THE IMPACT OF RURAL CREDIT ON AGRICULTURE AND LAND USE AN ANALYSIS OF BRAZILIAN BIOMES





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Rural credit provides essential financing for Brazilian agribusiness, with the amounts of credit established annually in government plans corresponding to nearly 30% of the total value of agricultural production in the country.¹

Previous analyses by researchers from Climate Policy Initiative/Pontifical Catholic University of Rio de Janeiro (CPI/PUC-Rio) have highlighted the inefficiencies of rural credit in Brazil, evaluated the credit impact, and presented pathways for improving public policies. The empirical evidence suggests that rural credit increases agricultural production and productivity. With the increase of credit supply in municipalities, less productive activities are substituted for more productive ones, through the conversion of pastures to crop land. The intensification of production reduces deforestation pressures. This evaluation of rural credit has been disaggregated into three important dimensions: lines of credit, types of producers, and types of loans.^{2,3} Results show that the effects of rural credit in increasing agricultural productivity while reducing deforestation are more relevant for small producers than for large ones.

This work aims to deepen the understanding of rural credit impact, detailing the results by Brazilian biomes: Amazon, Cerrado, Pampas, Mata Atlântica, and Caatinga.⁴ The analysis also focuses on the type of product, comparing the impact of credit on grain production to other crops.

The impact of rural credit varies across Brazil's different biomes given the diversity of native vegetation, agricultural production, crop potential, climate, and type of soil. While increases in credit supply generate higher agricultural production in most of the biomes, the effects that credit has on land use are larger in the Amazon and the Cerrado. For those two biomes, rural credit boosts agricultural activity while reducing pressures driving deforestation.

¹ The country's total agricultural production in 2019 was R\$ 631 billion (Ministério da Agricultura, Pecuária e Abastecimento. 2020. Available at: <u>bit.ly/2IK3NSG</u>) and for the 2019/20 agricultural year, the government earmarked R\$ 223 billion for the rural credit. Of this amount, R\$ 191 billion were actually borrowed under different credit lines (Rural Credit Data Matrix, Brazilian Central Bank).

² Assunção, Juliano and Priscila Souza. The Impact of Rural Credit on Brazilian Agriculture and the Environment. 2019. Available at: bit.ly/3mqCg6s.

³ Assunção, Juliano and Priscila Souza. The Impacts of Rural Credit on Agricultural Outcomes and Land Use: an Analysis by Credit Lines, Producer Types and Credit Uses. 2020. Available at: <u>bit.ly/3p5alFg</u>.

⁴ Estimates of credit impact for the Pantanal biome were also made, but statistically significant results were not found, given that the econometric analysis is at the municipality level and the Pantanal only covers nine municipalities.

MAIN FINDINGS

In the Amazon, the increase in rural credit leads to an expansion of crop area and a reduction of pasture area. The net effect is a reduction of the total agricultural area, alleviating deforestation pressures. Therefore, the availability of credit results in larger areas of native forest. While credit leads to an increase in agricultural production, it also causes a decrease in crop productivity, possibly due to an expansion in lands less suitable for cultivation or with worse technology and production infrastructure. Analysis of cattle shows an increase in head of cattle, despite the reduction of pasture area. Consequently, there is an increase in cattle productivity.

In the Cerrado, the effects of increased credit on land use are similar to those observed in the Amazon biome: more rural credit is associated with the expansion of crop area over pasture. The net effect is a reduction in agricultural area and, thereby, less deforestation pressure on native vegetation.⁵ While there is an expansion of crop production, the crop productivity remains the same. This could indicate that farming in the Cerrado already operates with well-developed and highly productive techniques and conditions. Regarding cattle, the analysis shows a relevant increase in productivity as a response to the increase in rural credit.

In the Mata Atlântica, results show that increases in rural credit lead to a reduction in crop area and an increase in planted forests. They do not show significant effects on crop production, but there are increases in cattle and land productivity.

