Enhancing Climate Change and Energy Transition Policy Design through a Flexible Input-Output Simulation Model applied to Argentina

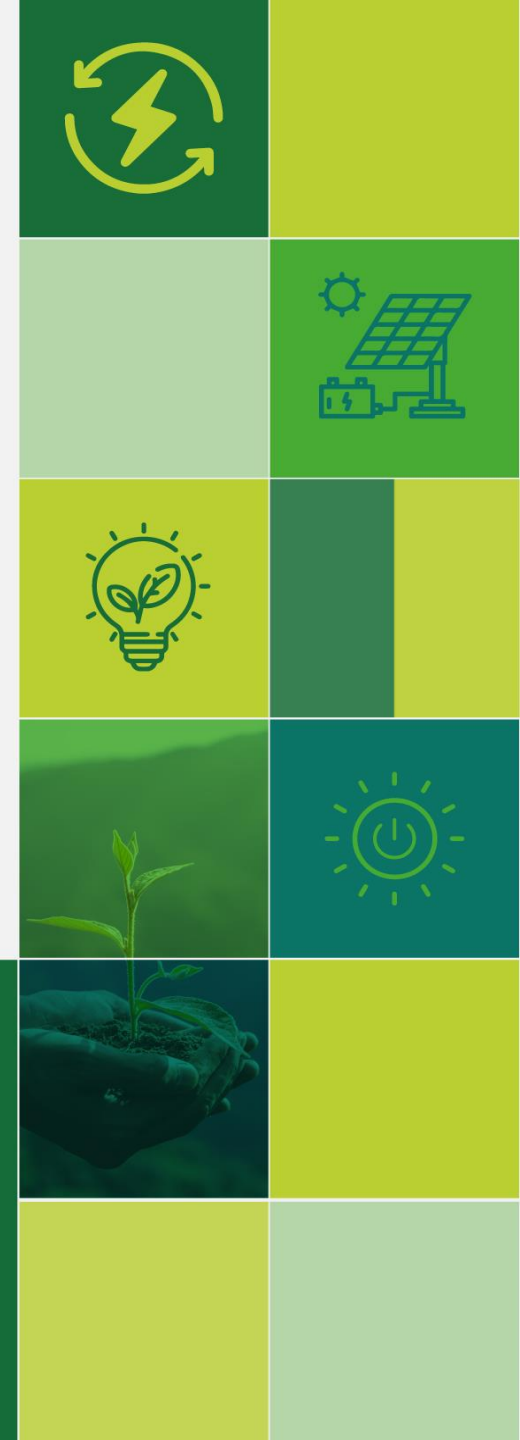
Exequiel Romero Gómez
IIEP (UBA & CONICET)

María Priscila Ramos
IIEP (UBA & CONICET)

Carlos Adrián Romero
IIEP (UBA & CONICET)

Juan Ignacio Mercatante
IIEP (UBA & CONICET)

María Laura Ojeda
IIEP (UBA & CONICET)



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Introduction

- The work was carried out within the framework of the agreement between FCE-UBA and the United Nations Environment Programme (UNEP) for the strengthening of the transparency framework on GHG Inventories and Climate Change Mitigation in Argentina.
- Developing climate change policies aligned with international commitments demands a flexible simulation tool.
- Our aim is to provide a friendly tool to help policymakers to:
  - Assess cross-sectoral impacts of climate actions
  - Identify the most effective policies or projects to achieve these goals.
- The input-output model developed is tailored to simulate sectoral policies aimed at reducing GHG emissions while evaluating their socio-economic impacts.
- Despite focusing on Argentina's climate policies, this tool can assist others facing similar resilient challenges.

Methodology approach

01 Data

- Social Accounting Matrix
- Employment Satellite Account
- Emissions Satellite Account
- Land Use Satellite Account

02 Construction of the IP Model

- Quantity Based
- Price Based

03 Construction of an Application

- Using Microsoft Excel

04 Scenario design and implementation

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- Environmental variables
- Economic variables
- Social variables

Data

Social Accounting Matrix: Comprehensive statistical tool that contains information on all transactions occurring in an economy between productive sectors and economic agents in a given year.

