Climate Change Mitigation: How Effective is Green Quantitative Easing?

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Research Question

- How much can Green QE contribute to climate change mitigation?
- Comparison of Green QE to Carbon Tax with respect to emission / temperature reduction
- Green QE understood as ...
  - ... shift in central banks' private sector securities portfolio ...
  - ... towards green assets
  - Rationale for QE itself not modeled

Approach

- Integrated Assessment Model (IAM)
  - World economy
  - General equilibrium
  - Two production sectors: **Clean** (green) and **Dirty**
  - Dirty energy sector emits CO2
  - Climate module
  - Portfolio choice: clean and dirty capital
    - Idiosyncratic return-risk
    - Imperfect correlation → partial crowding out

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- Policy Experiments:
  - Carbon tax
  - Green quantitative easing (QE)
  - Carbon tax + green QE

Green Quantitative Easing

- **Investigate maximum effect of (stylised) QE**
  - Immediate and complete shift towards green assets of central banks' portfolio of privately issued securities (held constant to total capital stock)
  - Perfect taxonomy
  - High elasticity of substitution between clean and dirty goods
  - Zero correlation of asset returns

Green Quantitative Easing

- **Investigate maximum effect of (stylised) QE**
  - Immediate and complete shift towards green assets of central banks' portfolio of privately issued securities (held constant to total capital stock)
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  - High elasticity of substitution between clean and dirty goods
  - Zero correlation of asset returns
- **Modest Carbon Tax**
- Carbon tax of 50 USD/tC ($\approx$ $13.6 USD/tCO2$), tax rate constant

- Green QE can contribute to climate change mitigating
- But less effective than a carbon tax
- Green QE complementary, if insufficient carbon pricing through taxes or other fiscal policies

Related Literature

- IAMs along the **transition**: Golosov et al. (2014), Kotlikoff et al. (2019, 2021), Nordhaus and Boyer (2000), Van Der Ploeg and Rezai (2021), etc.
- **DSGEs** with climate module and green monetary policy: Heutel (2012), Giovanardi, Kaldorf, Radke, and Wicknig (2021), Ferrari and Landi (2020), Benmir and Roman (2020)

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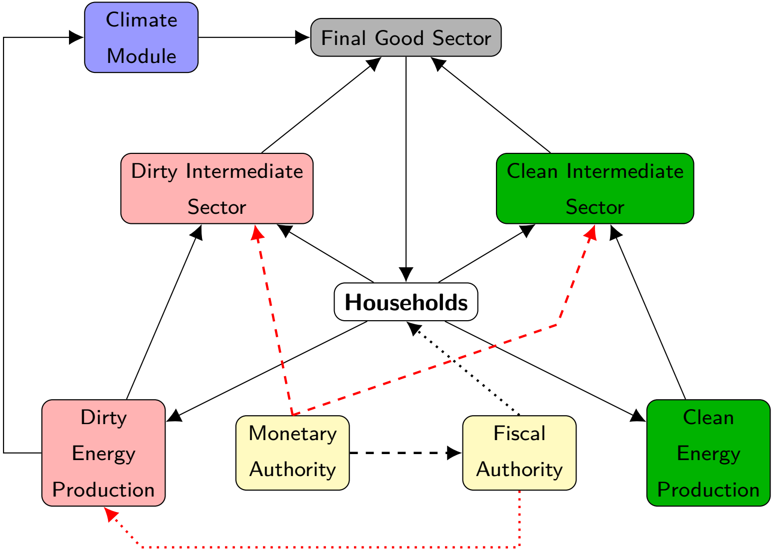
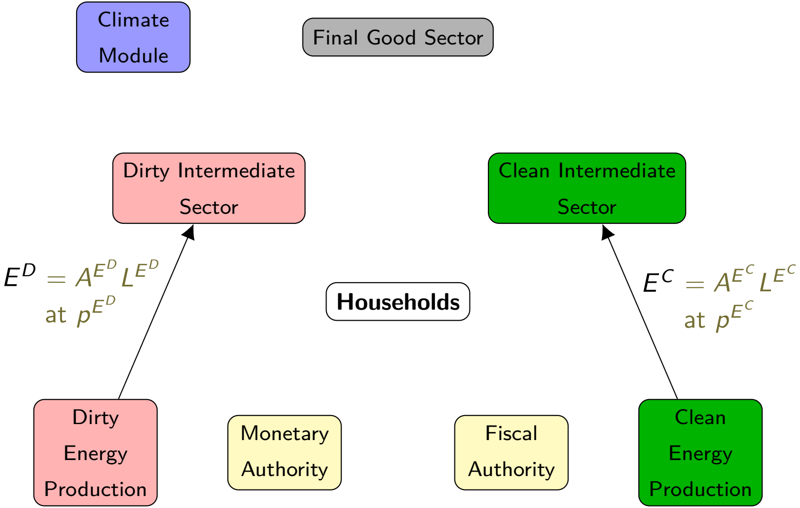
- Papoutsi, Piazzesi and Schneider (2021): Carbon bias in Eurosystem's corporate bond portfolio


