

Road to Net Zero: Carbon Policy and Redistributive Dynamics in the Green Transition

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”The challenge at the heart of the EU’s green transition is how we can bring (...) benefits to all as quickly and as fairly as possible.”

European Commission, 2021

Motivation

The objectives of the **European Green deal** are:

- no net emissions of greenhouse gases by 2050 [◀ EU CO2 Emissions Projections](#) ;
- no person and no place left behind;

But...

- transition to a Net Zero economy as a (permanent?) inflationary (or deflationary?) markup shock, lacking (green) technology growth; [◀ Carbon Shock](#)
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wealth-poor households unable to smooth consumption through savings;

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Research Question:

- What are the **macro** effects of the Net-zero emissions policy?
- What are the **distributional** consequences and which role plays carbon-tax revenues **redistribution**?

Preview

In a **two-agents** Environmental DSGE model:

- **perfect foresight** ⇒ increasing carbon tax:

recession and permanently higher energy prices;

but...agents anticipate tax path and fall in income: ↓ deflationary pressure;

targeted transfers are progressive, subsidies and tax cuts mitigate output loss;

efficiency-equity trade-off;

- **expectation errors** depress investment and labor market, worsen consumption gap, inflationary pressure;
- equal **abatement cost** implies extreme recession and deflationary transition.

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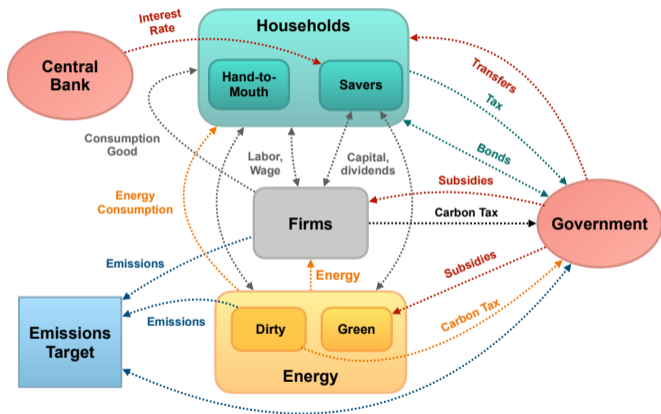
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Literature

- **Macroeconomic** effects of environmental policies:
 - ▶ Bettarelli et al. (2025), Känzig and Konradt (2023), and Metcalf and Stock (2023);
- **Distributional** effects of carbon tax shocks:
 - ▶ Ascari et al. (2025), Berthold et al. (2023), Cantore et al. (2025), Coenen et al. (2024), Känzig (2023), and Metcalf (2019);
- **TANK** and **E-DSGE** model :
 - ▶ Bilbiie (2008);
 - ▶ Annicchiarico and Di Dio (2015), Carattini et al. (2023), Ferrari and Nispi Landi (2023), Fischer and Springborn (2011), and Heutel (2012).

Contribution: TANK E-DSGE model for distributional issues, long-run analysis of transition to net zero economy; comparison of five tax revenues recycling schemes in terms of efficiency and equity. Add: compare diff expectation formation processes.

