ECONOMIC, SECTORAL AND REGIONAL IMPACTS OF FINANCING FOR THE RECOVERY OF DEGRADED PASTURES IN BRAZIL: AN ABC PLAN PROGRAM[1]

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This paper estimates the regional economic impacts of a Brazilian public policy aimed at mitigating greenhouse gas emissions in agriculture. More specifically, it examines the Degraded Pasture Recovery Program (RPD) of the ABC Plan during the period from 2015 to 2018 and the projected period (2019 to 2025). A computable general equilibrium (EGC) model is constructed and regionalized especially for this simulation, to differentiate geographical spaces according to their geomorphological, climatic and pedological characteristics. The results indicate that the impacts vary across regions and sectors. Furthermore, the higher the share of ABC Plan financing relative to the production value in the livestock sectors, the greater the accumulated decrease in the region's Gross Domestic Product (GDP). The policy is essential for the economic growth of regions that do not necessarily have large livestock production but in which the proportion of production financed by the program is high. In addition, the impact on production goes beyond the livestock sectors and may affect a range of sectors that are important to the economy, both agriculturally and industrially.

Keywords: mitigation policy; environmental policy; degraded pasture; computable general equilibrium model.

IMPACTOS ECONÔMICOS, SETORIAIS E REGIONAIS DO FINANCIAMENTO PARA RECUPERAÇÃO DE PASTAGENS DEGRADADAS NO BRASIL: UM PROGRAMA DO PLANO ABC

Este artigo estima os impactos econômicos regionais de uma política pública brasileira voltada para a mitigação de gases de efeito estufa na agricultura. Mais especificamente o Programa de Recuperação de Pastagens Degradadas (RPD) do Plano ABC durante o período de 2015 a 2018 e o período projetado (2019 a 2025). Um modelo de equilíbrio geral computável (EGC) é construído e regionalizado especialmente para esta simulação, a fim de diferenciar os espaços geográficos de acordo com suas características geomorfológicas, climáticas e pedológicas. Os resultados indicam impactos diferentes entre regiões e setores. Quanto maior a representatividade do financiamento do Plano ABC em relação ao valor da produção da pecuária, maior será a queda acumulada do produto interno bruto (PIB) da região. A política é essencial para o crescimento econômico de regiões que não têm necessariamente uma grande produção pecuária, mas têm uma elevada relação entre produção e

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valor financiado pelo programa. Além disso, o impacto na produção vai além dos setores pecuários e pode interferir com a produção de uma série de setores que são importantes para a economia, tanto em nível agrícola como industrial.

Palavras-chave: política de mitigação; política ambiental; pastagem degradada; modelo de equilíbrio geral computável.

IMPACTOS ECONÓMICOS, SECTORIALES Y REGIONALES DEL FINANCIAMIENTO PARA LA RECUPERACIÓN DE PASTOS DEGRADADOS EN BRASIL: UN PROGRAMA DEL PLAN ABC

Este artículo estima los impactos económicos regionales de una política pública brasileña dirigida a mitigar los gases de efecto invernadero en la agricultura. Más concretamente, el Programa de Recuperación de Pastos Degradados (RPD) del Plan ABC durante el periodo 2015 a 2018 y el periodo proyectado (2019 a 2025). Especialmente para esta simulación se construye y regionaliza un modelo de equilibrio general computable (CGE), con el fin de diferenciar espacios geográficos según sus características geomorfológicas, climáticas y edafológicas. Los resultados indican diferentes impactos entre regiones y sectores. Mientras mayor sea la representación del financiamiento del plan ABC en relación con el valor de la producción ganadera, mayor será la caída acumulada del PIB de la región. La política es esencial para el crecimiento económico de regiones que no necesariamente tienen una gran producción ganadera, pero tienen una alta relación entre producción y valor financiado por el programa. Además, el impacto en la producción va más allá de los sectores ganaderos y puede interferir con la producción de una serie de sectores importantes para la economía, tanto a nivel agrícola como industrial.

Palabras clave: política de mitigación; política ambiental; pastos degradados; modelo de equilibrio general computable.

JEL: Q5; Q58; C68.

1 INTRODUCTION

Climate change, mainly caused by anthropic interference, has been shown to be one of humanity's greatest current challenges (Brasil, 2015). The entire planet earth is vulnerable to climate change and may present significant socioeconomic and environmental problems. Thus, a schedule global aimed at minimizing global environmental problems was consolidated in 1992 along with the elaboration of the United Nations Framework Convention on Climate Change (UNFCCC). Aiming at economic and social growth combined with environmental preservation and climate balance, countries have been implementing policies to significantly reduce emissions and increase sinks of greenhouse gases.

Brazil, at the 15th Conference of the Parties (COP15), in 2009, pledged to reduce greenhouse gas (GHG) emissions by 36.1% to 38.9% by 2020. Among the policies implemented by Brazil aimed at Fulfilling its international commitments is the Sectoral Climate Change Mitigation and Adaptation Plan for the Consolidation of a Low Carbon Economy in Agriculture (Plan ABC).

Agriculture and livestock activities, as well as the land use and forestry change sector are the main GHG emitters in Brazil. Together they account for a quarter of gross national emissions – considering all emission sources (Brasil, 2015). In addition to contributing significantly to carbon emissions in the atmosphere, the agricultural sector is also extremely climate sensitive, making production vulnerable to likely climate change. As Brazil is among the world's largest producers and exporters of agricultural products, stimulating industry growth and reducing greenhouse gas emissions are two challenges to be overcome.

Thus, according to the Ministry of Agriculture, Livestock and Supply – Mapa (Brasil, 2012), the ABC Plan is a sectoral public policy whose general objective is to promote the reduction of GHG emissions in agriculture, improving the efficiency of the use of natural resources and increasing the resilience of production systems and rural communities, enabling the adaptation of the agricultural sector to climate change, ensuring productivity.

The ABC Plan, approved in 2011, is nationwide with a period of validity up to 2020. The Plan's goal is to reduce GHG emissions in agriculture by 134 to 163 million tons of CO2 through seven programs, six of them referring to mitigation technologies and the last one with actions to adapt to climate change. One of the mitigation programs, called Degraded Pasture Recovery (RPD), aims to recover 15 million of the country's current 63 million hectares of degraded pasture (Observatório ABC, 2017).

For the execution of the ABC Plan, the then Program for the Reduction of Greenhouse Gas Emissions in Agriculture (ABC Program) was prepared, a credit program associated with Rural Credit, with subsidized interest rates. The amount of funds made available, the credit limits to the producer, the maximum repayment period, the grace period and the interest rates are adjusted annually. For the 2018/2019 crop year, there was an increase in the credit limit for all purposes financed by the Program, as well as an interest rate drop from 7.5% to 6% to 5.25%, depending on the purpose of the financing (Brasil, 2012).

Initially, an estimated amount of R$ 152.3 billion (FGV, 2017) was required to implement the ABC Plan objectives from 2010 to 2020. However, according to data released by the Central Bank, the amounts financed by the Plan in january 2013 to December 2019 are equivalent to only R$ 14.4 billion, or 9.5% of the initial estimate. The reports released by the ABC Observatory (Observatório ABC, 2017; FGV, 2017) cite, mainly, bureaucratic difficulties on the part of farmers to obtain credit. The ABC Plan requires a technical project attesting the potential for GHG productivity and mitigation against other less bureaucratic and fast rural credit lines.

Historically, among all programs, RPD has the highest demand for funding, which is justified by its ease of implementation, unlike, for example, the more complex implementation of Crop-Livestock-Forest (iLPF) program, resulting in lower adherence by small and medium farmers. Between 2016 and 2019 (focus period of this research) the RPD program received R$ 3.1 billion of funding, which is equivalent to 49% of the total funded by the ABC Plan during this period. The Brazilian states that most received funding for RPD were Goiás, Minas Gerais and Tocantins, totaling R$ 1.3 billion, which is equivalent to 43% of the national total.

Regarding the goals achieved by the ABC Plan over the ten years of implementation, the ABC Platform Periodic Estimates Technical Note (Brasil, 2021) produced estimates of expansion of adoption (in hectares) and mitigation (million Mg CO2 eq.) of the Plan. According to the report, mitigation technologies were adopted over a total area of 27.65 million hectares (Mha), corresponding to 77% of the target set and mitigating a total of 100.21 million Mg CO2 eq., 68% of the target. Regarding the RPD program, 4.46 Mha of pastures were recovered by 2018, corresponding to 30% of the target range. Thus, there was a mitigation of 16.9 million Mg CO2 eq., reaching 18% of the established target.

As the ABC Plan expires in 2020, policy revisions and updates are planned, adjusting it to societal demands, new technologies and incorporating new actions and goals. The new Brazilian challenge set in Paris during the 2015 United Nations Conference on Climate Change (COP 21) is to reduce greenhouse gas emissions by 37% by 2025 and 43% by 2030, compared to 2005 levels. Thus, the challenge is to expand the area of iLPF and RDP by 20 Mha by 2030.

Therefore, understanding not only the environmental but also the economic impacts achieved during the last years, and projecting possible compensatory measures for a policy renewal, is extremely important. Thus, the main objective of this research is to estimate the regional economic impacts of the RPD program of the ABC Plan for the period from 2015 to 2018, as well as for the projected period from 2019 to 2025. As this is a financing policy that has already been implemented and is now in its final stage, a decline in livestock activity will be simulated in proportion to the amount financed by the program between 2015 to 2018. Thus, the impacts resulting from the absence of the policy will allow an assessment of its regional, sectoral and macroeconomic importance.

This article is further subdivided into 5 sections in addition to this introduction. The second section presents a brief literature review that analyzes the economic impacts of climate change and mitigation policies. Section 3 then details the computable general equilibrium model developed for the analysis in question. Following, section 4 details the scenarios and closure adopted. In section 5 the results found are reported and discussed. And the final section weaves the main conclusions of the study.

2 ECONOMIC IMPACTS OF CLIMATE CHANGE AND MITIGATION POLICIES

According to Fischer, Mahendra and Velthuizen (2002), climate change may impact not only environmental but also social and economic systems. Using ecological-economic integration models, these authors assessed the agroecological impact of climate change and concluded that developing regions will suffer a loss in grain yield in all scenarios analyzed. The overall decrease in cereal production may range from -0.7% to -1.2% in 2080. And African countries' Gross Domestic Product (GDP) may fall by 7 to 9%, although overall GDP may grow to 2, 6% in the period analyzed.

For Brazil, Domingues, Magalhães and Ruiz (2008) analyze the impacts of climate change in the Northeast. The authors use an interregional Computable General Equilibrium (EGC) model that considers the availability of unsuitable land for agricultural activity according to Embrapa (2008) estimates and considers the global warming scenarios of the International Panel of Climate Change (IPCC). The results indicate a loss of -13.1% of GDP and -5.95% of employment in the region in 2050, compared to the reference scenario, with Pernambuco, Piauí, Paraíba and Ceará being the most affected Brazilian states. The agricultural activity presents a fall of 70.6% and the economic effects on employment, can generate significant impacts on migratory flows.