Climate
Module
Final Good Sector
Dirty Intermediate
Sector
Clean Intermediate
Sector
Households
Dirty
Energy
Production
Monetary
Authority
Fiscal
Authority
Clean
Energy
Production

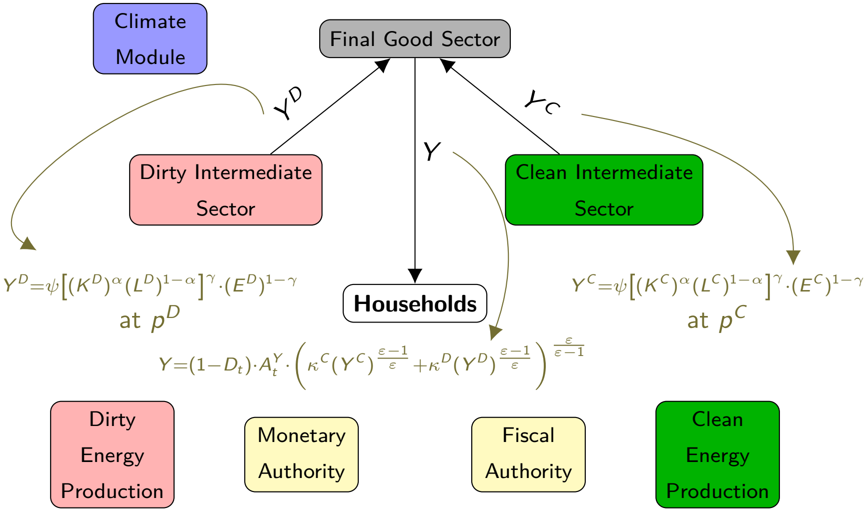
Model Overview

Energy Production



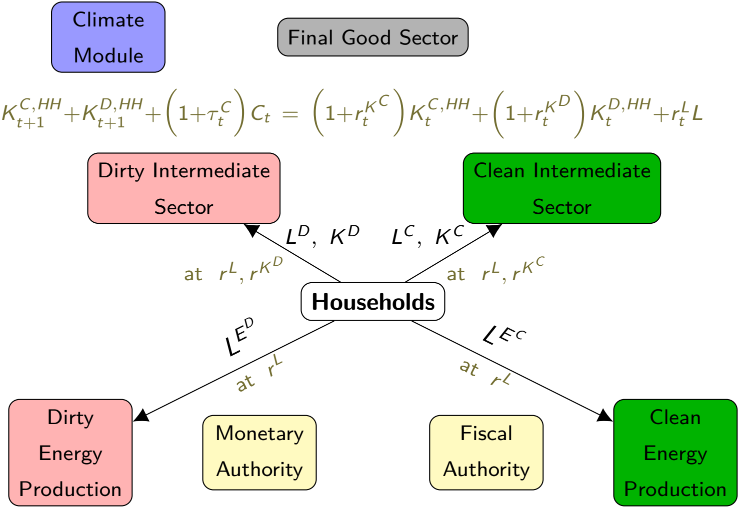
Model Overview

Intermediate Sectors



Model Overview

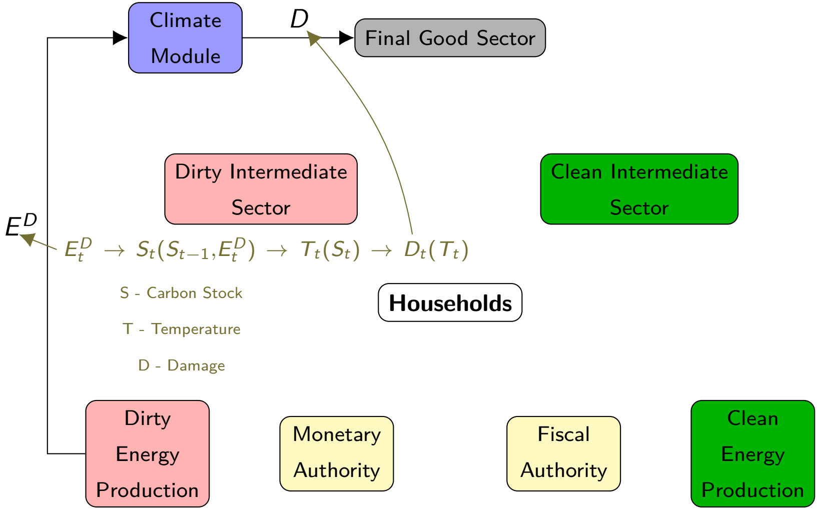
Households



$$K_{t+1}^{C,HH} + K_{t+1}^{D,HH} + \left(1+\tau_t^C\right) C_t = \left(1+r_t^{K^C}\right) K_t^{C,HH} + \left(1+r_t^{K^D}\right) K_t^{D,HH} + r_t^L L$$