In the Pampas, evidence indicates that rural credit leads to an expansion in crop area, with no significant changes in pasture area. There is an increase in crop productivity and production, but no significant effects for cattle.

In the Caatinga, the increase in credit is associated with a reduction in pasture area and increases in crop and cattle productivity.

In comparison with the Amazon and the Cerrado, credit has a more limited impact on land use in the Mata Atlântica, Pampas, and Caatinga biomes. Nevertheless, in those last three biomes, rural credit is associated with increases in crop productivity.

The results also show that the effect of credit differs by the type of product. In municipalities with greater credit supply, grains have substantially larger increases in production and productivity compared to other crops. Between 2002 and 2018, grains experienced a boom and, therefore, were an attractive option for the credit resources at the municipality level.

⁵ Native vegetation is defined in this work as corresponding to the category "forests" in MapBiomas (MapBiomas v.5.0. 2020. Available at: plataforma.mapbiomas.org), which includes: natural forests (divided in forest formation, savanna formation, and mangrove) and forest plantation. Other natural formations such as flooded grassland, swamped area, grassland, salt flat, and rocky outcrop are not included in the definition of native vegetation in our analysis.



AGRICULTURE IN BRAZILIAN BIOMES

Brazil has six biomes: the Amazon, occupying 49.7% of national territory; the Cerrado, 23.1%; the Mata Atlântica, 12.9%; the Pampas, 2.2%; the Caatinga, 10.1%; and the Pantanal 2.0%.⁶ More than 75% of crops are cultivated in the Mata Atlântica and the Cerrado, which are responsible for almost 80% of the national crop production.⁷ Note that crop production is more intensive in the Mata Atlântica, where more crops are produced per hectare (see Figure 1). Figure 2 shows that the Amazon biome has a relevant share of cattle, comprising 30.1% of Brazil's head of cattle,⁸ an activity that is primarily concentrated in municipalities closer to the Cerrado.



Figure 1. Crop Production by Municipal Area in Brazilian Biomes, 2018

Source: Climate Policy Initiative with data from IBGE

⁶ For this analysis, municipalities were assigned to the biome for which the majority of a municipality's territory fell into, data on the area of each municipality are available from the IBGE at: <u>bit.ly/3h22J96</u>.

⁷ Calculated with data from the Municipal Crop Production (IBGE. Produção Agrícola Municipal. 2018. Available at: bit.ly/3nqZdl1).

⁸ Calculated with data from the Municipal Cattle Survey (IBGE. Pesquisa Pecuária Municipal. 2018. Available at: bit.ly/38aeuqb).





Figure 2. Cattle Production by Municipal Area in Brazilian Biomes, 2018

Source: Climate Policy Initiative with data from IBGE



Figure 3 shows the distribution of forests in the country, which covers 62% of the national territory. Municipalities in the Amazon had 80% of their area covered by natural forests in 2018, a reduction of four percentage points in comparison to 2002. In 2018, native vegetation covered 47% of the Cerrado's area, also representing a four percent drop with respect to 2002 levels. In 2018, the Caatinga had 60% of its territory covered with native vegetation, while the Mata Atlântica, the Pantanal, and the Pampas had only 34%, 34% and 17%, respectively.



Figure 3. Forest by Municipal Area in Brazilian Biomes, 2018

Source: Climate Policy Initiative with data from MapBiomas v.5.0



From 2002 to 2018, the growth of agriculture in the Cerrado and the Amazon stands out (see Figure 4). In the Cerrado, the crop area expanded more than 15.7 million hectares over that period, increasing the annual production by R\$ 77.4 billion. In the Amazon, the cultivated area expanded 2.5 times, from 3.7 to 9.4 million hectares, while the crop production more than tripled from R\$ 10.7 billion in 2002 to R\$ 35.3 billion in 2018 (in real terms).⁹ The Amazon biome also experienced the greatest expansion of pastureland, rising by 12 million hectares.