Moraes (2010) also uses an EGC model to measure the effects of climate change on Brazilian agricultural production. Similarly to Domingues, Magalhães and Ruiz (2008), land was considered a factor of agricultural production according to the suitability of Embrapa (2008). According to the results, in the scenario of less severe and more severe climate change, the Northeast and the Midwest are the regions most affected. There is a drop in overall economic activity of 0.29% of GDP in 2020 and 1.09% in 2070 and a drop in agricultural activities at the national level, most significantly in soybean and coffee production.

Using a dynamic, recursive and interregional ECG model, Ferreira Filho and Horridge (2010) analyze the potential impacts of climate change scenarios on Brazilian agriculture on internal migrations in Brazil. The authors find modest results of cumulative GDP variation and real investment, falling by -0.82% and -0.5% respectively by 2070. Soybean and coffee production would be the most affected by climate change and unlike other studies, the Northeast region would not be the most affected but the state of Mato Grosso do Sul, with a reduction in GDP of -4.13%.

The study Economics of Climate Change in Brazil (Margulis and Dubeux, 2010) also sought to measure the impacts of climate change on the Brazilian economy by integrating different models, including the Economic Forecasting Equilibrium System (EFES) general equilibrium model. The results indicate a cumulative GDP loss of -0.5%, considering IPCC scenario A2, and -2.3% in scenario B2, from 2008 to 2050. In both scenarios, poverty increases, but of almost negligible way and the reductions in consumption of Brazilians, accumulated until 2050, would represent a fall of 60% to 180% of the per capita annual consumption of 2010.

Several types of mitigation policies have been adopted by countries, but little is known about the possible economic and social impacts of such mechanisms. Gurgel (2012), using the Emissions Prediction and Policy Analysis (EPPA) model (Paltsev et al., 2005), seeks to evaluate how the adoption of new low carbon technologies and the introduction of restrictions on GHG emissions can change the structure. relative prices and the competitiveness of Brazilian products and sectors. The results indicate that mitigation via deforestation reduction in Brazil produces a slight decrease of -0.3% of GDP, however, intensification of the policy can generate losses that reach -4% of GDP in 2050. In addition, the author concludes that adopting global climate policies would reduce mitigation costs in developed countries through carbon trading, as well as achieving a steady and satisfactory level of emissions.

As noted by Magalhães and Domingues (2013), aggressive GHG emission reduction policies may be an obstacle to growth or may be regressive from a distributive point of view. In this sense, using a dynamic-recursive general equilibrium model, the authors analyze alternative policies to reduce price-induced emissions, such as carbon taxation. Regarding the share of emissions related to fuel use, the authors conclude that ambitious emission reduction targets must be associated with long periods of time, as the Brazilian energy matrix is intensive in "clean" sources. Otherwise, a very high cost would be imposed on the Brazilian economy. Regarding the effects on income classes, the results indicated that carbon taxation has a regressive effect both in terms of consumption and changes in the Gini coefficient.

Carvalho (2014) seeks to analyze the economic losses resulting from deforestation control policies in the Legal Amazon through the REGIA model, of the interregional and dynamic type. Among the simulations a control policy aimed at reducing deforestation by 80% by 2020, followed by a 100% reduction target for the period between 2021 and 2030 indicated a cumulative fall in Legal Amazon GDP of -1.06%, in relation to the reference scenario. The Brazilian states that would lose the most with the control of deforestation would be: Mato Grosso (-1.88%), Rondônia (-1.55%), Acre (-1.35%) and Pará (-0.95%). Employment also declines, as do household income and consumption, indicating that the policy causes a loss of well-being.

Regarding the ABC Plan, there are few studies that evaluate the economic impacts of the policy. There are studies in the literature of the ABC Observatory (FGV, 2017) and Lima (2017). Both sought to quantify the economic and environmental impacts of the policy, but specifically the RPD and iLPF programs.

They use an EGC model calibrated for 2009, representing the five Brazilian macroregions plus the Matopiba region (Maranhão, Tocantins, Piauí and Bahia states). Two scenarios are analyzed, in the first the RPD is implemented in the most degraded pastures and in the second, the recovery is made by free allocation. This second scenario simulates how the program actually occurs, since there is no pre-definition of priority areas for the program.

The results show that investment expenditures to meet the plan's targets are lower than originally planned and that the ABC Program's level of resource adoption is well below the amount that would be required to meet the mitigation targets. There is also a "land-saving effect" with the implementation of the programs, allowing an increase of at least 4.8 Mha in forest and secondary vegetation areas.

Regarding welfare, the results indicate a loss and R$ 3.71 of consumption per inhabitant in the first scenario and a gain of R$ 41.18 in the second. Regarding environmental impacts, the potential accumulation in the carbon stock of forest formations and natural vegetation would be greater if pasture recovery occurred in the priority areas. In addition, if the RPD and iLPF targets were achieved, between 32% and 39% of the total emission reduction target for the entire ABC Plan would be achieve (FGV, 2017). In this sense, Assad (2015) considers that the ABC Plan would have the capacity to reduce between 133 and 166 million tons of CO2 equivalent, that is, for this author, the plan would be able to meet and even exceed the mitigation target.

3 METHODOLOGY

EGC models are capable of dealing with policy shocks and answering complex questions that involve multiple agents. Moreover, in this type of modeling, sectors are interrelated and the productive structure of economies or regions is explicitly addressed. As Brazil is a world leader in the production and export of agricultural products, emissions mitigation policies in this sector can directly or indirectly impact the other sectors and the general price structure of the economy. There may be changes to the economic and regional scenario that must be analyzed and even projected. Therefore, the EGC models are suitable for this research.

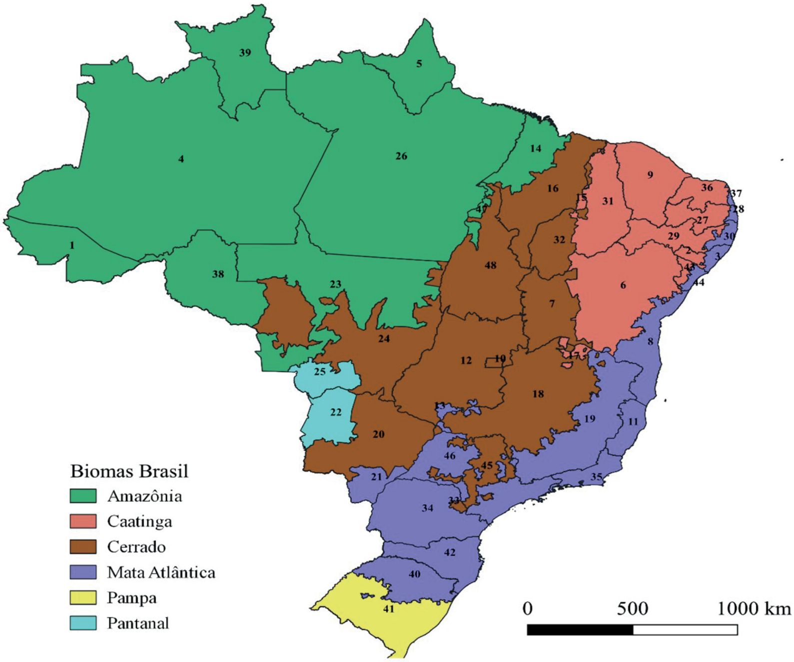
The EGC model constructed for this study is the Brazilian Biomes, Land Use and Emissions Economic Model (BLUME). BLUME is an interregional computable equilibrium model with recursive dynamics, developed for analysis of the Brazilian economy and its regions. It follows the theoretical framework of the regional The Enormous Regional Model (Term) developed by the Centre of Policy Studies (CoPS) of Australia (Horridge, Madden and Wittwer, 2005). The results reported herein were obtained using the economic modeling software GEMPACK (Horridge et al., 2018).

The BLUME database was built through a regionalization procedure using the national BRIDGE model as a structure (Domingues et al., 2010) and other models developed at the Centro de Desenvolvimento e Planejamento Regional da Universidade Federal de Minas Gerais (Cedeplar/UFMG) such as IMAGEM-B (Domingues et al., 2009), REGIA (Carvalho, 2014). Further methodological details can be found at Souza (2022). BLUME's base year is 2015, according to the sectoral and product classification of the most recent Brazilian Institute of Geography and Statistics' (Instituto Brasileiro de Geografia e Estatística – IBGE) input-output matrix. The mathematical structure of the model is represented by a set of linearized equations with solutions obtained in the form of growth rates.

The main differential of the BLUME model is its regionalization. As the main objective of the research involves the impacts of degraded pasture recovery, it is necessary that the regionalization of the model differentiates the geographical spaces according to their geomorphological, climatic and pedological characteristics, which makes regionalization by biomes the most important. appropriate to address the issue. Thus, the regionalization of BLUME was carried out according to the six Brazilian biomes, namely Atlantic Forest, Caatinga, Cerrado, Pampa, Pantanal and Amazon and considering the 27 Brazilian states. The first step towards this regionalization was to classify the 5,570 Brazilian municipalities according to their predominant biomes. The next step aggregated these municipalities within each federation unit according to specific biomes, resulting in 48 different regions, as shown in the map in figure 1.

For regionalization, the procedure developed by Horridge (2006) adapted to the Brazilian case was used. The procedure consists of building a database for a bottom-up multiregional EGC model from the region's share data in sectoral production and components of final demand. Following the regionalization procedure, the national database, composed of 127 sectors, was aggregated into 52 sectors and opened to 48 regions. The sectors follow in table A.1 of appendix A.

FIGURE 1
Regions of model



	Região	Estado		Região	Estado
1	AC_Amazonia	Acre	25	MT_Pantanal	Mato Grosso
2	AL_Caatinga	Alagoas	26	PA_Amazonia	Pará
3	AL_Mata Atlant.	Alagoas	27	PB_Caatinga	Paraiba
4	AM_Amazonia	Amazonas	28	PB_Mata Atlant.	Paraiba
5	AP_Amazonia	Amapá	29	PE_Caatinga	Pernambuco
6	BA_Caatinga	Bahia	30	PE_Mata Atlant.	Pernambuco
7	BA_Cerrado	Bahia	31	PI_Caatinga	Piaui
8	BA_Mata Atlant.	Bahia	32	PI_Cerrado	Piaui
9	CE_Caatinga	Ceará	33	PR_Cerrado	Paraná
10	DF_Cerrado	Destrito Federal	34	PR_Mata Atlant.	Paraná
11	ES_Mata Atlant.	Espirito Santo	35	RJ_Mata Atlant.	Rio de Janeiro
12	GO_Cerrado	Goiás	36	RN_Caatinga	Rio Grande do Norte
13	GO_Mata Atlant.	Goias	37	RN_Mata Atlant.	Rio Grande do Norte
14	MA_Amazonia	Maranhão	38	RO_Amazonia	Rondônia
15	MA_Caatinga	Maranhão	39	RR_Amazonia	Roraima
16	MA_Cerrado	Maranhão	40	RS_Mata Atlant.	Rio Grande do Sul
17	MG_Caatinga	Minas Gerais	41	RS_Pampa	Rio Grande do Sul
18	MG_Cerrado	Minas Gerais	42	SC_Mata Atlant.	Santa Catarina
19	MG_Mata Atlant.	Minas Gerais	43	SE_Caatinga	Sergipe
20	MS_Cerrado	Mato Grosso do Sul	44	SE_Mata Atlant.	Sergipe
21	MS_Mata Atlant.	Mato Grosso do Sul	45	SP_Cerrado	São Paulo
22	MS_Pantanal	Mato Grosso do Sul	46	SP_Mata Atlant.	São Paulo
23	MT_Amazonia	Mato Grosso	47	TO_Amazonia	Tocantins
24	MT_Cerrado	Mato Grosso	48	TO Cerrado	Tocantins

Authors' elaboration.
Note: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

The theoretical model specification follows the standard in national and regional EGC models. Productive sectors minimize production costs subject to a technology of constant returns to scale, where the combination of intermediate inputs and primary (aggregate) factor is determined by fixed coefficients (Leontief). In the composition of inputs there is substitution via prices between domestic and imported products, through constant substitution elasticity (CES) functions. In the composition of the primary factor there is also substitution via price between capital and labor for CES functions. Although all sectors have the same theoretical specification, substitution effects via prices differ according to the domestic/imported composition of the sector inputs – present in the database (Carvalho, 2014).

