Debt Sustainability and Fiscal Consolidation in a HANK Model

François Langot[⊕◇*] & Selma Malmberg[⊕*]
Fabien Tripier[⊕•] & Jocelyn Maillard[⊕]
Jean-Olivier Hairault[⊕◇]

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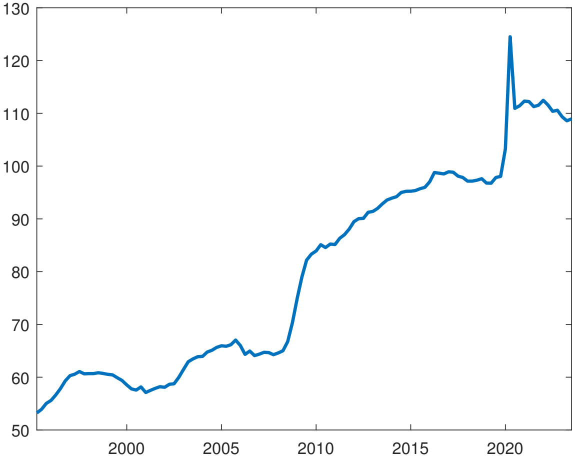
[⊕] **ObsMacro CEPREMAP**, ENS-Paris
[◇] **PSE**, Ecole d'Economie de Paris
[*] **GAINS-TEPP & IRA**, Le Mans Université
[•] **LEDa**, Université Paris Dauphine

Public debt: the French situation



Debt-to-GDP Ratio

Why study “Fiscal consolidation”

1. Macroeconomic context:
   - Debt-to-GDP ratio has risen steadily over the last decades, with no significant periods of debt reduction.
   - Budget deficit each year whatever the business cycle (recession or expansion).
   - Recent reversal in nominal interest rates after decades of declining trends.
     - ⋆ “Across advanced economies, the celebrated (r - g) appears to have durably changed sign.” Blanchard (2023).
2. Political context:
   - The renewed Growth and Stability Pact exerts pressure for a credible debt reduction path for the French economy.

Why study “Fiscal consolidation” with a HANK model

- Fiscal consolidation programs often fail for two reasons.
  1. Their recessionary impact may be so substantial that there is no reduction in debt-to-GDP ratio.
  2. They tend to exacerbate inequality, potentially leading to electoral outcomes that undermine the continuity of these programs.

- Advantages of using a HANK model for evaluating fiscal consolidation.
  1. To get accurate fiscal/budgetary multipliers, which are often inadequately measured in representative agent models.
  2. To anticipate the distributional effects of these programs, as they may impact households differently.

Why study "Fiscal consolidation" calls for forecasting

- To assess a fiscal consolidation policy, we need:

#1 A general equilibrium model.

- Fiscal decisions interact with the key drivers of public debt accumulation; e.g. $r - g = (i - \pi) - g$.

#2 A forecast methodology.

- A fiscal consolidation policy is a forecast of the debt-to-GDP ratio $x-$years ahead in reaction to current policy change.

⇒ We apply the conditional-forecast method to our HANK model using the sequence-space method introduced by Auclert et al. (2021a).

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⇒ Reallocation of public spending is key for successful fiscal consolidation policies.

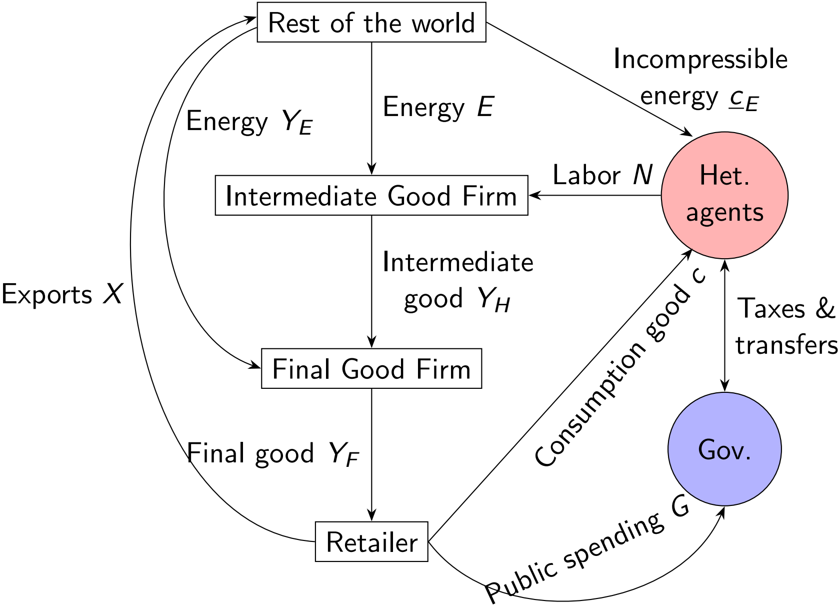
- Cutting only public consumption is too contractionary and cutting public transfers homogeneously is too unequal.
- Cutting Bismarckian transfers while increasing Beveridgian transfers reduces debt without penalizing growth or worsening inequalities.

Contribution to the literature

1. Quantitative HANK Models.
   - Kaplan et al. (2018), Auclert et al. (2021b) Auclert et al. (2023), Auclert et al. (2023), Pieroni (2023), Bayer et al. (2023) etc.
   - Quantitative HANK for the French economy; see Langot et al. (2023).
2. Fiscal consolidation and Debt sustainability.
   - Effect on growth (Blanchard and Leigh (2013, 2014), IMF (2023)), inequality (Ball et al. (2013), Brinca et al. (2021))), and electoral outcomes (Brender and Drazen (2008)).
   - Macroeconomic and distributive effects in general equilibrium with stochastic debt sustainability analysis.
3. Conditional forecasts.
   - In VAR models (Waggoner and Zha (1999), Antolin-Diaz et al. (2021)) and RANK (Del Negro and Schorfheide (2013)).
   - Extension to HANK models by Langot et al. (2023) to evaluate the tariff shield and here for fiscal policy.

Model overview

1. Household heterogeneity. Utility Budget
   - Idiosyncratic productivity shocks (standard HA assumptions) and skill heterogeneity (low, medium, high skill labor markets).
   - Progressive income taxation, Beveridgian transfers (decreasing with income) and Bismarckian transfers (increasing with income).
2. Unions set wages by skill with adjustment costs. Unions
3. Production. Labor Intermediate Final Retailers
   - Efficient labor is produced by combining 3-skill labor inputs.
   - Labor is combined with energy to produce intermediate goods.
   - Consumption good is produced using interm. goods and energy.
   - Consumption good is sold by retailers with sticky prices.
4. Public authorities.
   - ECB Taylor rule which depends on French inflation. ECB
   - Government public debt dynamics. Government
5. Equilibrium: asset, labor, good, and energy markets. Equilibrium


Rest of the world
Incompressible energy $\underline{c}_E$
Energy E
Energy Y_E
Het. agents
Labor N
Intermediate Good Firm
Intermediate good Y_H
Exports X
Consumption good c
Taxes & transfers
Final Good Firm
Gov.
Final good Y_F
Public spending G
Retailer

