Climate change, agriculture and economic effects on different regions in Brazil

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- This paper is based on Gustavo Inácio de Moraes Doctoral dissertation at ESALQ/USP.

Motivation

- Climate change is likely to create important negative effects on Brazilian agriculture.
- With a large part of Brazil's territory located in tropical and subtropical areas, the country will probably suffer serious setbacks as a result of the increase in temperature, as indicated by the most recent scenarios of the Intergovernmental Panel on Climate Change (IPCC).
- The Stern Review (Stern, 2007) does not provide information on the impacts of climate change on agriculture in developing countries.
- Studies in Brazil. These studies included those by Nobre and Assad (2005), Marengo (2007) and Pinto and Assad (2008).

Objective

- Assess the potential economic effects of climate change on Brazilian agriculture scenarios in different regions in a general equilibrium framework.
- A detailed regional economic database for year 2005 was built, and it was used to calibrate a CGE model of Brazil.
- Contributions to the literature:
  - Detailed shocks by product: beneficial effects for some.
  - Highlight the conexions between CC impacts and labor markets.
  - Tracks the link between CC forecasts for agriculture and household expenditure.

Methodology: computable general equilibrium model of Brazil

- Static, inter-regional, bottom-up.
- 35 sectors.
- 35 products (11 agricultural products)
- 10 types of workers (wage classes)
- 27 regions inside Brazil
- 10 household types (income classes)
- Linearized, solved with GEMPACK.

Simulation strategy

- The criteria used for simulating the impacts of climate change on agriculture are based on the concept of agriculturally viable areas, or the loss of an area's viability for agriculture due to climate change.
- The papers from Assad *et al*. (2007), Pinto and Assad (2008) and Lobell *et al*. (2008) are thereferences for the shocks to agriculture used in our simulations.
- Among them, the most important study for our purposes is the paper by Pinto and Assad (2008),4 which presents detailed maps of agricultural land loss in different scenarios.
- Only main agricultural activities: beans, sugarcane, coffee, cassava, rice, cotton, corn and soybeans.

Scenarios: two time spans

- IPCC:
  - A2 scenario for years around 2020
  - B2 scenario for years around 2070.
- This choice is based on the idea of adaptation: the more severe scenario for 2020 means that no adaptation would take place in the short run, while the less severe scenario for 2070 means that some adaptation would take place over time.

The rationale behind thise scenarios

- GHG concentration around 2020/A2 is less than 2070/B2, even if B2 is a more adapted trajectory in comparison with A2 scenarios.
- This happens due to the longer time span around 2070 (an additional 50 years of concentration in GHG emissions in
- the atmosphere).
- Then, 2070/B2 is more impacting than 2020/A2.

Calculating the shocks: several steps

- Maps supplied by Pinto and Assad (2008) to identify regions which would lose suitability for agriculture, organized by state.
- This was compared to a county grid map by IBGE (2009): identification of the way each micro-region and state would be affected by each product.
- Variation in land use and production loss by agricultural activity calculated using information from the *Pesquisa Agricola Municipal* (IBGE, 2006b).
- Maximum loss of 80% considered "ad hoc" to avoid total elimination of agriculture in some regions.

Calculating the shocks: several steps

- The shocks are particularly severe in the northeastern and center-western regions of Brazil, especially in the cultures of cotton, soybean, rice, corn and coffee.
- Gustavo2020.cmf
- Gustavo2070.cmf
- Climashk.har

Sugar cane as a special case

- No direct loss of areas in the scenarios
- A reduction in the area under sugar cane would not be required in the absence of a general fall in total area that would be viable for agriculture.
- The aggregate fall in land availability by state, however, would require a decrease in sugar cane areas in the northern and northeastern regions, as well as a slight decrease in the sugar cane area in the southern region, according to the A2/2020 scenario.
- In the first scenario, there would be an increase in sugar cane productivity in some regions as a consequence of temperature and CO2 increases.