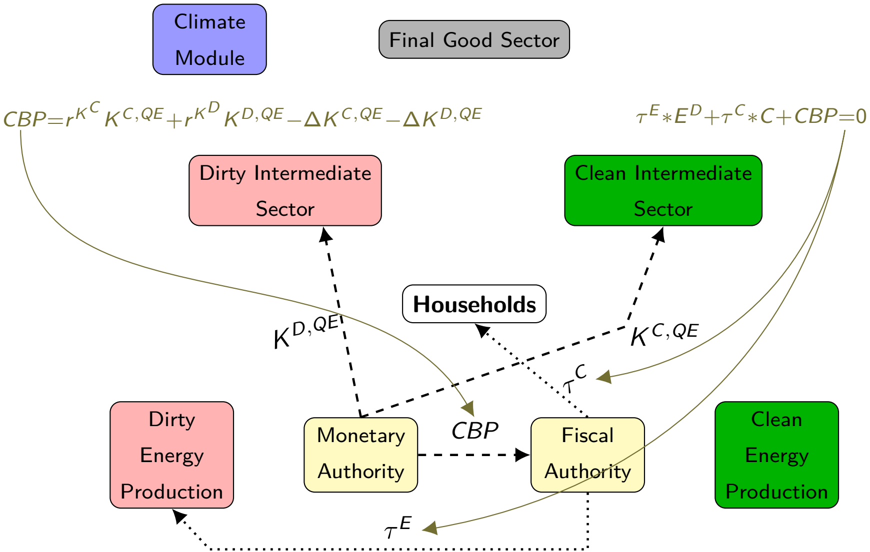
Model Overview

Climate Module



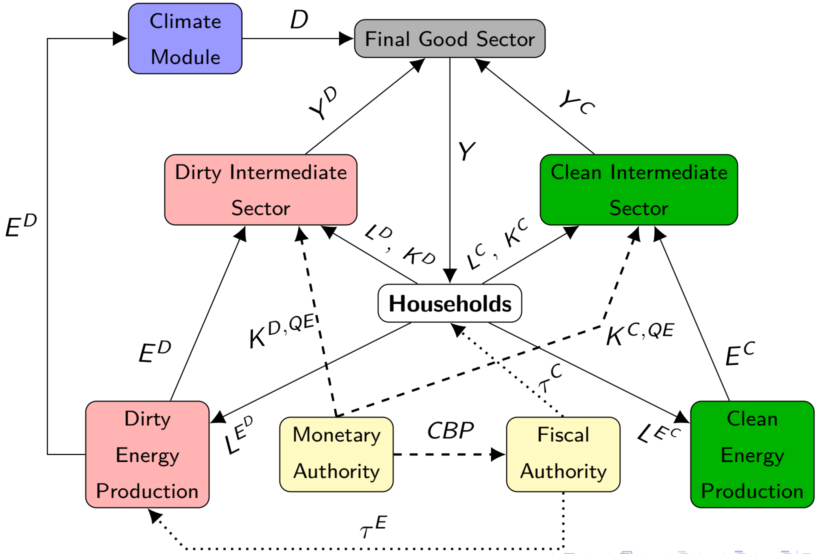
Model Overview

Monetary and Fiscal Authorities



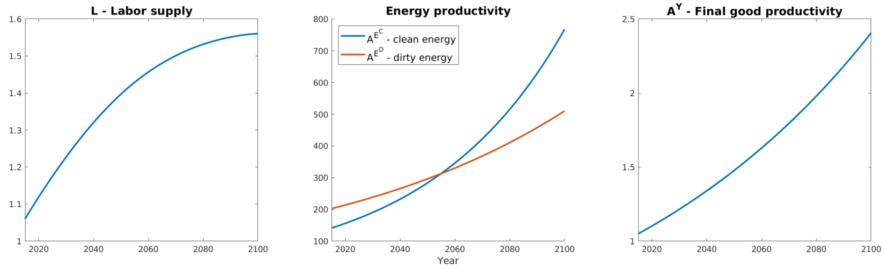
Model Overview

All Together



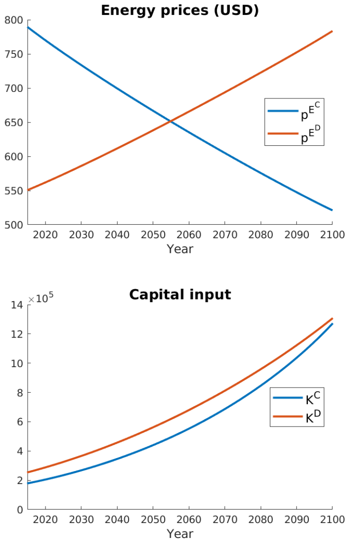
Results - Baseline

Exogenous Driving Forces



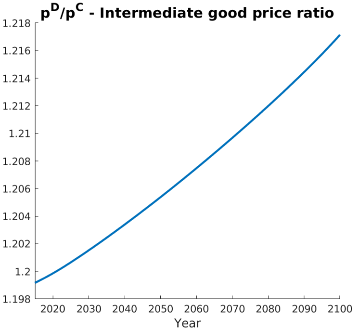
Results - Baseline

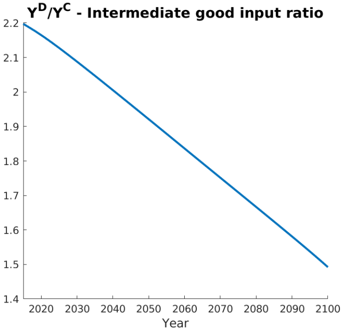
Intermediate Production Inputs



Results - Baseline

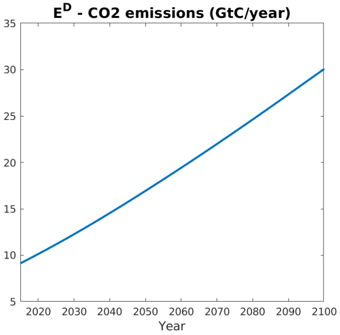
Final Production Inputs

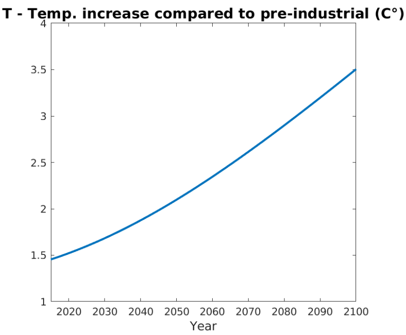




Results - Baseline

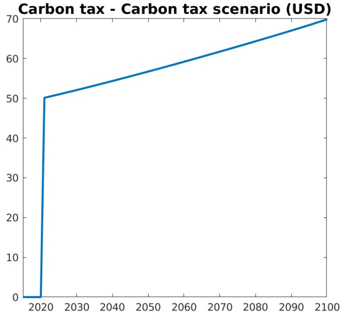
Climate Variables

