The Macroeconomic and Redistributive Effects of Shielding Consumers from Rising Energy Prices: the French Experiment*

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Abstract

France implemented a subsidy on the purchase of energy products to shield consumers from rising energy prices during the energy crisis that started in 2021. We develop a new-Keynesian business cycle model with heterogeneous agents to assess the macroeconomic and redistributive effects of this energy subsidy. We propose a new methodology for ex-ante policy evaluation based on the government forecasts embedded in budgetary law. From a macroeconomic perspective, this policy supports economic growth and curbs inflation at a sustainable fiscal cost. In terms of redistribution, this policy contains the rise in consumption inequalities even if the subsidy is not targeted at particular households. We compare the effects of this policy with alternative policies such as a re-indexation of wages on prices or a redistributive policy targeted at the most vulnerable households.

Keywords: HANK model, Energy crisis, Tariff shield, Policy evaluation.

JEL codes: C54, C63, E32, E65, H12, Q43.

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1 Introduction

At the start of 2022, Russia's invasion of Ukraine generated an energy shock in Europe of an unprecedented magnitude in the Euro Area's history. With a gas price multiplied by more than five and a barrel price multiplied by more than two since 2021, the inflationary shock has been very significant: starting from an average of 2%, inflation rates in 2022 have jumped 8% in Italy, 8.3% in Germany, 12% in the Netherlands, but "only" 6.2% in France. France thus stands out from its European partners by virtue of its lower inflation. Despite this dampening of this negative supply shock, the post-Covid recovery was immediately halted in France, bringing growth forecasts down from 6.2% to 2.85% for 2022 and from 3.7% to 1% for 2023. Finally, this shock to energy prices affects households unevenly, because the poorest devote a larger share of their income to the purchase of energy products than the wealthiest.[1] As a significant part of these energy expenditures can be considered incompressible, the sharp rise in their price is therefore much more difficult to dampen for low-income households.

In this context, the French government has put in place from the beginning of 2022 a freezing of gas prices at their October 2021 level, a capping of the increase in electricity prices as well as a discount at the pump as of April 2022. All these measures have been renewed for the year 2023. For the French statistical institute (INSEE) the amplitude of the shock and its impact on inflation thus has been halved. According to the INSEE, the increase in energy prices between 4Q2021 and 4Q2022 would have been 28.5%, compared to 54.2% without these measures. This likely led to an increase in inflation of 3.1 points, as opposed to 6.2 points without these measures.

The objective of this paper is to assess the impact of this tax shield on the French economy. Thanks to the use of a Heterogeneous-Agent New-Keynesian (HANK) model, this evaluation can study at the same time both the impacts on the macroeconomic aggregate variables (such as output, inflation or public debt) and also the dynamics of inequalities across households. As this is shown in Table 1, our model suggests the tax shield would have supported economic growth which would reach 1.9% per year on average between 2022 and 2023, while limiting inflation (5.6% per year on average between 2022 and 2023) and would contain the rise in consumption inequality in crisis times. The fiscal cost is substantial (about 2% of GDP per year, i.e. 58 billion euros per year) yet sustainable in

[1] In France, the share of income spent on energy is more than 10% for those with an income lower than the median and 8% for those in the top 10% of income.

Scenario	GDP growth 2022	GDP growth 2023	Inflation rate 2022	Inflation rate 2023	Inequality evolution	Debt-to-GDP ratio Long-term (2027)
No tariff shield	1.11%	0.92%	7.5%	6.4%	Increase	110.7%
Tariff shield only in 2022	2.85%	0.55%	6.4%	5.0%	Decrease	112.8%
Tariff shield in 2022 and 2023	2.85%	1.0%	6.4%	4.6%	Decrease	112.5%
Wage indexation on prices	2.22%	1.03%	7.5%	4.8%	Decrease	114.1%
Targeted transfers	1.65%	1.27%	7.8%	6.5%	Decrease	119.3%