Calibration

1. Calibration based on steady-state restrictions for the aggregate economy (standard). Calibration table
2. Calibration based on the distributions of income, assets, consumption and transfers by type (Beveridgian vs Bismarckian). Calibration table
   - Beveridgian assistance-based transfers are decreasing with income (as social action and housing transfers).
   - Bismarckian insurance-based transfers are increasing with income (e.g. pension and unemployment insurance transfers).
3. Heterogeneous MPCs and energy consumption. MPC and Energy

Calibration based on steady-state restrictions Calibration

$$\min_{\Phi_2} [\Psi_s(\Phi_2) - \Psi_d] W [\Psi_s(\Phi_2) - \Psi_d]' \quad \text{with } W = Id$$

Parameter Φ_2: firms & productivity		**Value**	**Moment Ψ_z**	**Data**	**Model**
Dividends rule $\bar{d}(e) = e^{a_{div}}$	a_{div}	= 1.775	Dividends D10/D1	66.25	65.34
Productivity-persistence low-skill	ρ_l	= 0.97	Gross income D10/D1	11.67	11.64
Productivity-persistence middle-skill	ρ_m	= 0.965	Gross income D5/D1	2.94	2.73
Productivity-persistence high-skill	ρ_h	= 0.94	Average productivity persistence	0.966	0.966
Productivity-variance low-skill	σ_l	= 0.36	Net consumption D10/D1	3.07	3.12
Productivity-variance middle-skill	σ_m	= 0.64	Net Consumption D5/D1	1.49	1.49
Productivity-variance high-skill	σ_h	= 1.4	Net income D10/D1	4.16	3.72

Parameter Φ_2: Government		**Value**	**Moment Ψ_z**	**Data**	**Model**
Beveridgian transfer rule $\bar{\tau}(e) = e^{a_{beve}}$	a_{beve}	= -0.47	Beveridgian Transfer D10/D1	0.36	0.36
Bismarckian transfer rule $\bar{T}(e) = e^{a_{bism}}$	a_{bism}	= 0.815	Bismarckian Transfer D10/D1	5.43	5.43
Level of the income tax $(1-\lambda)z^{1-\tau_z}$	λ	= 0.089	Net income D5/D1	1.57	1.42
Progressivity of the income tax $(1-\lambda)z^{1-\tau_z}$	τ_z	= 0.35	Income-tax revenues/GDP	0.115	0.115
Level of VAT	τ_c	= 0.213	VAT revenues/GDP	0.17	0.17
Level of social security contribution	τ_l	= 0.242	Social-security contribution revenues/GDP	0.195	0.195
Level of the corporate tax	τ_f	= 0.27	Corporate-tax revenues/GDP	0.045	0.045

Model estimation using historical data

Given data $\mathcal{Y}_t$, structural shocks $\mathcal{E}_t$, calibrated parameters Φ and estimated parameters Θ

$$\mathcal{Y}_t = \mathcal{M}(\mathcal{E}_t|\Theta, \Phi) \text{ with } dim(\mathcal{Y}_t) = dim(\mathcal{E}_t) = 15$$

$$\Rightarrow \quad \widehat{\Theta} = \text{argmax } \mathcal{L}\left(\Theta|\{\mathcal{Y}_t\}_{t=1}^{T}, \Phi\right)$$

$\mathcal{Y}_t$	GDP	Inf	Int. rate BCE	Int. rate debt	Energy Price	Government spend.	Government trans.	Energy sub.	Debt-to-GDP
$\mathcal{E}_t$	ε^{β}	ε^{μ}	ε	ε^{ϑ}	ε^{P_E}	ε^{G}	ε^{T}	ε^{s_H}	e

$\mathcal{Y}_t$	Hours l	Hours m	Hours h	Wages l	Wages m	Wages h
$\mathcal{E}_t$	ε^{φ_l}	ε^{φ_m}	ε^{φ_h}	ε^{A_l}	ε^{A_m}	ε^{A_h}

In blue the shocks identified independently to the model

$AR(1)$ estimates

Conditional forecasts for future periods

- Method: "Conditional forecasts"

$$\underbrace{\mathcal{Y}_{T+h} = \mathcal{M}(\mathcal{E}_{T+h}|\widehat{\Theta}, \Phi)}_{\text{classical use}} \quad \Rightarrow \quad \underbrace{\mathcal{E}_{T+h} = \mathcal{M}^{-1}(\mathcal{Y}_{T+h}|\widehat{\Theta}, \Phi)}_{\text{inverse use}}$$

- To get the future realization of shocks $\mathcal{E}_{T+h}$, we need to feed the model with observables for the future $\mathcal{Y}_{T+h}$.
- $\mathcal{Y}_{T+h} \equiv$ Government forecasts ("consensus of forecasters" + very large information set).
- Alternative policies are assessed in an economic context that is exactly consistent with the government's assumptions.
- We should consider all shocks (and not policy shocks only) to evaluate policies which may change the model's multipliers.

Dynamics of each shock | Shock decomposition | Multipliers and policy evaluation | Lucas critique

The challenge of fiscal consolidation

- The threefold objective:
  1. Reducing the debt-to-GDP ratio by 5pp between 2023 and 2027 while reducing its variance.
  2. Without penalizing GDP growth.
  3. Without worsening inequalities.
- Can we do better than the government?

  Each economy experiences exactly the same business cycle and shares the same initial conditions.
- We assess the potential benefits of adding fiscal rules to government forecasts.

  $$Z_t = \rho_Z Z_{t-1} + \tau_Z (b_t - b) + \varepsilon_{Z,t+1}$$

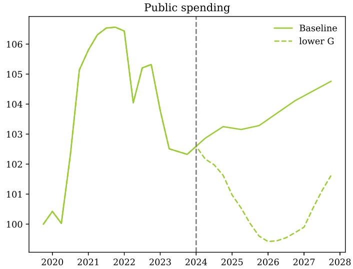
  where $Z \in \{G, T, T_{Bism}, T_{Beve}\}$

Assessing alternative policies

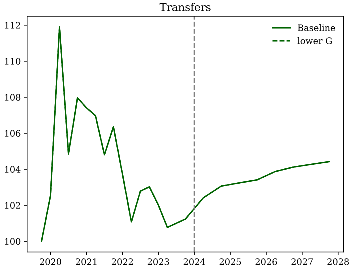
- We look first at two ways to decrease public spending by €20 billion per year from 2Q2024 to 4Q2027:

1. A decrease of public consumption G;
2. A homogeneous decrease of public transfers T.

Scenario 1: Decrease of government spending

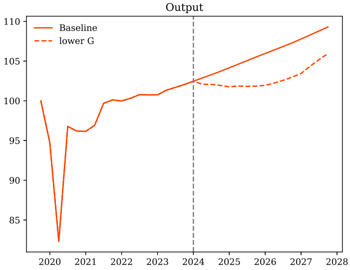


(a) Government spending

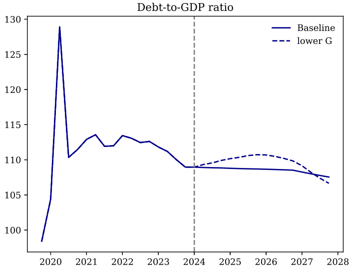


(b) Transfers

Scenario 1: Decrease of government spending



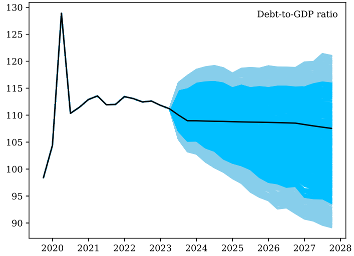
(a) GDP



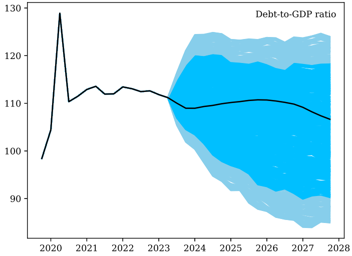
(b) Debt-to-GDP ratio

Inequalities	Top/Bottom	Top/Middle	Middle/Bottom
Benchmark	4.82	2.60	1.86
Scenario 1	4.83	2.59	1.87