The Amazon and the Cerrado experienced the most intense deforestation during the period analyzed. In the Amazon region, 17.7 million hectares were deforested, and in the Cerrado, 8.4 million hectares of native vegetation were removed (see Figure 4).¹⁰ These biomes received R\$ 82.6 billion of rural credit in 2018, almost four times more than the R\$ 21.7 billion in 2002 (in real terms). This growth resulted in the two biomes receiving 44.7% of loans in 2018, nearly reaching the relative importance of the Mata Atlântica (44.8% of the credit amount).

⁹ All values in this report were deflated by the Broad Consumer Price Index (*Índice de Preços ao Consumidor Amplo* - IPCA) and represent constant values from December 2018.

¹⁰ According to data from MapBiomas (MapBiomas v.5.0. Sistema de Validação e Refinamento de Alertas de Desmatamento com Imagens de Alta Resolução. 2020. Available at: <u>plataforma.mapbiomas.org</u>).







Source: Climate Policy Initiative with data from MapBiomas v.5.0



While it may seem like an increase in subsidized credit drives deforestation, using the shift-share methodology to correctly identify the effects of rural credit yields the exact opposite conclusion. Analysts find that in the Amazon and the Cerrado, this policy is associated not only with production and productivity gains, but also with reductions in deforestation. Estimates indicate that this occurs due to a loss in the relative importance of cattle, a key driver in the expansion of the agriculture frontier.

THE IMPACTS OF RURAL CREDIT IN BRAZILIAN BIOMES

Estimates of rural credit's impact on land use and agricultural production are presented below for Brazil's biomes from 2002 to 2018. Figures represent the estimated impacts of a 1% increase in municipal credit supply. In technical terms, the estimates are interpreted as elasticities.

To illustrate the magnitude of the effects, this analysis calculates the impact of a R\$ 1 million increase in rural credit at the municipality level. For example, a 1% increase in loans generates an expansion of 0.29% in crop area in the Amazon. Furthermore, R\$ 1 million represents 6.14% of the average municipal credit amount in this biome. Therefore, a R\$ 1 million increase in the credit supply of an average municipality in the Amazon should generate an increase of 1.75% (corresponding to 6.14*0.29) in the cultivated area. Since a municipality in the Amazon has, on average, 12,686 hectares of crop area, the impact of a R\$ 1 million increase in municipal credit is an expansion of 222.02 hectares (corresponding to 1.78% of 12,686 hectares).



AMAZON

The Amazon Biome was the most affected by deforestation and had the largest increase in pastures in the analyzed period. Even in this context, Figure 5 indicates that rural credit acts in the direction of reducing deforestation. An increment of 1% in rural credit is associated with an increase of 0.29% in crop area and 0.21% in crop production. The slight reduction (0.08%) in crop productivity may be due to crop expansion into lands less suitable for cultivation or with worse technology and production infrastructure available. There is also a 0.15% reduction in pasture area, accompanied by a 0.20% increase in cattle productivity. Consequently, results show a reduction in deforestation that leads to a 0.02% increase in forest area. Quantitatively, a R\$ 1 million increase in rural loans in a municipality of the region raises agricultural production by R\$ 555,000 and results in 886 more hectares of preserved forest.

Therefore, this analysis shows that when financial resources are available, rural producers in the region decide to reduce deforestation and invest in crop production. Credit restrictions, however, often do not allow them to make the investments associated with that choice.



Figure 5. Impact of Rural Credit on Land Use and Agricultural Production in the Amazon, 2002-2018

Source: Climate Policy Initiative with data from Central Bank of Brazil and IBGE



CERRADO

Between 2002 and 2018, the country's crop area increased by 24 million hectares, 15.7 million (65.0%) of them in the Cerrado.¹¹ The effects of rural credit on land use in this biome follow the same pattern observed in the Amazon, but with larger impacts on pastures (see Figure 5). An increment of 1% in rural credit at the municipality level increases crop area by 0.26% and sharply reduces pasture area by 0.32%. Consequently, credit reduces the deforestation of native vegetation. For each 1% increase in rural credit, municipalities see an additional 0.03% of forest area preserved compared to the scenario in which there is no credit available. This means that a R\$ 1 million increase in credit supply reduces pasture area by 457 hectares and leads to 62 more hectares of preserved forest.