Table 1: Results in terms of growth, inflation and indebtedness for a range of policies.

terms of public finances because the debt-to-GDP ratio would rise by 2.2 points in 2027. According to the same indicators, Table 1 also shows that this policy yields better results than alternative scenarios such as indexing wages to inflation (at the time of energy shock, the nominal wage are indexed in less than one year on the inflation of the consumer price) or a targeted redistribution policy. To model a credible scheme of redistribution, we assume that all households receive a lump sum transfer calibrated to finance their incompressible energy consumption, homogeneous among households but representing a larger share of expenditures for the poorest. Over the years 2022 and 2023, the indexation of wages on consumer prices (the implementation of a redistributive policy) lead to an average growth rate would be 1.6% (1.4%) with an inflation rate reaching 6.3% (7.4%) and a larger indebtedness (+3.4 points and +8.6 points respectively).

This quantitative analysis is achieved thanks to an original method that proposes an ex-ante evaluation of the policies. This ex-ante evaluation must be available before the vote in parliament in order to be used as a decision aid tool. It is then computed before the economist has the observations of the macroeconomic series. This is possible because the government commits itself to its expenditures and receipts by presenting, in the law, the implications of its policy on the output, inflation and debt. These "government forecasts" are based on a mixture of non-structural models using a very large set of information (statistical information and informal knowledge). Thus, our benchmark scenario will constrain our HANK model to reproduce these government forecasts concerning output, inflation and public debt, conditionally to the paths for government's expenditures and receipts also contained in this project of budgetary law. Therefore, our quantitative method mixes non-structural (government forecasts) and structural (HANK forecasts) approaches.[2] In the

[2] There is a large literature on the optimal way to mix non-structural and structural DSGE approaches for forecasting. See e.g. Boivin and Giannoni (2006), Schorfheide et al. (2010), Del Negro and Schorfheide (2013) or Gelfer (2019). We let future research discuss this point in the context of HANK models.

first step, we reveal the time-specific realizations of the structural shocks of our HANK model that make consistent its endogenous variables to the government's forecasts. Hence, these time-specific realizations of these shocks can be interpreted as the evolution of the economic conditions necessary to make credible the government's forecasts to the eyes of the model. Given that the law contains the tax shield on energy products, its evaluation can be conducted by making a counterfactual simulation where there is no tax shield but the same path for all sequences of exogenous shocks. The same applies to all alternative policies. This quantitative method can be implemented thanks to the dynamic response of the model obtained after computing the sequence-space Jacobian of the system, the first-order perturbation of the model around the steady-state is performed (Auclert et al. (2021a)). Indeed, this Jacobian gives the model's MA(∞) coefficients when subject to an AR(1) shock. Leveraging on this, one can determine the unique sequence of unanticipated shocks allowing one to fit given observed time series. This shock decomposition allows us to uncover the benchmark scenario defined as the sequence of structural shocks of our model that make consistent its endogenous variables to the government's forecasts (to which the government must commit itself by the law). Next, to evaluate an alternative policy, we keep the paths of all exogenous variables as given by the benchmark and only change the policy tool under consideration.

Literature. Our paper contributes to several strands of the literature. We contribute to the literature on the role of household heterogeneity in business cycle models. Following the seminal contributions of Aiyagari (1994) and Krusell and Smith (1998), an extensive literature has expanded over the past few years to develop quantitative models with heterogeneous agents, which also included market frictions, as price and wage rigidities, relevant for business cycle analysis.[3] Kaplan et al. (2018) and Auclert et al. (2021b) demonstrate the empirical performance of these HANK (for Heterogeneous Agents and New Keynesian) models and their relevance for macroeconomic policy evaluations.[4] HANK models have been widely estimated to explain the business cycle and inequality

[3]Many new methods have been developed to more easily use these models. In continuous time, Achdou et al. (2022) have popularized an approach based on solving Kolmogorov-Fokker-Planck forward equations coupled with HJB backward equations (See e.g. Kaplan and Violante (2018)). In discrete time, Reiter (2009), Reiter (2010), Winberry (2018) and Bayer and Luetticke (2020) have developed methods to improve the accuracy and resolution speed of these heterogeneous agent models. The Auclert et al. (2021a) approach integrates the set of tools necessary for macro-economists to use these HANK models to make economic policy assessments: it is possible *(i)* to compute the dynamic responses to aggregate shocks, *(ii)* to check the stability of the dynamics, *(iii)* to estimate parameters and shock realizations and *(iv)* to use a very friendly Python toolbox. We use this approach.

