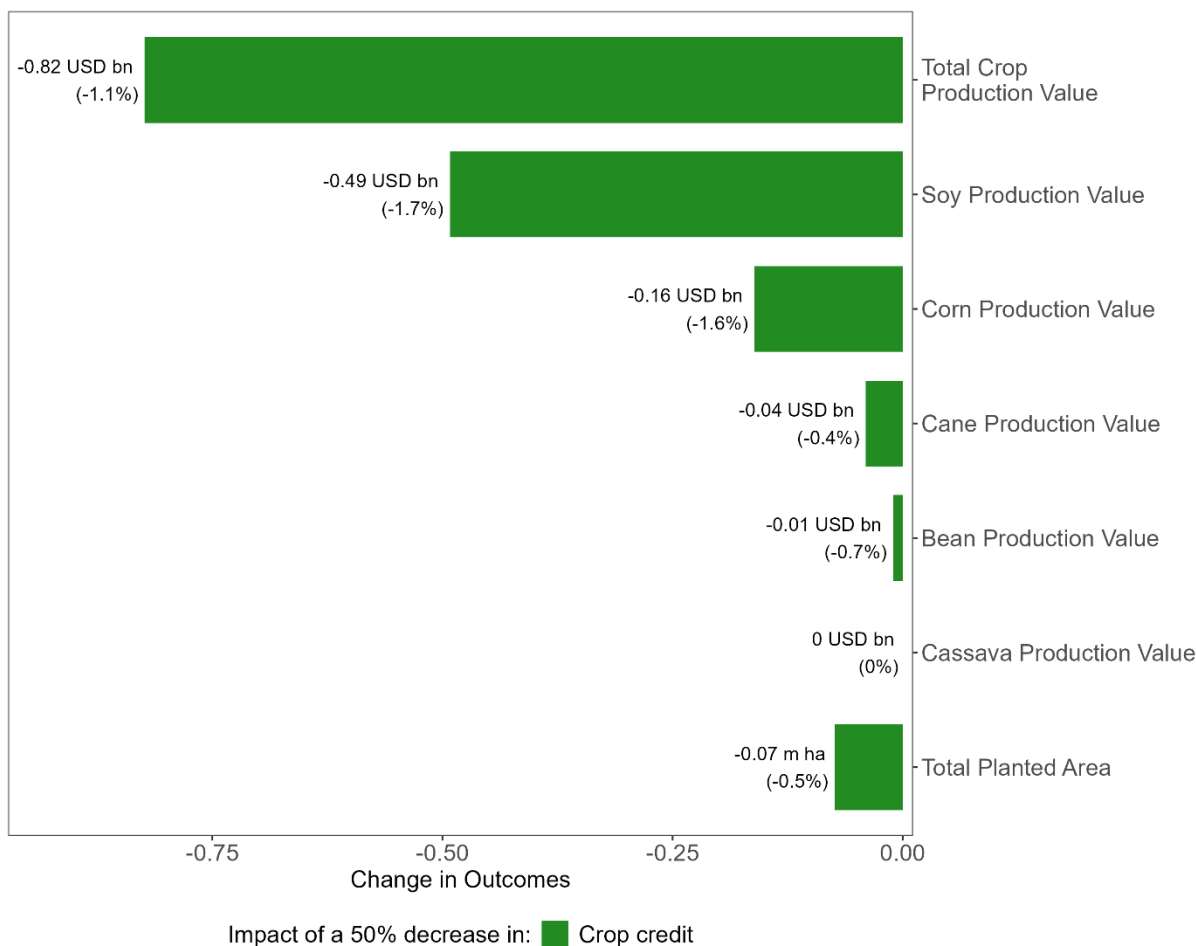
- (i) agricultural production;
- (ii) agricultural productivity;
- (iii) land use change;
- (iv) agricultural practices.

Agricultural production indicators capture total crop output, which can also be broken down by specific crops. Similarly, agricultural productivity indicators show the output per hectare, both in terms of monetary value and physical quantity. LUC reflects shifts in the allocation of land across different agricultural uses. Understanding the effects of Plano Safra on these indicators is crucial to determine whether the policy promotes diversification or leads to a greater concentration of activities within the agriculture sector. Finally, agricultural practices consider the adoption of various techniques and management strategies, providing additional insights into how production is evolving in terms of sustainability and diversification. Each of these areas is explored in detail in this section to assess the broader impact of Plano Safra on economic diversification.

The regression coefficients (figure A2) show an important association between rural credit and crop production value: a 10% increase/decrease in rural credit is linked to a 0.16% increase/decrease in crop

production value, mainly driven by soy and corn. These crops are more likely to be associated with a business production model. On the other hand, the production value of crops associated with family farming is much less sensitive to changes in the amount of rural credit available.¹⁷ Figure 6 uses these coefficients to estimate the potential losses in crop production if the credit available through Plano Safra was reduced by half. The results suggest a total loss of nearly USD 0.8 billion, equivalent to about 1.1% of average annual crop production between 2013 and 2024. The impact would be even more pronounced for soybean production, with estimated losses reaching USD 0.5 billion (or 1.7%).

Figure 6. Annual effect of a 50% cut in rural credit on crop production



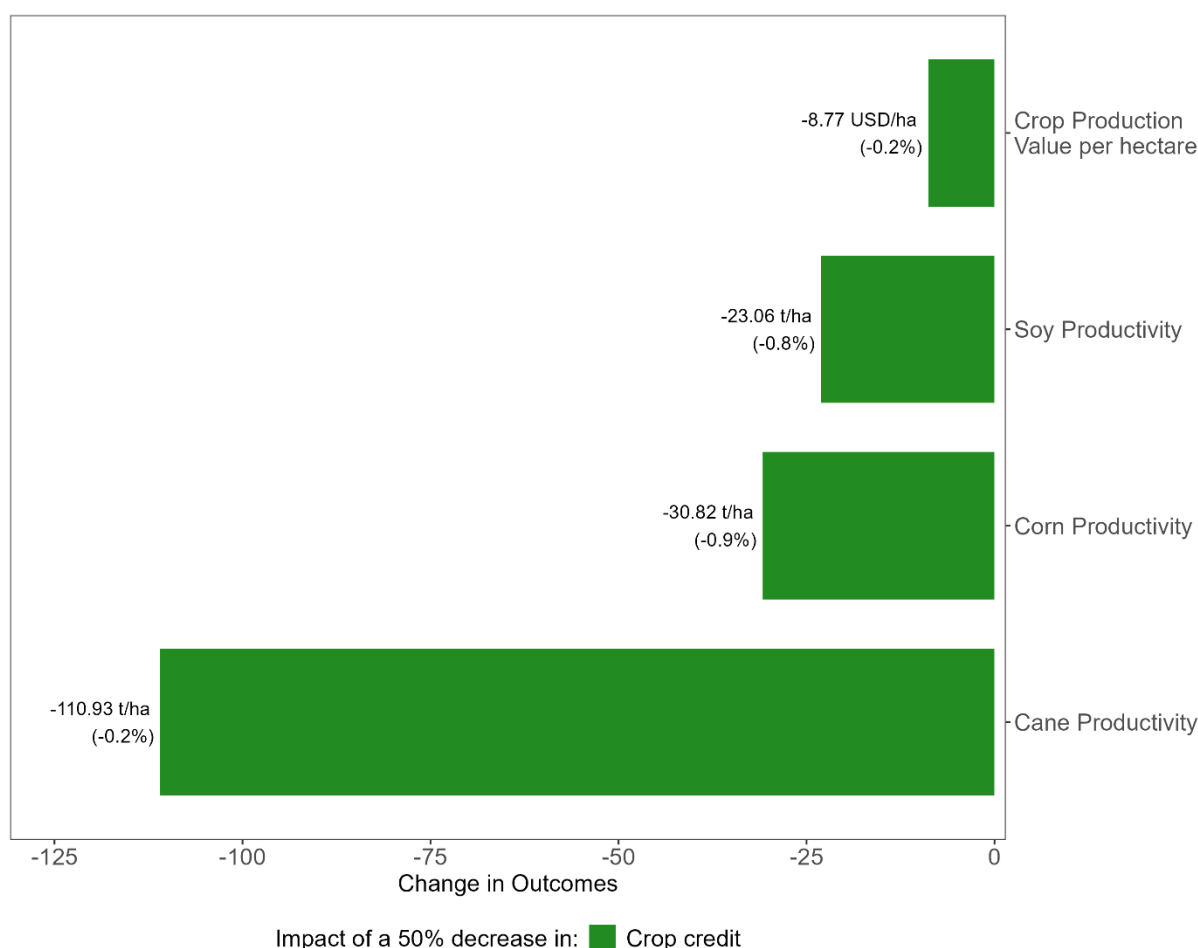
Source: Authors' elaboration based on PAM and BCB (2025a).

Notes: These results were estimated using the coefficients in figure A2, with reference to the average crop outputs and rural credit from 2013 to 2024.

As regards the effects on productivity, coefficients in figure A1 show that rural credit is only weakly associated with productivity. These results shed light on how rural credit might have some problem in expanding food supply. In terms of the impact on average productivity, figure 7 shows how a 50% reduction in rural credit available through Plano Safra for crops would lower average productivity. In monetary terms, this reduction would decrease productivity by around USD 8.8 per hectare, representing only 0.2% of the average productivity over the period. In physical terms, the total effects would be larger for sugarcane; however, they would be more significant for soybean and corn, whose productivity would decline by approximately 1%.

¹⁷ Costa et al. (2023) document more acute impacts of droughts in family farming products in the semi-arid region of Brazil.

Figure 7. Annual effect of a 50% cut in rural credit on crop productivity



Source: Authors' elaboration based on PAM and BCB (2025a).