Furthermore, crop production increases by 0.25%, meaning that an additional R\$ 1 million in loans generates an increase of R\$ 512,400 in crop production. However, there is no significant impact on crop productivity, which may be associated with the fact that agricultural production in the Cerrado already operates with modern technology, leading to high land productivity. While no significant changes in cattle production occur, the reduction in pasture areas leads to a 0.36% increase in cattle productivity.



Figure 6. Impact of Rural Credit on Land Use and Agricultural Production in the Cerrado, 2002-2018

Source: Climate Policy Initiative with data from Central Bank of Brazil and IBGE

11 Calculated with data from the Municipal Crop Production (IBGE. Produção Agrícola Municipal. 2018. Available at: bit.ly/38w1DyX).



MATA ATLÂNTICA

The Mata Atlântica is the biome with the highest agricultural production in Brazil, accounting for 41.2% of national production in 2018.¹² Furthermore, in that same year, 22.9% of the country's head of cattle were in this biome.¹³ In the Mata Atlântica, where 34% of municipalities' areas are covered by native vegetation, the increases in rural credit do not induce relevant changes in land use. The exceptions are small reductions in crop area and increases in planted forests.¹⁴ In this scenario, an increase of 1% in rural credit available in the average municipality of this biome generates productivity gains in crop (0.14%) and cattle (0.13%). If a municipality receives an additional R\$ 1 million in loans, every 100 hectares of crop produces R\$ 1,178 more and every 100 hectares of pasture increases by 75 head of cattle.

LAND USE AGRICULTURAL PRODUCTION 0.4 0.4 0.3 0.3 0.2 0.2 0.1 0.1 n.s. n.s n.s. 0 0 n.s. n.s. -0.1 -0.1 -0.2 -0.2 -0.3 -0.3 -0.4 -0.4 Forested Area **Crop Production** Cattle Production/ Farming Area Pasture Area Crop Area Natural Forested Area Crop Production/Crop Area non significant n.s. **Cattle Production** Pasture Area Planted Forested Area (statistically)

Figure 7. Impact of Rural Credit on Land Use and Agricultural Production in the Mata Atlântica, 2002-2018

Source: Climate Policy Initiative with data from Central Bank of Brazil and IBGE

¹² Calculated with data from the Municipal Crop Production (IBGE. Produção Agrícola Municipal. 2018. Available at: bit.ly/3nqZdl1).

Calculated with data from the Municipal Cattle Survey (IBGE. *Pesquisa Pecuária Municipal*. 2018. Available at: <u>bit.ly/38aeuqb</u>).
From 2002 to 2018, the planted forest area in Brazil more than doubled, going from 3.6 million hectares to almost 8 million hectares. A relevant share of this expansion happened on municipalities from the Mata Atlântica, where 55% of the area designated to planted forest is located.



PAMPAS

Even though the Pampas only makes up 2.2% of Brazil's total area, the biome concentrates 7.3% of the nation's cultivated area and 6.6% of the national crop production. A greater availability of rural credit only impacts farming, with effects being larger than in other biomes. An increase of 1% in rural loans in the municipality is associated with an increase in crop area (0.21%) and production (0.40%). For a R\$ 1 million increment in credit, crop land expands by approximately 91.3 hectares and crop production in R\$ 602,500. Given that the productivity of pastures in this biome is much greater than the national average, cattle production in the Pampas is not significantly affected by the availability of rural credit.¹⁵

Figure 8. Impact of Rural Credit on Land Use and Agricultural Production in the Pampas, 2002-2018