[4]See also Bilbiie (2019), Acharya et al. (2020).

dynamics of the US economy, our contribution to this literature is to extend the analysis of these models to the French economy whose specificity is to belong to a monetary union. The Taylor rule is then adapted to account for the fact that the European Central Bank (ECB) only partly responds to French inflation due to the low weight of France in the total euro economy.

We also contribute to the literature on the unequal consequences of energy taxation. The carbon tax is regressive since it impacts more heavily on the most disadvantaged households whose consumption is more energy intensive. The redistribution of the proceeds of the tax is therefore key to understanding the effects of this tax on inequalities. Rausch et al. (2011) and Goulder et al. (2019) provide general equilibrium-based analysis of the distributional effects of carbon pricing. We contribute to this literature by considering these distributional effects in a stochastic model that allows us to include the business cycle in the analysis as well as the role of short-run macroeconomic policy as the monetary policy. To do so, we extend the Auclert et al. (2021b)'s model to account for the consumption of energy by households but also as an input for production. Additionally, households have to consume an incompressible level of energy consumption. Depending on the scenario considered, we model the relevant fiscal tools used by the government (subsidy on energy prices or transfers to households for instance). Our analysis of the energy taxation in the context of the French economy supplements other applications to HANK models with an explicit energy sector; Känzig (2021) study the impacts of the European carbon market reforms on the euro area economy, Pieroni (2022) the consequences of an energy shortfall for the German economy, and Benmir and Roman (2022) the implications of the net-zero emissions target in the U.S. for the US economy.

Finally, we also contribute to the literature on policy evaluations based on conditional forecasts. Conditional forecasts are particularly useful for developing counterfactual policy scenarios. These forecasts are based on external information that predicts the evolution of certain economic variables and derives economic shocks that are consistent with these paths. Conditional forecasts have focused on the monetary policy interest rate in VAR (Waggoner and Zha (1999) and Antolin-Diaz et al. (2021)) and DSGE models (Del Negro and Schorfheide (2013)). Our contribution consists to estimate conditional forecasts based on the official government's forecasts for public finance and macroeconomic aggregates using the Auclert et al. (2021a)'s sequence-space Jacobian methodology and then to evaluate policy using counterfactual scenarios deduced from our HANK model.

The remainder of the article is organized as follows. Section 2 presents the model. Section

3 describes the quantitative methodology.[5] The section 4 analyzes the quantitative results of the calibrated model and the section 5 concludes.

2 Model

The model presented in this section is close to Auclert et al. (2021b) and Auclert et al. (2018). Additional features are included to account for energy as a consumption and an input. Moreover, fiscal tools are introduced to explain how the French government fight the inflation rise during the energy crisis. Finally, the Taylor rule is adapted to account for the low weight of the French economy in the Euro Area.

2.1 Households

In each household, the worker's productivity can take values $e_t \in \mathcal{E}$ at each date conditionally to a previous value $e_{t-1} \in \mathcal{E}$. The transition matrix between productivity levels is $\mathcal{P}(e_t, e_{t+1})$.

Each household consumes home goods c_H, paid at the price P_H, and energy goods c_{FE} paid at the price P_{FE}. The value of a household's total expenditures for consumption is Pc, where total expenditures for consumption c are paid at price P. Therefore, the value of total consumption is

$$Pc \equiv P_H c_H + (1 - s_H) P_{FE} c_{FE}$$

where s_H denotes the subsidy of energy purchases induced by policy distortions.