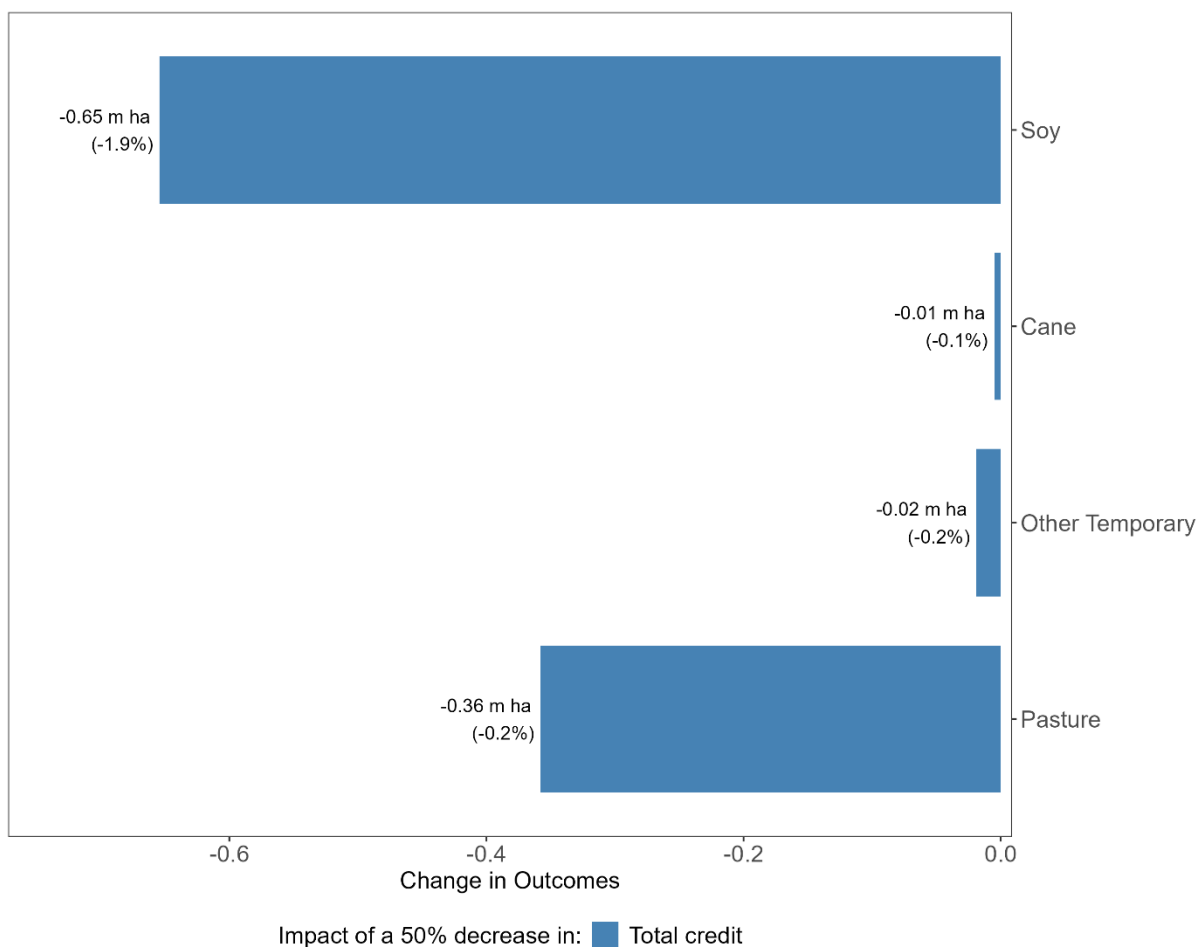
Notes: These results were estimated using the coefficients in figure A2, with reference to the average crop outputs and rural credit from 2013 to 2024.

Although it is not possible to carry out a deep analysis on food security using the data, the results show that, in the case of Brazil, rural credit is positively associated with production primarily destined for the export market (soybeans and meat, for example). Moreover, according to Sen (1981), food security should not be understood primarily as a problem of inadequate food production. Rather, it reflects the breakdown of people's ability to access food through work, trade or transfers. Thus, famine occurs not only when food is scarce, but when vulnerable groups cannot secure it.

An important conclusion is that rural credit has an effect on crop production, but this is rather linked to an increase in the extensive margin (more area devoted to crop production) than in the intensive margin (increase in productivity). Moreover, growing cash crops, like soy and corn, relies more heavily on support from Plano Safra. Hence, it appears that Plano Safra, as it is currently designed, is not conducive to economic diversification, but rather a concentration on plantation crops.

This conclusion is reinforced by the effects of Plano Safra on land use (coefficients in figure A3). Rural credit is more or less essentially associated with an increase or decrease in land allocated to soy production and pasture. Figure 8 illustrates the potential impact of a 50% reduction in credit available through Plano Safra on different agricultural land uses. The figure highlights that soybeans and pasture are particularly reliant on rural credit, with their areas projected to decrease by 0.65 and 0.36 million hectares respectively, under this scenario. Given that soy production and pasture occupy the largest area of agricultural land in Brazil, with 14.4% and 59.5% of the total farming area respectively (MapBiomass, 2025), the results confirm that the rural credit policy favours activities associated with economic concentration in the

Figure 8. Annual effect of a 50% cut in rural credit on agricultural land uses



Source: Authors' elaboration based on MapBiomas (2025) and BCB (2025a).

Notes: These results were estimated using the coefficients in figure A3, with reference to the average forest cover and rural credit from 2013 to 2024.

To better understand how Plano Safra may influence economic diversification, examining the impact on different agricultural production techniques may be very useful. Indicators such as the adoption of no-tillage, contour planting, organic farming and the use of agrochemicals provide insight into the ways rural credit shapes farming practices. By analyzing these indicators, it is possible to assess whether credit encourages the expansion of farming conventional, input-intensive crops or supports the adoption of more diverse and sustainable production systems. In this sense, production techniques serve as a lens to evaluate the broader effects of Plano Safra on both sustainability and the potential for economic diversification within the agriculture sector.

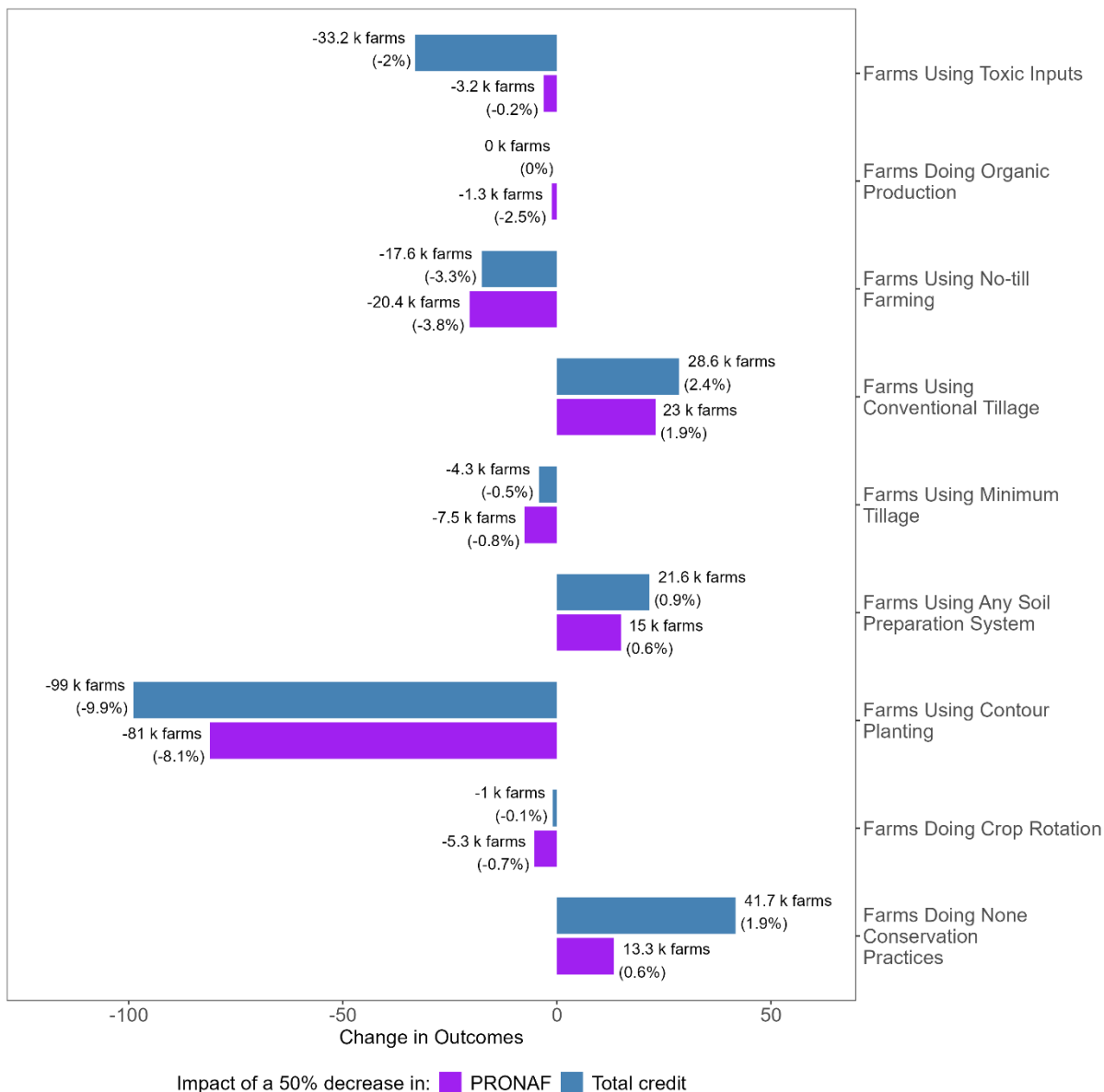
The coefficients of the regressions (figure A4) shows that there is a strong relationship between rural credit (both total credit and credit allocated to family farming) and no-till farming. This is related to the fact that no-tillage is common in soybean production, especially in the Brazilian savannah (the *Cerrado* biome).¹⁸ Total rural credit is also positively associated with the use of toxic herbicides and pesticides – practices associated with conventional crops such as soybeans, corn and sugarcane (Reyna et al., 2020).¹⁹ Figure 9 indicates that a 50% reduction in Plano Safra would be associated with a decrease of about 33,000 farms using toxic inputs (a 2% decrease) and 18,000 farms practising no-tillage (a 3.3% decline).

¹⁸ Fuentes-Llanillo et al. (2021) discuss the importance of no-tillage practices to permit the expansion of soybean crop farming to new areas in Brazil.

¹⁹ Dias et al. (2023) document an increase of 5% in infant mortality between 2000 and 2010 for populations living in municipalities located downstream from locations where glyphosate was used.

Alongside the positive association of Plano Safra with such practices, the coefficients in figure A4 indicate there is a positive relationship between (i) family farming credit (PRONAF) and the number of farms with organic production and (ii) rural credit and conservation practices, such as contour planting. Figure 9 shows that a 50% reduction in PRONAF would result in a decline of about 2.5% of farms engaged in organic production (around 1,300 farms), while the same proportional cut in the overall Plano Safra would reduce the number of farms practicing contour planting – a key conservation technique – by approximately 99,000 (10%). This result provides a counterexample to the previous findings and shows that rural credit can also contribute to the adoption of sustainable practices, which may indirectly facilitate the implementation of new cropping systems.

Figure 9. Effect of a 50% cut in rural credit on farm production techniques



Source: Authors' elaboration based on 2006 and 2017 Agricultural Census, BCB (2025b,c).

