Economics of Climate Change in Brazil

1st LAMP Meeting

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Team

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The economics of climate change in Brazil

Modeling strategy

“Flavor” of results

Next steps
This study was part of a broader project whose purpose was to make an economic assessment of the impacts of climate change in Brazil.

For different climate change scenarios, the study identified key vulnerabilities in the Brazilian economy and society, and identified cost-effective strategies to address the risks associated with these climate scenarios.

A fundamental question addressed was the extent to which, and how, climate change would impact on Brazil’s development agenda.

This study built capacity and lays the groundwork for policy debate and development in the relevant economic, social and political contexts.

The study was prepared by Brazil’s leading public and non-public institutions working in the area, which have a wealth of knowledge and expertise. Where required and desirable, they draw on international experts in the field. The consultative and collaborative nature of this study will ensure its academic rigor and independence to enhance dialogue and consensus among stakeholders.
Economics of Climate Change in Brazil Modeling Logical Structure

A RELATIONS’ NETWORK: the way the sections of this study are structured
“Economic synthesis”

Two scenarios consistent with the hypotheses of IPCC (A2 and B2)

Consider different spatial scales (country, macro-regions, state, micro-regions)

Dynamic spatial CGE system
  - Hybrid (bottom-up versus top-down)
  - Recursive dynamics

Very detailed (Why? Enhance possibilities of integration with other modules/more sources of uncertainty)
  - 110 products
  - 56 sectors
  - 27 regions (bottom-up)
  - 558 micro-regions (top-down)
Outline

The economics of climate change in Brazil

✓ Modeling strategy

“Flavor” of results

Next steps
Spatial CGE system integrated with other models (sequentially or semi-iteractively/soft links)

CGE *locus* in the integrated system

- Scenarios of climate change (A2 e B2)
  - Agriculture and land use
  - Energy
  - Population

CGE system

- Economic impacts
- Social impacts
In the first part of the project, two scenarios (*baselines*) were produced

Projections of economic variables: macroeconomic, sectoral and regional

Time horizon: 2050

Baselines: *without* GCC (temperature and precipitation)
In the second part of the project, we incorporated the effects of GCC

Using the very same modeling structure used for the elaboration of the baselines, we incorporate the specific effects of GCC in specific sectors (agriculture, livestock and energy)

The objective was to verify whether such changes would potentially generate impacts that would redirect the future of regions towards a more equitable growth path, both spatially and socially

Thus, one can assess the potential impacts of GCC in terms of benefits and costs for the country and its regions
PROBIO-IPCC Global models used: IPCC TAR (HadAM3)-Version 1

**Downscaling**

Modelos do IPCC: HadAM3

**Climatology**

1961-90

**IPCC Scenarios**

A2, B2

Climate anomalies (future-present), from regional multimodel ensemble Time slices 2071-2100, A2, B2

**Regional models**

- RegCM3
- HadRM3
- Eta CCS

Maps and data of climate anomalies 2071-2100, A2, B2
The land-use model produces estimates of changes in the allocation of land to agriculture, pasture and forestry;...
## Results: percentage changes in areas
### Scenario A2 - regions

<table>
<thead>
<tr>
<th>Region</th>
<th>2010-2040</th>
<th>2040-2070</th>
<th>2070-2100</th>
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<tr>
<td></td>
<td>lavoura</td>
<td>pasto</td>
<td>lavoura</td>
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<tr>
<td>Norte</td>
<td>-2.4%</td>
<td>17.7%</td>
<td>17.9%</td>
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<tr>
<td>Nordeste</td>
<td>-27.6%</td>
<td>28.3%</td>
<td>-18.9%</td>
</tr>
<tr>
<td>Sudeste</td>
<td>7.0%</td>
<td>4.9%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Sul</td>
<td>27.9%</td>
<td>-6.0%</td>
<td>30.4%</td>
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<tr>
<td>Centro-Oeste</td>
<td>-6.4%</td>
<td>8.4%</td>
<td>-7.1%</td>
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</tbody>
</table>
### Results: percentage changes in areas
**Scenario B2 - regions**