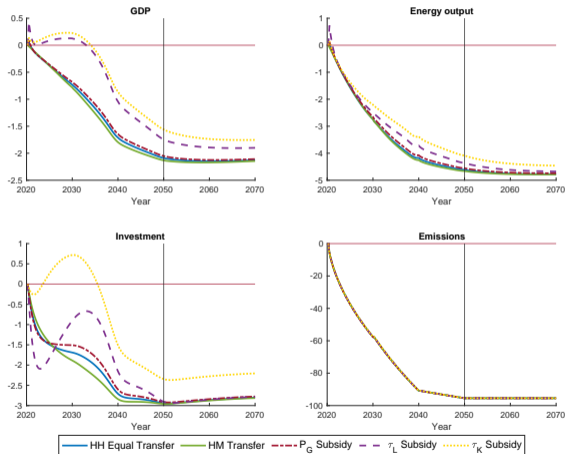
Two-agents E-DSGE: Model Overview



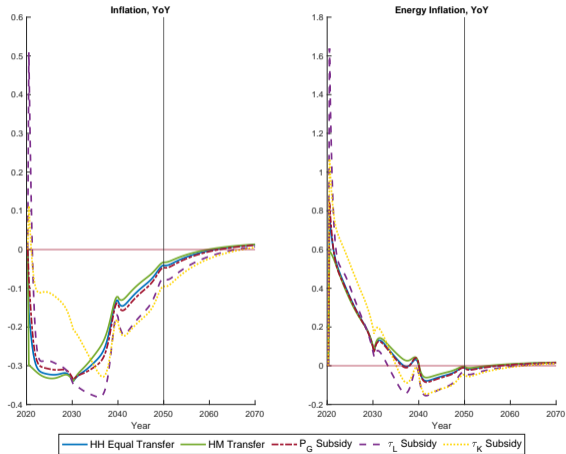
Redistribution Schemes

Policy	Description	
$\mathcal{T}_{HM,t}$	Lump-sum (targeted) transfers to HM households	$(\sigma = 1, \sigma_{HH} = 1, \sigma_{HM} = 1)$
$\mathcal{T}_{HH,t}$	Lump-sum (weighted) transfers to all households	$(\sigma = 1, \sigma_{HH} = 1, \sigma_{HM} = \Delta)$
$\mathcal{T}_{pG,t}$	Production subsidies to green firms	$(\sigma = 1, \sigma_{HH} = 0)$
$\mathcal{T}_{\tau_L,t}$	Reduction in labor income tax	$(\sigma = 0, \xi_L = 1)$
$\mathcal{T}_{\tau_K,t}$	Reduction in capital income tax	$(\sigma = 0, \xi_K = 1)$

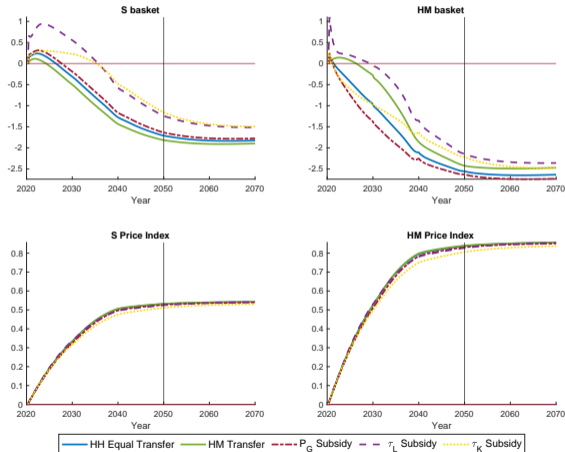
The Net Zero Policy: Macro Dynamics



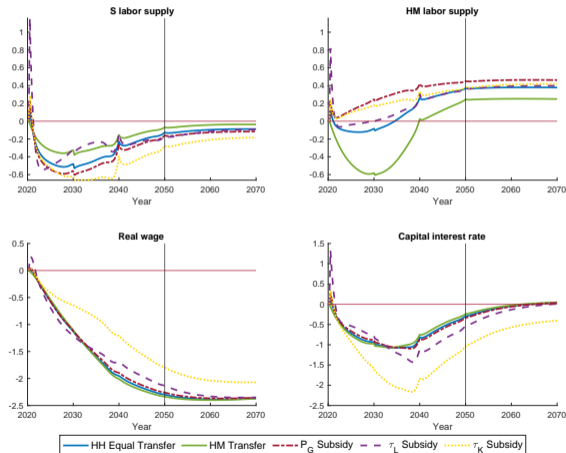
Inflation



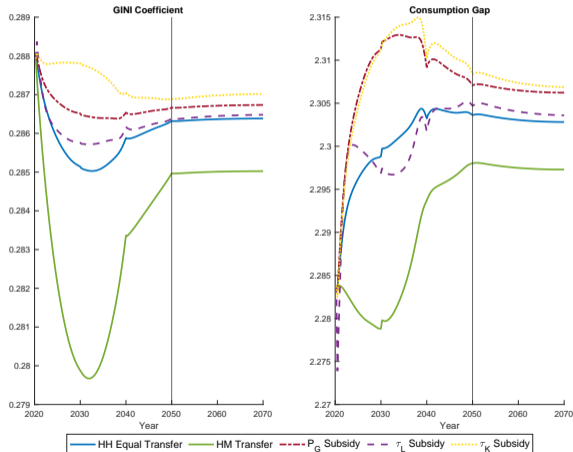
Household dynamics



Labor and Capital Market



Inequality Measures



Conclusion

TANK E-DSGE model, with disaggregated energy and non-energy sectors; comparison of five tax revenues recycling schemes. Main conclusions:

- 1 carbon tax policy is recessionary (long run), absent technological progress; resources reallocate toward green energy; energy price permanently higher, but deflationary pressure;
- 2 trade-off between efficiency and equity;
- 3 transition more volatile when agents are only gradually informed of intermediate targets;
- 4 **Add:** effect of carbon policy shock mixed (inflationary recession, regressive, but depend on redis. scheme).