Employment Satellite Account: Complementary statistical tool that indicates the number of jobs in each sector of the economy.

Emissions Satellite Account: A complementary statistical tool that indicates the amount of greenhouse gas emissions produced by each sector of the economy.

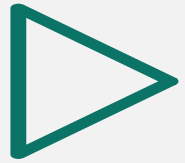
Land Use Satellite Account: Complementary statistical tool that indicates the number of hectares used by crops and other sectors of the economy (livestock and forestry).

For this project, a Social Accounting Matrix, Employment, Emissions and Land Use Satellite Accounts for Argentina 2022 were prepared with a sectorial disaggregation of 69 sectors.

Construction of the SAM for Argentina

- We use the IO Matrix for Argentina 2017, was updated to 2022 values, expanding its sectoral breakdown to include the activities relevant to the analysis.
    - The energy sector is disaggregated by product and technology.
    - Land use disaggregated by crops.

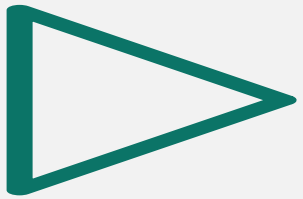
Agriculture, livestock, forestry and fishing



- **Soybeans**
- **Corn**
- **Sugarcane**
- **Other Agriculture**
- **Livestock and hunting**
- **Deforestation**
- **Other forestry**
- **Fishing**

Construction of the SAM for Argentina

Electricity, gas and water generation and distribution



- Thermal Power Generation
- Hydroelectric Power Generation
- Nuclear Power Generation
- Wind Renewable Energy Generation
- Solar Renewable Energy Generation
- Other Power Generation
- Transportation and Distribution
- Gas production; distribution of gaseous fuels through pipelines
- Water collection, purification and distribution

Satellite Accounts

- Emissions correspondences require assigning categories from the National Greenhouse Gas Inventory (INGEI): the assignments between IPCC, ISIC, and SAM sectors were made considering INDEC's 2018 Supply and Use Tables, GPV and Eurostat recommendations.
  - Total GHG emissions can be disaggregated by gas type.
- The Employment account main challenges were limited data disaggregation where official employment data is lacking (green hydrogen and electricity generation by technology).
  - Total employment can be analyzed by gender, qualification and green employment.
- Land use vector was included for the land intensive sectors such as Crop production, Cattle, Silviculture and Deforestation.

Construction of the IP Model

Quantity Model

Allows us to analyze the impact of changes in the quantities demanded by one or more sectors.

- ✓ Changes in energy demand
- ✓ Infrastructure investments
- ✓ Changes in land use

Pricing Model

Reflects the effects of changes in the cost structures of the productive sectors.

- ✓ Introduction of carbon taxes
- ✓ Change in land productivity
- ✓ Change in biofuels cuts
- ✓ Increased distributed power generation capacity and landfill capture plants

Construction of an Application

- The IP model was built using Microsoft Excel
- Visual Basic tools were also used

- ✓ Tool easy to manipulate by a non-specialized user
- ✓ Easy interpretation of aggregate and sectoral results
- ✓ Pre-programmed for the evaluation of 9 policy scenarios (with flexible parameters)