<table>
<thead>
<tr>
<th>Region</th>
<th>2010-2040</th>
<th>2040-2070</th>
<th>2070-2100</th>
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<tbody>
<tr>
<td></td>
<td>lavoura</td>
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<tr>
<td>Norte</td>
<td>4,0%</td>
<td>13,0%</td>
<td>10,3%</td>
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<tr>
<td>Nordeste</td>
<td>-26,6%</td>
<td>25,5%</td>
<td>-23,5%</td>
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<tr>
<td>Sudeste</td>
<td>13,6%</td>
<td>3,5%</td>
<td>16,3%</td>
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<tr>
<td>Sul</td>
<td>22,6%</td>
<td>-2,7%</td>
<td>27,1%</td>
</tr>
<tr>
<td>Centro-Oeste</td>
<td>-5,1%</td>
<td>8,0%</td>
<td>-9,1%</td>
</tr>
</tbody>
</table>
... the agriculture productivity model produces estimates of productivity changes, by different crops;...
... and the energy model produces estimates of changes in the energy matrix.

Evolution of regional intensities:

- Energy input
- Sector
These physical changes are then translated into shocks in the spatial CGE system

<table>
<thead>
<tr>
<th>“Physical” changes</th>
<th>Shocks in CGE variables</th>
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</thead>
<tbody>
<tr>
<td>Changes in the allocation of land to agriculture, pasture and forestry</td>
<td>Capital-augmenting technical change in agriculture and livestock (regional shocks)</td>
</tr>
<tr>
<td>Changes in productivity by crops</td>
<td>All-input-augmenting technical change in agriculture (regional shocks)</td>
</tr>
<tr>
<td>Changes in the energy intensity use</td>
<td>Technical changes variables for import/domestic composites related to energy products (sectoral shocks)</td>
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</tbody>
</table>
Outline

The economics of climate change in Brazil

Modeling strategy

✓ “Flavor” of results

Next steps
Differential results across sectors and regions, and over time

- Economic growth (-)
- Welfare (-)
- Regional concentration (-)
- Regional inequality (-)

Some sectors and regions may be positively affected

Impacts are magnified over time
Costs (benefits) of GCC (1)

Percentage difference

SMCG – without GCC
CMCG – with GCC

2008 2035 2050
Costs (benefits) of GCC (2)

Costs over time
(PV of differences – marginal flows)

- SMCG – without GCC
- CMCG – with GCC
Macroeconomic outlook

Adjusted to present values, discounted at a rate of 1% a year, these losses would range between R$ 719 billion and R$ 3.6 trillion, which would be equivalent to losing at least an entire year of growth over the next 40 years.

The average Brazilian citizen would lose between R$ 534 (US$ 291) and R$ 1,603 (US$ 874). The present value (2008) of the reductions in Brazilian consumption accumulated to 2050 would range between R$ 6,000 and R$ 18,000, representing 60% to 180% of current per capita annual consumption.
Mudanças climáticas podem causar perdas de R$ 3,6 trilhões ao país

Prejuízo equivale a perda de um ano de crescimento do PIB. Estudo é inédito no Brasil e aponta o cenário para 2050.
Regional outlook

The regions most vulnerable to climate change in Brazil are the Amazon and the Northeast.

In the Amazon, temperatures may increase 7-8°C by 2100, possibly leading to a radical change in the Amazon forest – the so-called “savonization”. It is estimated that climate changes would bring about a 40% reduction in the forest cover in the south-southeast-east region of the Amazon, being substituted by a savanna biome.