Scenario 1: Decrease of government spending



(a) Benchmark

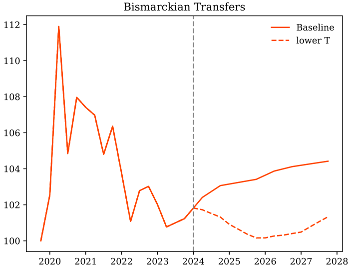


(b) Scenario 1

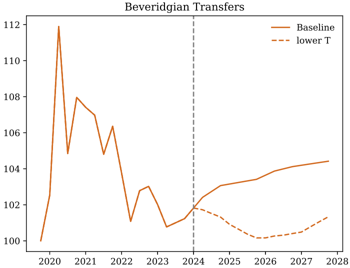
Decreasing government spending:

- Fails at reducing the debt-to-GDP ratio enough (-2.7 vs -2.3pp);
- Strongly increases risk (interquantile range at 27.1 vs 20.8pp).

Scenario 2: Homogeneous decrease of transfers



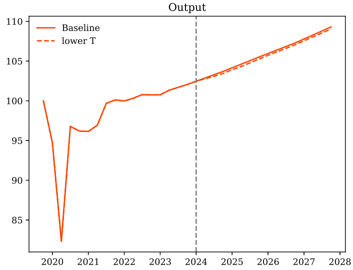
(a) Bismarckian transfers



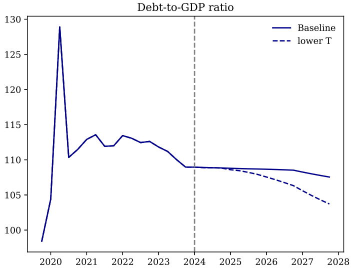
(b) Beveridgian transfers

- €11.2 billion for Bismarkian transfers;
- €8.8 billion for Beveridgian transfers.

Scenario 2: Homogeneous decrease of transfers



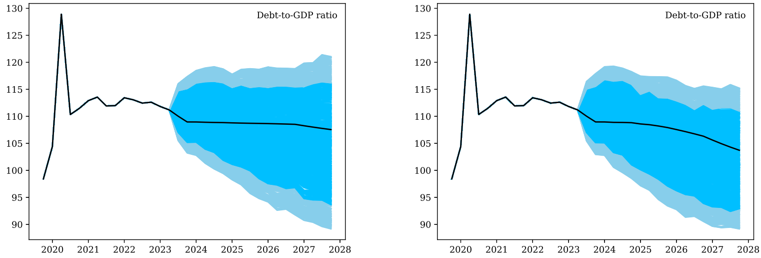
(a) GDP



(b) Debt-to-GDP ratio

Inequalities	Top/Bottom	Top/Middle	Middle/Bottom
Benchmark	4.82	2.60	1.86
Scenario 2	4.99	2.60	1.92

Scenario 2: Homogeneous decrease of transfers



(a) Benchmark (b) Scenario 2

Decreasing transfers homogeneously:

- Succeeds at reducing the debt-to-GDP ratio (-6.1 vs -2.3pp);
- Reduces risk (interquantile range at 17.7 vs 20.8pp).

Scenario 3: Decrease of transfers with reallocation

- Can we do better than the previous scenarios?

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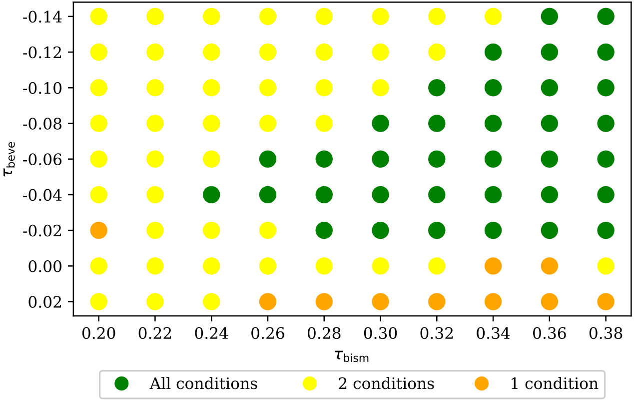
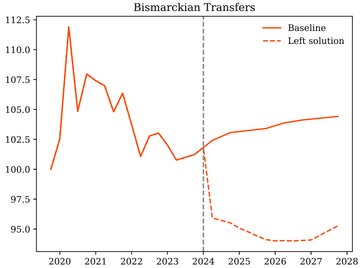
- Can we do better than the previous scenarios?

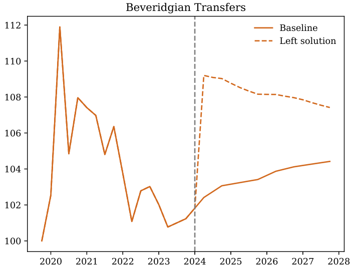
  ⇒ Yes, when Bismarkian transfers ↓ and Beveridgian transfers ↑



Scenario 3: Decrease of total transfers with reallocation



(a) Bismarckian transfers

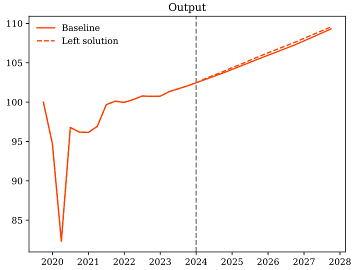


(b) Beveridgian transfers

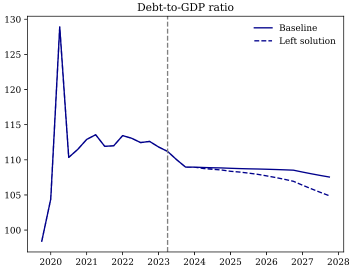
- €35 billion for Bismarkian transfers;

\+ €15 billion for Beveridgian transfers.

Scenario 3: Decrease of total transfers with reallocation



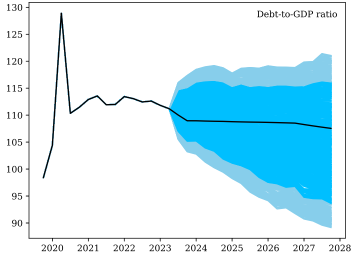
(a) GDP



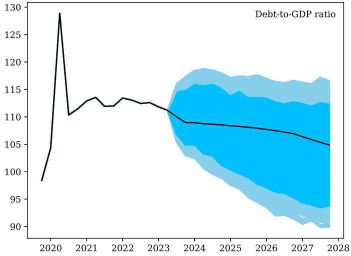
(b) Debt-to-GDP ratio

Inequalities	Top/Bottom	Top/Middle	Middle/Bottom
Benchmark	4.82	2.60	1.86
Scenario 3	4.80	2.59	1.85

Scenario 3: Decrease of total transfers with reallocation



(a) Benchmark



(b) Scenario 3

Decreasing Bismarkian transfers while increasing Beveridgian ones:

- Succeeds at reducing the debt-to-GDP ratio (-5.0 vs -2.3pp);
- Reduces risk (interquantile range at 17.8 vs 20.8pp).