Notes: These results were estimated using the coefficients in figure A4, with reference to the average share of farms under each production technique and rural credit of 2006 to 2017 (Agricultural Census years).

On one hand, Plano Safra encourages sustainable practices, such as organic production, reducing toxic inputs, and soil conservation. These measures may indirectly suggest a degree of economic diversification by enabling new cropping systems compatible with these agricultural practices. On the other hand, despite the efforts to stimulate sustainable practices and the substantial amount of credit devoted to family farming (nearly

18% of the total granted), the results indicate that Plano Safra still tends to foster economic concentration rather than diversification, relying on production expansion through land rather than intensification and favouring conventional crops such as soybeans and pasture.

C. Just transition

Another key dimension for assessing Plano Safra is its potential contribution to a just transition in the agriculture sector. In this regard, the analysis considers the relationship between the *Plano Safra* and:

- (i) farm size groups;
- (ii) family farming production;
- (iii) the share of family establishments.

Indicators related to farm size groups provide insight into how credit may contribute to land concentration among small, medium and large farms. Family farming production reflects the output of smallholder farms, underscoring the importance of targeted credit lines such as PRONAF in sustaining these producers. Finally, the share of family farming establishments captures how widespread family-based production is within the sector, helping to assess the extent to which Plano Safra can encourage and support this production model. Examining these indicators makes it possible to evaluate whether Plano Safra contributes to a transition that is both economically and socially just, as explored in detail in this section.

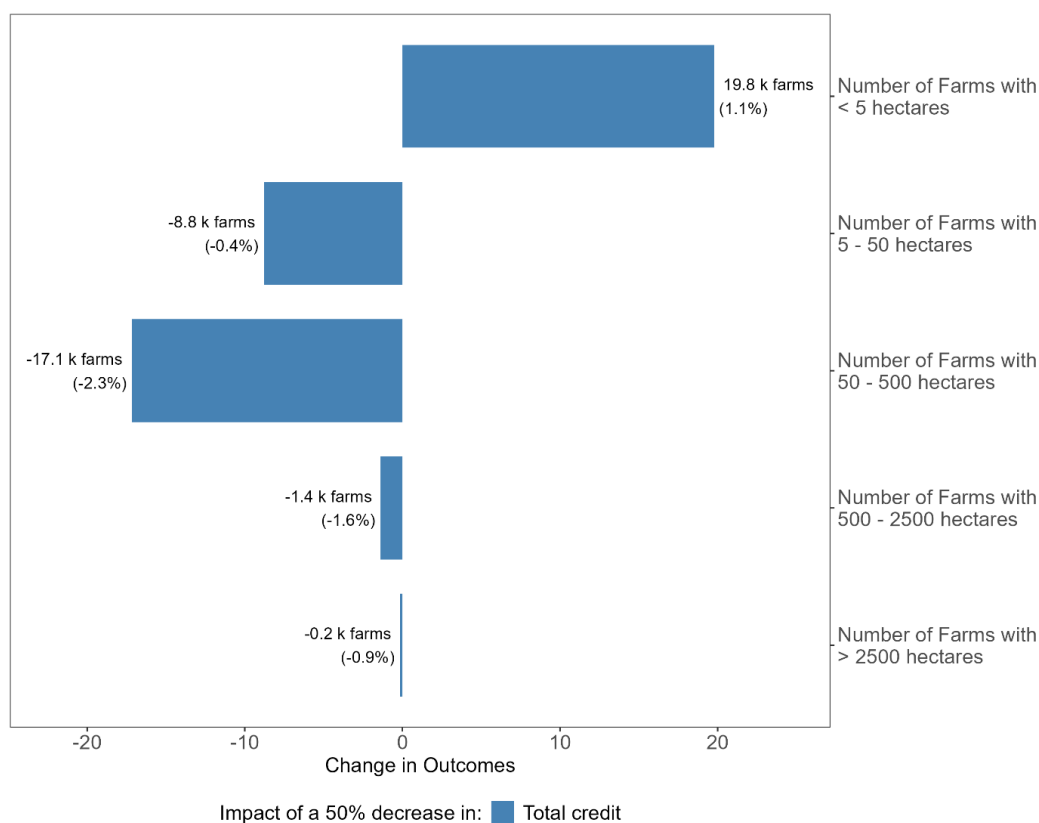
Descriptive statistics show that Plano Safra's dedicated budget for family farming (PRONAF) constitutes nearly 20% of total rural credit. In recent years (2023–2024), the annual implicit subsidies (i.e. the difference between the interest rates of the programme and those on the market) were on average USD 4.2 billion. Large-scale producers received 38% (or USD 1.4 billion) of the subsidies, while small landholders received USD 1.5 billion (40%), and medium landholders received the remaining amount. In aggregate terms, small farms benefit more from rural credit, as they receive 19% of total credit but account for 40% of the total subsidy, equivalent to approximately 11.4% of the contracted credit value. In contrast, large landholders receive only 4.4% of the subsidy relative to their contracted amount. However, the average subsidy per contract is substantially higher for large landholders (USD 10,300) than for small farms (USD 842), which may end up indicating a greater incentive for large landowners.

This feature of the rural credit programme translates into a positive association between Plano Safra and the number of large farms. From the coefficients in figure A5, figure 10 shows the effects of a 50% cut in rural credit under Plano Safra on the increase or decrease in the number of farms by size groups. With this level of reduction, there would be an increase of 46,000 very small properties (less than 5 hectares), and reductions in other property groups, mainly 39,000 fewer properties between 50 and 500 hectares and 3,200 properties between 500 and 2,500 hectares. Although larger properties may indicate some resilience among landowners, this is not so clear in the Brazilian context inverse relationship between farm size and productivity²⁰, while others show that land inequality tends to increase deforestation.²¹ In this sense, a future improvement in Plano Safra would be to carefully design it to avoid the promotion of land concentration and its negatives externalities.

²⁰ Assunção, J. J., and Ghatak, M. (2003). Can unobserved heterogeneity in farmer ability explain the inverse relationship between farm size and productivity. *Economics Letters*, 80(2), 189-194.

²¹ Sant'Anna, A. A. (2017). Land inequality and deforestation in the Brazilian Amazon. *Environment and Development Economics*, 22(1), 1-25.

Figure 10. Effect of a 50% cut in rural credit on share of farm sizes

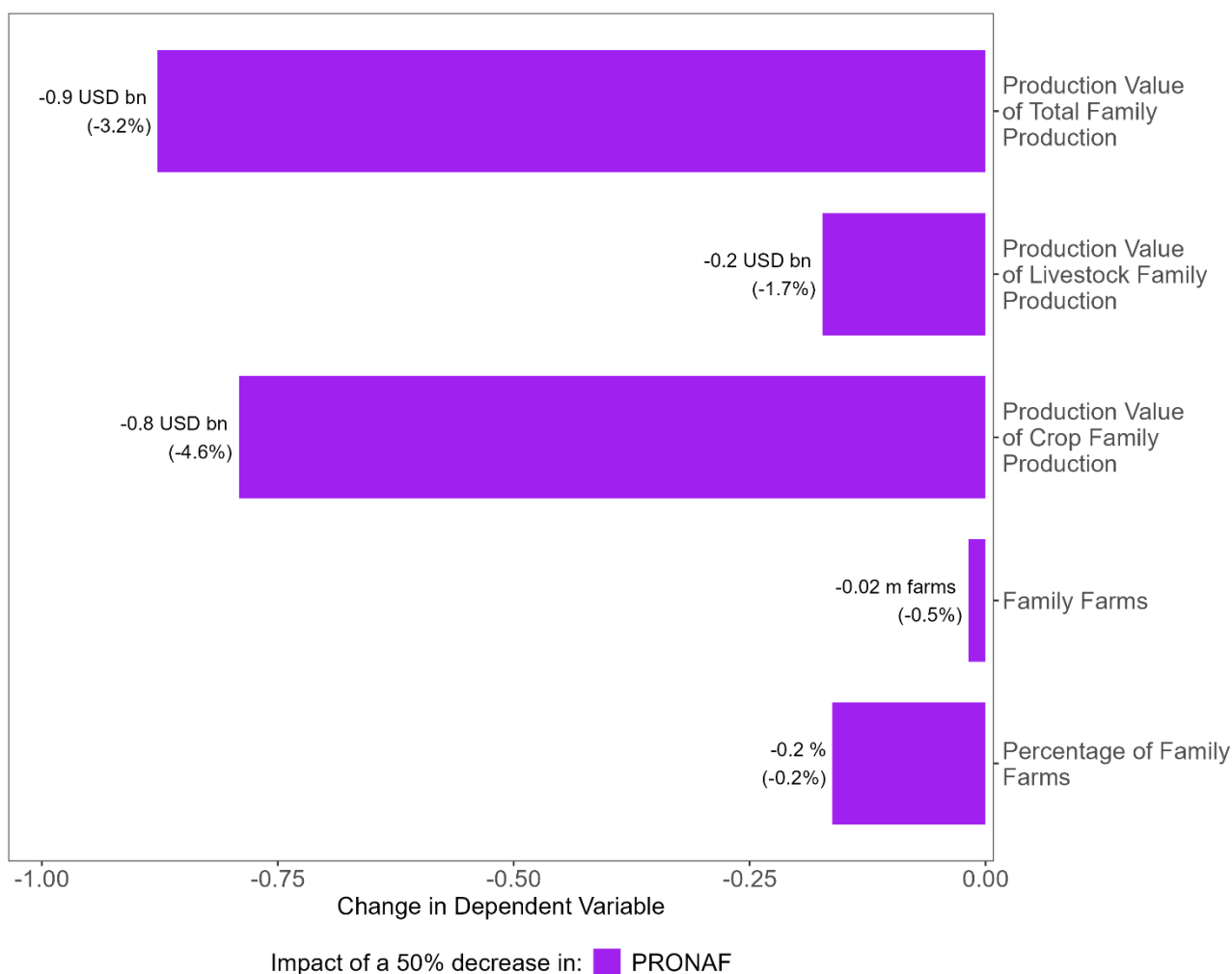


Source: Authors' elaboration based on 2006 and 2017 Agricultural Census, BCB (2025b,c).

Notes: These results were estimated using the coefficients in figure A5, with reference to the average share of farms under each production technique and rural credit of 2006 to 2017 (Agricultural Census years).

Despite the possible effect of rural credit on land concentration, a specific programme (PRONAF) is dedicated to family farming. When analysing the effects of this programme on family farming indicators, such as agricultural production, productivity and the number and share of family farms, the coefficients (figure A6) are greater than those recorded for the overall agriculture sector. Using these coefficients, figure 11 shows the effect of a 50% decrease in PRONAF on family production, both for crops and livestock. In this scenario, there would be an annual reduction of around USD 0.9 billion in family agricultural production (around 3.2% of production for the period), with the effect being worse for crop production, reaching a loss of 0.8 billion (4.6%) per year. A 50% reduction in PRONAF funding would also lead to roughly 20,000 fewer family farms, representing about 0.5% of the total.