We assume that the household's problem is constrained by an incompressible level of energy consumption $\underline{c}_{FE}$. Energy gives utility if and only if $c_{FE} \geq \underline{c}_{FE}$. By denoting $\widetilde{c}_{FE} \equiv c_{FE} - \underline{c}_{FE}$, we deduce that $Pc - (1 - s_H) P_{FE} \underline{c}_{FE} = P_H c_H + (1 - s_H) P_{FE} \widetilde{c}_{FE}$ where $P_H c_H + (1 - s_H) P_{FE} \widetilde{c}_{FE}$ gives the value of expenditures net of the ones needed to finance the incompressible consumption. The consumption basket is given by

$$c \quad = \quad \left(\alpha_E^{\frac{1}{\eta_E}} \left(\widetilde{c}_{FE} \right)^{\frac{\eta_E - 1}{\eta_E}} + (1 - \alpha_E)^{\frac{1}{\eta_E}} \left(c_H \right)^{\frac{\eta_E - 1}{\eta_E}} \right)^{\frac{\eta_E}{\eta_E - 1}} \quad \text{, with } \widetilde{c}_{FE} \equiv c_{FE} - \underline{c}_{FE}$$

[5] *The results presented are obtained thanks to a preliminary version of the model that does not yet incorporate a fully estimated income process for France. A simple AR(1) is used in this preliminary version. Similarly, the persistence of the aggregate shocks is not yet estimated on historical data as this requires the full income process to be considered.*

The consistent definition of the Consumer Price Index (CPI denoted P), such that $Pc = P_H c_H + (1-s_H)P_{FE}\widetilde{c}_{FE}$, is given by

$$P = \left[\alpha_E((1-s_H)P_{FE})^{1-\eta_E} + (1-\alpha_E)P_H^{1-\eta_E}\right]^{\frac{1}{1-\eta_E}}$$

This implies that $c = p_H c_H + (1-s_H)p_{FE}\widetilde{c}_{FE}$ with $p_H = P_H/P$ and $p_{FE} = P_{FE}/P$. The decision rules of the household are deduced from

$$\begin{aligned} V_t(e, a_-) &= \max_{c,a} \left\{ u(c) - v(n) + \beta \sum_{e'} V_{t+1}(e', a)\mathcal{P}(e, e') \right\} \\ (1+\tau_c)c + a &= (1+r_t)a_- + (1-\tau_l)wen + \tau\bar{\tau}(e) + d\bar{d}(e) - (1+\tau_c)(1-s_H)p_{FE}\underline{c}_{FE} \\ a &\geq 0 \end{aligned}$$

where all nominal variables are deflated by the CPI and where $1 + r = \frac{1+i_{t-1}}{1+\pi}$ stands for the real interest rate, i is the nominal interest rate, and $\pi = \frac{P}{P_{t-1}} - 1$ the inflation rate. The fiscal system is characterized by τ_c the tax rate on consumption spending, τ_l the tax rate on labor income, and $\bar{\tau}(e)$ transfers to households which are dependent on the household productivity e such that $\bar{\tau}'(e) < 0$. The variable d refers to the transfers of firm dividends to households, which are increasing with household productivity, $\bar{d}'(e) > 0$. The labor supply n is determined by unions (see below). Finally, we assume that

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} \quad \text{and} \quad v(n) = \varphi\frac{n^{1+\nu}}{1+\nu}$$

Solving household's problem. The Household's problem determines the intertemporal choices $\{c, a\}$. Therefore, each household chooses the level of its consumption basket c and buys it at price P from retailers. The intratemporal choices are managed by firms that create final goods that combine home goods and energy services by satisfying the households' preferences. This allows us to introduce a Phillips curve on the CPI via an adjustment cost on price adjustment paid by the retailers. As for goods, the intratemporal choices between tasks that are combined to obtain the aggregate hours worked n are determined by unions, which also set nominal wages by supporting adjustment costs. This also leads to a Phillips curve on nominal wages.