Conclusion

- HANK is a relevant framework to assess fiscal consolidation.
  - ⋆ To get accurate multipliers and assess the distributive effects.
- Conditional-forecast methods allow to compare various policies in a controlled environment.
  - ⋆ Government forecasts is a valuable input.
- The composition of public spending is key to achieve fiscal consolidation and debt sustainability.
  - ⋆ Essential for achieving the threefold objective.

Model: Households

Model overview

- 3 skills $s \in \{l, m, h\}$: low (l), medium (m), and high, (h)
- Within s, idiosyncratic productivity shocks e: $\mathcal{P}(e, e')$

Household decisions are deduced from

$$\begin{aligned} V_t(e_t, a_{t-1}) &= \max_{c_t, a_t \geq 0} \left\{ \begin{array}{l} u(c_t) - v(n_t) \\ +\beta_t \sum_{e_{t+1}} \mathcal{P}(e_t, e_{t+1}) V_{t+1}(e_{t+1}, a_t) \end{array} \right\} \\ s.t. \quad a_t &= a_{t-1} + y_t(a_{t-1}, e_t) - (1+\tau_c)[c_t + (1 - s_{H,t}) p_{E,t} \underline{c}_E] \end{aligned}$$

- Household state (a, e): wealth and productivity
- $\underline{c}_E$: subsistence level for the energy consumption
- s_H: tariff shield ("bouclier tarifaire")
- p_E: relative price of energy
- τ_c: consumption tax

Model: Households

Model overview

The net income $y(a, e)$ and the taxable labor income net of social contributions $z(a, e)$ are defined as follows

$$\begin{aligned} y_t(a_{t-1}, e_t) &= r_t a_{t-1} + (1-\tau_f) d_t \bar{d}(e) + (1-\lambda)(z_t(e_t))^{1-\tau_z} + \tau_t \bar{\tau}(e \\ z_t(e_t) &= (1-\tau_l) w_t e_t n_t + T_t \bar{T}(e) \end{aligned}$$

- $1 + r_t = \frac{1+i_{t-1}}{1+\pi_t}$ and $\pi_t = \frac{P_t}{P_{t-1}} - 1$
- Dividends d_t are distributed across households according to $\bar{d}'(e) > 0$
- Tax rate on firms' dividends is τ_f
- Social contributions rate τ_l
- T_t: Bismarckian transfers (pensions and unemployment benefits), with $\bar{T}'(e) > 0$.
- τ_t: Beveridgian transfers (health, family ,...), with $\bar{\tau}'(e) < 0$

Model: Unions

Model overview

$\forall s \in \{l, m, h\}$, a union sets a wage by task k, $\forall e \in \mathtt{E}$ and $\forall a \in \mathtt{A}$
The union's program for the skill group s is

$$U^s_{k,t}(W^s_{k,t-1}) = \max_{W^s_{k,t}} \left\{ \begin{array}{l} \int_e \int_a \left[u(c^s_{i,t}(e_i, a)) - v(n^s_{i,t}(e_i, a)) \right] d\Gamma^s \\ -\frac{\psi^s_W}{2} \left(\frac{W^s_{k,t}}{W^s_{k,t-1}} - 1 \right)^2 + \beta U^s_{k,t+1}(W^s_{k,t}) \end{array} \right\}$$

$$s.t. \quad N^s_{k,t} = \left(\frac{W^s_{k,t}}{W^s_t} \right)^{-\varepsilon^s} N^s_t; \quad W^s_t = \left(\int_k \left(W^s_{k,t} \right)^{1-\varepsilon^s} dk \right)^{\frac{1}{1-\varepsilon^s}}$$

where the equilibrium distribution satisfies $\sum_s \omega^s \int_e \int_a d\Gamma^s = 1$.
The unions' decisions for the nominal wages lead to the NKPCs:

$$\pi^s_{W,t} = \kappa^s_W \left(N^s_t v'(N^s_t) - \frac{1}{\mu^s_w} td^s_t \frac{W^s_t}{P_t} N^s_t \widetilde{u}'_t(c^s, \overline{\mathcal{T}}^s) \right) + \beta \pi^s_{W,t+1}$$

with tax distortion $td^s_t = \frac{(1-\tau_{inc})(1-\tau_{ssc})}{1+\tau_c}$, union markup $\mu^s_w = \frac{\varepsilon_s}{\varepsilon_s - 1}$, wage rigidity parameters $\kappa^s_w \equiv \frac{\varepsilon^s}{\psi^s_W}$ that are specific to each s and $\overline{\mathcal{T}}$ the average tax rate.

Model: Basic-good producers

Model overview

Basic-good producers produce Y_N using only labor and minimize their production costs

$$\min_{n^l_{i,t}, n^m_{i,t}, n^h_{i,t}} \left\{ W^l_t N^l_t + W^m_t N^m_t + W^h_t N^h_t \right\}$$

$$s.t. \quad \begin{cases} Y_{N,t} & \leq & \left(\sum_i \alpha_i^{\frac{1}{\varepsilon_N}} \left(A^i_t N^i_t \right)^{\frac{\varepsilon_N - 1}{\varepsilon_N}} \right)^{\frac{\varepsilon_N - 1}{\varepsilon_N}} \\ N^s_t & = & \sum_i \omega^s \pi^s_i e^s_{i,t} n^s_{i,t} \quad \forall s \in \{l, m, h\} \end{cases}$$

where ω^s is the fraction of s-type in the population, $\sum_i \pi^s_i e^s_i = \varpi^s$ is the average productivity of each population

Assuming perfect competition leads to:

$$w_t = mc_{N,t}, \quad \text{with} \begin{cases} w_t & = & \frac{W_t}{P_t} \\ MC_{N,t} & = & \left(\sum_s \alpha_s \left(\frac{W^s_t}{A^s_t \varpi^s} \right)^{1-\varepsilon_N} \right)^{\frac{1}{1-\varepsilon_N}} \\ mc_{N,t} & = & \frac{MC_{N,t}}{P_t} \end{cases}$$

Model: Intermediate-good producers

Model overview

Intermediate-good producers produce Y_H with energy E and basic goods Y_N while minimizing their production costs

$$\min_{E_t, Y_{N,t}} \{W_t Y_{N,t} + P_{E_t} E_t\} \qquad s.t. \;\; Y_{H,t} \leq Z_t \left(\alpha_f^{\frac{1}{\sigma_f}} E_t^{\frac{\sigma_f - 1}{\sigma_f}} + (1-\alpha_f)^{\frac{1}{\sigma_f}} Y_{N,t}^{\frac{\sigma_f - 1}{\sigma_f}} \right)^{\frac{\sigma_f}{\sigma_f - 1}}$$

Assuming perfect competition leads to:

$$p_{H,t} = mc_{H,t}, \quad \text{with} \begin{cases} p_{H,t} &= \frac{P_{H_t}}{P_t} \\ MC_{H,t} &= Z_t^{-\frac{1}{\sigma_f}} \left(\alpha_f P_{E,t}^{1-\sigma_f} + (1-\alpha_f) W_t^{1-\sigma_f} \right)^{\frac{1}{1-\sigma_f}} \\ mc_{H,t} &= \frac{MC_{H,t}}{P_t} \end{cases}$$