Figure 11. Effect of a 50% cut in rural credit on family production and share



Source: Authors' elaboration based on 2006 and 2017 Agricultural Census, BCB (2025b,c).

Notes: These results were estimated using the coefficients in figure A6, with reference to the average share of farms under each production technique and rural credit of 2006 to 2017 (Agricultural Census years).

A comparison of the estimated coefficients in figure 6 and figure 11 shows that family farms rely more on rural credit than large scale commercial farms— or that the PRONAF credit is more effective in enhancing total output and productivity than overall credit. A 50% reduction in Plano Safra credit would lead to a loss of about USD 0.8 billion in crop production value (1.1% of the sector's average), whereas the same proportional cut in PRONAF would result in losses of a similar magnitude – around USD 0.9 billion per year – but equivalent to 3.2% of family farming production. The contrast is even clearer when looking only at crop production: soybean losses alone under Plano Safra would reach USD 0.5 billion (about 1.7% of soybean output), while family farming crop production would fall by USD 0.8 billion, or 4.6% of its average.

This result corroborates the literature findings (Assunção and Souza, 2020; Assunção et al., 2020) on the significance of credit constraints on agricultural production and investment. Therefore, the expansion of rural credit to family farming by relaxing credit constraints leads to agricultural gains, especially related to the intensive margin, with increases in productivity.

III. Lessons learned and recommendations

A. Lessons on the use of econometrics in policy making

The econometric analysis of Plano Safra shows the importance of having transparent, disaggregated and reliable data, how to provide robust answers to research questions, and limitations and necessary assumptions to determine policies' causal relationship. These lessons learned will be discussed in the sections below.

B. Transparent and disaggregated data for insightful policy analysis

Data collection is a fundamental step in any econometric analysis, as it presents a series of challenges that can significantly impact the validity of the study's conclusions. In the context of Plano Safra, these challenges are especially pronounced due to the complexity and diversity of the data involved.

A key challenge is ensuring the availability and accessibility of high-quality data. For Plano Safra, data had to be gathered from various sources, including governmental databases, agricultural surveys, financial institutions providing credit and the BCB. Access to these data sources often involves navigating bureaucratic procedures and securing the necessary permissions, which can be time-consuming and limit the timeliness of the analysis.

Fortunately, the microdata on credit from the BCB are public and available for use. This provides information on rural credit contracts from all Brazilian commercial banks. Other datasets used in this study are disaggregated at the municipal level and have to be aggregated for the final credit database, but the credit contract dataset allows researchers to work with details that would not be possible with only municipal data, for example, identifying the credit allocated to each programme (PRONAF, *Programa ABC* etc.), and some characteristics of the borrower, such as gender.

Having access to detailed datasets allows segmented analyses to be conducted that provide insights beyond aggregate figures. For instance, by examining the credit data disaggregated by gender, line of credit or economic activity (such as agriculture versus livestock), it is possible to identify patterns and disparities that might be obscured in more aggregated datasets. This level of detail is crucial to elaborate policy recommendations to make the distribution of financial resources more equitable and to enhance the programme effectiveness.

The importance of transparent and disaggregated data cannot be understated. Transparent data guarantees that researchers and policymakers can examine the intricacies of credit distribution with precision. In the case of Plano Safra, credit trends were analysed at the municipal level, and this granularity was important for comparing the credit database with other datasets that are also available at the municipal level.

The capacity to track where credit is flowing, whether towards small-scale farmers or to specific farming products or practices, sheds light on the effectiveness of policy measures designed to support economic growth and development. It also enables a more nuanced evaluation of how well financial products and services align with policy goals and the needs of the beneficiaries.

A very important issue is the credibility of the data used. In this regard, the datasets for the report originate from the BCB and the IBGE, the institute responsible for official national statistics. Although datasets from private companies are often quite useful, they were not used in this case as they always raise questions about reliability and are linked to their own interests.

Ultimately, the availability of transparent and disaggregated data fosters accountability and trust, not only in financial systems but also in the public institutions that oversee them. It empowers researchers, practitioners and policymakers to make data-driven decisions that can lead to more equitable and efficient outcomes. In essence, such data serve as the bedrock for informed policy making and sustainable economic development.

C. Importance of econometrics in policy evaluation and extent to which it can be used

Econometrics plays a pivotal role in the evaluation of public policies as it offers a structured, analytical approach that is both quantitative and data driven. This discipline provides policymakers and researchers with

the tools necessary to analyse the effects of policy interventions in a rigorous way, allowing for informed decisions that can significantly impact societal welfare. At its core, econometrics bridges the gap between economic theory and real-world data.

The quantification of the impacts is essential to assess the cost-effectiveness of a policy. For example, by applying econometric techniques, analysts can estimate how much additional agricultural output can be attributed to a certain increase in credit provided to farmers under Plano Safra. This enables policymakers to make more precise cost-benefit analyses and allocate resources more efficiently.

Another crucial aspect of econometrics is the capacity to handle and analyse complex datasets. Given the increasing availability of data from various sources (administrative data, survey data or big data), econometric methods allow researchers to integrate and analyse large volumes of information. This capability is invaluable when evaluating programmes like Plano Safra, where data on credit distribution, agricultural yields and socio-economic indicators need to be analysed simultaneously to provide comprehensive insights.

It is also important to assess how well the method can address the specific research questions being investigated. The analysis of Plano Safra, and that of other response measures, and its relationship with just transition and diversification indicators, can be conducted through econometrics or examining temporal trends in the datasets. For instance, the proportion of women or small family farmers who have access to rural credit is better analysed by inspecting the trends in these numbers rather than through econometric analyses. On the other hand, the different impact of Plano Safra on programmes aimed at family farmers compared to large commercial entities is a question that can only be addressed through econometric analysis.

Another example is the investigation of Plano Safra's impact on the income of rural households. While the credit contract databases are disaggregated, the databases on rural households are not. Therefore, it was not possible to directly investigate the effect of Plano Safra on rural households' income. However, it was possible to investigate its effect on production indicators by property size, using municipal data from the agricultural census. The disadvantage is that these data are not provided on an annual basis and are only available for 2006 and 2017. Nevertheless, they provide a good proxy for rural household income in that ~~time~~ period.

D. Causal effects: dealing with methodological limitations

One of the most significant advantages of using econometrics in the field of policymaking is its ability to discern causality from correlation. In public policy, it is not enough to know that two variables move together; policymakers need to understand whether one causes changes in another. This causality is critical, for instance, when assessing the impact of Plano Safra on agricultural productivity or when determining its effects on socio-economic outcomes in rural areas.

Methodological limitations are an inherent aspect of econometric analysis and effectively addressing them is crucial for drawing reliable insights from the data. In the context of Plano Safra evaluation, several methodological challenges emerged, requiring a careful approach to model specification, estimation and interpretation.

One of the key limitations is the potential variable bias, for instance, when a model fails to include one or more relevant variables that influences the results. In the case of Plano Safra, factors such as regional climate variations, differences in local infrastructure or unobserved farmer characteristics might not be fully captured within the model. To mitigate this, fixed effects models were used to help control unobserved variables and isolate the causal effect of Plano Safra on other indicators.

The validity of the approach depends on several hypotheses. The most important and challenging one is that unobserved characteristics that vary over time (e.g. the level of activity, the price of inputs and the occurrence of climate disasters) cannot be correlated with the amount of rural credit granted under Plano Safra. To address this, some observable variables considered relevant were included in the model, such as population, average temperature and precipitation. However, if there are unobserved variables that change over time and are correlated with Plano Safra, it becomes difficult to isolate its effect from these other factors. Thus, the key assumption is that unobserved municipal characteristics that vary over time do not influence the allocation of rural credit.

In summary, policymakers and other stakeholders can and should use econometrics to measure the impact of response measures on indicators of interest, but they need to be cautious about data quality, reliability and availability. They should also consider what type of questions econometrics can effectively answer and where other analyses might be more appropriate, as well as understand the assumptions and limitations of econometrics to provide answers on causal relationships. Other countries and programmes can benefit from this study as it illustrates how reliable and disaggregated administrative data can help assess the impact of response measures on indicators of interest, evaluate which questions are best addressed with econometric analysis rather than observing data trends, and recognize and clearly articulate the methodological limitations and assumptions underlying econometric analysis.

E. Key findings from the studies

The following key findings summarize the main quantitative and qualitative results from the assessment of Plano Safra's implementation. These findings highlight critical aspects of credit allocation, the effectiveness of sustainability instruments, recent enhancements to environmental safeguards, and remaining gaps in policy outcomes.

Together, these insights provide an evidence base for understanding the impacts of rural credit policies on agricultural production, equity, and environmental sustainability. They also offer important lessons for the design and implementation of future financial support mechanisms in the agriculture sector.

1. Credit allocation and subsidies

- o Approximately USD 70 billion in credit concessions were provided in 2024.
- o Implicit credit subsidies (difference between the interest rates granted through the programme and those on the market) were on average USD 4.2 billion per year in 2023–2024.
- o In 2024 large landholders received 38.5% of the total subsidy under Plano Safra, while family farmers received only 17% of credit.
- o The average subsidy per contract for large landholders was USD 10,300 and USD 842 for small farmers.

2. Sustainability instruments

- o Low-Carbon Agriculture Programme (*ABC/RenovAgro*) finances climate-resilient practices (e.g. agroforestry, no-tillage, integrated systems, recovery of degraded pastures) but accounts for less than 4% of total credit, with current levels at around USD 2 billion.

3. Environmental safeguards (2023–2025 enhancements)

- o Lower interest rates were introduced for properties with a validated Environmental Rural Registry (CAR).
- o Properties with environmental embargoes or post-2019 deforestation activities were excluded from credit eligibility (CMN Resolution 5193/2024 effective from 2026).
- o Preferential interest rates were introduced for agroecological and organic practices under PRONAF (0.5% annual interest rate).²²

4. Policy effectiveness and enforcement gaps

- o Econometric analysis (fixed-effects model by year and municipality) shows positive effects on productivity and production value.

²² See <https://www.gov.br/mda/pt-br/aceso-a-informacao/acoes-e-programas/programas-projetos-acoes-obras-e-atividades/plano-safra-da-agricultura-familiar/documentos/resumo-linhas-plano-safra-pronaf-2025-2026.pdf>

- o No significant shift towards deforestation-free production or GHG emission reductions has been observed at scale.