2.2 Supply

We assume that intermediate goods Y_H are produced with energy E and labor N

$$Y_H \leq Z \left(\alpha_f^{\frac{1}{\sigma_f}} E^{\frac{\sigma_f - 1}{\sigma_f}} + (1-\alpha_f)^{\frac{1}{\sigma_f}} N^{\frac{\sigma_f - 1}{\sigma_f}} \right)^{\frac{\sigma_f}{\sigma_f - 1}}$$

Final goods Y_F are produced with intermediate goods Y_H and energy Y_{FE}

$$Y_F = \left(\alpha_E^{\frac{1}{\eta_E}} Y_{FE}^{\frac{\eta_E - 1}{\eta_E}} + (1-\alpha_E)^{\frac{1}{\eta_E}} Y_H^{\frac{\eta_E - 1}{\eta_E}} \right)^{\frac{\eta_E}{\eta_E - 1}}$$

This combination between home goods (Y_H) and energy services (Y_{FE}) corresponds to the households' preference, composed by goods c_H and $\widetilde{c}_{FE}$ and satisfying the constraint $c_{FE} \geq \underline{c}_{FE}$ through the term $p_{FE}\underline{c}_{FE}$ in the households' budgetary constraint.

Each retailer i produces consumption goods using final goods according to a linear production function: $Y_i = Y_{i,F}$. The produced consumption goods is an imperfect substitute to the consumption good $i' \neq i$. The elasticity of substitution between these consumption goods is ε_d and the basket is defined by

$$Y = \left(\int Y_i^{\frac{\varepsilon_d - 1}{\varepsilon_d}} di \right)^{\frac{\varepsilon_d}{\varepsilon_d - 1}} \quad \text{for } Y = c, G$$

These retailers sell Y_i goods to consumers and the government; They determine their optimal prices in a monopolistic market where there are price adjustment costs.

2.2.1 Intermediate Goods

Intermediate goods Y_H are produced with energy E and labor N. The optimal decisions of the firms are solutions of the following program:

$$\min_{E,N} \{WN + (1-s_F)P_{FE}E\} \quad s.t. \quad Y_H \leq Z \left(\alpha_f^{\frac{1}{\sigma_f}} E^{\frac{\sigma_f - 1}{\sigma_f}} + (1-\alpha_f)^{\frac{1}{\sigma_f}} N^{\frac{\sigma_f - 1}{\sigma_f}} \right)^{\frac{\sigma_f}{\sigma_f - 1}}$$

The optimal demands of production factors are:

$$N = (1-\alpha_f) \left(\frac{W}{MC_H} \right)^{-\sigma_f} Y_H, \qquad E = \alpha_f \left(\frac{(1-s_F)P_{FE}}{MC_H} \right)^{-\sigma_f} Y_H$$

with a marginal cost defined as follows

$$MC_H = Z^{-\frac{1}{\sigma_f}} \left(\alpha_f((1-s_F)P_{FE})^{1-\sigma_f} + (1-\alpha_f)W^{1-\sigma_f}\right)^{\frac{1}{1-\sigma_f}}$$

Assuming perfect competition on this market, profits and free entry condition leads to:

$$\Pi_H = (P_H - MC_H)Y_H = 0 \quad \Rightarrow \quad P_H = MC_H \quad \Leftrightarrow \quad p_H = mc_H, \quad \text{with } p_H = \tfrac{P_H}{P} \text{ and } mc_H = \tfrac{MC_H}{P}$$

2.2.2 Final Goods

Final goods Y_F are produced with intermediate goods Y_H and energy Y_{FE}. The optimal decision of these firms are solutions of the following program:

$$\min_{Y_H, Y_{FE}} \{P_H Y_H + (1-s_H)P_E Y_{FE}\} \quad s.t. \quad Y_F \leq \left(\alpha_E^{\frac{1}{\eta_E}} (Y_{FE})^{\frac{\eta_E-1}{\eta_E}} + (1-\alpha_E)^{\frac{1}{\eta_E}} (Y_H)^{\frac{\eta_E-1}{\eta_E}}\right)^{\frac{\eta_E}{\eta_E-1}}$$