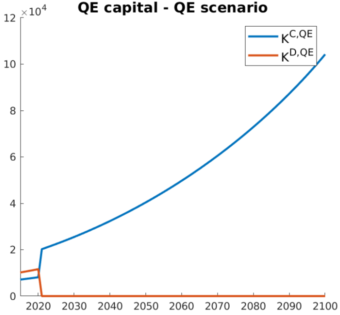




Policy Scenarios

Driving Forces

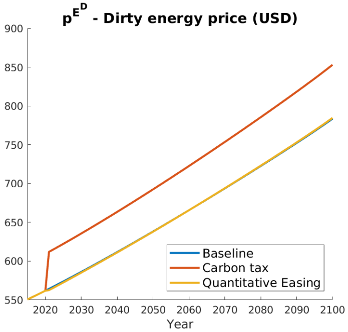


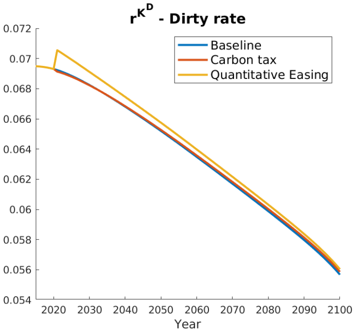


1. **Carbon tax**: $\tau_t^E = 50$ USD/tC $=$ **13.6 USD/tCO2**, growing with dirty energy price ($\approx 0.4\%$)
2. **Green QE**: **full shift** to K^C, growing with capital ($\approx 2.0\%$)

Results - Scenarios

Dirty Energy Price & Capital Return





- **Carbon Tax**: 2 mechanisms of a dirty **energy price increase** $p^{E^D} \uparrow$
  1. **Final** production: Shift **away** from dirty intermediate good: $p^{E^D} \uparrow \rightarrow\ p^D \uparrow \rightarrow\ Y^D \downarrow \rightarrow\ E^D \downarrow$
