What are the Costs of Rigidity? A General Equilibrium Study of the Fuel Market in Argentina

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Outline

- Introduction
- Policy Issues
- Methodology and data
- Counterfactual exercises and results
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- Economies need to produce in an environmentally friendly manner $\Rightarrow$ Fuels and related policies are a key aspect of the transition.
- Energy policies are a tool to create incentives in favor of this transition.
- Fuels are a common input across all value chains. Energy policies directly or indirectly impact them.

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Fuel Market

- In this article, the **relevant market** for fuels is defined as the one containing: **diesel, gasoline, and biofuels**.
- Biofuels: Liquid fuels made from biomass.
- Nowadays, the most relevant are **bioethanol** and **biodiesel** (First generation).
- **Argentina** has **proven comparative advantages** in biofuel production: it exports 8% of the biofuels traded and is in the top ten of biodiesel and bioethanol production (Torroba, 2021).

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How Are Biofuels Usually Regulated?

- The mandatory blend:
  - Biofuels are usually mixed with fossil fuels (**blending**).
  - The mandatory blend is not determined by **economic incentives** (relative prices vs. relative productivities) but by **regulation** (Law 27.640).
  - Sets a minimum level of biofuel in the mix.
- Fiscal incentives and price controls:
  - Subsidies for R&D and production.
  - Tax incentives for biofuels.
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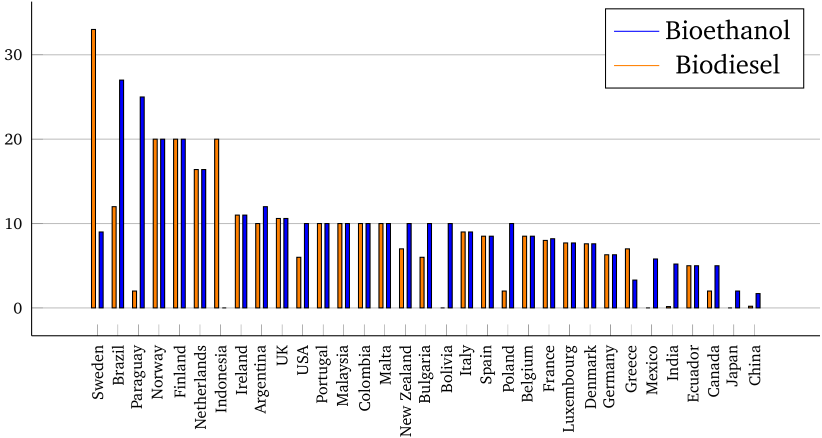
The Mandatory Blend for Different Countries



Source: Torroba (2021)

Advantages and Disadvantages of Biofuels

- Biofuels have been supported for Thofern (2011): :
  - Energy security.
  - Rural development.
  - Climate change mitigation.
- However, there can be indirect effects.
  - Changes in land and water use ⇒ variation in planted crops and deforestation (Gao et al., 2011; Valin et al., 2015; Romeu-Dalmau et al., 2018).
  - New demand for primary inputs ⇒ competition with food (Kretschmer et al., 2012; Judit et al., 2017).
  - Agricultural commodity prices correlated with oil prices ⇒ source of volatility (Taghizadeh-Hesary et al., 2019; FAO, 2011).
  - Efficiency gaps (Bioethanol=1.3 and Biodiesel=1.07). (US Department of Energy, 2022).

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This paper: Research questions

- What are the costs and benefits of the mandatory blend in terms of activity level, household welfare, income distribution, and environmental performance of the economy?
- How does this policy impact energy security conditions?
- Which policy is better to induce the use of biofuels: a blending constraint or a tax on fossil fuels?
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- Methodological Contribution:
  - Explicitly embedding a constrained fuel blending model into a CGE setup.
- Applied Contribution:
  - Calibration of a dynamic recursive general equilibrium model for Argentina and the development of the corresponding energy-oriented SAM.
  - Impact assessment of the mandatory blend for the case of Argentina:
    - The mandatory blend is effective in terms of emissions. However, it is not a double-dividend policy.
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The Model

- Energy issues cannot be evaluated independently of the rest of the economy ⇒ **importance of value chains and indirect effects** (Kretschmer and Peterson, 2010). Lit
- Recursive dynamic CGE model for Argentina (base year = 2018) together with a constrained fuel blending model. SAM
- The model consists of:
  - 66 productive sectors ⇒ Grouped into 49.
  - 10 households differentiated by per capita income ⇒ Grouped into quintiles.
  - Government.
  - Rest of the world.
- The model spans 12 periods (2018 → 2030).
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The Blender's Problem