15 The average pasture productivity among municipalities in the Pampas is 90.7 head of cattle per hectare. On the other hand, the average productivity in Brazilian municipalities is 6.2 head of cattle per hectare. To calculate municipal productivity, researchers divided the head of cattle by the pasture area for each municipality obtained from MapBiomas (MapBiomas v.5.0. *Sistema de Validação e Refinamento de Alertas de Desmatamento com Imagens de Alta Resolução*. 2020. Available at: <u>plataforma.mapbiomas.org</u>). However, adding pasture areas with non-forest natural formation areas, Brazil has 226 million hectares available for cattle rearing. This leads to a productivity of approximately one head of cattle per hectare. The relevant differences for the numbers calculated here are the following: 1) the inclusion of non-forest natural formation areas in the calculation of one head of cattle per hectare; and 2) the calculation of the average productivity across Brazilian municipalities, which results in 6.2 head of cattle per hectare, gives an equal weight for all municipalities, regardless of area. Therefore, a small and very productive municipality has the same weight as a large and less productive municipality. This means that the average of municipal productivity is higher than the average calculated using head of cattle and land available for cattle in Brazil.



CAATINGA

The Caatinga comprises 5.4% of Brazil's cultivated area and 14.4% of the country's pastures, but it generates only 3.5% of its crop production and has 6.1% of national cattle. Overall, the biome's agricultural production has lower productivity than the rest of the country. Municipalities in the Caatinga received only 2.5% of rural credit in 2018.

In this biome, rural credit does not seem to have significant impacts on municipalities' land use, except for a small reduction in pasture area (0.08%). However, an additional 1% in credit supply generates significant increases in productivity, for both crop (0.11%) and cattle (0.15%), showing that rural producers face credit restrictions that hinder the modernization of production. An increase of R\$ 1 million in credit at the municipality level in the Caatinga, which corresponds to 27.5% of the average municipal credit supply of this biome, increases crop production by R\$ 28,997 for every 100 hectares and leads to an increase of 39 head of cattle for every 100 hectares of pasture.



Crop Production/Crop Area

Cattle Production

Figure 9. Impact of Rural Credit on Land Use and Agricultural Production in the Caatinga, 2002-2018

Source: Climate Policy Initiative with data from Central Bank of Brazil and IBGE

Natural Forested Area

Planted Forested Area

Crop Area

Pasture Area

Pasture Area

(statistically)

n.s. non significant



IMPACT EVALUATION IN GRAINS AND OTHER CROPS

This section compares the impacts of rural credit on grain production compared to its effects on other crops.¹⁶ While the production of grains in Brazil grew 124% from 2002 to 2018, other farming products, all together, experienced a growth of 48%. In the same period, the national GDP increased by 84%.

Figures 10 and 11 show that, in 2018, more than 70% of grains and other types of crops were cultivated in the Cerrado or in the Mata Atlântica. Of the total area designated for grain production, 43.8% are in the Cerrado and 30.4% are in the Mata Atlântica. Whereas 30.1% of other crops are cultivated in the Cerrado and 48.0% in the Mata Atlântica. The Amazon biome is the third most relevant producer, with 13.0% of the area for grain and 8.5% of the area for other cultures. In the Amazon, grain producers are concentrated in the South, near the Cerrado, while other cultures are dispersed across the biome.

¹⁶ This analysis follows the grain definition from PAM, which includes: soy, corn, coffee, wheat beans, sorghum, oats, barley, sunflower, broad bean, triticale, peas and rye. The category of other crops includes: sugar cane, cotton, orange, cassava, rice, banana, and others. The complete list is available at: <u>bit.ly/2Wp0AuW</u>.





Figure 10. Grain Production by Municipal Area in Brazilian Biomes, 2018

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Figure 11. Production of Other Crops by Municipal Area in Biomes, 2018



Rural credit had a larger impact on grains than on other crops in the period of 2002-2018. Figure 12 shows the effects of rural credit on production values, planted area, and productivity for both categories of products considered. If the supply of rural credit at the municipality level increases by 1%, the production value of grains increases by 0.28% and the productivity of land designated for grains increases by 0.38%. Therefore, if for a given municipality, the amount of rural credit increases by R\$ 1 million, the production of grains increases by approximately R\$ 289,000, producing R\$ 3,543 more for every 100 hectares.