Model: Final-good producers

Model overview

Final-good producers combine goods in order to satisfy the households' preferences. They minimize their production costs

$$\min_{Y_{H,t},Y_{E,t}} \{P_{H,t}Y_{H,t} + (1 - s_{H,t})P_{FE,t}Y_{E,t}\}$$

$$s.t. \qquad Y_{F,t} \leq \left(\alpha_E^{\frac{1}{\eta_E}} Y_{E,t}^{\frac{\eta_E - 1}{\eta_E}} + (1-\alpha_E)^{\frac{1}{\eta_E}} Y_{H,t}^{\frac{\eta_E - 1}{\eta_E}}\right)^{\frac{\eta_E}{\eta_E - 1}}$$

Assuming perfect competition leads to:

$$p_{F,t} = mc_{F,t}, \quad \text{with} \begin{cases} p_{F,t} &= \frac{P_{F_t}}{P_t} \\ MC_{F,t} &= \begin{pmatrix} \alpha_E((1-s_{H,t})P_{E,t})^{1-\eta_E} \\ +(1-\alpha_E)\left(P_{H,t}\right)^{1-\eta_E} \end{pmatrix}^{\frac{1}{1-\eta_E}} \\ mc_{F,t} &= \frac{MC_{F,t}}{P_t} \end{cases}$$

Model: Retailers

Model overview

Retailers produce $y_{i,t}$ differentiated goods. The i-retailer's objective is to maximize the profits

$$\Pi(P_{i,t-1}) = \max_{P_{i,t}} \left\{ \frac{P_{i,t} - P_{F,t}}{P_t} y_{i,t} - \frac{\psi_P}{2} \left(\frac{P_{i,t}}{P_{i,t-1}} - 1 \right)^2 Y_t + \frac{1}{1 + r_{t+1}} \Pi(P_{i,t}) \right\}$$

$$s.t. \qquad y_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon_d} Y_t$$

This leads to the following NKPC:

$$\pi_t = \kappa_P \left(mc_t - \frac{1}{\mu_t} \right) + \frac{1}{1 + r_{t+1}} \frac{Y_{t+1}}{Y_t} \pi_{t+1}$$

with $mc_t = \frac{P_{F,t}}{P_t}$ and $\kappa_P = \frac{\varepsilon_d}{\psi_P}$.
The firm's profit are distributed through its dividends d

Model: ECB and risk premium

Model overview

The central bank, here the ECB, follows a monetary rule:

$$\begin{aligned} i_t^* &= \rho_r i_{t-1}^* + (1-\rho_r)\left(i_{ss}^* + \phi_\pi(\mu_{FR} + (1-\mu_{FR})\rho_\pi)\pi_t\right) + \varepsilon_t \\ \text{with } \pi_t &= \frac{P_t}{P_{t-1}} - 1 \\ \pi_t^{EU} &= \mu_{FR}\pi_t + (1-\mu_{FR})\pi_t^{REU} \\ \pi_t^{REU} &= \rho_\pi \pi_t + \pi_t^{REU*} \\ \varepsilon_t &= \widetilde{\varepsilon}_t + \phi_\pi(1-\rho_r)(1-\mu_{FR})\pi_t^{REU*} \sim AR(1) \end{aligned}$$

The interest rate decided by the central bank i_t^* may differ from the effective interest rate on the French-government debt. The effective nominal interest rate is

$$i_t = i_t^* + \vartheta_t \quad \text{with } \vartheta_t \sim AR(1)$$

where ϑ_t is an exogenous wedge that can be either positive (due to risk premium) or negative (due to the maturity composition of government debt).

Model: Government

Model overview

Public debt (B_t) finances the differences between government revenues R_t and expenditures D_t:

$$R_t = \sum_s \int_a \int_e \mathcal{T}_l^s(e) d\Gamma^s(a,e) + \tau_l \sum_s \int_a \int_e w_t^s n_t^s e d\Gamma^s(a,e) + \tau_c(c_t + p_{E,t}\underline{c}_E)$$

$$D_t = \left(\int g_{i,t}^{\frac{\epsilon_d - 1}{\epsilon_d}} di \right)^{\frac{\epsilon_d}{\epsilon_d - 1}} + \Xi_t + s_{H,t} p_{E,t}(Y_{E,t} + (1+\tau_c)\underline{c}_E)$$

$$b_t = (1+r_t)b_{t-1} - R_t + D_t$$

where $b = B/P$ is the real public debt and Ξ_t the real transfers. To ensure public-debt dynamics's stability, the lump-sum transfer incorporates a fiscal brake

$$\Xi_t = \Upsilon_t - \theta\left(\frac{b_{t-1}}{b} - 1\right) + e_{\tau,t} \quad \text{with } \Upsilon_t = \sum_s \int_a \int_e [\tau\bar{\tau}(e) + T\overline{T}(e)] d\Gamma^s(a,e)$$

Υ_t is the observed transfers paid by the government to households (Beveridgian $\int \tau\bar{\tau}(e) d\Gamma^e(e)$ and Bismarckian $\int T\overline{T}(e) d\Gamma^e(e)$ components of transfers) and e_τ is a measurement error.

Model: Equilibrium

Model overview

Market-clearing conditions used to determine the unknowns $\{N, w, p_{FE}\}$ are

$$\text{asset market:} \quad b_t = \mathcal{A}_t \equiv \sum_s \int_{a_-} \int_e a_t^s(a_-, e) d\Gamma^s(a_-, e)$$

$$\text{labor market:} \quad N_t = \mathcal{N}_t \equiv \sum_s \int_{a_-} \int_e n_t^s(a_-, e) d\Gamma^s(a_-, e)$$

$$\text{energy market:} \quad \overline{E}_t = \mathcal{E}_t \equiv Y_{E_t} + \underline{c}_E + E_t$$

and the market clearing condition on the goods market can be used to check the Walras law:

$$Y_t \left(1 - \frac{\psi_P}{2}\pi^2\right) = p_{E_t}\overline{E}_t + \mathcal{C}_t + G_t$$

Calibration based on external information

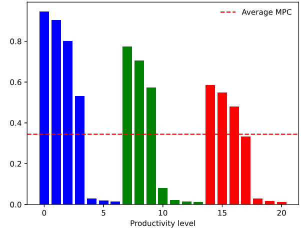
Calibration

Preferences	**Values**	**Targets**
Discount factor β	0.9888	Real interest rate $r = 0.74\%$ per quarter
Frisch elasticity of labor supply φ	1	Chetty et al. (2012)
Elasticity of intertemporal substitution σ	1	Log-utility for consumption
Incompressible energy consumption $\underline{c}_E$	0.041	20% of households' energy consumption
Wage markup μ_w	1.1	Auclert et al. (2021a)
Low-skill labor desutility ϕ_l	0.3634	Low-skill wage
Middle-skill labor desutility ϕ_l	0.3278	Middle-skill wage
High-skill labor desutility ϕ_l	0.1482	High-skill wage
Elasticity of substitution between production inputs η_E	0.5	Negative impact on GDP of energy-price shock
Share parameter (energy, intermediate good) α_E	0.043	Sharing rule: 40% of energy to households
Production	**Values**	**Targets**
Elasticity of substitution between production inputs σ_f	η_E	Simplifying assumption
Share parameter (energy, labor) α_f	0.056	Sharing rule: 60% of energy to firms
Firm markup μ	1.2	Auclert et al. (2021a)
Productivity parameters A_s	1	Normalization
Energy price	0.105	Share of energy in GDP of 3.18%
Nominal rigidity	**Values**	**Targets**
Price rigidity κ	0.95	Arbitrary higher than Auclert et al. (2018)
Wage rigidity κ_w	0.1	Auclert et al. (2018)
Monetary policy	**Values**	**Targets**
Taylor rule coefficient $\phi_\pi(\mu_{FR} + (1-\mu_{FR})\rho_\pi))$	1.2	With $\phi_\pi = 1.5$, $\mu_{FR} = 20\%$, and $\rho_\pi = 0.75$
Persistence of monetary policy ρ_r	0.85	Carvalho et al. (2021)