Household demand is specified from a nonhomothetic utility function of Stone-Geary (Peter et al., 1996), in which the composition of consumption by product between domestic and imported is controlled through substitution elasticity functions constant (CES). Sectoral exports respond to demand curves negatively associated with domestic production costs and positively affected by the exogenous expansion of international income, adopting the small country hypothesis in international trade. Government consumption is typically endogenous and may or may not be associated with household consumption or tax collection. Inventories accumulate according to production variation (Carvalho, 2014).

Investment and capital stock follow mechanisms of accumulation and intersectoral displacement based on pre-established rules associated with the depreciation and return rate. The labor market also has an element of intertemporal adjustment, which involves variables such as real wage, current employment and trend employment (Carvalho, 2014).

The operationalization of an EGC model consists of two parts. The first is the specification, which consists in determining the functional forms, based on the traditional consolidated microeconomic theory. The second part is called calibration and consists of determining an initial solution. To perform these two steps two types of data are required: those from the absorption matrix (core of the model database), which depict the flows of the economy, and also the behavioral parameters related to the adopted functional forms – as per export elasticities, substitution elasticities (Carvalho, 2014). The core structure of the model database is detailed in appendix B.

4 SIMULATION AND CLOSURE

In the historical simulation, the behavior of the main observed macroeconomic aggregates of the economy is represented, making them exogenous. The historical simulation updates the model to the period for which data exist, incorporating the observed changes in the components of the macroeconomic dynamics in relation to the base scenario. That is, it incorporates observed changes in real GDP, household consumption, government spending, investment and export. In addition to the macroeconomic variables, the observed data on agricultural exports and population growth are incorporated. Changes in these observed exogenous variables allow changes in endogenous variables to be measured.

The macroeconomic aggregates observed between 2016-2018 and which received shocks in the historical simulation were: i) household consumption; ii) government consumption; iii) real investment; iv) real GDP; and v) export volume. Each of these variables has its endogenous counterpart, respectively: i) national rate of real household consumption in relation to real GDP; ii) variation in government demand; iii) displacement of normal gross rate of return; iv) productivity of primary factors; and v) variation in quantity exported.

The exogenous variables “fqexp” (variation in exported quantity) and “nhou” (population quantity) also receive shocks in the historical simulation. The variable “nhou” incorporates the population growth observed in the period and “fqexp” changes in exports from the agricultural and livestock sectors.

The base scenario includes the period from 2016 to 2025. From 2016 to 2018 the historical simulation is incorporated and from 2019 to 2025 the projections of economic growth, agricultural exports and population growth are considered. In the projections, macroeconomic aggregates grow by 2% a.a., agricultural exports evolve further according to the Brasil (2019) and OECD and FAO (2015) projections and the population grows according to IBGE projection estimates.

The policy simulation of this illustrative experiment refers to the elimination of funding for Plan ABC’s degraded pasture recovery, which obviously means the absence of public policy. The option to keep the term “policy scenario” is justified to maintain the term established in the literature for this exercise, “policy simulations”.

In this simulation, two variables were changed in their endogenous/exogenous status, xtot (total product quantity) and xcap (quantity of capital use). This swap occurred only in sectors 15 and 16, Cattle and Other animals respectively, as these sectors are directly impacted by the policy analyzed. The objective of this swap was to endogenize the sectoral production quantity variables through the productivity variable.

The policy simulation considered the amounts financed from the ABC Plan for pasture recovery in relation to annual production, from 2016 to 2019, in the Cattle and Other animals sectors. This shock is negative since it is intended to evaluate a scenario without policy implementation. Thus, the simulation aims to estimate regional economic costs in a scenario without funding for degraded pasture recovery.

Table 1 shows the amount financed for RPD between 2016-2019 and the production of the Cattle and Other animals sectors for each region of the model. The amount destined for the recovery of degraded pasture represented 41.01% of livestock production in the TO_Cerrado region during this period. This suggests that the ABC Plan Financing could significantly impact livestock sectors in this region. In contrast, the regions AP_Amazonia, MA_Caatinga, RN_Mata Atlant. and SE_Mata Atlant did not present amounts financed for the RPD, being also the regions with the lowest sectorial production. It is interesting to note that not necessarily the regions with the largest amount of funding are those with the highest livestock production in monetary terms. Although the RS_Pampa region has a high production value of the sector, the ABC Plan funding represents only 1.39% of this value. The GO_Cerrado region, on the other hand, obtained the largest funding for RPD, which represents 8.97% of the value of production in the region.

Finally, the values calculated in the annual shock were attributed to the model as a decrease in annual production in the period 2016-2019, by swapping the productivity (atot) with the production (xtot) variable for both livestock sectors. The capital stock of these sectors becomes exogenous and assumes that same cut-off value. Thus, a decrease in production and capital is simulated, consistent with a withdrawal of financing from the economy. Thus, both the use of primary and intermediate inputs fall back at the same rate, representing the fall in livestock activity in the regions due to the absence of RPD financing.

TABLE 1
ABC financing, livestock production and shock implemented

Regions	Sum of funding for RPD 2016-2019 (R$ 1 million)	Sum of Cattle and Other Animal Production (MAKE) (R$ 1 million)	RPD financing variation in relation to sectoral production (% variation)	Annual shock (% variation)
TO_Cerrado	367.80	896.77	41.01	-8.23
RR_Amazonia	36.54	92.96	39.31	-7.95
TO_Amazonia	43.41	321.81	13.49	-3.11
AC_Amazonia	41.12	319.69	12.86	-2.98
MG_Cerrado	296.39	2,747.01	10.79	-2.53
MA_Cerrado	82.87	785.48	10.55	-2.48
ES_Mata Atlant.	45.58	436.83	10.43	-2.45
BA_Mata Atlant.	127.07	1,283.54	9.90	-2.33
BA_Cerrado	57.82	599.30	9.65	-2.28
PA_Amazonia	272.09	2,828.26	9.62	-2.27
MA_Amazonia	67.48	719.88	9.37	-2.22
GO_Cerrado	409.67	4,568.78	8.97	-2.12
PI_Cerrado	20.72	241.81	8.57	-2.03

(Continues)

(Continued)

Regions	Sum of funding for RPD 2016-2019 (R$ 1 million)	Sum of Cattle and Other Animal Production (MAKE) (R$ 1 million)	RPD financing variation in relation to sectoral production (% variation)	Annual shock (% variation)
PR_Cerrado	5.00	61.94	8.07	-1.92
RO_Amazonia	115.27	1,637.33	7.04	-1.69
MG_Mata Atlant.	103.47	1,684.73	6.14	-1.48
MT_Cerrado	118.40	2,028.21	5.84	-1.41
MT_Amazonia	165.39	2,866.05	5.77	-1.39
GO_Mata Atlant.	8.64	153.88	5.61	-1.36
MG_Caatinga	4.65	110.75	4.20	-1.02
MT_Pantanal	10.09	254.08	3.97	-0.97
RJ_Mata Atlant.	13.30	368.01	3.62	-0.88
MS_Cerrado	154.94	4,941.75	3.14	-0.77
SP_Cerrado	43.49	1,685.88	2.58	-0.63
RN_Caatinga	26.08	1,109.43	2.35	-0.58
AL_Mata Atlant.	3.91	175.54	2.23	-0.55
PR_Mata Atlant.	89.92	4,384.97	2.05	-0.51
SP_Mata Atlant.	86.21	4,399.36	1.96	-0.48
MS_Mata Atlant.	27.66	1,479.00	1.87	-0.46
MS_Pantanal	10.42	599.61	1.74	-0.43
PB_Caatinga	27.28	1,723.79	1.58	-0.39
RS_Pampa	89.40	6,432.31	1.39	-0.34
BA_Caatinga	68.22	5,722.40	1.19	-0.30
AL_Caatinga	4.76	401.24	1.19	-0.29
PE_Mata Atlant.	6.09	560.59	1.09	-0.27
SC_Mata Atlant.	12.92	1,507.71	0.86	-0.21
RS_Mata Atlant.	14.32	1,744.87	0.82	-0.20
AM_Amazonia	1.94	263.50	0.74	-0.18
PB_Mata Atlant.	0.37	61.90	0.60	-0.15
PI_Caatinga	8.76	1,647.97	0.53	-0.13
PE_Caatinga	10.21	2,317.05	0.44	-0.11
CE_Caatinga	9.71	2,969.69	0.33	-0.08
DF_Cerrado	0.16	105.04	0.15	-0.04
SE_Caatinga	0.30	487.85	0.06	-0.02
AP_Amazonia	0.00	9.08	0.00	0.00
MA_Caatinga	0.00	17.17	0.00	0.00
RN_Mata Atlant.	0.00	18.02	0.00	0.00
SE_Mata Atlant.	0.00	217.24	0.00	0.00

Authors' elaboration.

5 ANALYSIS AND DISCUSSION OF RESULTS

As much as the policy analyzed involves land use change, it is important to note that the reported results do not consider the possible changes and reallocations of this factor of production or changes in its productivity, which will be considered in future developments of this research. Ahead, follow the regional, sectoral and national results.

5.1 Regional and sectoral

Regional results for the policy scenario are reported as the cumulative percentage deviation (2016-2025) from the base scenario. According to the mechanisms of the model, the policy analyzed implies a reduction in the production of livestock sectors in a scenario where financing for pasture recovery does not occur. Thus, it is intended to verify if the absence of the policy would generate regional economic losses and the size of this impact.

Table 2 presents the results of the main aggregate indicators, by regions of the model. In general, there is a negative impact on regional GDP, most notably in the TO_Amazonia region (-3.11%) followed by TO_Cerrado (-1.02%). These values indicate that the TO_Amazonia region, for example, would have a cumulative growth between 2016 and 2025 lower by 3.11% if the financing policy did not occur. Even though it is a region with one of the smallest shares of national GDP and low participation of the land factor among the regions, these locations are among the ones that received the most resources for Plan ABC's pasture recovery, which represents an important portion in relation to the level region's production In this case, the negative variations on the production of livestock sectors in the regions are significant, which justifies the relevant impact on GDP. The region with the lowest GDP drop is MT_Pantanal (-0.17%), a region with low production value in the livestock sectors and, consequently, low financing.