The optimal decisions satisfy

$$Y_{FE} = \alpha_E \left(\frac{(1-s_H)P_{FE}}{MC_F}\right)^{-\eta_E} Y_F, \qquad Y_H = (1-\alpha_E)\left(\frac{P_H}{MC_F}\right)^{-\eta_E} Y_F$$

with the marginal cost $MC_F = \left(\alpha_E((1-s_H)P_E)^{1-\eta_E} + (1-\alpha_E)(P_H)^{1-\eta_E}\right)^{\frac{1}{1-\eta_E}}$. Assuming perfect competition on this market, profits and free entry condition leads to:

$$\Pi_F = (P_F - MC_F)Y_F = 0 \quad \Rightarrow \quad P_F = MC_F \quad \Leftrightarrow \quad p_F = mc_F, \quad \text{with } p_F = \tfrac{P_F}{P} \text{ and } mc_F = \tfrac{MC_F}{P}$$

2.2.3 Retailers

The retailers buy final goods on a perfectly competitive market and sell them to the household after transforming them into imperfect substitutes. Retailers obtain a markup, but they support an adjustment cost when they change their prices. The price setting rule is deduced from optimal behaviors of a continuum of identical firms producing differentiated goods and entering competition monopolistically:

$$\Pi_t(P_{i,-}) = \max_{P_i} \left\{ \frac{P_i - P_F}{P} y_i - \frac{\psi_P}{2} \left(\frac{P_i}{P_{i,-}} - 1 \right)^2 Y + \frac{1}{1+r_+} \Pi_{t+1}(P_i) \right\} \quad \text{s.t. } y_i = \left(\frac{P_i}{P} \right)^{-\varepsilon_d} Y$$

This leads to the following NKPC:

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

with $mc_t = \frac{P_{Ft}}{P_t}$, $\kappa_P = \frac{\varepsilon_d}{\psi_P}$ and $\mu = \frac{\varepsilon_d}{\varepsilon_d - 1}$.[6] The firm profit (its dividends) is defined by

$$D_t = P_t Y_t - P_{Ft} Y_{Ft} - \frac{\psi_P}{2} \left(\frac{P_t}{P_{t-1}} - 1 \right)^2 P_t Y_t,$$

knowing that with a linear production, we have $Y_t = Y_{FT}$.

For the redistribution of firms dividends, we assume that $D_t(e_t) = D_t \Psi(e_t)$, where the share of dividend $\Psi(e_t)$ redistributed to each household depends on its productivity e. In the following, we assume that $\Psi(e_t) = e_t$, implying an increasing share with productivity e.

2.3 Unions

Unions represent the workers' interests. A union set a unique wage by task k whatever the levels of productivity $e \in \mathcal{E}$ and wealth $a \in \mathcal{A}$. The union's program is:

$$\begin{aligned} U_t^k(W_{k,-1}) &= \max_{W_k} \int_e \int_a \left[u(c(e,a)) - v(n(e,a)) \right] d\Gamma_a d\Gamma_e - \frac{\psi_W}{2} \left(\frac{W_k}{W_{k,-}} - 1 \right)^2 + \beta U_{t+1}^k(W_k) \\ \text{s.t. } N_k &= \left(\frac{W_k}{W} \right)^{-\varepsilon} N \quad \text{with } W = \left(\int_k W_k^{1-\varepsilon} dk \right)^{\frac{1}{1-\varepsilon}} \end{aligned}$$

where the equilibrium distribution of households satisfies $\int_e \int_a d\Gamma_a d\Gamma_e = 1$. The purchasing power (income after wages and consumption taxes) of the household i is

$$\frac{1-\tau_l}{1+\tau_c} e_i w n_i = \frac{1-\tau_l}{1+\tau_c} e_i \int_k \frac{W_k}{P} n_{ik} dk$$

[6] Remark that for π "small", we have $(\pi_t + 1)\, \pi_t \approx \pi_t \equiv \frac{P_t}{P_{t-1}} - 1$.