Results

Table 2. *Selected macro results (percentage change)*

	Real GDP		*Real wages*		*Real household consumption*		*Employment*		*Consumer price index*	
Scenarios	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*
N	−0.01	+0.15	−0.19	−1.46	+0.36	−1.03	0.45	0.48	0.27	0.41
NE	−4.07	−6.13	−2.44	−4.54	−4.73	−7.58	−2.18	−2.95	0.61	0.85
SE	+0.83	+0.36	−0.22	−1.30	+0.15	−0.80	0.34	0.55	−0.14	−0.13
S	−0.15	−1.35	−0.19	−1.78	+0.19	−1.70	0.38	0.02	−0.11	−0.42
CW	−2.98	−4.41	−0.75	−1.46	−0.70	−0.95	−0.17	0.43	−0.26	−0.18
Brazil	−0.28	−1.12	−0.53	−1.81	−0.70	−2.09	0	0	–	–

Source: Model results.

Table 3. *Decrease in land use by macro region, two scenarios (percentage change)*

	Macro-region									
	North		*Northeast*		*Southeast*		*South*		*Center-west*	
Scenario	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*
Rice	−6.1	−15.1	−54.5	−57.8	−12.2	−21.5	−9.7	−18.5	−3.7	−9.2
Corn	−3.9	−15.7	−49.7	−70.6	−3.2	−5.4	−5.8	9.0	−5.4	−6.4
Wheat	−12.1	−22.6	−17.2	−23.3	−33.5	−49.6	−9.9	3.8	−3.1	−20.7
Sugar cane	−51.5	−11.2	−4.2	−2.3	0.0	0.0	−0.2	0.0	0.0	0.0
Soybean	−20.8	−24.0	−47.7	−46.7	−4.7	−32.5	−37.0	−74.9	−33.3	−35.0
Cassava	−3.9	−14.2	−34.0	−38.4	−11.1	−20.6	−18.4	−7.2	5.2	−17.1
Tobacco	−11.1	−22.3	−30.2	−59.7	−30.8	−50.4	−12.5	−14.9	−13.9	−31.0
Cotton	−5.8	−17.6	−19.4	−24.3	−25.9	−39.2	−8.3	28.6	−2.7	−23.6
Citric fruits	−10.8	−20.5	−43.0	−80.0	−30.2	−48.0	−10.2	−9.5	−19.8	−36.9
Coffee	−80.0	−80.0	−80.0	−80.0	−11.2	−31.6	−7.8	24.7	−80.0	−80.0
Forestry	−10.5	−19.9	−21.4	−45.2	−31.6	−46.1	−10.4	0.0	−3.3	−20.8
Live animals	−7.7	−19.2	−44.3	−82.5	−31.3	−46.1	−10.3	−9.4	−4.3	−24.3
Raw milk	−7.3	−19.4	−50.3	−82.6	−26.3	−41.2	−11.4	−9.4	−8.3	−26.0
Other agric.	−7.8	−18.0	−13.9	−19.3	−3.3	−5.2	−11.3	−10.4	0.3	−2.7
Region total	−2.0	−4.2	−9.8	−24.0	−1.3	−2.7	−12.2	−20.6	−12.4	−21.2

Source: Model results.

Table 4. *Model results, GDP variation, by state (percentage change)*

State	Macro-region	Real GDP A2/20	Real GDP B2/70	State	Macro-region	Real GDP A2/20	Real GDP B2/70
Rondonia	N	−1.24	−1.37	Alagoas	NE	−1.16	−5.42
Acre	N	+0.84	−0.12	Sergipe	NE	−0.55	−0.32
Amazonas	N	+0.06	+0.89	Bahia	NE	−1.57	−2.34
Roraima	N	+0.84	+0.72	Minas Gerais	SE	+0.19	−0.88
Para	N	+0.82	+1.10	Espirito Santo	SE	+0.73	+1.50
Amapá	N	−2.93	−3.89	Rio de Janeiro	SE	+0.67	+0.79
Tocantins	N	−2.13	−3.92	São Paulo	SE	+1.05	+0.50
Maranhão	NE	−4.39	−6.30	Parana	S	−0.73	−3.88
Piaui	NE	−12.06	−16.39	Santa Catarina	S	+0.44	−0.31
Ceara	NE	−6.42	−8.84	Rio Grande do Sul	S	+0.03	+0.30
Rio Grande do Norte	NE	−6.16	−8.50	Mato Grosso do Sul	CW	−7.19	−9.11
Paraiba	NE	−6.71	−9.90	Mato Grosso	CW	−8.48	−11.20
Pernambuco	NE	−5.42	−8.94	Goias	CW	+0.12	−1.46
				Distrito Federal	CW	+0.05	+0.20

Source: Model results.

