Green Energy Transition and the Importance of Cross-Border Coordination

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Motivation

- Climate change is one of the most important issues of the 21st century.
- One of the most frequently used mitigation strategies is green transition.

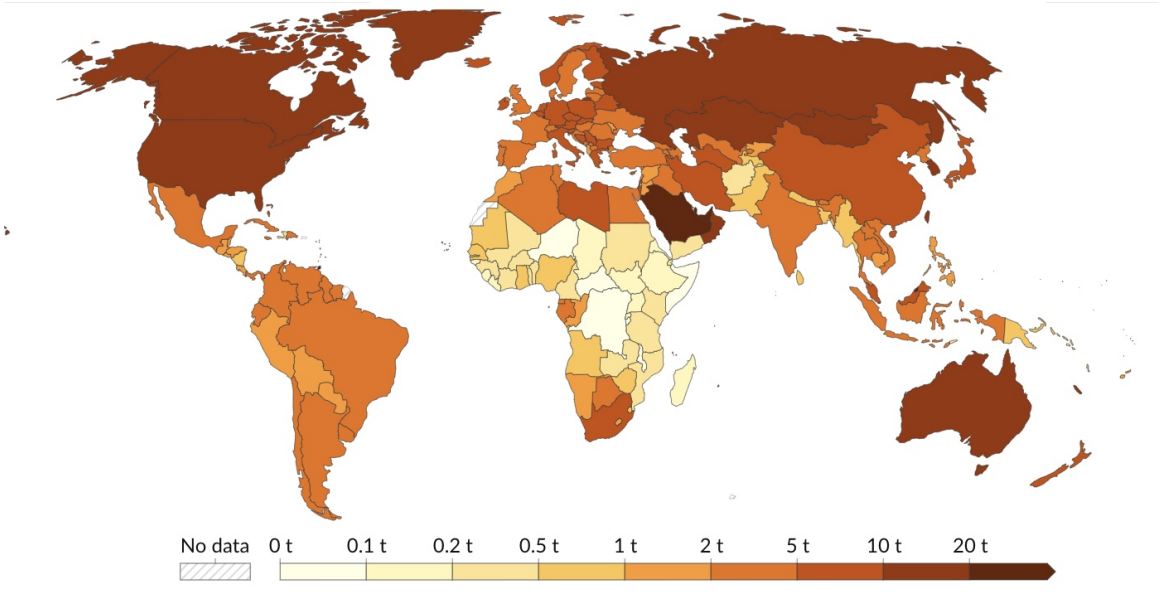

Figure: Per capita CO_2 emissions, 2023.
Carbon dioxide (CO_2) emissions from fossil fuels and industry.
Source:WHO2024 (2024)

Motivation

Figure: Windsor, Ontario

Figure: Guelph, Ontario

Literature

- Role of green energy in sustainable growth (Acemoglu et al. 2016; Fatouros and Stengos, 2023).
- Empirical evidence on renewable energy and economic growth (Chen et al., 2020; Doytch and Narayan, 2021; Kumar et al., 2024).
- Strategic interaction in environmental policies (Copeland, 1996; Copeland and Taylor, 2017).

BASELINE MODEL

Assumptions

- Closed economy
- Consumers obtain utility from consumption and disutility from pollution
- Firm uses two sources of energy: green energy and fossil fuel
- Social Planner wants to maximize the social welfare

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Social Planner wants to maximize

$$U = \int_0^{\infty} e^{-\rho t} u(c_t, P_t) dt$$

where:

- P is the pollution stock
- c is the consumption level
- ρ is the time preference parameter
- $u(c_t, P_t)$ is the instantaneous utility function:

$$\underset{(+,-)}{u(c_t, P_t)} = w ln c_t - (1 - w) ln P_t$$

Firm's side:

$$q = \phi(x_t, z_t) = A x_t^{(1-\gamma)} z_t^{\gamma}$$

where:

- q is the final good
- ϕ is the production function
- A is a constant technological factor
- x is the green energy
- z is the fossil fuel
- x and z are substitutes

Law of Motion of Emissions

$$S_t = \alpha z_t$$

- fossil fuels produce emissions
- green energy does not lead to emissions

$$\dot{S} = \frac{z_t}{z_t + x_t} \rightarrow \dot{S} = \frac{S_t}{\alpha x_t + S_t}$$

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Law of Motion of Pollution

$$\dot{P} = S_t + \xi c_t + \theta\phi(x_t, S_t/\alpha) - \delta P_t$$

where:

- Emissions increase the pollution level in a one-to-one rate
- Consumption pollutes the environment by a rate equal to ξ
- Production increases pollution by θ
- Environment is self-renewed by δ