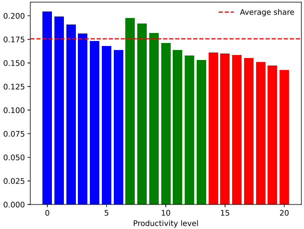
Government	**Values**	**Targets**
Public debt B	5.418	Debt-to-GDP ratio = 100%
Public spending G	0.236	Public spending-to-GDP ratio = 17.5%
Transfers (Bev. + Bism.)	0.192+0.242	Transfers-to-GDP ratio (Bev. + Bism.) = 32.1%

Calibration: Behaviors

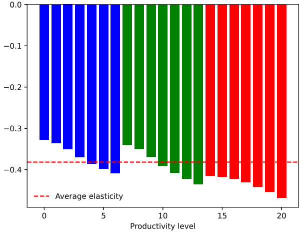
Calibration

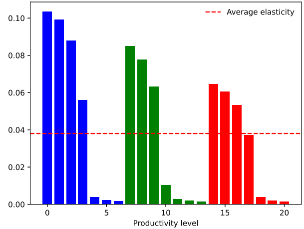


(c) Marginal Propensity to Consume



(d) Share of Energy in Consumption





Estimation: $AR(1)$ processes for 2003-2019 back

Shock	Z	Persistence ρ^Z Mean	Standard dev. σ^Z Mean	Variance $\frac{(\sigma^Z)^2}{1-(\rho^Z)^2} \times 100$
Preference	β	0.729671 (0.029348)	0.013046 (0.002123)	0.0363997672356
Price markup	μ	0.789200 (0.027489)	0.034667 (0.003339)	0.3186420040907
Energy price	p_E	0.826006 (0.018871)	0.110864 (0.008170)	3.8685179416384
Monetary policy	ε	0.594361 (0.042767)	0.006363 (0.000537)	0.0062603336598
Spread	ϑ	0.833475 (0.033896)	0.001173 (0.000118)	0.0004483501182
Disutility l	φ_l	0.789716 (0.044887)	0.021579 (0.002791)	0.1237292213442
Disutility m	φ_m	0.796583 (0.042019)	0.020735 (0.00257)	0.1176450201556
Disutility h	φ_h	0.702865 (0.058066)	0.031981 (0.004064)	0.2021389700213
Productivity l	A^l	0.797419 (0.031630)	0.016618 (0.001469)	0.0758419464546
Productivity m	A^m	0.788554 (0.031699)	0.015493 (0.001395)	0.0634701479995
Productivity h	A^h	0.852304 (0.030063)	0.017113 (0.001516)	0.1070462117039
Government spending	G	0.708019 (0.057510)	0.004230 (0.000373)	0.0035878431247
Transfers	T	0.787820 (0.043248)	0.005321 (0.000467)	0.0074637705758
Measurement error	e_τ	0.775047 (0.045756)	0.017671 (0.004227)	0.0782024947092

Changes in Model Multipliers and Policy Evaluation back

Let $\emptyset$ denotes the benchmark policy and $\mathcal{P}$ the alternative one (with parameter changes and additional shocks ε^{ς}).

$$dY_{\emptyset,t} = \sum_{s=0}^{\infty} \sum_{Z \in \mathcal{Z}} m_{\emptyset,s}^{Y,Z} \varepsilon_{t-s}^{Z}$$

$$dY_{\mathcal{P},t} = \sum_{s=0}^{\infty} \sum_{Z \in \mathcal{Z}} \left[m_{\mathcal{P},s}^{Y,Z} \varepsilon_{t-s}^{Z} + m_{\mathcal{P},s}^{Y,\varsigma} \varepsilon_{t-s}^{\varsigma} \right]$$

where Y are endogenous variables, m multipliers, ϵ shocks. The evaluation of the alternative policy is given by

$$dY_{\mathcal{P},t} - dY_{\emptyset,t} = \sum_{s=0}^{\infty} \sum_{Z \in \mathcal{Z}} \left[(m_{\mathcal{P},s}^{Y,Z} - m_{\emptyset,s}^{Y,Z}) \varepsilon_{t-s}^{Z} + m_{\mathcal{P},s}^{Y,\varsigma} \varepsilon_{t-s}^{\varsigma} \right]$$

As all multipliers $m_{\mathcal{P},s}^{Y,Z}$ have changed, evaluating policy $\mathcal{P}$ depends on the sequences of all shocks by combining all IRFs.

Conditional forecasts and Lucas critique

back

In our **Just-identified** model

$$\mathcal{Y}_{T+h} = \mathcal{M}(\mathcal{E}_{T+h}|\widehat{\Theta}, \Phi) \quad \text{with } dim(\mathcal{Y}_{T+h}) = dim(\mathcal{E}_{T+h}) = 15$$

Case 1: If the parameters are stable

$$\Rightarrow \quad \mathcal{E}_{T+h} = \mathcal{M}^{-1}(\mathcal{Y}_{T+h}|\widehat{\Theta}, \Phi) \quad \text{with } \mathcal{E}_{T+h} \in CI$$

Case 2: If the parameters are unstable i.e. $\mathcal{E}_{T+h} \notin CI$

$$\widetilde{\Theta}_x = \text{argmax } \mathcal{L}\left(\Theta_x|\{\mathcal{X}_{T+h}\}_{h=T}^{T+H}, \Phi\right) \quad \text{for } \mathcal{X}_{T+h} \in \mathcal{Y}_{T+h}$$

$$\Rightarrow \quad \mathcal{E}_{T+h} = \mathcal{M}^{-1}(\mathcal{Y}_{T+h}|\{\widehat{\Theta}_{-x}, \widetilde{\Theta}_x\}, \Phi)$$

where x are the variables controlled by the government

Conditional forecasts and the Lucas critique

- Government's decision rules are unstable if $\mathcal{E}_{T+h} \notin CI$:

$$y_t^g = \begin{cases} \widehat{\rho}_g y_{t-1}^g + \widehat{\sigma}_g \varepsilon_t^g & \text{if } t \leq T \quad \text{Old policy rule} \\ \widetilde{\rho}_g y_{t-1}^g + \widetilde{\sigma}_g \varepsilon_t^g & \text{if } t > T \quad \text{New policy rule} \end{cases}$$