Table 5. *Labor demand variation by skill and state (percentage change)*

	Macro-region									
	North		*Northeast*		*Southeast*		*South*		*Center-west*	
Scenario	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*
Labor1	+2.05	+2.49	−1.19	−1.14	+0.67	+0.72	+0.91	+0.37	+2.01	+2.00
Labor2	+2.13	+2.44	−2.09	−1.85	+0.24	+0.39	+1.33	+0.52	+1.32	+1.59
Labor3	+1.17	+1.22	−2.25	−2.22	+0.95	+1.00	+1.34	+0.84	+0.97	+1.39
Labor4	+0.73	+0.86	−1.98	−2.35	+0.46	+0.60	+0.76	+0.66	+0.28	+0.64
Labor5	+0.75	+0.74	−2.08	−2.83	+0.31	+0.77	+0.75	+0.06	−0.03	+0.69
Labor6	+0.84	+0.67	−2.67	−3.62	+0.28	+0.63	+0.76	+0.32	−0.30	+0.35
Labor7	+0.54	+0.26	−2.01	−3.22	+0.10	+0.54	+0.66	−0.11	+0.19	+0.70
Labor8	+0.24	+0.17	−2.45	−3.63	+0.29	+0.54	+0.47	−0.02	−0.62	+0.41
Labor9	−0.08	+0.18	−2.25	−3.29	+0.35	+0.46	+0.29	+0.17	−0.78	−0.18
Labor10	+0.04	+0.05	−2.19	−3.31	+0.35	+0.52	+0.06	−0.20	−0.23	+0.35

Source: Model results.

Obs: Nova reversão fluxos migratórios no Brazil: NE-->SE.

Table 6. *Consumption bundle prices variation (percentage changes)*

	Macro-regions									
	North		*Northeast*		*Southeast*		*South*		*Center-west*	
Scenarios	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*	*A2/20*	*B2/70*
Househ1	+0.54	+1.22	+2.18	+3.39	+0.31	+0.87	+0.17	+0.33	+0.14	+0.88
Househ2	+0.50	+1.08	+1.73	+2.07	+0.18	+0.70	+0.09	+0.32	−0.05	+0.65
Househ3	+0.43	+0.84	+1.19	+1.85	+0.08	+0.48	+0.02	+0.13	−0.07	+0.44
Househ4	+0.33	+0.58	+0.76	+1.09	+0.05	+0.38	+0.02	0.00	−0.16	+0.39
Househ5	+0.35	+0.59	+0.49	+0.77	−0.09	+0.18	−0.04	−0.16	−0.22	+0.08
Househ6	+0.19	+0.22	+0.13	+0.13	−0.12	+0.09	−0.08	−0.25	−0.32	−0.07
Househ7	+0.16	+0.09	−0.09	−0.16	−0.20	−0.09	−0.18	−0.45	−0.37	−0.28
Househ8	+0.05	−0.14	−0.10	−0.31	−0.15	−0.27	−0.20	−0.61	−0.31	−0.37
Househ9	+0.04	−0.20	−0.35	−0.76	−0.18	−0.44	−0.18	−0.76	−0.38	−0.66
Househ10	−0.03	−0.47	−0.41	−0.98	−0.26	−0.55	−0.21	−0.98	−0.38	−0.83

Source: Model results.

Análise de sensibilidade: 3 parâmetros

- Elasticity of substitution between primary factors,
- Elasticity of substitution between labor types,
- Imported/domestic elasticity of substitution,
- Values 20 per cent lower and higher than the ones used in the simulations.
- The results for national GDP are virtually the same as the ones observed in the main simulation.
- Results are stable.

Conclusions

- Relativelly small economic impact on the Brazilian economy in aggregate terms, in the long run.
- Effects are distributionally regressive.
- The negative shocks to land use and production are concentrated in regions where the percentage of agriculture from the national total is relatively small, leading to small GDP losses in aggregate terms.
- Severe consequences would appear at regional level.
- This paper highlights the importance of regional detail when approaching such phenomena in large countries such as Brazil.

- Thank you.

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