Scenario design and implementation

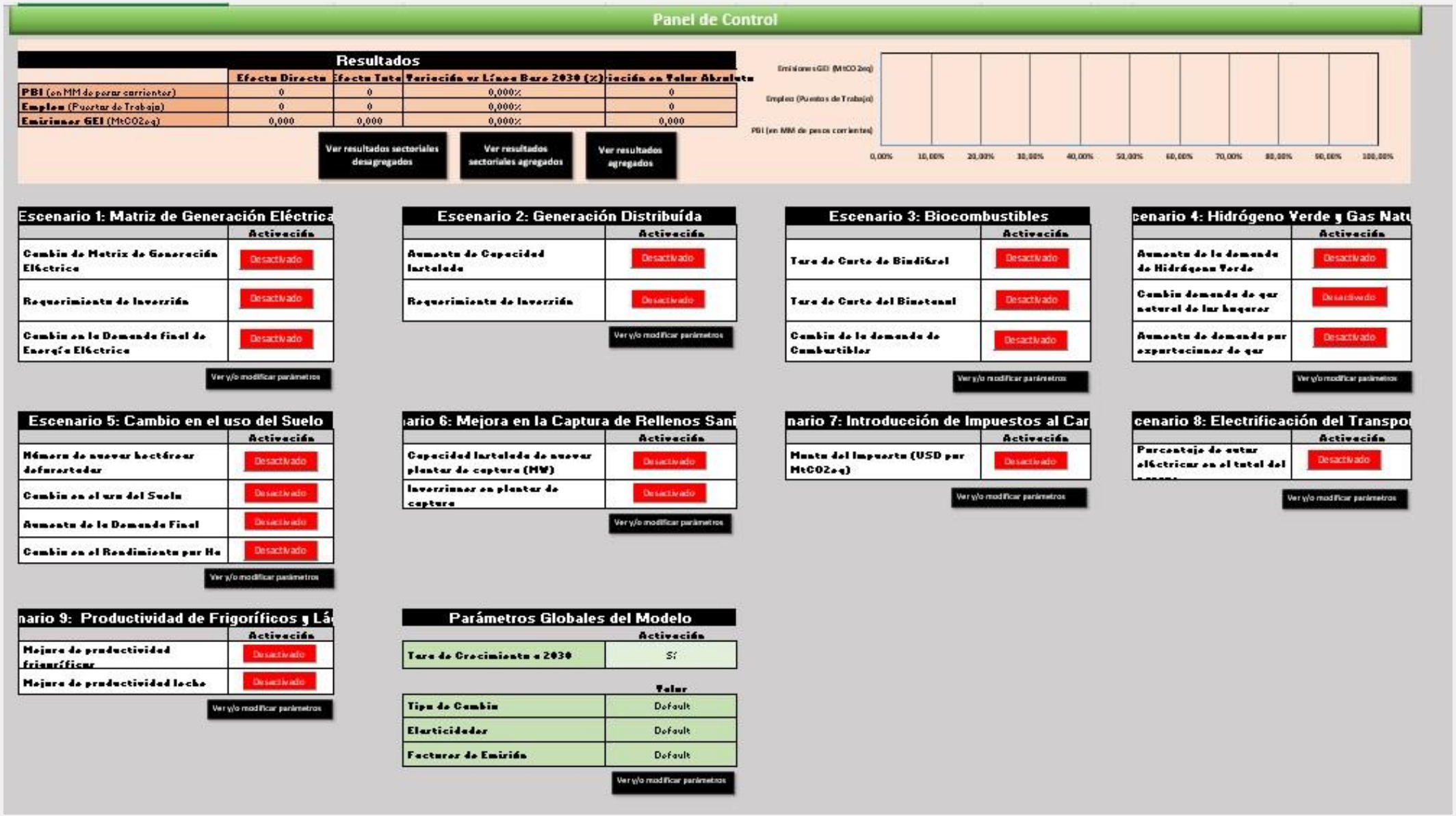
1	Modification of the Electric Generation Matrix	Expansion of generation capacity by technology + Investment
2	Distributed Power Generation	Increases in installed capacity + Investment
3	Biofuels	Variations in biofuel cut rates + Increase in demand
4	Green Hydrogen and Natural Gas Development	Impacts of an expansion of Green Hydrogen and its use in place of Natural Gas + Increased Gas Exports
5	Land Use Change	Deforestation + Land Use Change + Productivity
6	Landfill Capture Improvement	Changes in installed capacity + Investments
7	Carbon Tax	Impact of changes in the percentage of electric cars as a percentage of the total vehicle fleet
8	Transportation Electrification	Impacto de cambios en el porcentaje de autos eléctricos sobre el total del parque automotor
9	Increased productivity of cold storage and dairy plants	Evaluate improvements in productivity translated as a percentage reduction in purchases from the livestock sector without reducing production.