In the Northeast, rainfall would tend to drop 2-2.5 mm/day by 2100, causing agricultural losses in all states of the region. The water deficit would lead to a 25% reduction in pasture for slaughter cattle, thus stimulating a return to low-output cattle ranching.
Regional outlook

The decline in rainfall would affect river flows of the Northeast basins, such as the Parnaíba and the East Atlantic, important for electric power generation, with flows dropping by up to 90% between 2070 and 2100.

There would be severe losses for agriculture in all states, with the exception of the colder South-Southeast states, where temperatures would be less severe.
Sectoral outlook

**Water resources.** The projected results would be alarming for certain basins, especially in the Northeast region, with a sharp reduction in flows by 2100.

**Electric power.** Greater uncertainty in the hydroelectric power generation capacity, with firm energy reductions ranging between 31.5% and 29.3%. The more pronounced impacts would be felt in the North and Northeast. In the South and Southeast the impacts would be minimal or even positive, but would not offset the losses in the North and Northeast.
Sectoral outlook

**Agriculture and livestock.** With the exception of sugarcane, reductions in low-risk production areas would affect all crops, especially soybeans (-34% to -30%), corn (-15%), and coffee (-17% to -18%). Productivity would drop particularly for subsistence crops in the Northeast.

**Coastal zone.** Under the worst scenario of sea level rise and extreme meteorological events, the estimated value of infrastructure and properties at risk along the Brazilian coast ranges between R$ 136 and R$ 207.5 billion.
Spatial distribution of costs of GCC – B2 (in % of the projected GRP without GCC) (1)
Regional costs (benefits) of GCC – B2 (1)

Discount rate: 1%
State costs vs. Capital-city costs – B2
(in % of the projected GRP without GCC) (1)
Regional costs (benefits) of GCC (2)

<table>
<thead>
<tr>
<th></th>
<th>A2-BR</th>
<th>B2-BR</th>
<th>A2-BR</th>
<th>B2-BR</th>
<th>(R$ bilhões de 2008)</th>
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<tr>
<td>Rondônia</td>
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<td>Amazonas</td>
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<td>Roraima</td>
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<td>Minas Gerais</td>
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<td>-446,4</td>
<td>-0,55</td>
<td>-1,58</td>
<td>283,2</td>
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</tbody>
</table>

Taxa de desconto: 1%
Aquecimento global pode custar R$ 1,2 tri a SP

É como se a economia paulista parasse por 16 meses

Gislaine Miranda e Lucas de Abreu Maia - Do Curau de Focas do Estado
Centro-Oeste perde mais com clima quente, diz estudo

Monday, February 8, 2010 7:20

Notícia da Categoria: Meio Ambiente

O Centro-Oeste sofrerá as maiores perdas econômicas do Brasil, em termos proporcionais, com aquecimento global. Até 2050, o prejuízo pode atingir R$ 639 bilhões, o equivalente a dois anos e meio de crescimento. Só em Mato Grosso, principal polo do agronegócio da região, o valor chega a R$ 333 bilhões. É como se o Estado parasse de gerar riquezas durante mais de cinco anos.

As informações fazem parte de uma nova etapa do estudo “Economia do Clima”, que no fim do ano passado estimou prejuízo de até R$ 3,6 trilhões nos próximos 40 anos em todo o Brasil. Um novo relatório, com lançamento oficial previsto para o primeiro trimestre, detalha onde e como acontecerão os estragos.

Agricultura

Em entrevista à Folha, Carolina Dubeux, coordenadora operacional do projeto (que reúne...
Adjusted to present values, discounted at a rate of 1% a year, losses for the State of Minas Gerais would range between R$ 155 billion (scenario A2-BR) and R$ 446 trillion (scenario B2-BR), which would be equivalent to losing from 55% to 158% of 2008 State GRP.