Implication: policy is **regressive**; need to address **efficiency–equity trade–off**.

Households: "Hand-to-mouth" vs "savers"

Utility maximization problem: maximize w.r.t consumption and labor, s.t. budget balance and law of motion of capital:

$$u(x_{j,t}, \ell_{j,t}) = \frac{x_{j,t}^{1-\varphi_c} - 1}{1 - \varphi_c} - \psi_j \frac{\ell_{j,t}^{1+\varphi_\ell}}{1 + \varphi_\ell} \quad \text{where } j = \{\text{HM}, \text{S}\} \quad (1)$$

HM budget:

$$p_{\text{HM},t} x_{\text{HM},t} = (1 - \tau_\ell) w_{\text{HM},t} \ell_{\text{HM},t} + \mathcal{T}_{\text{HM},t} \quad (2)$$

S budget:

$$b_t + p_{\text{S},t} x_{\text{S},t} + i_{\text{S},t} = b_{t-1} \frac{r_{t-1}}{\pi_t} + (1 - \tau_{k,t}) r_{k,t} k_{\text{S},t-1} + (1 - \tau_{\ell,t}) w_{\text{S},t} \ell_{\text{S},t} + \mathcal{T}_{\text{S},t} \quad (3)$$

Households' consumption basket

CES basket: final good and energy consumption:

$$x_{j,t} = \left[\gamma_j^{\frac{1}{\epsilon_j}} c_{j,t}^{\frac{\epsilon_j-1}{\epsilon_j}} + (1 - \gamma_j)^{\frac{1}{\epsilon_j}} E_{j,t}^c \frac{\epsilon_j-1}{\epsilon_j} \right]^{\frac{\epsilon_j}{\epsilon_j-1}} \quad (4)$$

Demand:

$$c_{j,t} = \gamma_j \left(\frac{1}{p_{j,t}} \right)^{-\epsilon} x_{j,t} \quad (5)$$

$$E_{c,j,t} = (1 - \gamma_j) \left(\frac{p_{E,t}}{p_{j,t}} \right)^{-\epsilon} x_{j,t} \quad (6)$$

Non-energy producers

Final good production:

$$y_t(i) = TFP_{y,t} \left[v^{\frac{1}{\xi_y}} (VA_t(i))^{\frac{\xi_y-1}{\xi_y}} + (1-v)^{\frac{1}{\xi_y}} (A_{E,t} E_{y,t}(i))^{\frac{\xi_y-1}{\xi_y}} \right]^{\frac{\xi_y}{\xi_y-1}}, \quad (7)$$

where $VA_t(i) = A_{y,t}(i) (k_{y,t-1}(i))^\alpha (\ell_{y,t}(i))^{1-\alpha}$ with $\alpha \leq 1$ (8)

and $TFP_{y,t}(i) = (1 - D_t(\mathbf{e}_{s,t}))$ (9)

Profit function:

$$\Pi_{y,t} = y_t - w_t \ell_{y,t} - r_{k,t} k_{y,t-1} - \tau_{y,t} \mathbf{e}_{y,t} - \theta_{y,1} (\mu_{y,t})^{\theta_2} y_t - p_{E,t} E_{y,t} \quad (10)$$

Energy producers

Non-renewable Energy production:

$$E_{D,t} = A_{D,t} (k_{D,t-1})^{\alpha_E} (\ell_{D,t})^{1-\alpha_E}, \quad (12)$$

$$s.t. \quad \Pi_{D,t} = p_{D,t} E_{D,t} - \tau_{D,t} e_{D,t} - \theta_1 (\mu_{D,t})^{\theta_2} E_{D,t} - w_t \ell_{D,t} - r_{k,t} k_{D,t-1} \quad (13)$$

Non-renewable energy firms face a trade-off between paying an environmental tax on their polluting emissions or sacrifice a share of their output to abate emissions.