TABLE 2
Aggregate indicators by model region
(In %)

Regions	Real GDP	Consumption of families	Government	Investment	Employment	Export	Import
AC_Amazonia	-0.56	-0.37	0.15	-0.81	-0.26	-0.07	-0.12
AP_Amazonia	-0.43	-0.50	0.16	-0.87	-0.39	-0.07	-0.16
AM_Amazonia	-0.34	-0.44	0.14	-0.88	-0.33	-0.11	-0.25
MA_Amazonia	-0.44	-0.42	0.15	-0.86	-0.30	-0.05	-0.16
MT_Amazonia	-0.86	-0.21	0.11	-0.48	-0.09	-0.13	0.28
PA_Amazonia	-0.52	-0.44	0.18	-0.81	-0.33	-0.31	-0.09
RO_Amazonia	-0.59	-0.39	0.13	-0.83	-0.27	-0.08	-0.06

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Regions	Real GDP	Consumption of families	Government	Investment	Employment	Export	Import
RR_Amazonia	-0.41	-0.39	0.13	-0.66	-0.28	-0.19	-0.09
TO_Amazonia	-3.11	0.74	0.14	-0.39	0.85	-0.13	0.57
AL_Caatinga	-0.46	-0.33	0.14	-0.79	-0.22	-0.12	-0.01
BA_Caatinga	-0.59	-0.21	0.14	-0.71	-0.09	-0.11	0.10
CE_Caatinga	-0.38	-0.45	0.15	-0.95	-0.34	-0.62	-0.18
MA_Caatinga	-0.32	-0.32	0.14	-0.94	-0.21	-0.10	0.04
MG_Caatinga	-0.30	-0.20	0.12	-0.84	-0.08	-0.12	0.08
PB_Caatinga	-0.44	-0.32	0.14	-0.91	-0.20	-0.12	0.01
PE_Caatinga	-0.44	-0.30	0.15	-0.77	-0.19	-0.12	0.05
PI_Caatinga	-0.30	-0.24	0.12	-0.91	-0.12	-0.15	0.08
RN_Caatinga	-0.42	-0.39	0.15	-0.88	-0.28	-0.09	-0.12
SE_Caatinga	-0.31	-0.28	0.11	-0.95	-0.17	-0.09	0.04
BA_Cerrado	-0.43	-0.26	0.14	-0.48	-0.15	-0.05	0.05
DF_Cerrado	-0.29	-0.39	0.11	-0.84	-0.27	-0.09	-0.15
GO_Cerrado	-0.46	-0.40	0.12	-0.74	-0.28	-0.13	-0.07
MA_Cerrado	-0.65	-0.35	0.17	-0.65	-0.24	-0.14	-0.07
MT_Cerrado	-0.35	-0.36	0.11	-0.56	-0.24	-0.06	0.00
MS_Cerrado	-0.43	-0.25	0.11	-0.47	-0.14	-0.07	0.21
MG_Cerrado	-0.46	-0.41	0.14	-0.77	-0.29	-0.14	-0.10
PR_Cerrado	-0.38	-0.39	0.12	-0.70	-0.27	-0.06	-0.05
PI_Cerrado	-0.34	-0.39	0.13	-0.85	-0.27	-0.13	-0.19
SP_Cerrado	-0.35	-0.47	0.15	-0.88	-0.35	-0.12	-0.21
TO_Cerrado	-1.02	-0.41	0.18	-0.72	-0.29	-0.16	-0.19
AL_Mata Atlant.	-0.36	-0.45	0.14	-0.88	-0.33	-0.09	-0.17
BA_Mata Atlant.	-0.40	-0.46	0.14	-0.92	-0.34	-0.08	-0.18
ES_Mata Atlant.	-0.33	-0.41	0.11	-0.78	-0.30	-0.05	-0.13
GO_Mata Atlant.	-0.54	-0.33	0.11	-0.67	-0.21	-0.12	0.06
MS_Mata Atlant.	-0.43	-0.21	0.11	-0.50	-0.10	-0.05	0.28
MG_Mata Atlant.	-0.34	-0.44	0.13	-0.87	-0.33	-0.12	-0.19
PB_Mata Atlant.	-0.35	-0.43	0.14	-0.97	-0.32	-0.06	-0.18
PR_Mata Atlant.	-0.34	-0.42	0.12	-0.84	-0.31	-0.12	-0.18
PE_Mata Atlant.	-0.37	-0.47	0.16	-0.95	-0.35	-0.13	-0.21

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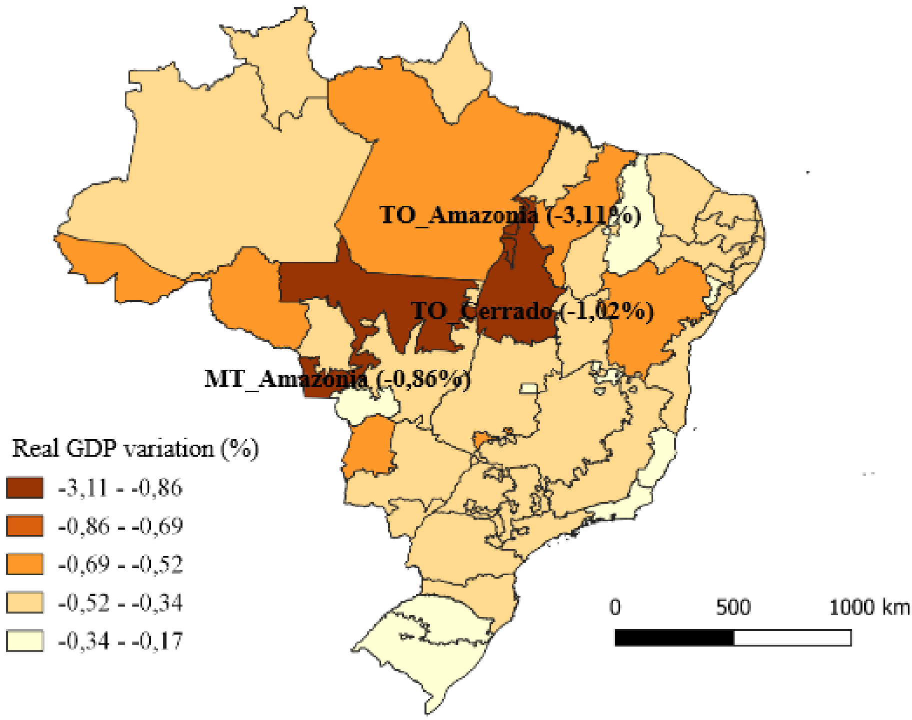
Regions	Real GDP	Consumption of families	Government	Investment	Employment	Export	Import
RJ_Mata Atlant.	-0.31	-0.41	0.09	-0.88	-0.30	-0.07	-0.21
RN_Mata Atlant.	-0.35	-0.45	0.16	-0.92	-0.34	-0.31	-0.17
RS_Mata Atlant.	-0.32	-0.41	0.12	-0.79	-0.30	-0.38	-0.13
SC_Mata Atlant.	-0.35	-0.45	0.11	-0.91	-0.34	-0.43	-0.21
SP_Mata Atlant.	-0.36	-0.49	0.15	-0.95	-0.38	-0.12	-0.28
SE_Mata Atlant.	-0.35	-0.38	0.11	-0.84	-0.27	-0.07	-0.07
RS_Pampa	-0.31	-0.37	0.13	-0.74	-0.26	-0.07	-0.16
MT_Pantanal	-0.17	-0.15	0.11	-0.67	-0.04	-0.06	0.14
MS_Pantanal	-0.52	-0.17	0.11	-0.83	-0.06	-0.11	0.25

Source: Simulation results with the BLUME model.
Authors' elaboration.

The regions MS_Cerrado and GO_Cerrado are the largest cattle producers and would have a cumulative fall of GDP in the period of -0.43% and -0.46%, respectively. This drop is explained by the low representativeness of the ABC plan financing compared to the production value in the livestock sectors of these regions, accounting for 3.14% and 8.97% of the total amount, respectively.

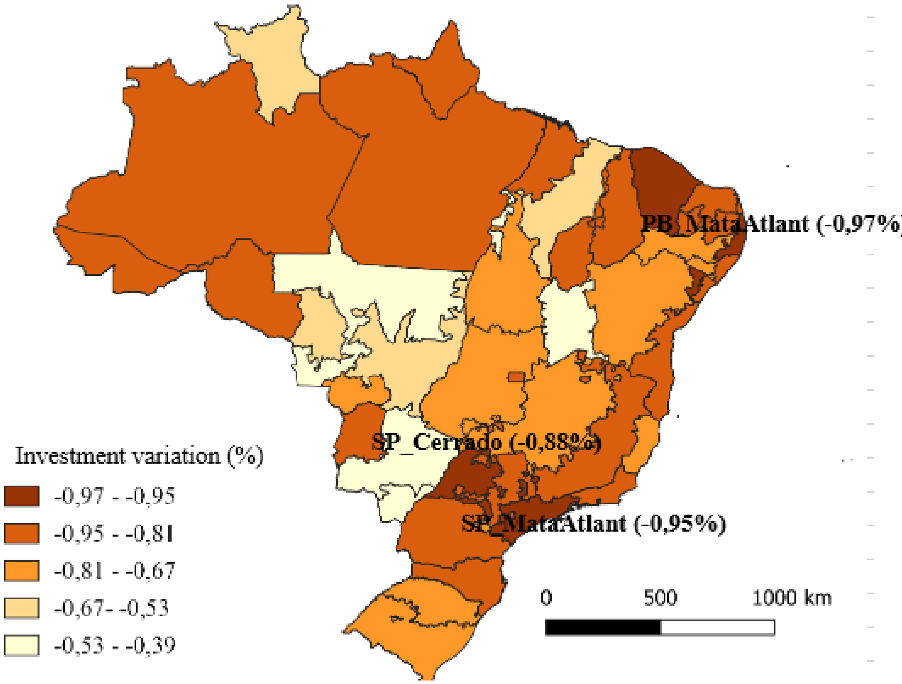
It is also noteworthy that the decline in investment is the primary driver behind the fall in GDP, followed by declines in household consumption and exports. The drop in investment is greater in the Caatinga (SE_Caatinga) and Atlantic Forest (PB_Mata Atlant.) biomes, which is attributed to the low return on capital in these regions. Furthermore, the regions of the state of São Paulo also exhibit significant drops in investment. The regional distribution of GDP and investment is presented in figures 2 and 3, respectively.

FIGURE 2
Real GDP variation
(In %)



Source: Simulation results with the BLUME model.
Authors' elaboration.
Note: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

FIGURE 3
Investment variation
(In %)



Source: Simulation results with the BLUME model.
Authors' elaboration.
Note: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

In addition, the absence of a pasture recovery policy increases the cost of livestock production, which is passed on to the final price of products, making it more expensive and discouraging exports. This effect of the decline in activity also causes a reduction in imports, especially in the Atlantic Forest biome.