Which regions would (potentially) be more affected?
PV of GRP marginal flows associated with GCC (in % of 2008 GRP)

Scenario A2-BR

Scenario B2-BR
Economic Vulnerability to Climate Change (2)*

* Location quotient of the impacts: ratio between the regional share in total impacts and the regional share in the State GRP
Regional Share in State GRP and Economic Vulnerability to GCC – Scenarios A2-BR and B2-BR (2)
Outline

The economics of climate change in Brazil

Modeling strategy

“Flavor” of results

✓ Next steps
Overcoming limitations

This is a challenging study, engaging a wide range of institutions, organizations and individuals. This provides opportunities in the form of increased integration between the institutions, more accurate data through information sharing and interdisciplinary approaches and a greater understanding of the potential impacts of climate change in Brazil to ensure the most effective response by the relevant political, economic and social sectors.

The challenge therefore also brings with it limitations and potential problems.

- Coordination and integration of studies (people, data and methods)
- Study content and substance
  - Various sources of potential inconsistency (theory, data, dynamics, integration, cascade of uncertainty, etc.)
Renewed interest in the theme

Various recent (major) initiatives after this pioneering (ongoing) effort in Brazil

Wide range of research opportunities

- REDE CLIMA ("intelligentsia")
  - “Instituto Nacional de Mudanças Climáticas” (Brazilian Model of Climate Change)
  - FAPESP

Focus on contributions to the debate on what Brazil should do about climate change based on sound technical and economic analyses – public policy
SUB-REDES DA REDE CLIMA
A REDE BRASILEIRA DE PESQUISAS SOBRE MUDANÇAS CLIMÁTICAS GLOBAIS

- INPA, Manaus, AM
  Serviços Ambientais dos Ecossistemas*

- MPEG, Belém, PA
  Biodiversidade e Ecossistemas

- UFCE, Fortaleza, CE
  Oceanos*

- UnB, Brasília, DF
  Desenvolvimento Regional

- Embrapa, Campinas, SP
  Agricultura
  Unicamp, Campinas, SP
  Cidades

- UFSC, Florianópolis, SC
  Desastres Naturais*

- FURG, Rio Grande, RS
  Zonas Costeiras

- UFPE, Recife, PE
  Recursos Hídricos

- UFRJ, Rio de Janeiro, RJ
  Energias Renováveis
  Fiocruz, Rio de Janeiro, RJ
  Saúde

- INPE, Cachoeira Paulista, SP
  Modelagem

- USP, São Paulo, SP
  Economia

*Em fase de implementação
Issues: forecasting, unscheduled events (natural disasters), financing and (regional) compensating schemes, modeling integration, downscaling

Goal: Brazilian Model of Climate Change

Task: From soft links to hard links

- Focus so far on high disaggregation and impact analysis (policy evaluation versus policy optimization)

Starting point: accumulated experience in this first multidisciplinary project + international partnerships (state-of-the-art)

Spatial dynamic CGE model as the core of the integrated system

Partnership with other countries (e.g. interregional models for Colombia, Ecuador, Azores, Lebanon, Austria, Chile)
Focus areas

CGE modeling
  - Impact analysis
  - Scenarios building

Methodological integration
  - Land use and Economics
  - Energy and Economics
  - Transportation and Economics
  - Health and Economics
Impact analysis (extreme events)

Regional economic impacts of extreme events In Brazil: An Interregional input-output Analysis of Itajaí’s Flood, 2008

Scenario 1 – Immediately (about 48 hours)

Scenario 2 – Very Short-Run (less than one week)

Scenario 3 – Short-Run (≤6 months)

Scenario 4 – Medium-Run (≤1 year)