Renewable Energy production:

$$E_{G,t} = A_{G,t} (k_{G,t-1})^{\alpha_E} (\ell_{G,t})^{1-\alpha_E}, \quad (14)$$

$$s.t. \quad \Pi_{G,t} = p_{G,t} E_{G,t} - (w_t - \mathcal{T}_{\ell_{G,t}}) \ell_{G,t} - r_{k,t} k_{G,t-1} \quad (15)$$

Climate Module and Redistribution scheme

- The climate module describes the interconnection between
 - ▶ Final good y , non-renewable energy production ED
 - ▶ Emissions $e_{y,E}$
 - ▶ Abatement effort $g(\mu_{y,E})$

$$e_{y,t} = (1 - \mu_{y,t}) \gamma_y (y_t), \quad e_{E,t} = (1 - \mu_{E,t}) \gamma_E (E_{D,t}) \quad (16)$$

$$g(\mu_{y,E,t}) = \theta_1 (\mu_{y,E,t})^{\theta_2}, \quad \mu_{y,E,t} \in [0, 1] \quad \& \quad \theta_{y,1} \neq \theta_1 \quad (17)$$

- Carbon tax revenues are redistributed to households (transfers), green energy firms (subsidies) or employed to cut (labor/capital) income taxes.

Market clearing

Capital market:

$$k_t = (1 - \Delta)k_{S,t} = k_{y,t} + k_{D,t} + k_{G,t} \quad (18)$$

Labor market:

$$l_{y,t} + l_{D,t} + l_{G,t} = \Delta l_{HM,t} + (1 - \Delta)l_{S,t} \quad (19)$$

Energy market:

$$E_t = E_{c,t} + E_{y,t} \quad (20)$$

Aggregate consumption:

$$x_t = \Delta x_{HM,t} + (1 - \Delta)x_{S,t} \quad (21)$$

Calibration

Table: Model parameters

Parameter	Description	Value	Source
Households			
β	Discount factor	0.995	Drygalla et al. (2018)
φ_C	Inverse elasticity of intertemporal sub.	1.5	Drygalla et al. (2018)
φ_I	Inverse Frisch elasticity	2	Coenen et al. (2024)
$\psi_{\ell_S}, \psi_{\ell_{HM}}$	Labor productivity	1.1, 0.9	calibrated
$\epsilon_S, \epsilon_{HM}$	Elasticity of subs energy/non-energy good, S, HM	0.275, 0.05	Känzig (2023)
γ_{HM}	Distribution parameter HM	0.118	Energy share $\omega_{HM} = 7.8\%$, EU-SILC
γ_S	Distribution parameter S	0.069	Energy share $\omega_S = 4.9\%$, EU-SILC
ϕ_i	Investment adjustment cost	10	Standard value
Δ	Share of HM households	40%	calibrated
Firms			
ξ_y	Elasticity of sub. between VA and energy	0.38 (long run)	van der Werf (2008)
ξ_y	Elasticity of sub. between VA and energy	0.02 (short run)	Hassler et al. (2021)
ξ	Elasticity of sub. between intermediate goods	6	Standard value
α	Share of capital in value added	0.37	Eurostat
$1 - \nu$	Share of energy in non-energy production	0.13	Eurostat
ϕ_p	Price adjustment cost	59.113	Implied from Ascari and Rossi (2012)
χ	Elasticity of sub. between energy sources	1.8	Standard value
ι	Weight of renewable energy	0.25	BMWK 2022
ν	Weighting parameter of renewable energy	0.35	Implied from ι
α_E	Share of capital in energy production	0.73	Eurostat