Employment would also decrease in most regions, suggesting that primary factors of production (land, capital and labor) become more costly. The fall in employment leads to a consequent reduction in household income and consumption, indicating that the absence of policy causes a loss of well-being, especially in the Amazon and Atlantic Forest biome regions. Except for the TO_Amazonia region, which despite the largest drop in GDP pointed to a positive variation in employment (0.85%), household consumption (0.74%) and imports (0.57%). This is explained by the reallocation of the factors of production.

Regarding the sectoral results, as expected, the sectoral production of Cattle and Other Animals was the most affected in all regions, especially TO_Cerrado

(-17.9% and -14.3%) and RR_Amazônia (-16.2% and -13.3%), the two regions with the largest share of financing for pasture recovery compared to the production value of the livestock sectors. The Amazon and Cerrado biomes would experience the largest declinesin livestock production. Due to the reallocation of factors of production among sectors and regions, production increases in some sectors, especially the Pork, Poultry and Eggs sectors. The swine sector shows an increase in almost all regions, most significantly in the state of Mato Grosso do Sul, reaching 0.23% increase in the cerrado biome (MS_Cerrado). The same is true for the Poultry and Eggs sectors, with increases of 0.28% and 0.26% respectively in the MS_Cerrado region. These results are shown in table 3 and in the maps of figures 4 and 5.

TABLE 3
Result of variation in sectoral output by model region
(In %)

Regions	Cattle	Other animals	Swine	Poultry	Eggs
AC_Amazonia	-9.10	-7.84	0.00	-0.03	-0.02
AP_Amazonia	-0.28	-1.30	0.03	0.02	-0.02
AM_Amazonia	-2.07	-1.16	0.07	0.07	0.03
MA_Amazonia	-5.73	-4.31	0.01	-0.05	-0.03
MT_Amazonia	-3.52	-3.28	0.17	0.13	0.16
PA_Amazonia	-5.80	-5.13	-0.01	-0.11	-0.08
RO_Amazonia	-5.77	-4.16	0.06	0.04	0.04
RR_Amazonia	-16.20	-13.29	0.00	0.01	0.00
TO_Amazonia	-6.80	-6.73	0.03	0.02	0.01
AL_Caatinga	-3.08	-1.55	0.10	0.01	0.02
BA_Caatinga	-2.80	-1.47	0.17	0.14	0.08
CE_Caatinga	-2.23	-0.68	0.03	-0.02	-0.04
MA_Caatinga	-2.17	-0.69	0.06	0.07	0.02
MG_Caatinga	-2.90	-3.20	0.10	0.10	0.04
PB_Caatinga	-3.22	-1.20	0.07	0.03	0.02
PE_Caatinga	-2.56	-0.98	0.13	0.06	0.01
PI_Caatinga	-2.66	-1.00	0.05	0.03	0.00
RN_Caatinga	-3.64	-1.68	0.07	0.00	-0.01
SE_Caatinga	-2.18	-0.43	0.11	0.08	0.01
BA_Cerrado	-7.23	-4.60	0.02	0.00	-0.02
DF_Cerrado	0.05	0.03	0.15	0.02	-0.01
GO_Cerrado	-4.27	-3.70	0.14	0.06	0.06
MA_Cerrado	-7.56	-6.38	-0.07	-0.15	-0.08
MT_Cerrado	-2.70	-2.32	0.21	0.14	0.09
MS_Cerrado	-0.58	-0.99	0.23	0.28	0.27

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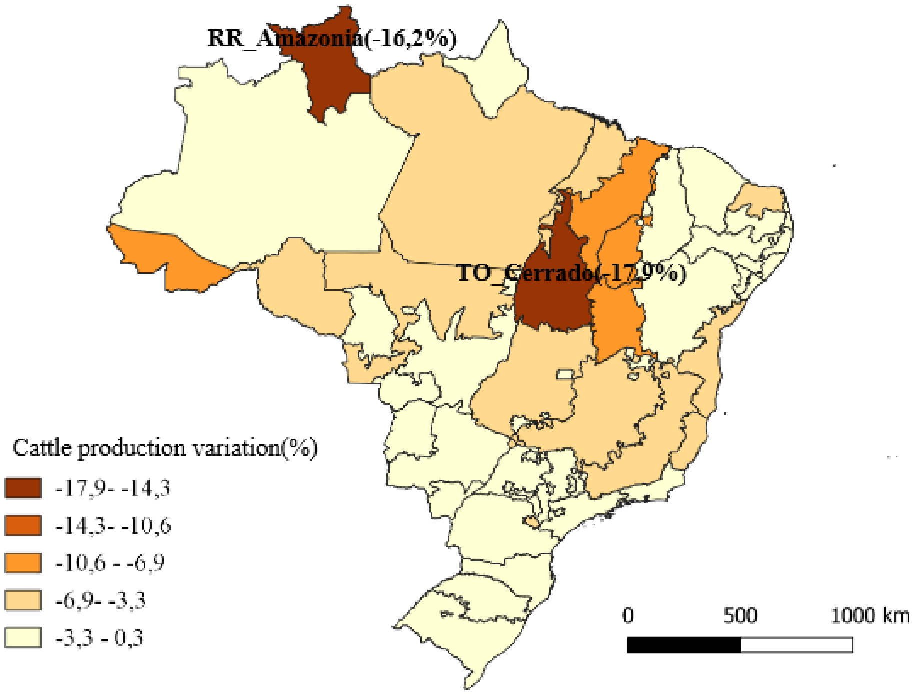
Regions	Cattle	Other animals	Swine	Poultry	Eggs
MG_Cerrado	-6.22	-4.26	0.07	-0.03	-0.01
PR_Cerrado	-4.95	-3.91	0.16	0.10	0.06
PI_Cerrado	-7.54	-5.63	0.00	-0.09	-0.06
SP_Cerrado	-1.47	-0.91	0.12	0.05	0.04
TO_Cerrado	-17.93	-14.26	-0.18	-0.43	-0.27
AL_Mata Atlant.	-2.31	-1.54	0.05	-0.02	-0.06
BA_Mata Atlant.	-5.72	-4.58	0.02	-0.10	-0.07
ES_Mata Atlant.	-5.91	-4.61	0.13	0.04	0.01
GO_Mata Atlant.	-2.00	-1.51	0.16	0.11	0.08
MS_Mata Atlant.	-0.34	-0.93	0.22	0.33	0.19
MG_Mata Atlant.	-4.52	-2.58	0.14	0.05	0.06
PB_Mata Atlant.	-2.06	-1.06	0.02	-0.06	-0.06
PR_Mata Atlant.	-2.18	-1.24	0.16	0.14	0.09
PE_Mata Atlant.	-2.61	-1.28	-0.03	-0.09	-0.05
RJ_Mata Atlant.	-3.14	-1.88	0.09	-0.04	0.02
RN_Mata Atlant.	-1.48	-0.70	0.02	-0.03	-0.02
RS_Mata Atlant.	-2.50	-0.90	0.15	0.15	0.13
SC_Mata Atlant.	-2.54	-0.79	0.12	0.11	0.06
SP_Mata Atlant.	-1.61	-1.80	0.08	0.02	0.01
SE_Mata Atlant.	-1.34	-0.18	0.05	0.00	-0.02
RS_Pampa	-0.93	-0.40	0.20	0.23	0.21
MT_Pantanal	-2.07	-3.20	0.12	0.14	0.10
MS_Pantanal	0.32	-0.93	0.20	0.17	0.17

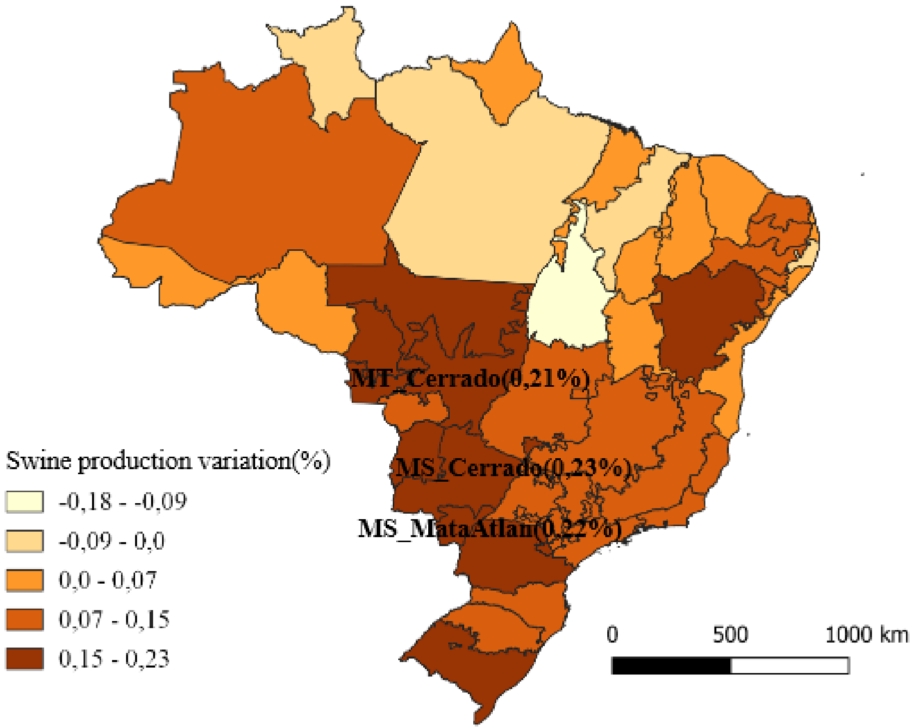
Source: Simulation results with the BLUME model.
Authors' elaboration.

FIGURE 4
Cattle production variation
(In %)



Source: Simulation results with the BLUME model.
Authors' elaboration.
Note: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

FIGURE 5
Swine production variation
(In %)



Source: Simulation results with the BLUME model.
Authors' elaboration.
Note: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

Table A.2 in appendix A shows the results of the variation in production across all sectors. In relation to the agricultural sectors, there is a decrease in production in most sectors and regions, except for the Corn in Grains sector, which increased mainly in the RS_Pampa (0.14%) and MS_Cerrado (0.11%) regions. The sectors with the largest production declines were Sugarcane, Orange and Other Perm. The region with the largest drop in sugarcane production was TO_Cerrado (-0.41%). In Orange production there is AM_Amazonia (-0.32%) and in Production of Other Permanent Products in the TO_Cerrado region (-0.42%).