Simulated scenarios

- The scenarios includes substitution between affected sectors by modifying the intermediate consumption.
    - These shocks are usually accompanied by an increase in final demand.
- Some policies implies a change in prices that are captured through a price model.

Scenarios	Substitution	Final Demand Shock	Price Model
Modification of the Electric Generation Matrix	✓	✓	
Distributed Power Generation	✓	✓	✓
Biofuels	✓	✓	✓
Green Hydrogen and Natural Gas Development	✓	✓	
Land Use Change	✓	✓	
Landfill Capture Improvement	✓	✓	✓
Carbon Tax			✓
Transportation Electrification		✓	
Increased productivity of cold storage and dairy plants	✓		✓

Application Developed



Application Developed

Display when scenario is OFF

Escenario 3: Biocombustibles	Activación
Tasa de Corte de Biodiésel	Desactivado
Tasa de Corte del Bioetanol	Desactivado
Cambio de la demanda de Combustibles	Desactivado

Ver y/o modificar parámetros

Double Click

Display when scenario is ON

Escenario 3: Biocombustibles	Activación
Tasa de Corte de Biodiésel	Activado
Tasa de Corte del Bioetanol	Desactivado
Cambio de la demanda de Combustibles	Desactivado

Ver y/o modificar parámetros

Application Developed

Escenario 3: Biocombustibles	Activación
Tasa de Corte de Biodiésel	Activado
Tasa de Corte del Bioetanol	Desactivado
Cambio de la demanda de Combustibles	Desactivado

Ver y/o modificar parámetros

Select and you will be redirected to a new sheet

Option 1: Use the parameters pre-established in the model

Parámetros para escenario de Biocombustibles	Default	Especificada por el Usuario	Corte Implícito Matriz 2022
Tasa de Corte de Biodiésel	26%		12%
Tasa de Corte del Bioetanol	26%		9%
Aumento de la demanda de Combustibles	10%		

In this case, a cut rate of 26% in biodiesel is adopted, as preset by the model.

Option 2: Enter specific parameters

Parámetros para escenario de Biocombustibles	Default	Especificada por el Usuario	Corte Implícito Matriz 2022
Tasa de Corte de Biodiésel	26%	30%	12%
Tasa de Corte del Bioetanol	26%		9%
Aumento de la demanda de Combustibles	10%		

In this case, a cut rate of 30% in Biodiesel was manually selected

Application Developed

Indicates only the direct effect of the selected scenario

Indicates the direct and indirect effect of the selected scenario

Shows the percentage change with respect to a 2030 scenario without mitigation policies

Resultados				
	Efecto Directo	Efecto Total	Variación vs Línea Base 2030 (%)	Variación en Valor Absoluto
PBI (en MM de pesos corrientes)	0	0	0,000%	0
Empleo (Puestos de Trabajo)	0	0	0,000%	0
Emisiones GEI (MtCO2eq)	0,000	0,000	0,000%	0,000