  2. **Intermediate** production: Shift **away** from dirty energy: $p^{E^D} \uparrow \rightarrow\ E^D \downarrow$

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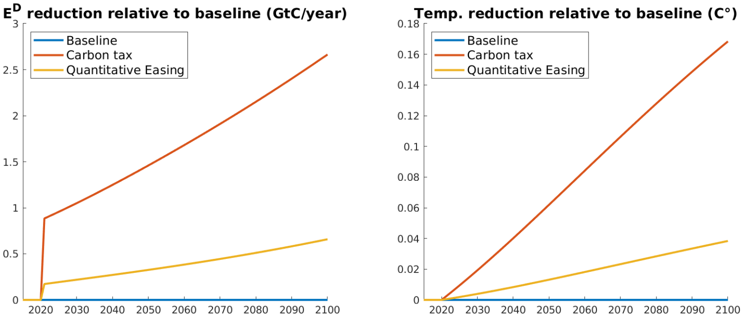
  2. **Intermediate** production: Shift **away** from dirty energy: $p^{E^D} \uparrow \rightarrow\ E^D \downarrow$
- **Green QE**: 2 mechanisms of a dirty **cost of capital increase** $r^{K^D} \uparrow$
  1. **Final** production: Shift **away** from dirty intermediate good: $r^{K^D} \uparrow \rightarrow\ p^D \uparrow \rightarrow\ Y^D \downarrow \rightarrow\ E^D \downarrow$
  2. **Intermediate** production: Shift **towards** dirty energy: $r^{K^D} \uparrow \rightarrow\ E^D \uparrow$