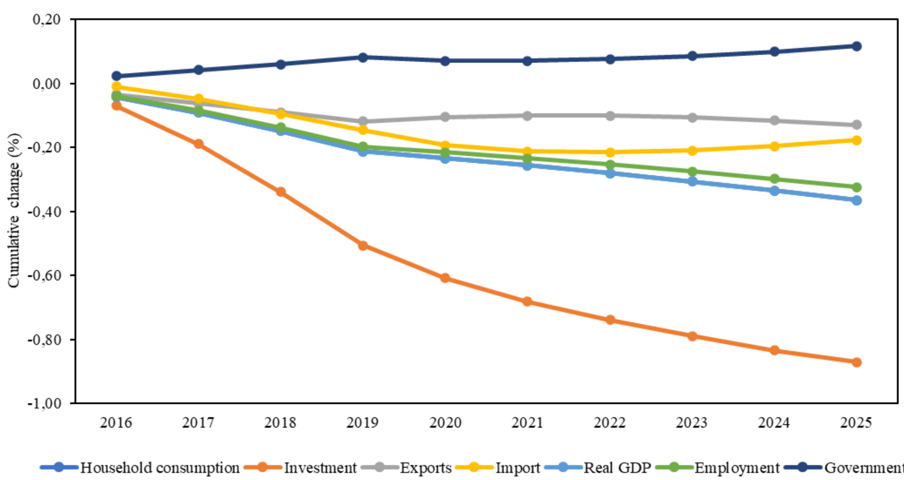
Some industrial sectors also pointed out significant variations. These are the Meat, Cow Milk, Animal Feed and Leather sectors, all indirectly dependent on livestock or related to production. It is worth mentioning that the main variations are found in the Amazon and Cerrado biomes, which are those that received the largest amount of funding in RPD.

5.2 Nationals

Regarding the national results, figure 6 shows the effects on the main macroeconomic aggregates. It is possible to observe an accumulated decline in almost all of these aggregates. Investment is likely to decline the most (by almost 1% from the base scenario) due to the fall in capital stock and, consequently, lower rates of return. The decline in investment and capital stock, coupled with a decrease in household consumption, results in an accumulated negative impact on GDP of approximately -0.4% by 2025. Aggregate employment follows the same trajectory as GDP. Economic growth or decline implies a greater or lesser use of primary production factors, and labor mobility facilitates the reallocation of these inputs across sectors and regions.

Exports maintain a negative trajectory, with an increase between 2020 and 2022. The national result is justified by the increase in the cost of livestock production after a shock of lack of financing for pasture recovery. Such prices are passed on to the final price of the products, making it more expensive, discouraging exports. Imports follow negative variations, due to the fall in the activity level, with a slight increase from 2023. Overall, the results point to relevant economic variations provided by the financing policy of recovering degraded pasture in the country.

FIGURE 6
Trajectory of national macroeconomic variables in the policy scenario (2016-2025)
(In %)



Source: Simulation results with the BLUME model.
Authors' elaboration.
Note: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

6 CONCLUSION

The main objective of this research was to estimate the regional economic impact of the funding provided for degraded pasture recovery under Plan ABC. To do this, a counterfactual scenario in which the policy did not exist was simulated for the period from 2016 to 2019, assuming a decline in livestock activity proportional to the program's financing during that period. A decrease in production and capital in the livestock sectors is expected to lead to a reduced utilization of productive factors and to their reallocation among other sectors and regions. Furthermore, the level of economic activity in some regions and at the national level is expected to decline.

Thus, due to factor reallocation and regional and sectoral interdependence, the results indicate varying impacts across regions and sectors. The higher the proportion of ABC Plan financing relative to the value of production in the livestock sectors, the greater the cumulative decrease in the region's GDP. Therefore, the absence of financing would lead to a sharper cumulative decline in GDP in the Amazon and Cerrado biomes – especially in the TO_Amazonia region – while the decrease would be less pronounced in the Pampa, Pantanal, and Mata Atlantica biomes, particularly in the MT_Pantanal region.

The reduction in livestock production also leads to a lower utilization of productive factors and an increase in the sector's production costs. This mechanism is passed on to the final product prices, making them more expensive, discouraging exports, and leading to a reduction in imports – especially in the Atlantic Forest biome. Furthermore, employment declines, particularly in regions within the Amazon and Atlantic Forest biomes. Labor reallocation benefits only the TO_Amazonia region. Therefore, the absence of the RPD policy would result in a loss of well-being, mainly in the Amazon and Mata Atlantica biomes.

Given the productive structure of the model, sectors reallocate production factors according to various supply and demand mechanisms, as well as the capital/labor relationship, among others. In the simulation of decreased production of cattle and other animals, sectors indirectly dependent on livestock – such as meat, cow's milk, animal feed, and leather – exhibit negative variations in almost all regions. Complementary sectors such as Pork, Poultry, and Eggs show positive production variations. Due to productive reallocation, some agricultural sectors – such as sugarcane, orange, and other perennial crops – experience declines in production, mainly in the Amazon and Cerrado biomes, while other sectors – such as corn in grains – show increased production.

Therefore, the financing policy for degraded pasture recovery in the country is observed to be relevant from macroeconomic, sectoral, and regional perspectives. It is concluded that the policy is essential for the economic growth of regions that do not necessarily have large livestock production but where the proportion of production financed by the program is high. Furthermore, the impact on production extends beyond the livestock sectors and may adversely affect a range of sectors important to the economy, both agriculturally and industrially.

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APPENDIX A

TABLE A.1
Brazilian Biomes, Land Use and Emissions Economic Model (BLUME) database sectors

Sectors			
1	Rice	27	Pigmeat
2	Wheat and other cereals	28	Meat birds
3	Corn grain	29	Industrial fishing
4	Cotton and other fibers	30	Cold milk/pasteurized
5	Sugarcane	31	Other dairy products
6	Soybean grain	32	Animal rations
7	Cassava	33	Food and beverages
8	Smoke in leaf	34	Clothing and textiles
9	Citrus fruits	35	Footwear and leather
10	Beans in grain	36	Wood product
11	Other temporary	37	Pulp
12	Orange	38	Diverse industry
13	Coffee beans	39	Ethanol and biofuel
14	Other permanent	40	Chemical
15	Cattle	41	Fertilizer and fertilizer
16	Other animals	42	Agricultural and disinfectant defensive
17	Cow's milk	43	Electronic
18	Other animal milk	44	Automotive machines and equipment
19	Pigs	45	Services
20	Birds	46	Electricity, gas and other
21	Eggs	47	Construction
22	Forestry	48	Trade, Wholesale and retail
23	Plant extraction	49	Cargo transport
24	Agricultural fishing	50	Transportation of others
25	Extractive industry	51	Financial and insurance institution
26	Beef and other animals	52	Public sector

Authors' elaboration.

TABLE A.2
Result of sectoral output variation by model region: total product quantity (xtot)
(In %)

Biome	Regions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	AC_AM	-0.2	-0.2	-0.1	-0.2	-0.4	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.3	-0.1	-0.3	-9.1	-7.8	-0.1
	AP_AM	-0.2	-0.2	0.0	-0.2	-0.4	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.3	-0.1	-0.4	-0.3	-1.3	0.0
	AM_AM	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.3	-0.1	-0.3	-2.1	-1.2	0.1
	MA_AM	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.3	-0.1	-0.3	-5.7	-4.3	-0.1
Amazon	MT_AM	-0.1	-0.2	0.0	-0.2	-0.3	-0.1	0.0	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.3	-3.5	-3.3	0.1
	PA_AM	-0.3	-0.2	-0.1	-0.2	-0.4	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.3	-0.1	-0.4	-5.8	-5.1	-0.1
	RO_AM	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-5.8	-4.2	0.0
	RR_AM	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.3	-0.1	-0.4	-16.2	-13.3	-0.1
	TO_AM	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.3	-0.1	-0.3	-6.8	-6.7	0.0
	AL_CA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.3	-0.1	-0.3	-3.1	-1.5	0.0
	BA_CA	-0.2	-0.2	0.1	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.8	-1.5	0.0
	CE_CA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.3	-0.1	-0.3	-2.2	-0.7	-0.1
	MA_CA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	-0.2	-0.1	-0.2	-2.2	-0.7	0.0
Caatinga	MG_CA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.9	-3.2	0.0
	PB_CA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.3	-0.1	-0.3	-3.2	-1.2	0.0
	PE_CA	-0.2	-0.2	0.1	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.6	-1.0	0.0
	PI_CA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.2	-2.7	-1.0	-0.1
	RN_CA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-3.6	-1.7	0.0
	SE_CA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.2	-0.4	-0.1
	BA_CE	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.2	-0.1	0.0	-0.1	-0.1	-0.3	-0.1	-0.4	-7.2	-4.6	-0.1
	DF_CE	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	0.0	0.0	0.1
	GO_CE	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.4	-4.3	-3.7	0.1
	MA_CE	-0.2	-0.2	-0.1	-0.2	-0.3	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.3	-0.1	-0.3	-7.6	-6.4	-0.1
	MT_CE	-0.1	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.7	-2.3	0.0
Cerrado	MS_CE	-0.1	0.0	0.1	-0.2	-0.3	-0.1	0.0	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-0.6	-1.0	0.2
	MG_CE	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.2	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.3	-6.2	-4.3	0.0
	PR_CE	-0.2	-0.1	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.4	-4.9	-3.9	0.1
	PI_CE	-0.2	-0.2	-0.1	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.3	-7.5	-5.6	-0.1
	SP_CE	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-1.5	-0.9	0.1
	TO_CE	-0.3	-0.2	-0.4	-0.2	-0.4	-0.2	-0.3	-0.2	-0.1	-0.2	-0.1	-0.3	-0.2	-0.4	-17.9	-14.3	-0.3