Ver resultados sectoriales desagregados

Ver resultados sectoriales agregados

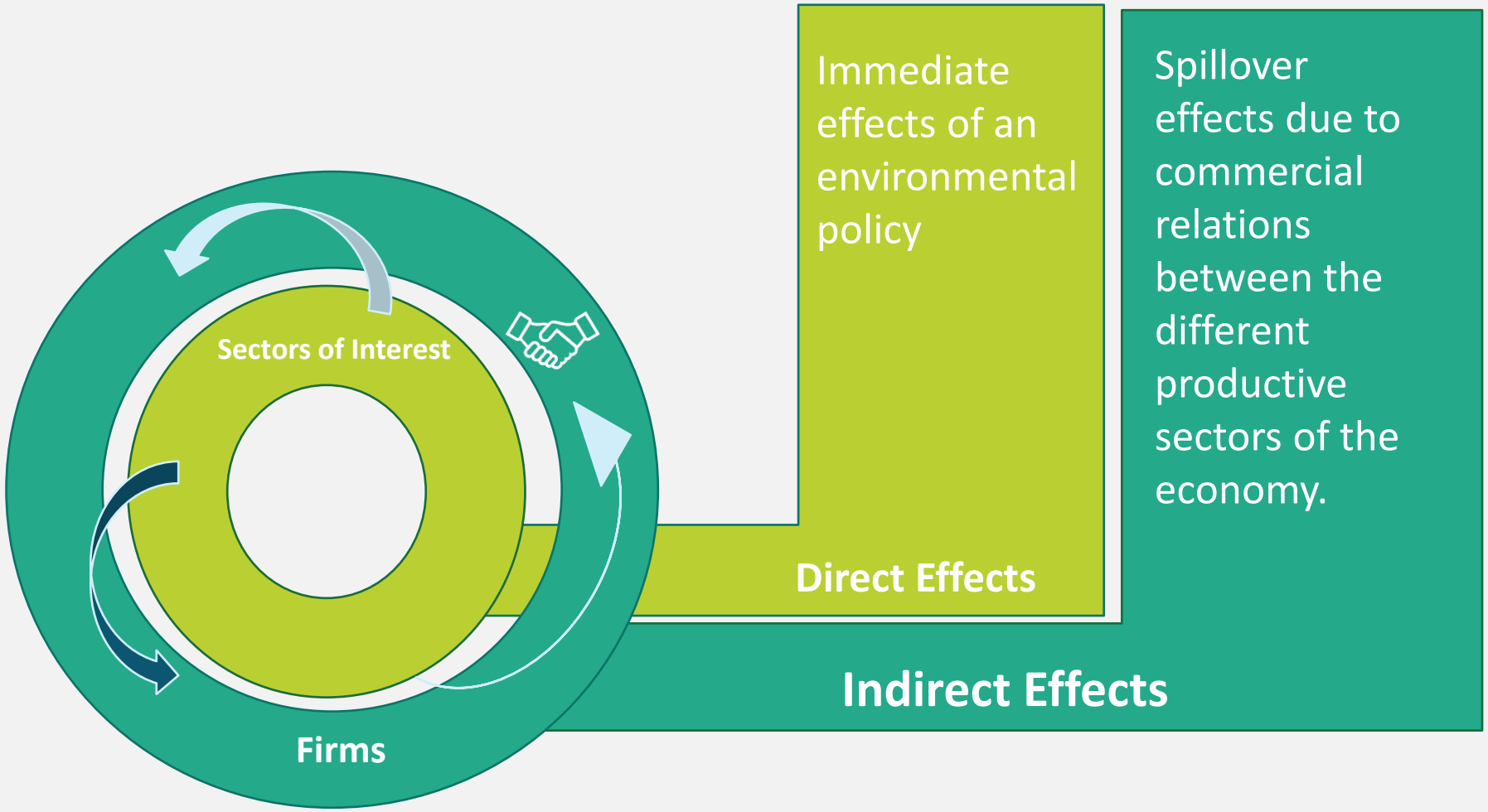
Ver resultados agregados

Select and you will be redirected to a sheet where it is possible to visualize the results for the 69 productive sectors

Select and you will be redirected to a sheet where it is possible to visualize the results for an aggregation of the 16 main productive sectors

Select and you will be redirected to a page where it is possible to visualize the aggregated results in terms of GDP, Production, Tax Collection, Employment and Emissions

Results Analysis



Results Analysis

- Trade-offs between GDP growth and emissions reduction are evident in scenarios like electricity generation matrix modification, carbon tax, and land use change.
- Certain scenarios, such as green hydrogen development, offer a dual gain with no trade-off between economic growth and emissions.

Land Use Simulation Results

- The scenario simulates a change in the composition of productive land use:
  - Increase of land use for crop with a reduction for livestock
  - Expansion of 10,000 km2 of productive land in 2030.