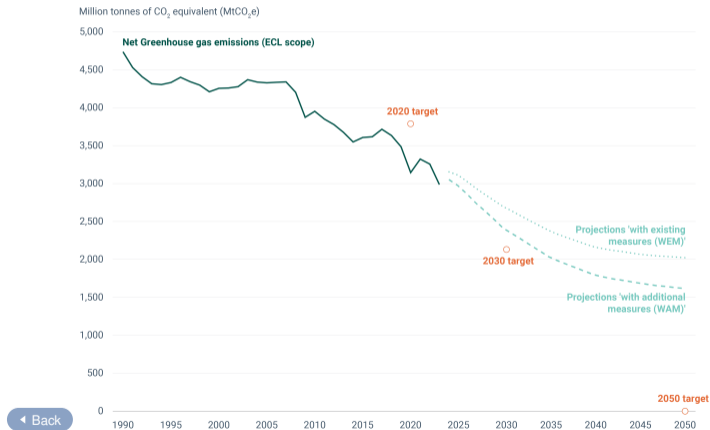
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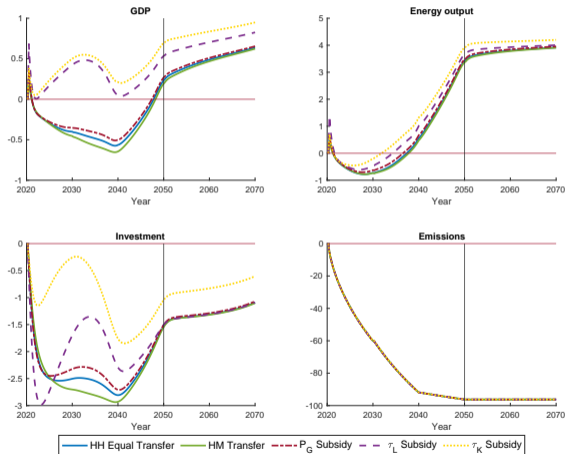
Parameter	Description	Value	Source
Environment			
Q_{Ec}	Share of energy used for consumption by HH	28%	Eurostat
Q_E	Energy sector share of total emissions	80%	Eurostat
γ_D	Energy sector emissions intensity	1.158	Implied from Q_E
γ_Y	Non-energy sector emissions intensity	0.050	Implied from Q_E
d_0	Damage function constant	-0.0076	Gibson and Heutel (2023)
d_1	Damage function linear parameter	8.1e-6	Gibson and Heutel (2023)
d_2	Damage function quadratic parameter	1.05e-8	Gibson and Heutel (2023)
θ_1	Abatement cost function coefficient	0.074	Gibson and Heutel (2023)
$\theta_{Y,1}$	Abatement cost function coefficient Non-energy firm	0.003	implied from γ_Y
θ_2	Abatement cost function exponent	2.6	Gibson and Heutel (2023)
η	Pollution decay rate	0.9965	Allen et al. (2018)
Other			
ϕ_π	Mon. pol. response to inflation	1.5	Standard value
ρ_m	Monetary policy inertia	0.8	Standard value
ρ_τ	Carbon tax shock inertia	0.95	Standard value

EU CO₂ Emissions Projections and EU Targets, % of 1990

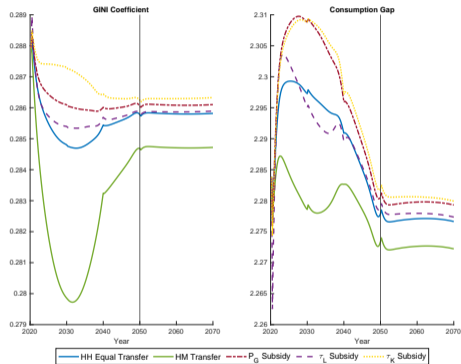
Sources: European Environment Agency (EEA), 2024



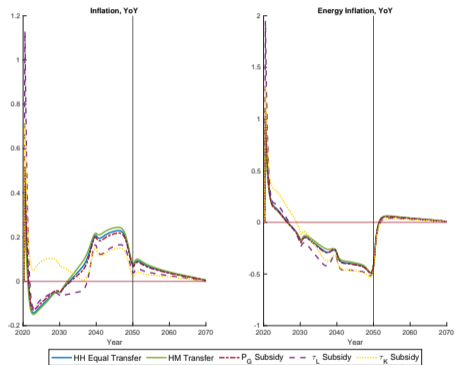
Net Zero Policy with Exogenous Green TFP Growth



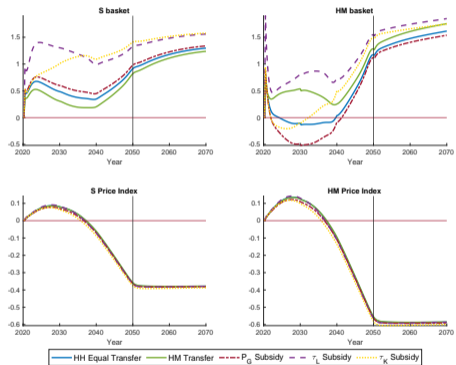
Inequality Measures with Exogenous Green TFP Growth