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Biome	Regions	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Amazon	AC_AM	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.1	-0.2	-1.1	-0.9	-1.0	-3.1	-0.8	-1.3	-0.1	-0.3	-0.4
	AP_AM	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.1	-0.2	-0.8	-0.7	-0.9	-2.6	-0.4	-0.9	0.0	-0.3	-0.4
	AM_AM	0.1	0.1	0.1	0.0	-0.2	-0.2	-0.1	-0.3	-0.8	-0.6	-0.7	-2.4	-0.3	-0.8	0.1	-0.3	-0.4
	MA_AM	-0.1	0.0	-0.1	0.0	-0.2	-0.2	-0.1	-0.2	-1.0	-0.9	-1.1	-2.8	-0.7	-1.2	0.0	-0.3	-0.4
	MT_AM	0.1	0.2	0.1	0.2	-0.1	-0.1	0.1	-0.2	-0.8	-0.6	-0.7	-2.5	-0.4	-0.9	0.3	-0.2	-0.3
	PA_AM	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	-1.0	-0.9	-0.9	-3.0	-0.8	-1.2	0.0	-0.4	-0.4
	RO_AM	0.0	0.1	0.0	0.0	-0.2	-0.2	0.0	-0.2	-0.9	-0.7	-0.8	-2.6	-0.5	-1.0	0.0	-0.3	-0.4
	RR_AM	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.1	-0.2	-1.2	-0.9	-1.0	-2.9	-0.8	-1.3	-0.1	-0.3	-0.4
	TO_AM	0.0	0.0	0.0	0.0	-0.2	-0.1	-0.1	-0.3	-1.0	-0.9	-1.1	-2.8	-0.7	-1.1	-0.1	-0.3	-0.4
Caatinga	AL_CA	0.0	0.1	0.0	0.0	-0.2	-0.2	-0.1	-0.3	-0.6	-0.6	-0.5	-2.3	-0.3	-0.8	0.0	-0.3	-0.4
	BA_CA	0.0	0.2	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.6	-0.6	-0.6	-2.3	-0.3	-0.7	0.3	-0.2	-0.4
	CE_CA	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.1	-0.3	-0.6	-0.7	-0.5	-2.4	-0.3	-0.7	0.3	-0.3	-0.4
	MA_CA	0.1	0.1	0.1	0.0	-0.2	-0.2	-0.1	-0.1	-0.5	-0.6	-0.5	-2.0	-0.1	-0.6	0.1	-0.3	-0.4
	MG_CA	0.1	0.1	0.1	0.0	-0.2	-0.1	-0.1	-0.2	-0.6	-0.6	-0.6	-2.2	-0.2	-0.7	0.0	-0.3	-0.4
	PB_CA	0.0	0.1	0.0	0.0	-0.1	-0.2	-0.1	-0.3	-0.7	-0.6	-0.5	-2.3	-0.3	-0.8	0.1	-0.3	-0.4
	PE_CA	0.0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.3	-0.6	-0.6	-0.4	-2.3	-0.3	-0.7	0.5	-0.3	-0.4
	PI_CA	0.0	0.1	0.0	0.0	-0.2	-0.2	-0.1	-0.2	-0.7	-0.5	-0.7	-2.3	-0.3	-0.8	0.0	-0.3	-0.4
	RN_CA	0.0	0.1	0.0	0.0	-0.2	-0.2	-0.1	-0.3	-0.7	-0.7	-0.8	-2.4	-0.4	-0.8	0.1	-0.3	-0.4
	SE_CA	0.0	0.1	0.1	0.0	-0.2	-0.2	0.0	-0.2	-0.5	-0.5	-0.3	-2.0	-0.2	-0.6	-0.2	-0.3	-0.4
Cerrado	BA_CE	0.1	0.0	0.0	0.0	-0.2	-0.2	-0.1	-0.3	-1.0	-0.9	-0.9	-2.9	-0.7	-1.2	-0.1	-0.3	-0.4
	DF_CE	0.1	0.1	0.0	0.0	-0.1	-0.2	-0.1	-0.3	-0.7	-0.6	-0.5	-2.5	-0.4	-0.8	0.0	-0.3	-0.4
	GO_CE	0.0	0.1	0.1	0.1	-0.1	-0.1	0.0	-0.3	-0.9	-0.6	-0.7	-2.7	-0.5	-0.9	0.2	-0.3	-0.4
	MA_CE	-0.1	-0.1	-0.2	-0.1	-0.2	-0.2	-0.1	-0.4	-1.2	-1.0	-1.3	-3.1	-1.0	-1.5	-0.3	-0.3	-0.4
	MT_CE	0.0	0.2	0.1	0.1	-0.1	-0.2	0.0	-0.3	-0.7	-0.5	-0.4	-2.4	-0.3	-0.7	0.3	-0.3	-0.4
	MS_CE	0.1	0.2	0.3	0.3	0.1	0.0	0.0	-0.2	-0.6	-0.4	-0.4	-2.1	-0.1	-0.5	0.9	-0.2	-0.3
	MG_CE	0.0	0.1	0.0	0.0	-0.2	-0.2	0.0	-0.3	-1.1	-0.8	-0.9	-2.8	-0.7	-1.1	0.1	-0.3	-0.4
	PR_CE	0.0	0.2	0.1	0.1	-0.2	-0.1	-0.1	-0.3	-0.9	-0.6	-0.6	-2.3	-0.3	-0.8	0.1	-0.3	-0.4
	PI_CE	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.4	-0.9	-0.9	-0.9	-2.7	-0.7	-1.1	-0.1	-0.3	-0.4
	SP_CE	0.1	0.1	0.0	0.0	-0.2	-0.1	0.0	-0.4	-0.8	-0.6	-0.6	-2.3	-0.3	-0.8	0.2	-0.3	-0.4
	TO_CE	-0.1	-0.2	-0.4	-0.3	-0.6	-0.3	-0.2	-0.4	-1.9	-1.5	-1.6	-4.3	-1.9	-2.3	-0.9	-0.4	-0.4

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Biome	Regions	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Amazon	AC_AM	-0.4	-0.3	-0.1	-0.4	-0.3	-0.3	0.0	-0.1	-0.5	-0.3	-0.3	-0.3	-0.7	-0.4	-0.3	-0.4	-0.5
	AP_AM	-0.4	-0.3	-0.1	-0.4	-0.3	-0.2	-0.1	-0.2	-0.5	-0.4	-0.4	-0.4	-0.7	-0.4	-0.3	-0.5	-0.5
	AM_AM	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.3	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.4
	MA_AM	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.7	-0.3	-0.3	-0.4	-0.4
	MT_AM	-0.4	-0.2	-0.1	-0.2	-0.3	-0.1	0.0	-0.1	-0.4	-0.4	-0.2	0.0	-0.5	-0.4	-0.1	-0.3	-0.3
	PA_AM	-0.4	-0.3	-0.1	-0.3	-0.4	-0.2	-0.1	-0.2	-0.5	-0.4	-0.4	-0.3	-0.7	-0.4	-0.3	-0.5	-0.5
	RO_AM	-0.4	-0.2	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.4	-0.3	-0.3	-0.3	-0.6	-0.4	-0.2	-0.4	-0.5
	RR_AM	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.4	-0.4	-0.5	-0.3	-0.2	-0.4	-0.5
	TO_AM	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	-0.1	-0.2	-0.5	-0.4	-0.1	-0.2	0.0	-0.3	-0.3	-0.4	-0.2
Caatinga	AL_CA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.2	-0.4	-0.3	-0.3	-0.3	-0.7	-0.3	-0.3	-0.4	-0.5
	BA_CA	-0.4	-0.2	-0.1	-0.2	-0.3	-0.1	0.1	0.0	-0.4	-0.3	-0.2	-0.1	-0.5	-0.3	-0.2	-0.3	-0.3
	CE_CA	-0.4	-0.3	-0.1	-0.4	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.5
	MA_CA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.7	-0.3	-0.2	-0.4	-0.4
	MG_CA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.6	-0.3	-0.3	-0.4	-0.4
	PB_CA	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	0.0	-0.2	-0.5	-0.5	-0.3	-0.2	-0.6	-0.3	-0.2	-0.4	-0.4
	PE_CA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.2	0.1	0.0	-0.5	-0.4	-0.3	-0.1	-0.6	-0.3	-0.2	-0.4	-0.4
	PI_CA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.2	-0.2	-0.4	-0.3	-0.2	-0.4	-0.4
	RN_CA	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.3	-0.7	-0.3	-0.3	-0.4	-0.4
	SE_CA	-0.4	-0.1	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.3	-0.3	-0.3	-0.3	-0.5	-0.3	-0.2	-0.4	-0.5
Cerrado	BA_CE	-0.4	-0.2	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.6	-0.3	-0.2	-0.4	-0.4
	DF_CE	-0.4	-0.3	-0.1	-0.4	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.2	-0.3	-0.7	-0.4	-0.3	-0.4	-0.4
	GO_CE	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.3	-0.6	-0.4	-0.2	-0.4	-0.4
	MA_CE	-0.5	-0.3	-0.1	-0.4	-0.3	-0.3	-0.1	-0.2	-0.5	-0.4	-0.3	-0.3	-0.6	-0.4	-0.3	-0.4	-0.4
	MT_CE	-0.4	-0.2	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.4	-0.4	-0.3	-0.2	-0.5	-0.3	-0.2	-0.3	-0.4
	MS_CE	-0.3	-0.1	-0.1	-0.2	-0.3	0.0	0.0	-0.1	-0.4	-0.4	-0.2	0.0	-0.3	-0.2	-0.1	-0.3	-0.3
	MG_CE	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	0.0	-0.2	-0.5	-0.5	-0.3	-0.3	-0.7	-0.4	-0.3	-0.4	-0.4
	PR_CE	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.3	-0.8	-0.3	-0.3	-0.4	-0.4
	PI_CE	-0.4	-0.2	-0.1	-0.4	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.7	-0.3	-0.3	-0.4	-0.4
	SP_CE	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	-0.1	-0.2	-0.6	-0.6	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.4
	TO_CE	-0.5	-0.4	-0.1	-0.5	-0.4	-0.6	-0.1	-0.2	-0.5	-0.4	-0.4	-0.6	-0.6	-0.6	-0.5	-0.5	-0.6

(Continues)

(Continued)

Biome	Regions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Atlantic Forest	AL_MA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.3	-0.1	-0.3	-2.3	-1.5	-0.1
	BA_MA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.3	-0.1	-0.3	-5.7	-4.6	-0.1
	ES_MA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.3	-0.1	-0.3	-5.9	-4.6	0.0
	GO_MA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.0	-1.5	0.1
	MS_MA	-0.1	-0.1	0.1	-0.2	-0.2	-0.1	0.0	-0.1	0.0	0.0	0.0	-0.2	0.0	-0.3	-0.3	-0.9	0.2
	MG_MA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.3	-4.5	-2.6	0.1
	PB_MA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.4	-2.1	-1.1	0.0
	PR_MA	-0.1	-0.1	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.2	-1.2	0.1
	PE_MA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.3	-0.1	-0.3	-2.6	-1.3	-0.1
	RJ_MA	-0.2	-0.2	0.0	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-3.1	-1.9	0.0
	RN_MA	-0.2	-0.2	0.0	-0.1	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.3	-0.1	-0.3	-1.5	-0.7	0.0
	RS_MA	-0.2	-0.1	0.0	-0.2	-0.3	-0.1	-0.2	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.3	-2.5	-0.9	0.1
	SC_MA	-0.2	-0.1	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.5	-0.8	0.0
	SP_MA	-0.2	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.4	-1.6	-1.8	0.1
	SE_MA	-0.2	-0.2	0.0	-0.3	-0.3	-0.2	-0.1	-0.1	0.0	-0.1	0.0	-0.3	-0.1	-0.3	-1.3	-0.2	0.0
Pampa	RS_PP	-0.1	-0.1	0.1	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-0.9	-0.4	0.2
Pantanal	MT_PT	-0.1	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	-2.1	-3.2	0.1
	MS_PT	0.1	-0.2	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.3	0.3	-0.9	0.1