F. Lessons learned from Brazil's Plano Safra

Development policies based on financial instruments, such as rural credit programmes, can play a significant role in advancing economic objectives, particularly by supporting production and investment. Drawing on the analysis of Brazil's Plano Safra, this study highlights how their broader impacts depend on how well social and environmental considerations are integrated alongside economic goals.

Designing such instruments offers an important opportunity to align economic growth with sustainability and equity objectives. Experience from the case study suggests that well-structured incentives can support more sustainable production patterns, enhance inclusiveness and contribute to climate goals. Strengthening the coherence and targeting of these incentives can further improve policy effectiveness and long-term outcomes.

The analysis also underscores the importance of ensuring that sustainability components are sufficiently scaled and embedded within broader policy frameworks. Targeted measures such as support for environmentally friendly practices or vulnerable groups can play a key role when they are effectively integrated into overall programme design.

In addition, aligning financial support with environmental and social criteria, alongside clear and transparent implementation mechanisms, can enhance accountability and help direct resources toward desired outcomes. This includes ensuring that incentives consistently encourage sustainable practices while reinforcing equitable access to support.

Overall, insights derived from the assessment of Brazil's Plano Safra illustrate that financial instruments in the agriculture sector can serve as powerful tools to advance multiple policy objectives simultaneously. Strengthening their design, implementation, and alignment with climate and development goals can enhance their contribution to sustainable development and just transitions.

The main lessons learned from the implementation of Plano Safra include:

1. **Ensuring that scaling of financial support aligns with sustainability objectives.** Expanding credit programme can drive agricultural growth while, when paired with strong environmental safeguards and sustainability criteria, effectively supporting climate and environmental outcomes.
2. **Ensuring equitable subsidy distribution.** Clear information on the allocation of subsidized credit enables decision makers to allocate resources more efficiently and strengthens accountability. Designing financial support mechanisms to ensure that subsidies reach a diverse range of producers, including small-scale and family farmers, can help to promote more inclusive, balanced and sustainable rural development.
3. **Strengthening and upholding social and environmental criteria.** Consistently linking incentives to inclusive practices and environmentally responsible production, together with robust monitoring and ensuring compliance with these criteria, helps to ensure that financial support mechanisms advance sustainability goals and prevent unintended negative impacts.
4. **Promoting equity and maximizing the impacts of positive incentives.** Implementing targeted support mechanisms ensures that financial programmes effectively reach small-scale and family which in turn fosters inclusivity and balanced rural development. Preferential rates and incentives for sustainable practices are most effective when combined with clear eligibility criteria, transparent monitoring and supportive mechanisms that encourage all producers to meet sustainability requirements.
5. **Ensuring policy coherence.** Aligning financial support policies with climate, environmental and development objectives enhance consistency, avoids contradictions and supports the achievement of national climate commitments.

6. **Building institutional capacity.** Supported by strong governance, strengthening institutional capacity is essential for upholding environmental safeguards, advancing climate mitigation and enabling a just transition through policy implementation.
7. **Advancing structural reform.** Effectively integrating sustainability into financial support policies requires not only positive incentives, but also clear standards, strong governance and transparent implementation to ensure environmentally responsible practices and continuous progress toward climate and development goals.
8. **Leveraging data, transparency, and robust monitoring for accountability.** Accessible, credible and transparent data, together with effective monitoring systems, are essential for evaluating policy effectiveness, ensuring accountability and supporting continuous improvement in financial support mechanisms

Building on the insights from this analysis, the experience of Brazil's Plano Safra highlights the importance of aligning rural credit policies with the principles of a just transition. This includes prioritizing sustainable agricultural practices, ensuring targeted support for family farming, and strengthening environmental criteria and compliance mechanisms so that public finance can simultaneously support productivity, resilience, and climate objectives. These considerations are particularly relevant for the design and implementation of current and future policy frameworks.

In conclusion, this study provides an important illustration of how financial support policies in agriculture can evolve from focusing primarily on production and export growth to supporting more balanced outcomes. Aligning economic, social and environmental objectives can enable policies to maximize agricultural productivity while also improving rural livelihoods and contributing to climate mitigation and adaptation.

G. Policy recommendations

A number of policy recommendations can be drawn from the results of this case study. They are intended to guide the design and implementation of agricultural financing mechanisms and programmes. They focus on aligning financial support with climate, sustainability and equity objectives, and on strengthening the effectiveness, accountability, and inclusivity of such programmes.

By addressing key areas such as targeting, monitoring, institutional capacity, and data transparency, these recommendations aim to support the transition toward more climate-compatible and resilient agricultural systems.

1. **Subsidies and financing support should be targeted to promote climate-compatible agricultural practices, including biodiversity conservation, organic production and regenerative approaches, across all scales of farming.** Provisions to support these include:
 - o Establishing quotas or differentiated interest rates to ensure that a minimum share of rural credit is directed toward climate-compatible agricultural practices or requiring a mandatory *ex ante* assessment of the potential economic, social and environmental impacts of these practices.
 - o Developing a monitoring and evaluation framework to assess the effectiveness of subsidies and credit distribution, prioritizing support for agricultural activities that align with sustainability and climate objectives. Indicators such as impacts on household income or contribution to deforestation can be included in the monitoring and evaluation framework.
 - o Strengthening environmental conditionalities by integrating robust monitoring systems, such as real-time deforestation alerts, into credit approval processes can help to ensure the credit is directed to activities that demonstrate legal compliance and sustainable land management, thereby advancing climate goals and promoting responsible agricultural practices.
 - o Increasing support to family and agroecological farming by expanding performance-based incentives for biodiversity conservation, organic production and regenerative practices.

- o Improving the definition of public targets linked to rural credit to enhance the effectiveness and accountability of the programmes.
2. **National institutional capacity and inter-agency coordination are vital to establish and implement monitoring and evaluation systems, ensuring the effectiveness of the targeted subsidies or financial mechanisms supporting climate-compatible agriculture practices.** Such capacity includes, among others, the capacity for assessments and analyses of economic, social and environmental impacts of different agricultural practices; the collection of data that can support such assessments and analyses; and in monitoring and evaluation of the implementation. Support from organizations or agencies with diverse expertise is necessary to build and enhance national institutional capacity.
 3. **Understanding their limitation and strengths, methodologies are powerful tools to assess and analyse the impacts of response measures and to evaluate their implementation.** The monitoring and evaluation of the implementation of response measures is necessary to ensure the achievement of their intended goals and to enhance the development and design of updated NDCs. Supporting and strengthening the capacity of Parties to undertake assessments and analyses is therefore vital.
 - o (Re)building and equipping national environmental and credit oversight bodies with environmental criteria to monitor compliance in the implementation of rural credit programmes.
 - o Improving the accessibility, transparency and integration of data for assessment and analysis, including by disclosing the spatial distribution of credit concessions, and link with deforestation data for accountability.

H. Conclusion

The study shows mixed results from the implementation of Plano Safra. While it has successfully mobilized substantial public resources to boost the agriculture sector, its contribution to climate goals and a just transition has been limited. The lessons learned from the study provide valuable insights for designing financial support mechanisms that align with sustainability equity and climate objectives, while also aiming for a diversified economy.

To inform ongoing and future policy frameworks, it is important to assess and analyse the effects of previous programmes, including the agricultural practices they supported. The study shows that robust data and rigorous analysis are vital for evaluating policy effectiveness and guiding improvements. While sound assumptions and proxy data can be useful, real and accessible data will provide more accurate results and strengthen accountability.

In summary, this study demonstrates that the assessment and analysis of past programme, using tools such as econometrics, play a critical role in supporting decision-making and effective implementation, ensuring that new initiatives build on evidence and experience to achieve balanced outcomes.