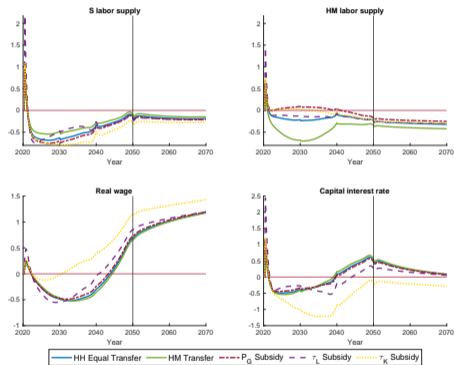
Inflation with Exogenous Green TFP Growth


[← Back](#)

Labor and Capital Market with Exogenous Green TFP Growth

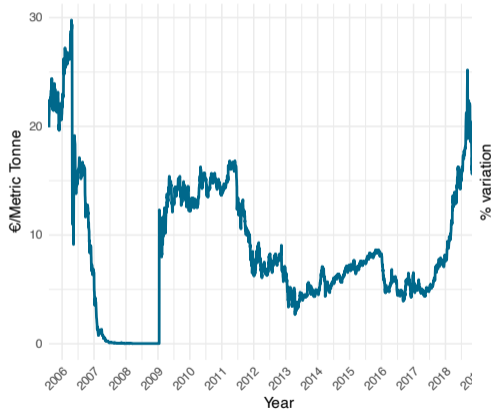


Labor and Capital Market with Exogenous Green TFP Growth



ETS Spot Price and Carbon Policy Surprise

Sources: Datastream and European Commission Climate Action news



The Effect of A Carbon Policy Shock

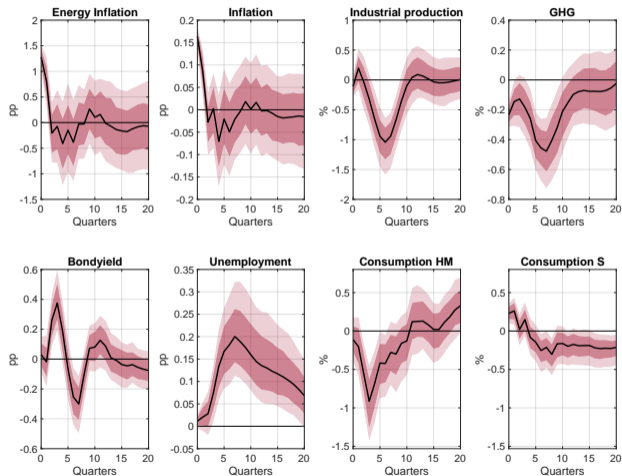
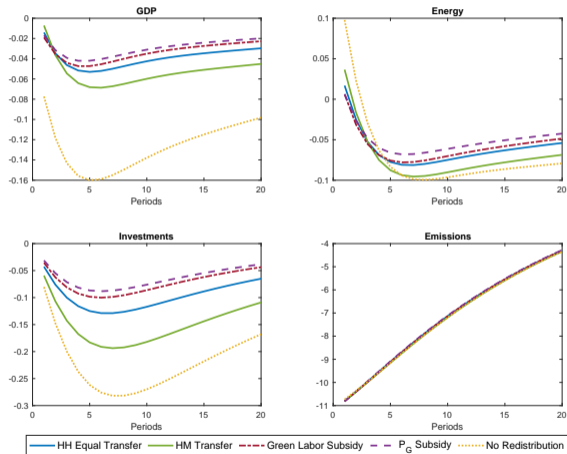
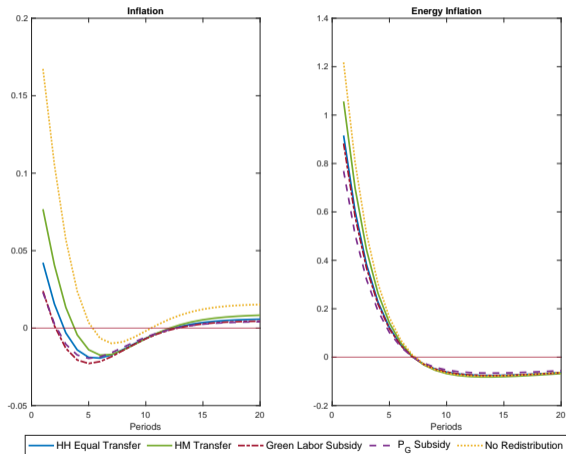