Maximization Problem

Social's planner problem:

$$\max \quad U = \int_0^\infty e^{-\rho t} u(c_t, P_t) dt$$

$$\text{s.t.} \quad \dot{S} = \frac{S_t}{\alpha x_t + S_t}$$

$$\dot{P} = S_t + \xi c_t + \theta \varphi(x_t, S_t/\alpha) - \delta P_t$$

which we solve with a Hamiltonian:

$$H = e^{-\rho t} u(c, P) + \lambda [\frac{S_t}{\alpha x_t + S_t}] + \mu [S_t + \xi c_t + \theta \phi(x_t, S_t/\alpha) - \delta P_t]$$

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CROSS-BORDER INTERACTIONS MODEL

Assumptions

- Two neighboring countries (i, j)
- Each facing the optimization problem addressed under the baseline model
- Perfect information
- No beliefs' update
- Simultaneously choose the consumption and the green energy path
- Emissions produced in a country affect its own pollution level and the level of the neighboring country
- Updated law of motion of pollution:

$$\dot{P}_i = S_{it} + \beta S_{jt} + \xi c_{it} + \theta\varphi(x_{it}, S_{it}/\alpha) - \delta P_{it}$$

where β is the externality rate

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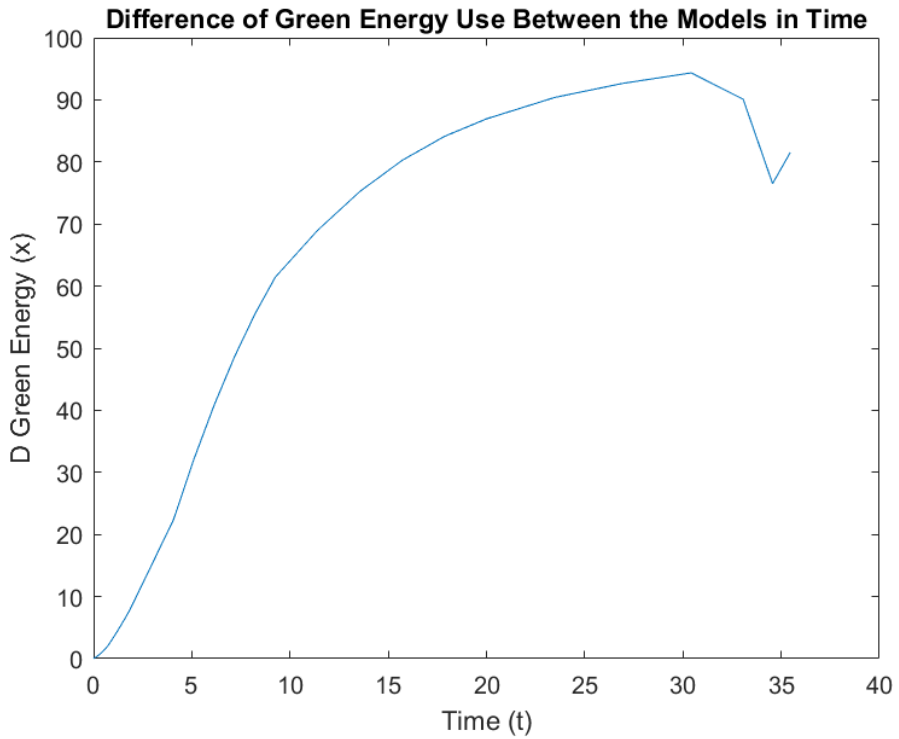
COMPARISON OF THE TWO MODELS

Parameter Values

Parameter	Value	Paper
Technology Level (A)	1	Allen (2009)
Discount Factor (ρ)	0.025	Jones and Tonetti (2020)
Weight of Consumption (w)	0.6	Delis and Iosifidi (2020)
Output Elasticity of Green Energy (γ)	0.3	Skare et al. (2024)
Emission Intensity of Dirty Energy (α)	1	Assumption
Pollution rate of Production (θ)	0.4	Ivanova et al. (2016)
Pollution rate of Consumption (ξ)	0.6	Ivanova et al. (2016)
Environmental Regeneration Rate (δ)	0.03	Acemoglu et al. (2016)

Table: Calibration Parameters

Comparison of Models



- Difference of green energy use between models over time: $Dx(t) = x_{baseline}(t) - x_{strategic}(t)$
- Countries face a prisoner's dilemma
- Key takeaway: strategic interaction slows down green transition

Conclusion and Next Steps

- We analyze the strategic interactive effect of neighboring countries' emissions on green transition.
- We compare the results of a standard macroeconomic model with its augmented counterpart (which takes into account strategic interactions).
- Countries are stuck in a prisoner's dilemma game, which highlights the need for binding agreements to ensure optimal policy outcomes.
- Next: Empirical Analysis in a Spatial Framework.

Thank You!