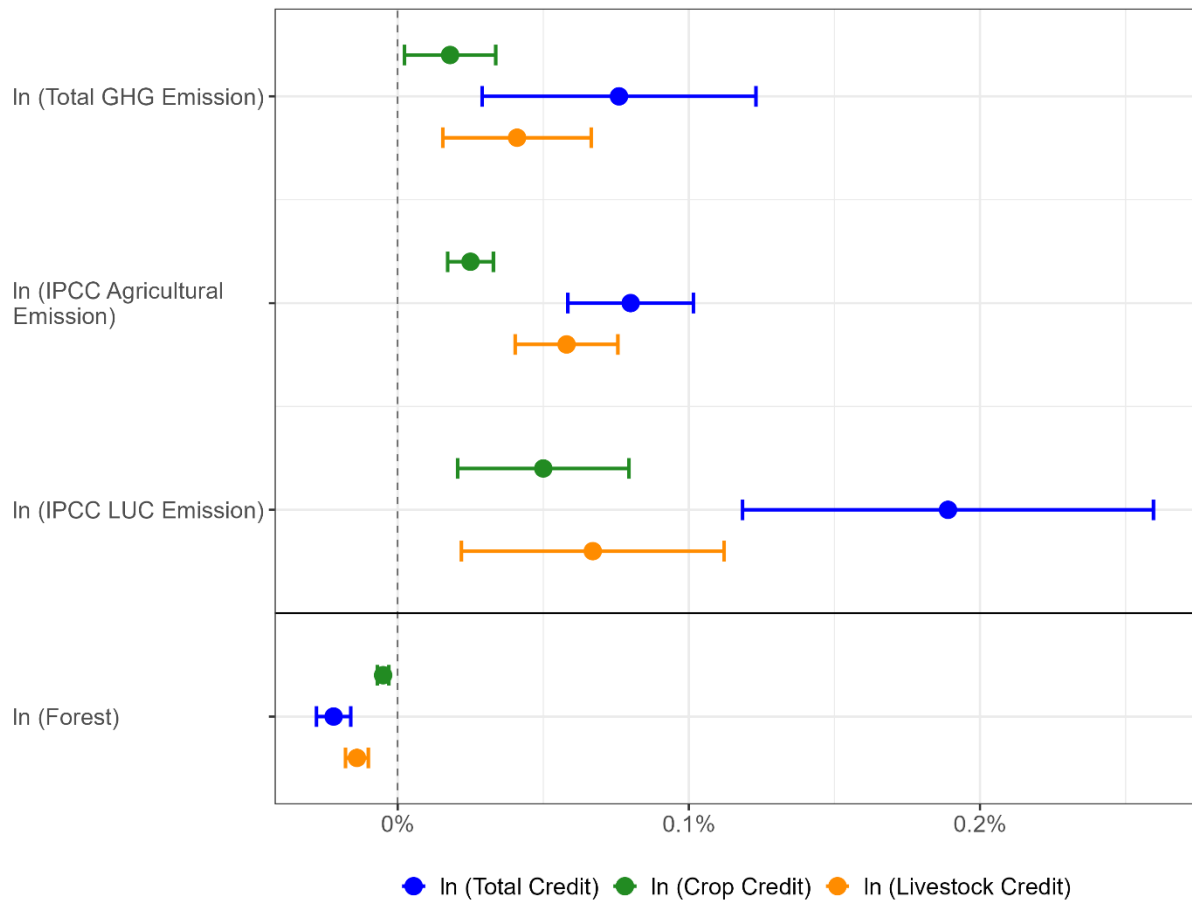
References

- Abadie, Alberto, Alexis Diamond, and Jens Hainmueller. (2010). "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program." *Journal of the American Statistical Association* 105 (490): 493–505.
- Abadie, A., and Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque Country. *American Economic Review*, 93(1), 113-132.
- Angrist, J. D., Imbens, G. W., & Rubin, D. B. (1996). Identification of causal effects using instrumental variables. *Journal of the American Statistical Association*, 91(434), 444-455.
- Angrist, J. D., and Pischke, J.-S. (2008). *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton University Press.
- Assunção, J., Gandour, C., Rocha, R., and Rocha, R. (2020). The effect of rural credit on deforestation: evidence from the Brazilian Amazon. *The Economic Journal*, 130(626), 290-330.
- Assunção, J., Gandour, C., Rocha, R., and Rocha, R. (2020). The effect of rural credit on deforestation: evidence from the Brazilian Amazon. *The Economic Journal*, 130(626), 290-330.
- Assuncao, J. J., and Ghatak, M. (2003). Can unobserved heterogeneity in farmer ability explain the inverse relationship between farm size and productivity. *Economics Letters*, 80(2), 189-194.
- Baltagi, B. H. (2021) *Econometric Analysis of Panel Data*. Springer Texts in Business and Economics.
- BCB (2025a). *SICOR - Matriz de Dados do Crédito Rural – Crédito Concedido, Visão por Município*. Accessed on 06/27/2025. Available at: <https://www.bcb.gov.br/estabilidadefinanceira/micrrural>
- BCB (2025b). *SICOR - Microdados do Crédito Rural e do Proagro (a partir de 2013)*. Accessed on 06/27/2025. Available at: <https://www.bcb.gov.br/estabilidadefinanceira/tabelas-credito-rural-proagro>
- BCB (2025c). *RECOR/PGRO - Microdados do Crédito Rural e do Proagro (1983 a 2012)*. Accessed on 06/27/2025. Available at: <https://www.bcb.gov.br/estabilidadefinanceira/tabelas-credito-rural-proagro>
- Card, D., and Krueger, A. B. (1994). Minimum wages and employment: A case study of the fast-food industry in New Jersey and Pennsylvania. *American Economic Review*, 84(4), 772-793.
- Costa, L., Sant'Anna, A. A., and Young, C. E. F. (2023). Barren lives: drought shocks and agricultural vulnerability in the Brazilian Semi-Arid. *Environment and Development Economics*, 28(6), 603-623.
- Cunningham, Scott (2021). *Causal Inference: The Mixtape*. Yale University Press.
- Dean, W. (1997). *With broadax and firebrand: the destruction of the Brazilian Atlantic Forest*. Univ of California Press.
- Dias, M., Rocha, R., and Soares, R. R. (2023). Down the river: Glyphosate use in agriculture and birth outcomes of surrounding populations. *Review of Economic Studies*, 90(6), 2943-2981.
- Fuentes-Llanillo, R., Telles, T. S., Junior, D. S., De Melo, T. R., Friedrich, T., and Kassam, A. (2021). Expansion of no-tillage practice in conservation agriculture in Brazil. *Soil and Tillage Research*, 208, 104877.
- Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., and Vermeersch, C. M. J. (2016). *Impact Evaluation in Practice* (2nd ed.). World Bank Publications.

- IBGE (2006). *Censo Agropecuário 2006*. Instituto Brasileiro de Geografia e Estatística, accessed on 06/27/2025. Available at: <https://sidra.ibge.gov.br/pesquisa/censo-agropecuario/censo-agropecuario-2006/segunda-apuracao>
- IBGE (2017). *Censo Agropecuário 2017*. Instituto Brasileiro de Geografia e Estatística, accessed on 06/27/2025. Available at: <https://sidra.ibge.gov.br/pesquisa/censo-agropecuario/censo-agropecuario-2017/resultados-definitivos>
- IBGE (2025). *Pesquisa Agrícola Municipal (PAM) - Table 5457*. Instituto Brasileiro de Geografia e Estatística, accessed on 06/27/2025. Available at: <https://sidra.ibge.gov.br/tabela/5457>
- Imbens, G., and Lemieux, T. (2007). Regression discontinuity designs: a guide to practice. NBER Working Paper Series, n. 13039.
- MapBiomass (2025). *Coverage statistics by biomes, states and municipalities*. MapBiomass Brasil Collection 9. Available at <https://doi.org/10.58053/MapBiomass/VEJDZC>
- Margulis, S. (2004). Causes of deforestation of the *Brazilian Amazon* (Vol. 22). World Bank Publications.
- Reyna, E. F., Braga, M. J., and Morais, G. A. de S. (2020). Impactos do uso de agrotóxicos sobre a eficiência técnica na agricultura brasileira. In J. E. R. Vieira Filho & J. G. Gasques (Orgs.), *Uma jornada pelos contrastes do Brasil: Cem anos do Censo Agropecuário* (pp. 287-310). Instituto de Pesquisa Econômica Aplicada (Ipea). Available at <https://repositorio.ipea.gov.br/server/api/core/bitstreams/4b3f032c-6ef2-4f17-b20e-a1589508d225/content>
- Sant'Anna, A. A., and Young, C. E. F. (2010). Direitos de propriedade, desmatamento e conflitos rurais na Amazônia. *Economia aplicada*, 14, 381-393.
- Sant'Anna, A. A. (2017). Land inequality and deforestation in the Brazilian Amazon. *Environment and Development Economics*, 22(1), 1-25.
- Sen, A. (1982). *Poverty and famines: an essay on entitlement and deprivation*. Oxford university press.
- SEEG (2024). *Greenhouse Gas Emissions and Removals Estimation System (V12)*. Observatório do Clima, accessed on 06/27/2025. Available at <https://plataforma.seeg.eco.br>
- Tiwari, A. K., Karn, N., Thakur, A., and Kumari, D. (2024). Soil Conservation and Restoration: Strategies to Combat Soil Erosion and Rehabilitate Degraded Lands. *A Comprehensive Exploration of Soil, Water, and Air Pollution in Agriculture*, 207.
- Ussami, K. A. (2022). *Rainforest conservation policy assessment: the case of the Atlantic Forest in Brazil* (Doctoral dissertation, Universidade de São Paulo).
- Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*. MIT Press.

Appendix A – Figures

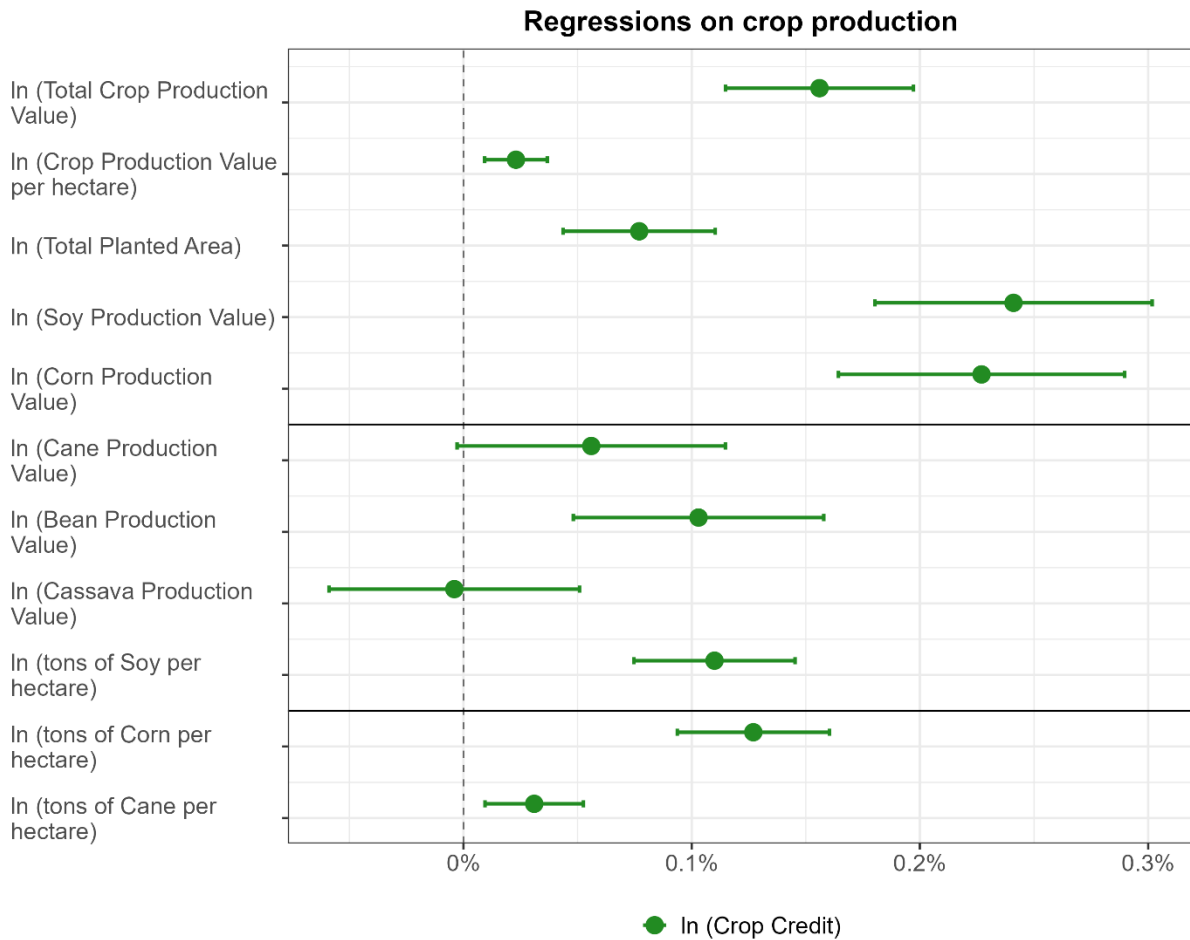
**Figure A1. Estimated coefficients for the relationship between rural credit and climate mitigation
Regressions on GHG emissions by sector**



Source: Authors' elaboration based on SEEG (2024), MapBiomass (2025) and BCB (2025a).

Notes: fixed effects regression using panel data from 2013 to 2024. Each coefficient plot was calculated in an individual regression, with year and municipality fixed effects and using precipitation, temperature and population variables as controls. Confidence intervals at 5%.