Figure: IRF to a 1 standard deviation carbon policy shock [◀ back](#)

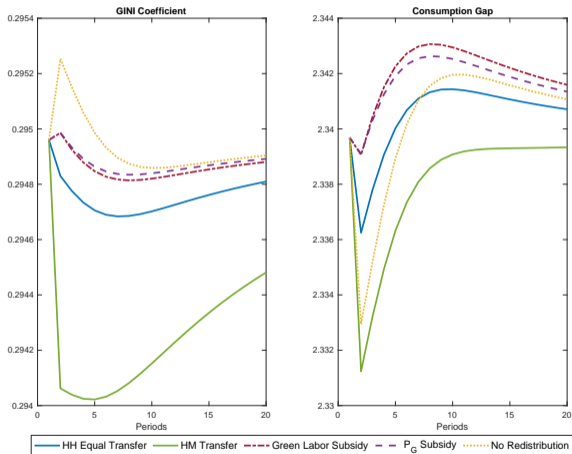
Macro Dynamics, Carbon Shock



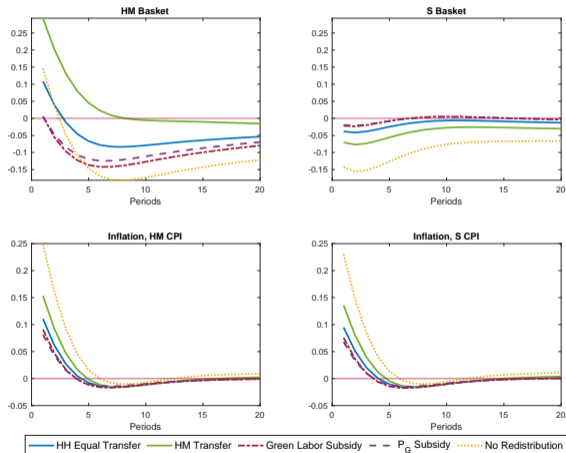
Inflation, Carbon Shock



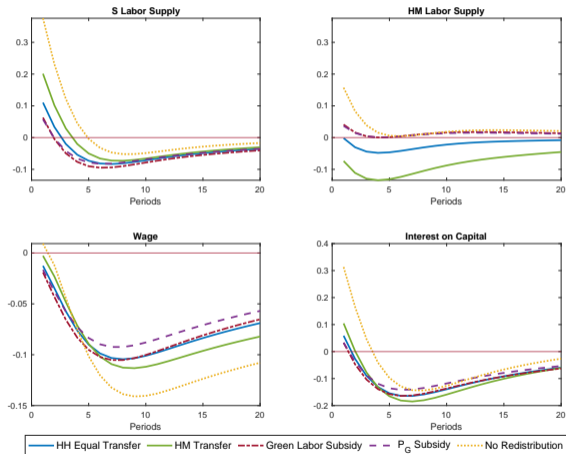
Inequality Measures, Carbon Shock



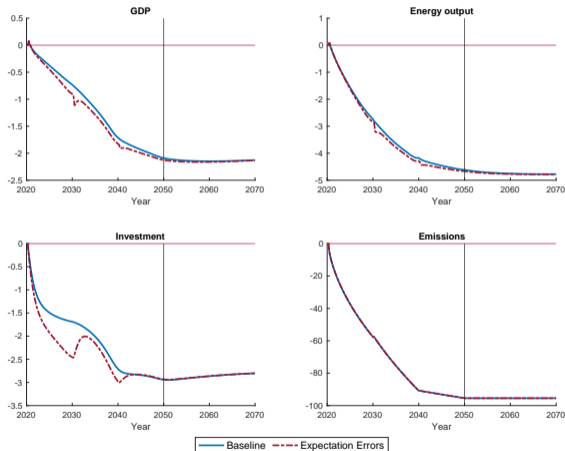
Households Dynamics, Carbon Shock



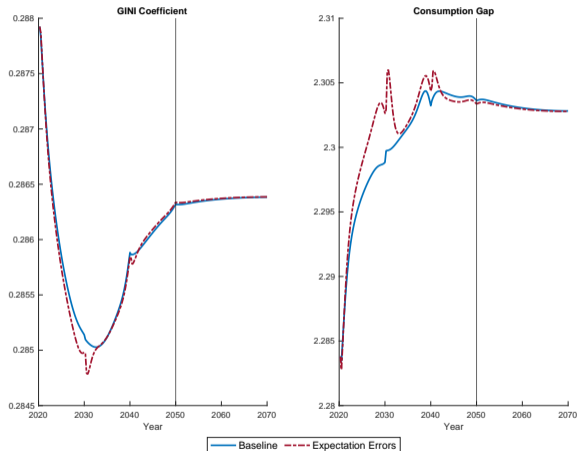
Labor and Capital Market, Carbon Shock