Regarding other crops, an increment of credit at the municipality level has a reduced impact. There is no significant increase in the production, but there is a small increase in crop area, resulting in a reduction of crop land productivity. This result could be a consequence of the competition for resources between those other cultures and the production of grains, which forces other cultures to use less productive inputs. The increase in credit at the municipality level expands the production of grains, which can lead to other crops being moved to less productive lands or losing more productive rural workers to grain production.



Figure 12. Impact of Rural Credit by Type of Crop, 2002-2018

Source: Climate Policy Initiative with data from Central Bank of Brazil and IBGE



CONCLUSION

This work details the impacts of rural credit on land use and agricultural production along two relevant dimensions: biome and type of product. Results show that the average (aggregated) impact of rural credit in Brazil – with patterns of increased productivity and reduced deforestation – are a result of the composition of the effects in each biome.

The effects of rural credit on land use are more pronounced in the Amazon and the Cerrado, where the expansion of crop area and the reduction of cattle area alleviates deforestation pressures, encouraging the preservation of native vegetation. While all biomes (with the exception of the Pampas) experience an increase in the productivity of pasture areas in response to an increase in rural credit, crop land productivity increases only in the Mata Atlântica, the Pampas, and the Caatinga. In the Cerrado, the absence of a significant effect in crop productivity may be associated with the fact that production in this biome operates with modern technology and makes intensive use of soil, possibly having access to other sources of financing.

In the disaggregation by type of product, observed impacts on grain production are significantly larger than on other crops. For grains, an increase in rural credit increases production and land productivity.

In all the biomes, the analysis shows that rural credit policy alleviates financing restrictions faced by rural producers and modifies their production decisions. Increases in credit supply help producers to improve their production efficiency, intensifying land use and reducing deforestation pressures.

METHODOLOGY

Estimating the impacts of credit on agricultural production and land use is complex because it requires a decoupling of causes and effects and the identification of impacts that credit generates. On the one hand, credit allows rural producers to fund costs and investments needed to increase production. On the other hand, banks tend to concentrate their operations on producers with better perspectives. Therefore, a positive correlation between rural credit and economic results does not necessarily imply that credit is the cause of observed changes.

To deal with those questions and obtain reliable estimates of the impacts of rural credit, the researchers use the shift-share methodology with data from all Brazilian municipalities in the period between 2002 and 2018. This methodology allows CPI/PUC-Rio researchers to isolate and quantify the impact of credit. The econometric approach focuses on the variation of credit availability, given by the interaction of two components: the distinct distribution of bank branches across municipalities and the aggregate variation at the country-level of funding sources for each bank. For example, if Banco do Brasil had more resources from Rural Savings in a given year, the method considers that municipalities with Banco do Brasil's agencies have a higher probability of having more credit available. Those variations, implemented at scale for all municipalities and banks in the period, allow researchers to estimate the impact of credit on variables of interest (e.g., productivity, land use, deforestation, etc.). Recent academic literature makes extensive use of this strategy to identify causal impacts.



The analysis presented uses several datasets. Rural credit data were obtained from the System of Rural Credit and Proagro Operations (SICOR) and the Common Record of Rural Operations (RECOR) from the Central Bank of Brazil. The area of municipalities and definitions of Brazilian biomes were produced by IBGE. Data regarding crop production and area were obtained from the Municipal Crop Production (*Produção Agrícola Municipal* – PAM) from IBGE, while data regarding cattle production is from the Municipal Cattle Survey (*Pesquisa Pecuária Municipal* – PPM), also from IBGE. Finally, areas for crop, cattle and forest were obtained from MapBiomas.

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