Biome	Regions	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Atlantic Forest	AL_MA	0.0	0.1	0.0	-0.1	-0.2	-0.2	-0.1	-0.2	-0.7	-0.6	-0.5	-2.3	-0.3	-0.8	-0.1	-0.3	-0.4
	BA_MA	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.2	-1.0	-0.8	-0.8	-2.8	-0.7	-1.2	-0.1	-0.3	-0.4
	ES_MA	0.1	0.1	0.0	0.0	-0.2	-0.2	0.0	-0.1	-0.8	-0.6	-0.5	-2.5	-0.4	-0.9	0.0	-0.3	-0.4
	GO_MA	0.1	0.2	0.1	0.1	-0.2	-0.1	0.0	-0.2	-0.7	-0.6	-0.6	-2.3	-0.3	-0.7	0.2	-0.3	-0.4
	MS_MA	0.1	0.2	0.3	0.2	0.0	0.0	0.0	-0.2	-0.6	-0.4	-0.4	-2.1	-0.1	-0.6	1.0	-0.2	-0.3
	MG_MA	0.1	0.1	0.1	0.1	-0.2	-0.2	0.0	-0.1	-0.9	-0.7	-0.7	-2.5	-0.4	-0.9	0.1	-0.3	-0.4
	PB_MA	-0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.3	-0.7	-0.6	-0.6	-2.3	-0.3	-0.8	0.0	-0.3	-0.4
	PR_MA	0.1	0.2	0.1	0.1	-0.1	-0.2	0.0	-0.3	-0.8	-0.6	-0.5	-2.3	-0.3	-0.8	0.3	-0.3	-0.4
	PE_MA	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.4	-0.7	-0.6	-0.6	-2.3	-0.4	-0.9	0.0	-0.3	-0.4
	RJ_MA	0.0	0.1	0.0	0.0	-0.1	-0.1	0.0	-0.2	-0.8	-0.6	-0.6	-2.4	-0.3	-0.8	0.0	-0.3	-0.4
	RN_MA	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.2	-0.7	-0.7	-0.7	-2.4	-0.4	-0.8	0.0	-0.3	-0.4
	RS_MA	0.1	0.1	0.2	0.1	-0.2	-0.2	0.0	-0.3	-0.8	-0.5	-0.5	-2.0	-0.2	-0.7	0.3	-0.2	-0.4
	SC_MA	0.1	0.1	0.1	0.1	-0.2	-0.2	0.0	-0.3	-0.9	-0.8	-0.6	-2.3	-0.3	-0.8	0.1	-0.3	-0.4
	SP_MA	0.1	0.1	0.0	0.0	-0.2	-0.2	0.0	-0.4	-0.9	-0.7	-0.6	-2.3	-0.4	-0.8	0.2	-0.3	-0.4
	SE_MA	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.1	-0.2	-0.6	-0.6	-0.5	-2.4	-0.3	-0.8	0.1	-0.3	-0.4
Pampa	RS_PP	0.3	0.2	0.2	0.2	-0.1	-0.1	0.0	-0.3	-0.6	-0.5	-0.4	-1.8	-0.2	-0.6	0.9	-0.2	-0.4
Pantanal	MT_PT	0.1	0.1	0.1	0.1	-0.1	-0.1	0.0	-0.2	-0.6	-0.5	-0.5	-2.1	-0.1	-0.6	0.2	-0.2	-0.4
	MS_PT	0.1	0.2	0.2	0.2	-0.1	-0.1	0.0	-0.1	-0.5	-0.5	-0.4	-2.0	-0.1	-0.5	0.5	-0.3	-0.3

(Continues)

(Continued)

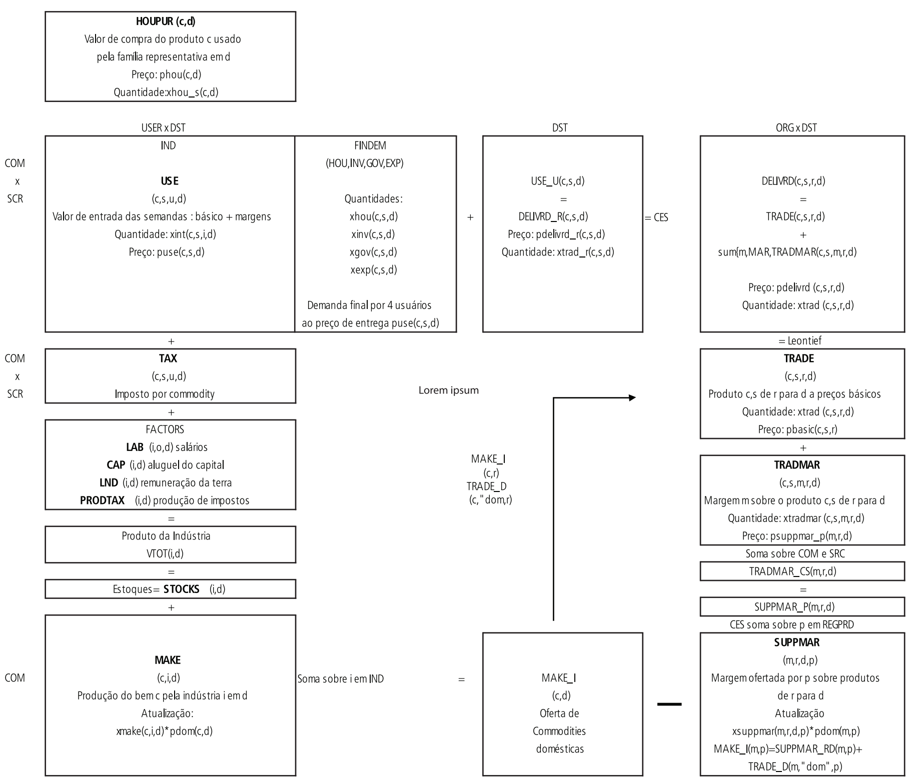
Biome	Regions	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Atlantic Forest	AL_MA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.8	-0.3	-0.3	-0.4	-0.5
	BA_MA	-0.5	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.2	-0.5	-0.4	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.5
	ES_MA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.3	-0.7	-0.3	-0.3	-0.4	-0.4
	GO_MA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.3	-0.2	-0.6	-0.3	-0.2	-0.3	-0.4
	MS_MA	-0.3	-0.1	-0.1	-0.2	-0.3	0.0	0.0	-0.1	-0.5	-0.4	-0.2	0.1	-0.5	-0.2	-0.1	-0.3	-0.3
	MG_MA	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.6	-0.5	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.4
	PB_MA	-0.5	-0.3	-0.1	-0.4	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.5
	PR_MA	-0.4	-0.3	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.2	-0.7	-0.3	-0.3	-0.4	-0.4
	PE_MA	-0.5	-0.3	-0.1	-0.4	-0.3	-0.4	-0.1	-0.2	-0.6	-0.5	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.4
	RJ_MA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.4	-0.3	-0.3	-0.8	-0.3	-0.3	-0.4	-0.4
	RN_MA	-0.4	-0.3	-0.1	-0.4	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.5
	RS_MA	-0.4	-0.3	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.6	-0.5	-0.3	-0.2	-0.7	-0.3	-0.2	-0.4	-0.3
	SC_MA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.3	0.0	-0.1	-0.5	-0.5	-0.3	-0.3	-0.8	-0.4	-0.3	-0.4	-0.4
	SP_MA	-0.4	-0.4	-0.1	-0.4	-0.3	-0.3	0.0	-0.2	-0.6	-0.6	-0.3	-0.3	-0.9	-0.4	-0.4	-0.4	-0.4
	SE_MA	-0.4	-0.2	-0.1	-0.3	-0.3	-0.1	0.0	-0.1	-0.4	-0.4	-0.3	-0.3	-0.6	-0.3	-0.2	-0.3	-0.4
Pampa	RS_PP	-0.4	-0.3	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.6	-0.5	-0.3	-0.2	-0.6	-0.3	-0.2	-0.3	-0.3
Pantanal	MT_PT	-0.4	-0.2	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.5	-0.3	-0.3	-0.2	-0.5	-0.3	-0.2	-0.4	-0.4
	MS_PT	-0.4	-0.2	-0.1	-0.3	-0.3	-0.2	0.0	-0.1	-0.4	-0.3	-0.3	0.0	-0.5	-0.2	-0.1	-0.3	-0.4

Authors' elaboration.
Obs.: Caption of sectors according to table A.1 and caption of regions according to figure 1.

APPENDIX B

The core structure of the model database is shown in figure B.1. As in Magalhães (2009), Carvalho (2014), Souza (2015), Ribeiro (2015), Cardoso (2016) and Sessa (2019), four final plaintiffs are considered in each region of the model: the representative family (HOU); capital formation (INV); government demand (GOV), corresponding to the federal, state and municipal levels; and demand for exports (EXP). In the USE matrix, the values are measured at sales prices, assuming the possibility that the goods may be re-exported. USE represents product use ratios (domestic and imported) for 56 users in each of 48 regions: 52 sectors and 4 final plaintiffs (households, investment, exports, government). The TAX matrix shows the tax revenue per product, containing elements corresponding to those of the USE matrix.

FIGURE B.1
Brazilian Biomes, Land Use and Emissions Economic Model (BLUME) database



Authors' elaboration.

These two matrices (USE and TAX), together with the primary factor cost and production tax matrices, form the production costs (or product value) of each regional industry. In accounting, the value of each regional industry's product also equals the sum of inventories with the value of each product's production by each industry in each region (MAKE). Although the production of different goods by different sectors is possible, the model will be used with the correspondence that each sector produces only one good, so the MAKE matrix becomes square and diagonal in each region. The MAKE byproduct, MAKE_I, shows the total output of each product in each target region. This whole structure is similar to the conventional input-output databases for each region.

The rest of the structure represents the regional supply mechanism. The regional origin of the goods is informed by the TRADE matrix, which represents the flow of trade between the regions for each of the 52 products in the model, both domestic and imported. The diagonal of this matrix shows the value of local usage that is offered locally. In the case of imported products, regional origin is the port of entry into the country. And the IMPORT matrix lists the total imports by each port, simply being an aggregation of the TRADE matrix import share. The TRADMAR matrix presents the margin value required to carry out the trade flows of each TRADE matrix element, but without any inference as to where the margin flow is produced. The sum of the TRADE and TRADMAR matrices gives rise to the "delivery" price of all product flows (DELIVRD).

The origin of margins is presented in the SUPPMAR matrix, regardless of the products or their origin, domestic or imported, so that the total use of margins to market or transport any product from one region to another follows the same proportion. The sum of the regional margins forms the matrix SUPPMAR_P, which has the same value as TRADMAR_CS, derived from the TRADMAR matrix from the margins of domestic and imported products. In this structure, TRADMAR_CS is an aggregation of SUPPMAR from a constant substitution elasticity (CES) function, and thus the margins for a given product on a given route are set according to the price of that margin in the various regions.

In the model, all users of a given good in a region have the same source mix, adopting the Armington substitution, where the DELIVRD_R matrix is a CES compound of the DELIVRD matrix. The existence of equilibrium depends on the sum of USE (USE_U) being equal to the sum of DELIVRD (DELIVRD_R).

Compatibility between supply and demand for household goods occurs between the MAKE_I matrix and the TRADE and SUPPMAR matrices. For non-margin products, the domestic elements contained in the TRADE matrix are added to the corresponding elements in the MAKE_I commodity supply matrix. And in the case of margin assets, the margin requirements of matrix SUPPMAR_RD and the direct demand presented in matrix TRADE_D are considered.

Investments are divided according to the destination industry or import entry point in the INVEST matrix.

In addition to the data presented so far, the BLUME model needs behavioral parameters and elasticities, which are usually found in other studies in the literature. The main parameters of the model are: intermediate goods substitution elasticity (ARMSIGMA), substitution elasticity between regions (SIGMADOMDOM), household spending elasticity (EPS), export demand elasticities (EXP_ELAST). CET transformation elasticities (SIGMAOUT) and CES substitution elasticity for primary factors (SIGMA1PRIM). For the elasticity calibration, the estimates of Faria and Haddad (2014), Kume and Piani (2013), Tourinho, Kume and Pedroso (2007) and Hoffmann (2010) were used. These estimates are the most recent found in the literature. It is noteworthy that the elasticity values had to be adjusted according to BLUME's sectoral and regional structure.

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