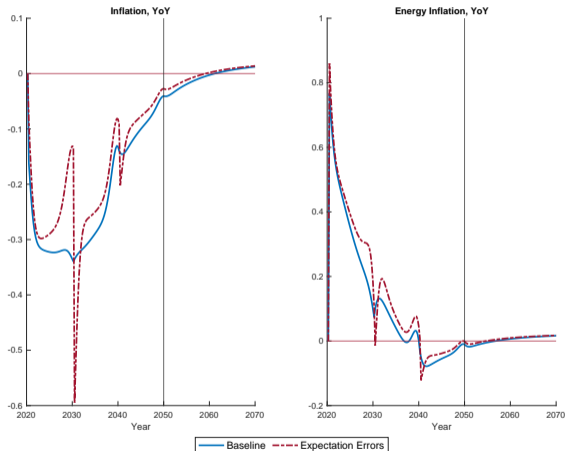
Transition Dynamics with Expectation Errors



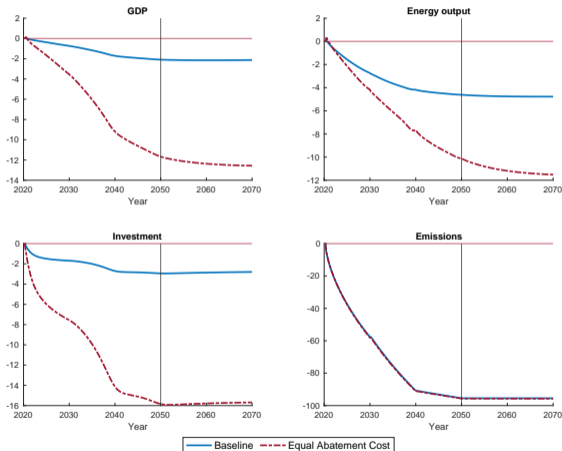
Inequality Measures with Expectation Errors



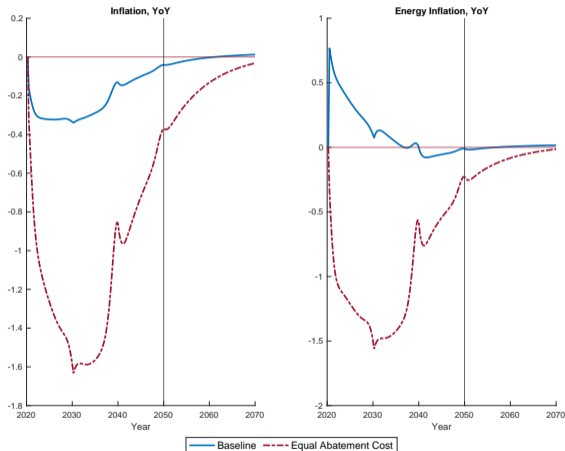
Inflation with Expectation Errors



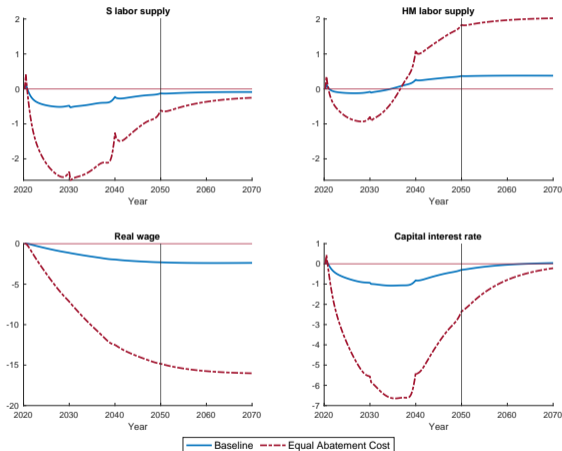
Transition Dynamics with Equal Abatement Cost



Inflation with Equal Abatement Cost



Labor and Capital Markets with Equal Abatement Cost



Transition Dynamics with Flexible Prices