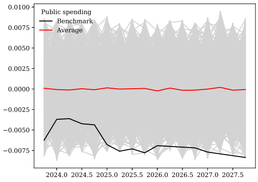
- The parameters $\widetilde{\Theta}_g = \{\widetilde{\rho}_g, \widetilde{\sigma}_g\}$ can be re-estimated using the government commitments $\{y_{T+h}\}_{h=1}^{H}$ and identification is:
  - ⋆ $\varepsilon_{T+h} = \frac{1}{\widetilde{\sigma}_g}(y_{T+h} - \widetilde{\rho}_g y_{T+h-1})$.
  - ⋆ $\mathcal{E}_{T+h} = \mathcal{M}^{-1}(\mathcal{Y}_{T+h}|\{\widehat{\Theta}_{-g}, \widetilde{\Theta}_g\})$
- Estimation outcome

Z	G	T
$\widetilde{\rho}^Z$	0.95953	0.90391
$\widetilde{\sigma}^Z$	0.00867	0.02299

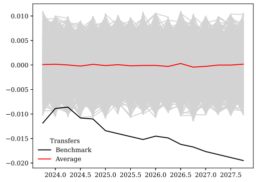
Table: Estimated parameters over 4Q-2019 to 4Q-2027

Innovations. (A) before and (B) after re-estimation

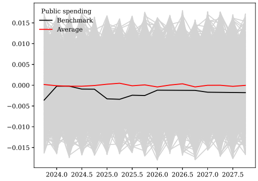
back



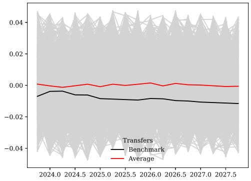
(a) Govt. consumption (A)



(b) Govt. transferts (A)



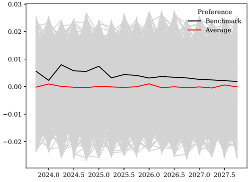
(c) Govt. consumption (B)



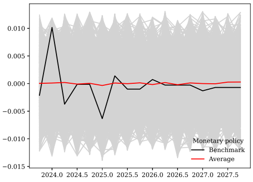
(d) Govt. transferts (B)

Innovations. (A) before and (B) after re-estimation

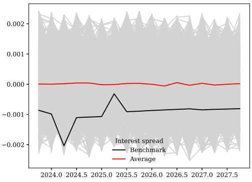
back



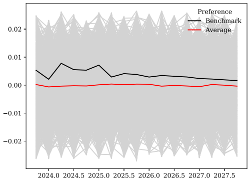
(a) Discount rate (A)



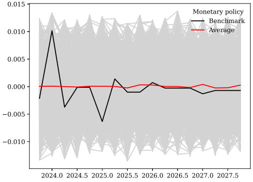
(b) Nominal rate (A)



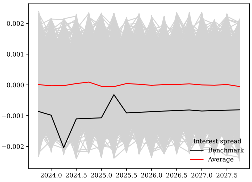
(c) Spread (A)



(d) Discount rate (B)

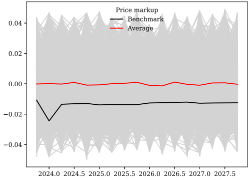


(e) Nominal rate (B)

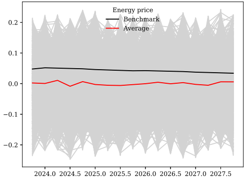


(f) Spread (B)

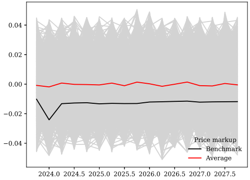
Innovations. (A) before and (B) after re-estimation back



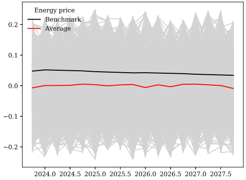
(a) Markup (A)



(b) Energy price (A)

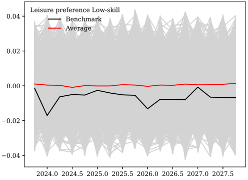


(c) Markup (B)

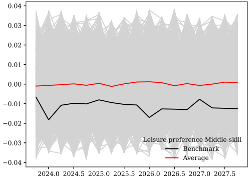


(d) Energy price (B)

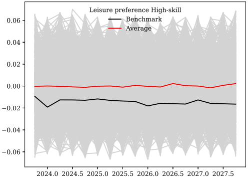
Innovations. (A) before and (B) after re-estimation back



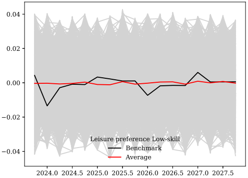
(a) Pref.: l-workers (A)



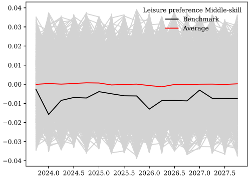
(b) Pref.: m-workers (A)



(c) Pref.: h-workers (A)



(d) Pref.: l-workers (B)



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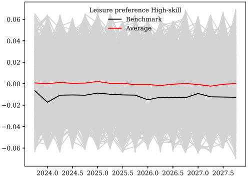
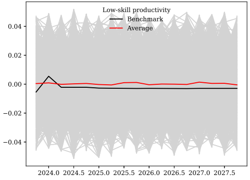
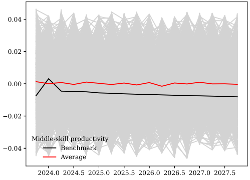


(f) Pref.: h-workers (B)

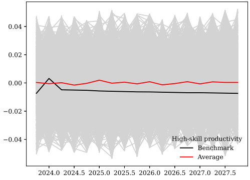
Innovations. (A) before and (B) after re-estimation back



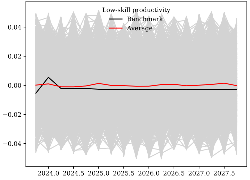
(a) Prod.: l-workers (A)



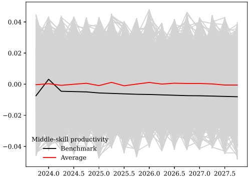
(b) Prod.: m-workers (A)



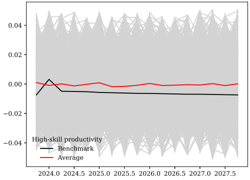
(c) Prod.: h-workers (A)



(d) Prod.: l-workers (B)

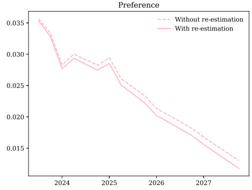


(e) Prod.: m-workers (B)



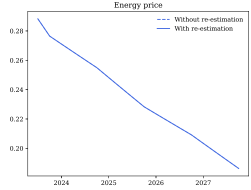
(f) Prod.: h-workers (B)