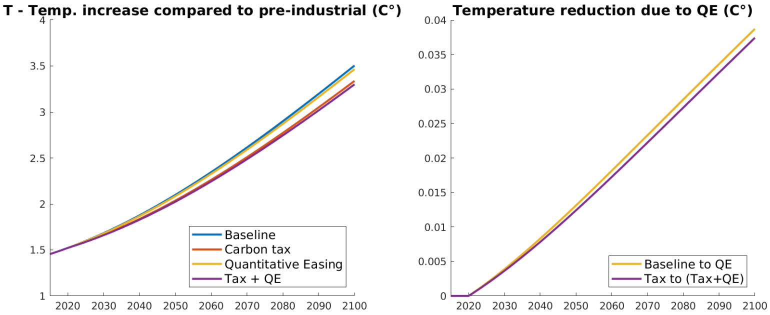
Climate Variables - Reductions



Year 2100 temperature reduction of **Green QE equivalent** to $\approx$ 11 USD/tC $\approx$ **3 USD/tCO2 carbon tax**

Results - Scenarios

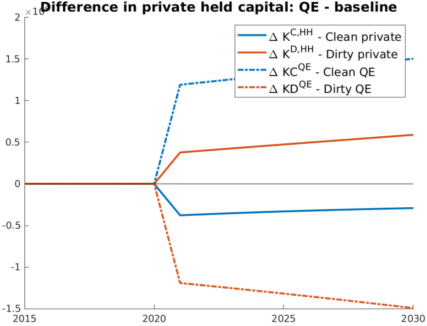
Combining Carbon Tax & Green QE



Green QE on top of carbon tax (somewhat) less effective than standalone.

Results - QE-Scenario

Why no crowding out?



Imperfect crowding out of private held capital $K^{C,HH}$ through quantitative easing $K^{D,HH}$ due to **imperfect correlation** of clean and dirty capital.

Sensitivity analysis

	Baseline	Flat QE	CO2 Bias	Pos. Corr.	Low SE	WAPR	CO2 Re.
T in 2100	3.505	3.505	3.505	3.408	3.539	3.190	2.566
ΔT-τ	-0.167	-0.167	-0.167	-0.170	-0.155	-0.149	-0.107
ΔT-QE	-0.039	-0.011	-0.056	-0.032	-0.005	-0.036	-0.029

Notes: Different calibrations for sensitivity analyses. "Flat QE": Size of monetary authority's balance sheet held constant over time. "CO2 Bias": Size of dirty assets on monetary authority's balance sheet 43% larger, i.e. $K^{m}_{0s=dt} = 12770$. "Pos. Corr.": Correlation between clean and dirty returns set to $\rho^{\zeta}_{cl,dt} = 0.4$. "Low SE": Low substitution elasticity $\varepsilon = 2.25$ such that energy elasticity is $\eta_{\frac{K_{t,s=dt}}{K_{t,s=cl}},\frac{P^{e}_{t,s=dt}}{P^{e}_{t,s=cl}}} = 1.05$. "WAPR": time varying working age population ratio ω_t. "CO2 Re.": strong CO2 reduction in baseline such that share of CO2 in GDP decreases at -1.5% annually.

Summary

$\downarrow$ - Lower CO2 emissions $\uparrow$ - Higher CO2 emissions

- Carbon tax leads to ...
  1. $\downarrow$ Final sector: **Lower demand** for dirty interm. good
  2. $\downarrow$ Interm. sector: **Lower demand** for dirty energy

Summary

↓ - Lower CO2 emissions ↑ - Higher CO2 emissions

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  2. ↓ Interm. sector: **Lower demand** for dirty energy
- Green QE leads to ...
  1. ↓ Final sector: **Lower demand** for dirty interm. good
  2. ↑ Interm. sector: **Higher demand** for dirty energy
  3. ↑ Partial crowding out of private capital

Summary

$\downarrow$ - Lower CO2 emissions $\uparrow$ - Higher CO2 emissions

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- Green QE leads to ...
  1. $\downarrow$ Final sector: **Lower demand** for dirty interm. good
  2. $\uparrow$ Interm. sector: **Higher demand** for dirty energy
  3. $\uparrow$ Partial crowding out of private capital
- Carbon tax stronger ($-0.167C^\circ$ vs. $-0.039C^\circ$ for green QE) ...
  - Green QE equivalent to carbon tax $\approx$ 3 USD/tCO2
- ... but green QE complementary to carbon tax

Thank you for your attention!