- The blender mixes fossil fuels (F) and biofuels (B) to obtain the blend (Y).
- The blender solves the following maximization problem:

$$\max_{\{F;B\}} \pi = \alpha F + \beta B - P_F F - P_B B$$

$$s.t : \frac{B}{F + B} \geq \hat{\theta}$$

- α and β are the marginal productivity of each fuel $\Rightarrow$ define the marginal rate of substitution $\Rightarrow$ here efficiency differences are included.
- P_F and P_B are the marginal costs $\Rightarrow$ define the relative prices.
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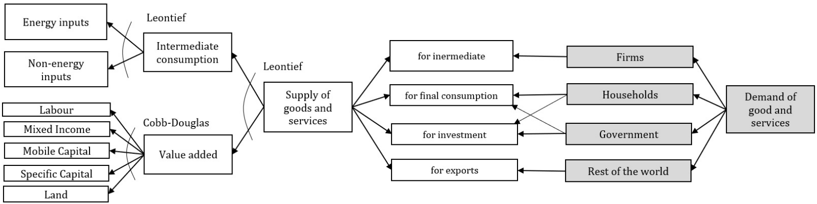
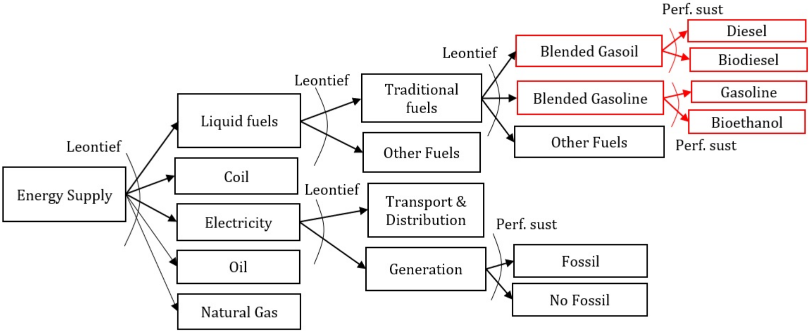
General Structure of the Model



- Sectors produce using value added (L, GMI, K, T) and intermediate consumption (Energy and Non-Energy),
- Each product has **4 possible destinations**: Intermediate Sales, consumption, investment, and exports.

Intermediate Energy Supply



- The energy supply consists of extraction goods (P, G & C), electricity, and fuels.
- Traditional fuels are produced by blending fossil fuels and biofuels ⇒ Blender's problem.

Counterfactual exercises

- Comparison between the full flexibility scenario ($\hat{\theta} = 0$) and different blending regimes ($\hat{\theta} \in [5, 10, 15, 20]$).
- Comparison of different blending regimes $\hat{\theta} \in [5, 10, 15, 20]$ vs. the equivalent tax on fossil fuels.
- International oil and agricultural commodities price shock with baseline blending vs. the same simulations with full flexibility.

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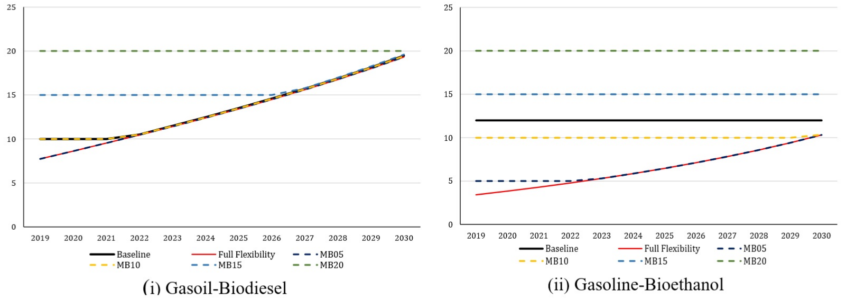
The evolution of the blend under different regimes

Fig 1. The evolution of the blending without minimum blending policy (red) and with different policy levels (others).



The Effect of the Mandatory Blend

Comparison between the full flexibility scenario ($\hat{\theta} = 0$) and different blending regimes ($\hat{\theta} \in [5, 10, 15, 20]$).

- The impact of the mandatory blend on the GDP index during the first year ranges from -0.12 p.p to -1.24 p.p compared to the situation of pure flexibility.
- By 2030, the impact on the GDP ranges from -0.01 p.p to -0.89 p.p.

- Maximum impact on the welfare of low-income households equal to -1.67 p.p in 2019 and -0.95 p.p in 2030 with the 20% mandatory blend.
- The maximum increase in the unemployment rate is 1.88 p.p. in 2019 and 0.82 p.p. in 2030 with the same blend.

- Worsening of affordability conditions.
- Negative impact on energy consumption.

- Improvements in terms of emissions that are increasing with the blending policy.
- Emission savings of -3.37 p.p. in 2019 and -2.74 p.p. in 2030 (in terms of the emissions index) compared to the flexible situation with the 20% mandatory blend.

Fuel Taxes vs. The Mandatory Blend

Comparison of different blending regimes $\hat{\theta} \in [5, 10, 15, 20]$ vs. the equivalent tax on fossil fuels. Taxes

- The fuel tax shows better short-term performance in terms of GDP, but the mandatory blend performs better in the long run.
- Driver: Different consumption and investment baskets between the government and the refinery owners.

- Both the results of the poorest deciles and the unemployment rate logically align with what happens at the activity level.
- There are no significant differences in terms of income distribution for both policies.

- Better short and long-term performance in terms of energy consumption for the mandatory blend.