Shocks Dynamics back

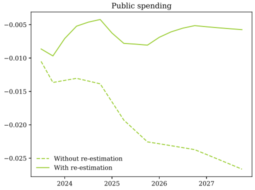


(a) Discount rate

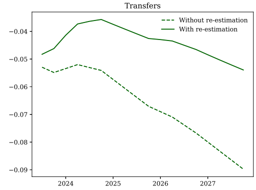
(b) Mark-up



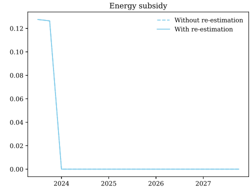
(c) Energy price



(d) Govt. consumption

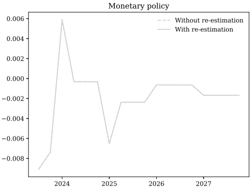


(e) Govt. transfers

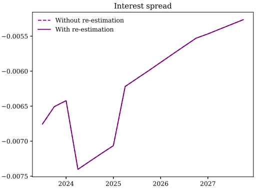


(f) Tariff shield

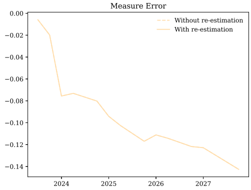
Shocks Dynamics back



(a) Nominal interest rate

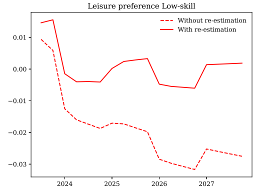


(b) Spread

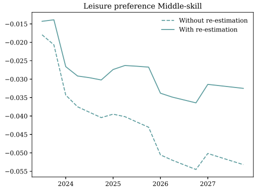


(c) Measurement error

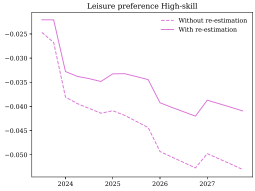
Shocks Dynamics back



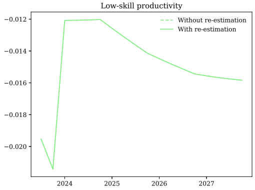
(a) Disutility of working l



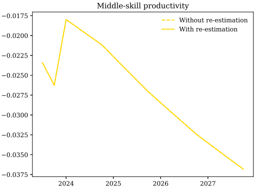
(b) Disutility of working m



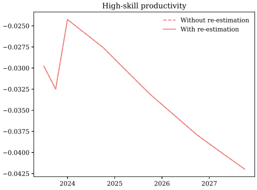
(c) Disutility of working h



(d) Work efficiency l

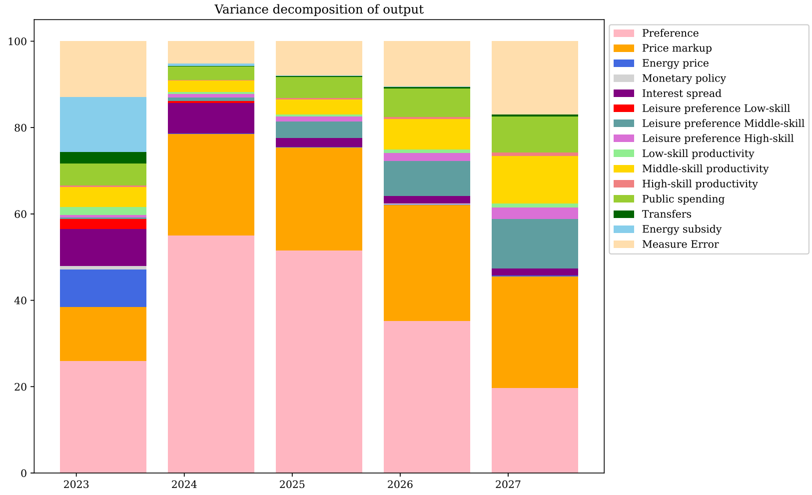


(e) Work efficiency m

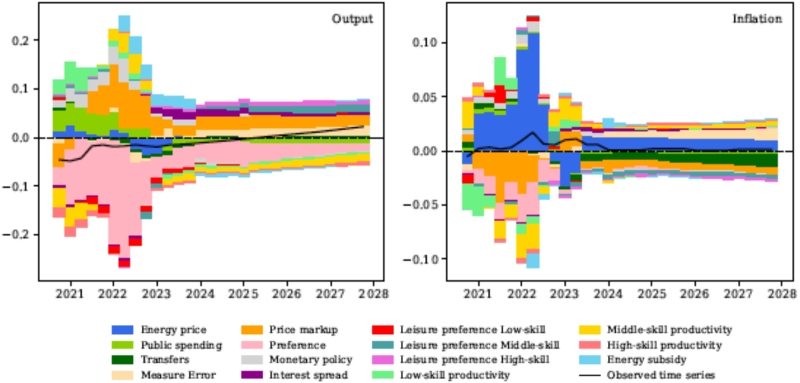


(f) Work efficiency h

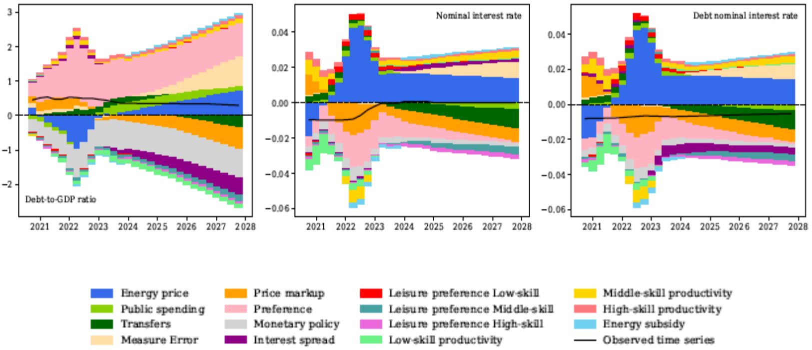
Variance decomposition: Output back



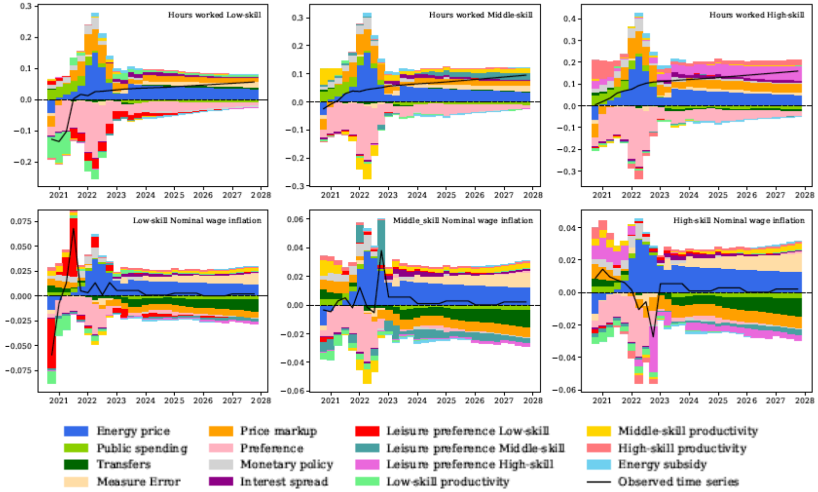
Historical decomposition: Output and Inflation back



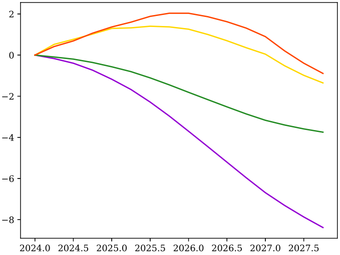
Historical decomposition: Debt-to-GDP, Interest rates back



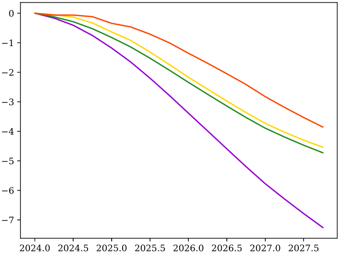
Historical decomposition: Labor markets back



DSA: Partial versus general equilibrium effects back



(a) Scenario 1



(b) Scenario 2

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