Simulated change in Land Use

Activity	Simulation	Reference
Soybean	40%	34%
Corn	20%	19%
Sugarcane	1%	1%
Rest Agriculture	17%	17%
Livestock	21%	27%
Forestry	1%	3%

Aggregated results

	Results			
	Direct Effect	Total Effect	Variation vs. Baseline 2030 (%)	Absolute Value Variation
GDP (MM Current ARS)	528.429	501.895	0,511%	501.895
Employment	120.909	170.361	0,779%	170.361
GHG Emissions (MtCO2eq)	-2,785	-16,787	-4,511%	-16,787

Land Use Simulation Results

Results for aggregated sectors

	Δ GDP		Δ GPV		Δ Tax Collection		Δ Employment		Δ GHG Emissions (MtCO2eq)	
	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total
Agriculture	217.726,37	477.681,52	464.015,66	1.013.763,71	67.595,27	157.302,70	73.031,07	170.155,79	3,17	7,44
Livestock and fishing	-7.077,87	-371.213,36	-12.948,16	-678.591,32	-2.292,33	-80.495,89	-2.622,38	-91.324,51	-0,99	-34,40
Forestry	-11.760,94	-39.540,13	-16.811,11	-56.518,74	-1.922,53	-5.788,55	-5.537,42	-16.672,61	2,88	8,68
Deforestation	126.414,24	138.061,88	184.773,72	201.798,53	11.200,83	11.360,57	61.707,87	62.587,94	0,00	0,00
Oil, gas and coal extraction	7.455,13	12.088,29	12.235,63	19.883,19	-24,65	1.563,19	-3,06	264,29	0,15	0,41
Food, beverages and tobacco	-157,65	-18.355,04	-75,49	-165.705,71	25.526,31	-6.082,39	4.384,71	-2.251,23	0,79	0,95
Fossil fuels	14.496,42	27.875,72	27.695,76	53.211,18	63,35	15.117,32	0,02	144,12	0,13	0,57
Biofuels and hydrogen	1.814,94	6.723,69	2.910,37	10.779,60	798,87	1.561,24	19,73	37,74	0,02	0,04
Thermal electricity generation	834,04	585,40	1.879,83	1.319,43	0,00	100,40	0,00	11,25	0,00	0,05
Renewable electricity generation	32,92	15,15	36,50	16,80	0,00	2,17	0,00	0,09	0,00	0,00
Other electricity generation	388,36	230,81	469,99	276,57	0,00	48,34	0,00	10,44	0,00	0,00
Transportation and distribution of electricity, gas and water	2.459,90	2.376,66	4.698,06	4.468,22	-15,75	700,88	-7,93	127,85	0,00	0,03
Other industries	60.921,69	105.286,61	88.056,52	145.516,71	-6.113,10	26.642,15	-3.569,74	4.346,63	0,65	1,70
Construction	464,37	-806,98	797,07	-1.385,14	-246,61	-127,35	-759,23	-392,05	0,00	0,00
Transportation services	25.338,79	49.566,87	63.188,84	123.236,92	87,90	14.569,92	89,17	16.497,24	11,88	21,10
Other services	89.078,00	111.318,21	128.764,99	158.576,62	-3.989,66	19.816,04	-5.824,23	26.818,42	-21,46	-23,36
Total	**528.429**	**501.895**	**949.688**	**830.647**	**90.668**	**156.291**	**120.909**	**170.361**	**- 2,785**	**- 16,787**

Final Remarks

- The project aimed to improve technical capacities of national and sub-national institutions and develop a powerful and easy-to-use tool for simulating 9 climate policy scenarios in Argentina.
- Most of these scenarios showed trade-offs between GDP growth and emissions reduction. However, certain scenarios, such as green hydrogen development, offered dual benefits.
- The model built for the app allows for future work, such as expanding scenarios and enhancing the tool with detailed financial, social, and regional impact analyses.

THANK YOU FOR YOUR ATTENTION

Instituto Interdisciplinario de Economía Política
Av. Córdoba 2122 - 1º y 2□ piso (C1120 AAQ)
Ciudad Autónoma de Buenos Aires, Argentina
+54 11 5285-6578 | www.iiep.economicas.uba.ar

@iiep_oficial