- The environmental result is always in favour of the special tax on fuels, as this policy has a negative differential impact on primary production, which is highly pollutant, and a positive initial differential impact on services.

International Price Shocks

International oil and agricultural commodities price shock with baseline blending vs. the same simulations with full flexibility.

- Facing international price shocks with full flexibility always yields a better outcome in terms of GDP: gains ranging between 0.06 and 0.6 p.p.
- The most affected sector is the primary: declines of up to 0.69 p.p. in terms of the activity index.

- Negative impact on the welfare of the poorest households and regressive in terms of income distribution.
- Increase in the unemployment rate in both cases.

- Deterioration of affordability conditions.
- Negative impact on energy consumption.

- Improvements in emissions: Emissions savings of -1.19 p.p. (2019) and -0.33 p.p. (2030) (in terms of the emissions index) for the oil price shock, and -1.26 p.p. (2019) and -0.55 p.p. (2030) for agricultural commodities →Scale effect.

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- However, emissions decrease.
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Thank you!

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How to Study Bioenergy Issues?

- Energy issues cannot be evaluated independently of the rest of the economy ⇒ **importance of value chains and indirect effects**
- Computable General Equilibrium (CGE) models have been widely used for the study of biofuels (Kretschmer and Peterson, 2010).
  - Timilsina et al. (2013) develop a CGE model of Argentina characterizing the BC and CF value chains to study the impact of different biofuel industry scenarios.
  - Wianwiwat and Asafu-Adjaye (2013) develop a CGE model of Thailand focusing on the energy sector and evaluate the renewable energy development plan, particularly biofuel policies.
  - Doumax et al. (2014) develop a CGE model for France and study different biofuel incentive policies.

Model

The Social Accounting Matrix (SAM)

Figure: MACRO-SAM Argentina 2018. Millions of 2018 USD.

Argentina 2018	Primario	Industria	Servicios	VA	Impuestos	Hogares	Gobierno	Inversión	Resto del mundo	Total
Primario	13,535	34,706	11,288			10,622		8,029	13,895	92,075
Industria	12,209	40,718	57,624			116,633	54	7,478	34,247	268,961
Servicios	15,062	36,589	130,324			232,277	82,850	42,471	26,149	565,722
VA	36,837	62,773	284,707							384,317
T_Prod.	4,258	44,009	29,029			1,933		1,407		80,636
T_Fact.	7,088	10,867	41,631							59,586
T_Dir.						233				233
Hogares				364,253			74,324			438,577
Gobierno				2,764	140,455					143,219
Inversión						68,803	11,195			79,998
Resto del mundo	3,085	39,299	11,118	17,300		10,429		20,614		101,846
BNI						-2,353	-25,204		27,556	0
Total	92,075	268,961	565,722	384,317	140,455	438,577	143,219	79,998	101,846	0

Source: Own elaboration

- This is the MACRO version of the SAM.
- The MICRO SAM includes 66 productive sectors and ten households differentiated by decile of per capita income.

SAM

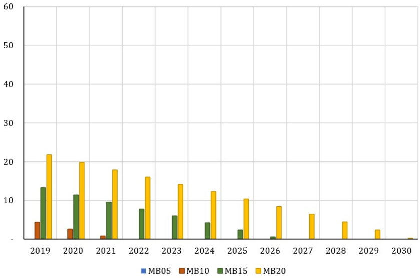
Indicators

Indicator	Measurement	Formula
GDP Index	Percentage (%)	$\left(\frac{GDP_t}{GDP_{base}} - 1\right) 100$
Public Consumption	Percentage (%)	$\left(\frac{PC^h_t}{PC^h_{base}} - 1\right) 100$
Household Welfare Index h	Equivalent variation (%)	$\left(\frac{EV_t}{EV_{base}} - 1\right) 100$
Gini Index	$[0, 100]$	$\frac{1}{n}\left(n + 1 - 2\frac{\sum_{i=1}^{n}(n+1-i)y_i}{\sum_{i=1}^{n} y_i}\right) 100$
GHG Emissions Index	Percentage (%)	$\left(\frac{GHG_t}{GHG_{base}} - 1\right) 100$
Consumption Index of good s	Percentage (%)	$\left(\frac{C(s)_t}{C(s)_{base}} - 1\right) 100$
Affordability Index of good s	$[0, \infty)$	$\frac{\sum_s C(s)_{base} P(s)}{y \Delta y} 100$

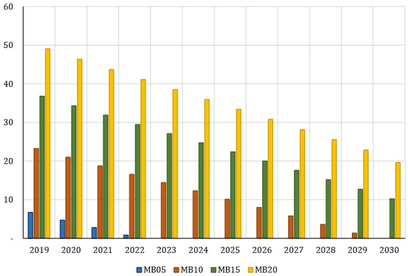
- The base year for each index is the calibration year.
- The impact of each scenario is calculated as the difference between the baseline and the simulation. Simulations

Equivalent Fuel Taxes

Fig 2. Tax rate required to induce the same allocation as the minimum blending requirement.



(i) Gasoil-Biodiesel



(ii) Gasoline-Bioethanol

Taxes