Scenario 5 – Long-Run (≥1 year)
### Scenario building

<table>
<thead>
<tr>
<th>Dimensão</th>
<th>Indicadores</th>
<th>Cenário A</th>
<th>Cenário B</th>
<th>Cenário C</th>
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<tbody>
<tr>
<td>Crescimento</td>
<td>PIB (crescimento médio anual)</td>
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<td>Médio prazo</td>
<td>2010-2015</td>
<td>4,5</td>
<td>5,3</td>
<td>3,2</td>
</tr>
<tr>
<td>Longo prazo</td>
<td>2015-2030</td>
<td>3,3</td>
<td>3,9</td>
<td>2,7</td>
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<td>Desempenho econômico</td>
<td>PIB em 2030 (US$ bilhões de 2010)</td>
<td>4,478</td>
<td>5,533</td>
<td>3,712</td>
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<td>Inserção internacional</td>
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<tr>
<td>Global</td>
<td>(X + M / PIB) em 2030</td>
<td>34,27</td>
<td>29,55</td>
<td>26,96</td>
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<td>Progresso técnico</td>
<td>Crescimento médio anual da PTF</td>
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<tr>
<td>Médio prazo</td>
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<td>1,8</td>
<td>2,3</td>
<td>1,3</td>
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<tr>
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<td>2015-2030</td>
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<td>1,9</td>
<td>1,1</td>
</tr>
<tr>
<td>Escolaridade</td>
<td>Média de ano de estudos em 2030</td>
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<td>9,9</td>
<td>9,9</td>
</tr>
<tr>
<td>Participação do Estado</td>
<td>Gastos do Governo (% do PIB) em 2030</td>
<td>22,40</td>
<td>21,37</td>
<td>23,42</td>
</tr>
<tr>
<td></td>
<td>Investimentos Públicos (% do PIB) em 2030</td>
<td>2,09</td>
<td>1,86</td>
<td>2,32</td>
</tr>
<tr>
<td>Mobilidade social</td>
<td>Transição para classe C</td>
<td>Média</td>
<td>Baixa</td>
<td>Alta</td>
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<tr>
<td>Mútizenergética</td>
<td>Participação de combustíveis fósseis em 2030</td>
<td>Transição para renováveis</td>
<td>Transição mais lenta</td>
<td>Transição mais rápida</td>
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<tr>
<td>Demografia</td>
<td>Taxa de crescimento populacional</td>
<td>IBGE</td>
<td>IBGE</td>
<td>IBGE</td>
</tr>
<tr>
<td>Capacidade de investimento</td>
<td>Taxa de investimento (FBCF / PIB) em 2030</td>
<td>20,21</td>
<td>21,10</td>
<td>19,44</td>
</tr>
<tr>
<td>Pré-sal</td>
<td>Pico de produção (2028, 2036) - inexistência sobre novas reservas (50, 75 e 30%)</td>
<td>Pico em 2028 (mais platônicamente)</td>
<td>Pico em 2028</td>
<td>Pico em 2036 (mais platônicamente)</td>
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<tr>
<td>P&amp;D</td>
<td>Investimento em P&amp;D</td>
<td>Terceirizado</td>
<td>Maior progresso técnico na indústria</td>
<td>Mais concentrado no setor público (agropecuária)</td>
</tr>
</tbody>
</table>
Land use and Economics

Various efforts in the integration of land use models and regional, interregional and spatial CGE models

- USP, Cedeplar-UFMG, Esalq-USP, IPEA (graduate students)
- Unified treatment ("hard links")
More rigorous modeling of the energy sectors embedded in the CGE systems

Santos (2010) – 2011 National Award for Best Ph.D. Dissertation in Economics in Brazil

**Regional Nested Production Technology – ENERGY-BR**
**Plano Nacional de Logística e Transportes (PNLT)**

- CO₂ emissions associated with specific transportation projects and future changes in the transportation matrix

**Impacts on GGE (accumulated 2011-2030)**

<table>
<thead>
<tr>
<th>Projeto</th>
<th>Emissões de Transportes (Gg CO₂-e)</th>
<th>Demais Emissões (Gg CO₂-e)</th>
<th>Emissões Totais (Gg CO₂-e)</th>
<th>% do total emissões</th>
<th>% sobre as emissões de 2005</th>
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Llamado a presentación de trabajos para el II Seminario Anual Internacional de Economía Regional, Bariloche, Argentina
The role of transportation services in the CEER model