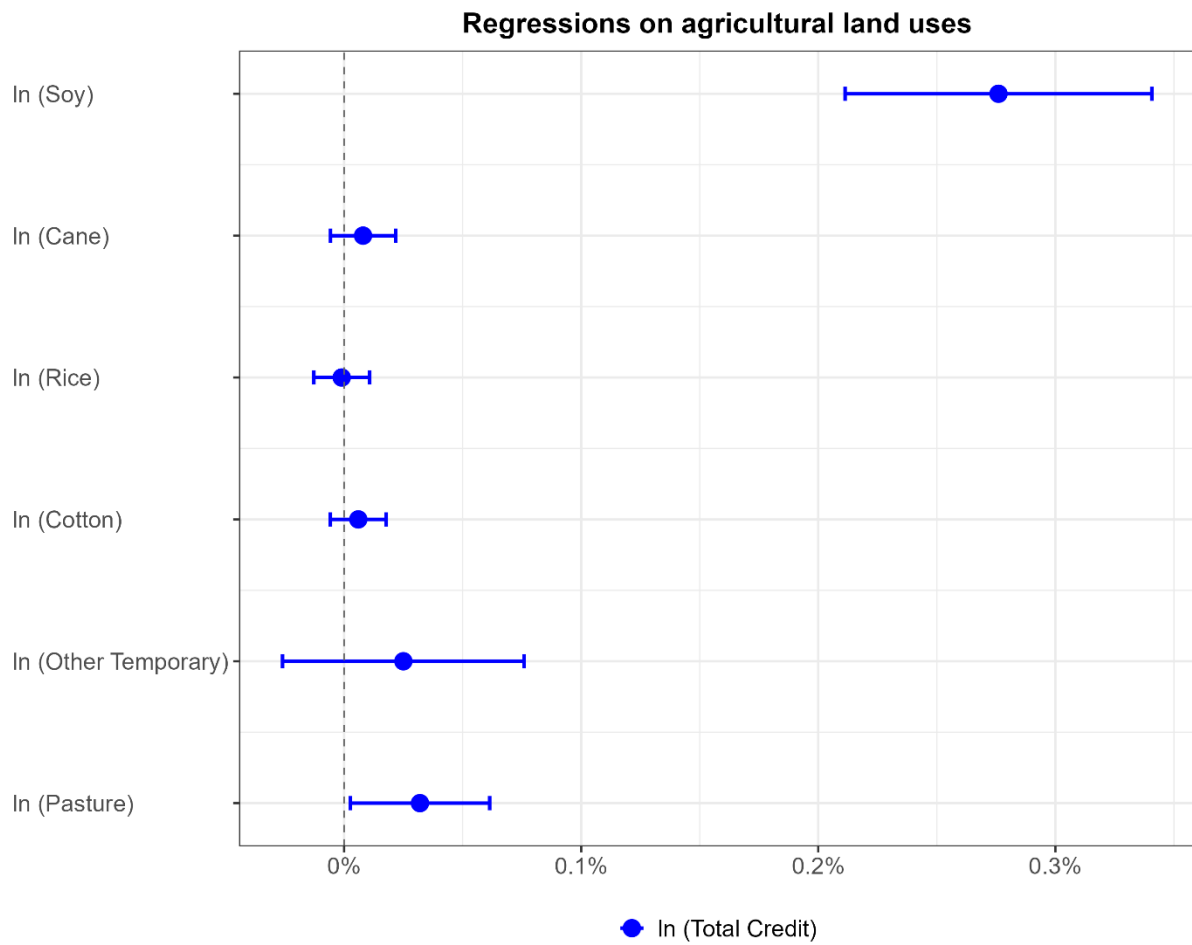
Figure A2. Estimated coefficients for the relationship between rural credit and crop production, productivity



Source: Authors' elaboration based on PAM and BCB (2025a).

Notes: fixed effects regression using panel data from 2013 to 2024. Each of the coefficient plots was calculated in an individual regression, using precipitation, temperature and population variables as controls. Confidence intervals at 5%.

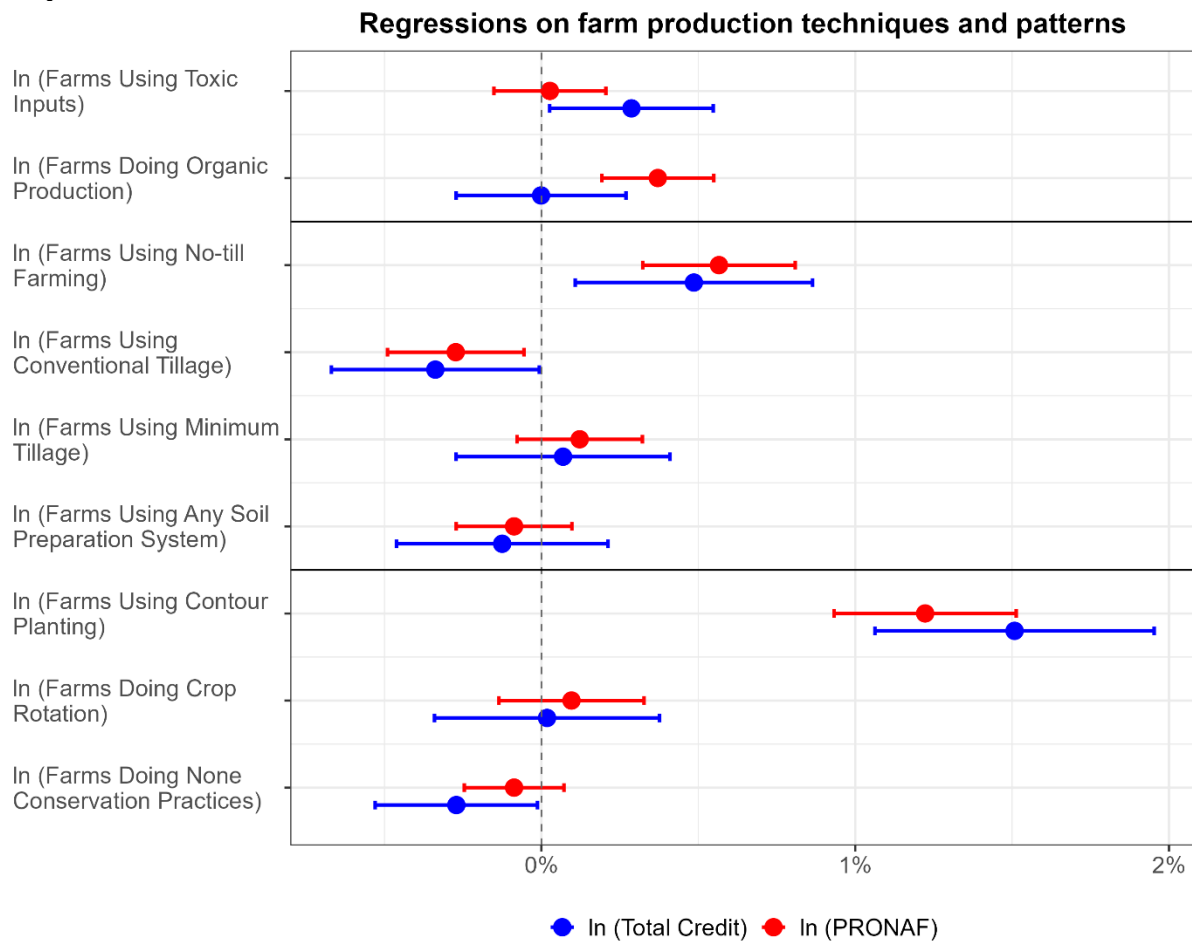
Figure A3. Estimated coefficients for the relationship between rural credit and land use



Source: Authors' elaboration based on MapBiomas (2025) and BCB (2025a).

Notes: fixed effects regression using panel data from 2013 to 2024. Each of the coefficient plots was calculated in an individual regression, using precipitation, temperature and population variables as controls. Confidence intervals at 5%.

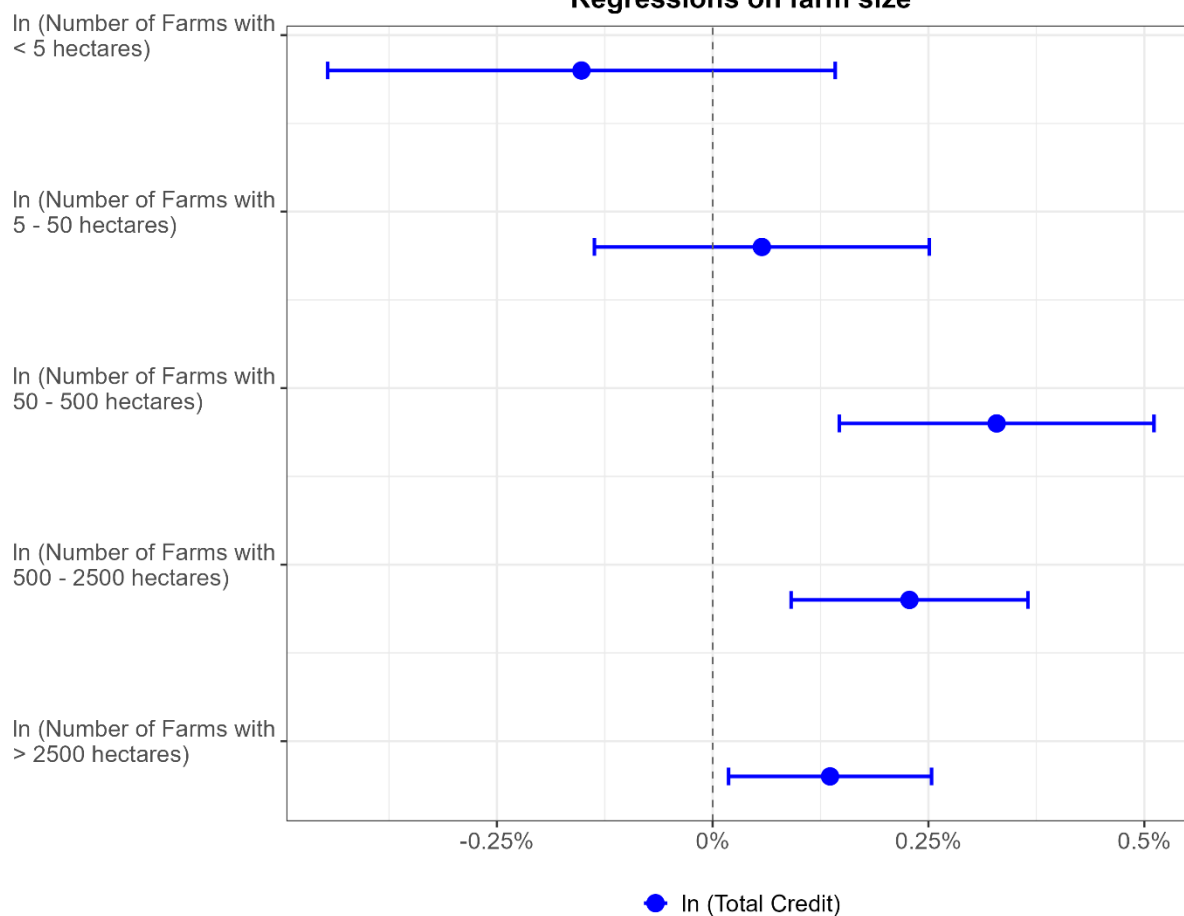
Figure A4. Estimated coefficients for the relationship between rural credit and farm production techniques



Source: Authors' elaboration based on 2006 and 2017 Agricultural Census, BCB (2025b,c).

Notes: fixed effects regression based on panel data with two time points (2006 and 2017). To avoid idiosyncratic variations in specific years or municipalities, the average rural credit received over the four years preceding the observed period was used (e.g., for the 2006 credit variable, the average rural credit received by the municipality between 2003 and 2006 was considered). Since RECOR data is not available at the municipality-year level, for this set of regressions the credit variable was created using the microdata (from RECOR and SICOR). As a result, some credit records in the microdata that did not contain specific municipality information had to be disregarded. Each of the coefficient plots was calculated in an individual regression, using precipitation, temperature and population variables as controls. Confidence intervals at 5%.

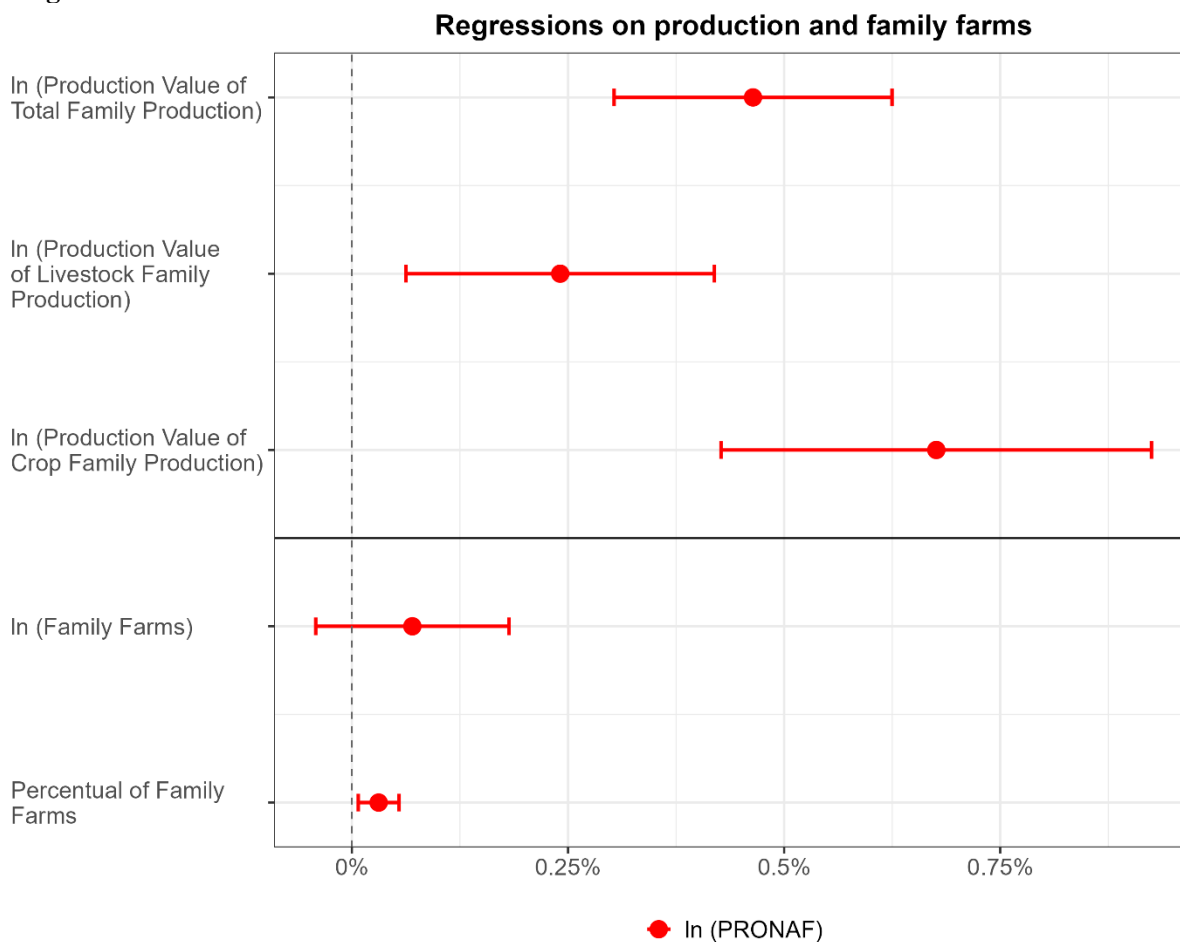
Figure A5. Estimated coefficients for the relationship between rural credit and number of farms by size
Regressions on farm size



Source: Authors' elaboration based on 2006 and 2017 Agricultural Census, BCB (2025b,c).

Notes: fixed effects regression based on panel data with two time points (2006 and 2017). To avoid idiosyncratic variations in specific years or municipalities, the average rural credit received over the four years preceding the observed period was used (e.g., for the 2006 credit variable, the average rural credit the municipality received between 2003 and 2006 was considered). Since RECOR data is not available at the municipality-year level, for this set of regressions the credit variable was created using the microdata (from RECOR and SICOR). As a result, some credit records in the microdata that did not contain specific municipality information had to be disregarded. Each coefficient plot was calculated in an individual regression, using precipitation, temperature and population variables as controls. Confidence intervals at 5%.

Figure A6. Estimated coefficients for the relationship between family farming rural credit and family farming indicators



Source: Authors' elaboration based on 2006 and 2017 Agricultural Census, BCB (2025b,c).

Notes: fixed effects regression based on panel data with two time points (2006 and 2017). To avoid idiosyncratic variations in specific years or municipalities, the average rural credit received over the four years prior to the observed period was used (e.g., for the 2006 credit variable, the average rural credit the municipality received between 2003 and 2006 was considered). Since RECOR data is not available at the municipality-year level, for this set of regressions the credit variable was created using the microdata (from RECOR and SICOR). As a result, some credit records in the microdata that did not contain specific municipality information had to be disregarded. Each coefficient plot was calculated in an individual regression, using precipitation, temperature and population variables as controls. Confidence intervals at 5%.

Appendix B – Econometric tools for causal inference

- Randomized control trials.** This is a method widely used in medicine studies and clinical trials. For example, to measure the efficacy of a vaccine, one group is randomly chosen to receive the vaccine and a control group to receive a placebo. The idea is to compare the infection rates (or survival rates) after both groups have been vaccinated. The difference is attributed to the causal effect of vaccination. This method is powerful, because as the groups are chosen randomly from a pool of individuals who want to participate in the study, they are similar on observable and non-observable characteristics. In such conditions, it is credible that the infection rates of people that receive the vaccine would be similar to the infection rates of the placebo group in the absence of the vaccine. Then, the difference of both infection rates post-treatment is a reliable measure of the average treatment effect of the immunization on treated individuals.
- Difference-in-differences.** This method compares trends in treated and untreated groups before and after a policy. The hypothesis is that if the trends in the indicator of interest in the control group follow the trends of the same indicator in the treated group before the treatment, then they would continue

even if the treatment did not happen. So, the difference between this indicator after and before treatment in the control group is a reliable counterfactual on what would have happened with the difference between this indicator after and before treatment in the treated group in the absence of the policy. The difference between after and before treatment for the treated group, and the same for the control group, measures the effect of the policy. The disadvantage of this method is that the choice of the control group is arbitrary. Usually, this is made using the researcher's intuition and, after the choice is made, testing if the group is a good estimation of the counterfactual situation (for example, testing if the trends are similar for both treated and control groups before the treatment).

- **Fixed effects models.** These models control for time-invariant differences across regions or individuals. The idea of this method is very similar to the previous one. The difference is that this method can identify the average effect on the treated group, as well as the effect of the intensity of the treatment. The regions or individuals that receive a higher level of treatment are compared with those that are less treated or not treated at all. The use of fixed effects is especially valuable to isolate the impact of the treatment from other factors occurring at the same time of the intervention. For example, if the federal government finances labour policies at different levels in different states and their effect on unemployment has to be measured, macroeconomic factors will also play a role across states (a common shock) and vary over time. Therefore, controlling for time fixed effects allows the effect of labour policies to be estimated net of macroeconomic influences—that is, independently of economy-wide changes that affect all observations. The other type of fixed effect is individual or regional. These are useful because using them on the regressions allows for the comparison of regions that were more treated with those that were less treated but are similar in terms of every other characteristic fixed in time. Regions that are very different can be compared in this way, but it is not possible to compare regions that are changing in a different way before treatment when looking at the indicator of interest to measure the effect of the policy. If this hypothesis is valid, the fixed effect model can be used to measure the impact of, for example, financing labour policies on unemployment.
- **Synthetic control.** The method is identical to the difference-in-differences method but in this case it is possible to control just one treated unit.
- **Regression discontinuity design.** This helps when a policy uses a continuous variable to discontinuously decide who is going to receive the treatment. For example, a university gives scholarships to those who have a grade above seven. People with better grades would perform better in the university even if they do not receive the scholarship. However, the group that had grades near and below seven is very similar to the group that had grades near and above seven. The idea of the method is to compare the performance achievement in and after university of these two groups (just below and just above grade seven) to measure the effect of scholarships on several indicators (grades along the course, employment outcomes after the university and others). The hypothesis is that in the absence of the scholarship the two groups would have similar trajectories on average.
- **Instrumental variables.** This helps when policies are targeted in ways that are not random. The most frequent problem in econometrics is that some variables are correlated with other factors that affect the indicator of focus. For example, education is correlated with parents' income. If the impact of one additional year of education on wages is measured, it is possible to identify among the effects not only the extra year of education, but also the fact that individuals with rich parents usually have extra years of education and also have more connections and are invited to better jobs. Extra years of education are not decided randomly, but instrumental variables can help. An instrumental variable for this case is a factor correlated with education but not correlated with labour income in any other way that is not by its correlation with education, for example the availability of schools in the neighbourhood the children lived in when they were in educational age. In this case, it is possible to prove that only this part of the variation in education can be used to measure the effect of an extra year of education on wages.