If we assume that unions consider only a representative worker, $n_{ik} = n_{i'k} \equiv N_k$, then

$$\frac{1-\tau_l}{1+\tau_c} e_i w n_i = \frac{1-\tau_l}{1+\tau_c} e_i \int_k \frac{W_k}{P} \left(\frac{W_k}{W}\right)^{-\varepsilon} N dk$$

and the union's objective is

$$\begin{aligned} U_t^k(W_{k,-}) &= \max_{W_k} \int_e \int_a u(c(e,a)) d\Gamma_a d\Gamma_e - v(N) - \frac{\psi_W}{2} \left(\frac{W_k}{W_{k,-}} - 1\right)^2 + \beta U_{t+1}^k(W_k) \\ \text{s.t. } N_k &= \left(\frac{W_k}{W}\right)^{-\varepsilon} N_t \quad \text{with } W = \left(\int_k W_k^{1-\varepsilon} dk\right)^{\frac{1}{1-\varepsilon}} \end{aligned}$$

Defining $\mu_w \equiv \frac{\varepsilon}{\varepsilon-1}$ and $\kappa_w \equiv \frac{\varepsilon}{\psi_W}$. The union sets the nominal wage leading to a New-Keynesian Phillips curve:

$$\pi_{Wt} = \kappa_w \left(N_t v'(N_t) - \frac{1}{\mu_w} \frac{1-\tau^l}{1+\tau^c} \frac{W_t}{P_t} N_t u'(C_t) \right) + \beta \pi_{Wt+1}$$

2.4 Government

The government collects revenue (R_t) and incurs expenditure (S_t), the differences between revenue and expenditure being financed by issuing public debt B_t. Therefore, we have

$$\begin{aligned} P_t R_t &= P_t \tau_{lt} w_t N_t^S + P_t \tau_{ct} C_t + \tau_{ct} P_t p_{FEt} \underline{c}_{FE} \\ P_t S_t &= P_t G_t + P_t \tau_t + s_{Ht} P_t p_{Et} Y_{FEt} + s_{Ft} P_t p_{Et} E_t + s_{Ht}(1+\tau_{ct}) P_t p_{FEt} \underline{c}_{FE} \\ B_t &= (1+i_{t-1}) B_{t-1} - P_t R_t + P_t S_t \\ b_t &= (1+r_t) b_{t-1} - R_t + S_t \end{aligned}$$

where $b = B/P$ is the real public debt. In order to ensure the stability of the public debt dynamics, we assume that the lump sum transfer incorporates a fiscal brake, such that

$$\tau_t = T_t - \theta \left(\frac{b_{t-1}}{b} - 1\right) + t_t$$

The transfer is reduced when debt is larger than its steady-state level. T_t is the observed dynamics of transfers paid by the government to households and t_t is a shock on lump-sum transfers.

2.5 Monetary Policy

The monetary policy of the central bank, here the ECB, is summarized by the following Taylor rule:

$$i_t = \rho_r i_{t-1} + (1-\rho_r)\left(r_{ss} + \phi_\pi \pi_t^{EU}\right) + \widetilde{\varepsilon}_t$$

with the European inflation defined as $\pi_t^{EU} = \mu_{FR}\pi_t + (1-\mu_{FR})\pi_t^{REU}$, where π_t^{REU} denotes the inflation in the rest of the Euro Area, and μ_{FR} the share of the French economy. Assuming that inflation in the rest of the Euro Area is correlated with the French inflation, i.e. $\pi_t^{REU} = \rho_\pi \pi_t + \pi_t^{REU*}$, the Taylor rule becomes:

$$i_t = \rho_r i_{t-1} + (1-\rho_r)\left(r_{ss} + \phi_\pi(\mu_{FR} + (1-\mu_{FR})\rho_\pi)\pi_t\right) + \varepsilon_t$$

with $\pi_t = \frac{P_t}{P_{t-1}} - 1$ and $\varepsilon_t = \widetilde{\varepsilon}_t + \phi_\pi(1-\rho_r)(1-\mu_{FR})\pi_t^{REU*}$. Hence, ε_t is not a "pure" monetary shock but a composite shock that also contains inflation shocks that occur in the rest of the Euro Area. Besides, the Fisher rule leads to $1 + i_t = (1+r_t)(1+\pi_{t+1})$.

2.6 Energy Market

The energy supply $\overline{E}$ is given while the price P_{FEt} clears the market:

$$P_{FEt}\overline{E} = P_{FEt}(E_t + Y_{FEt} + \underline{c}_{FE})$$

2.7 Equilibrium

The market clearing conditions used to determine the unknowns $\{r, w, p_{FE}\}$ are

$$\begin{aligned}
\text{asset market:} \quad & b = \mathcal{A} \equiv \int_{a_-}\int_e a(a_-, e)d\Gamma(a_-, e) \\
\text{labor market:} \quad & N = \mathcal{N} \equiv \int_{a_-}\int_e n(a_-, e)d\Gamma(a_-, e) \\
\text{energy market:} \quad & \overline{E} = \mathcal{E} \equiv Y_{FE} + \underline{c}_{FE} + E
\end{aligned}$$

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

$$Y\left(1 - \frac{\psi_P}{2}\pi^2\right) = p_{FE}\overline{E} + \mathcal{C} + G$$

3 Quantitative Method

In the first subsection, we briefly describe how we solve the dynamics of the model. This method is described in detail in Auclert et al. (2021a). In the second subsection, we present our original method for an ex-ante policy evaluation using HANK models.

3.1 Dynamics

We regroup in the system $\Phi(S_{t+1}, S_t, S_{t-1}) = 0$ all the equations describing firms, unions, government and central bank behaviors, with S_t the vector of aggregate variables controlled by these agents. Therefore, the equilibrium dynamic must satisfy

$$\mathbf{H}_t(\mathbf{Y}, \mathbf{Z}) \equiv \begin{pmatrix} \Phi(S_{t+1}, S_t, S_{t-1}) \\ \mathcal{A}_t - b_t \\ \mathcal{N}_t - N_t \\ \mathcal{E}_t - \overline{E} \end{pmatrix} = 0 \tag{1}$$

with $\mathbf{Y}$ gathering the time series of unknown aggregate variables and $\mathbf{Z}$ of exogenous aggregate shocks. For solving the dynamic paths of this economy, we use the approximation method developed by Auclert et al. (2021a). Given a vector $\mathbf{X}_t$ summarizing the exogenous variables for the households[7], the dynamic of individuals' choices and their distribution are given by

$$V_t(e, a_-) = \max_a u(e, a_-, a, \mathbf{X}_t) + \beta \mathbb{E} V_{t+1}(e', a) \qquad \text{(DP)}$$

$$D_{t+1}(e', \mathcal{A}) = \sum_e D_t(e, {a_t^*}^{-1}(e, \mathbf{X}_t)) P(e, e', \mathbf{X}_t) \qquad \text{(LoM)}$$

$$\mathbf{W}_t = \sum_e \int_a w(e, a_-; V_{t+1}, \mathbf{X}_t) D_t(e, da_-) \qquad \text{(Aggr.)}$$

where ${a_t^*}^{-1}(e, \mathbf{X}_t)$ denotes the unique value for a_- consistent with the optimal decision $a_t^*(e, \mathbf{X}_t)$ and $\mathbf{W}_t$ the vector of the aggregates for w (consumption, wealth, hours worked,...) summarizing

[7] For the households, the exogenous variables are not necessarily the vector $\mathbf{Z}$, but also prices or wages contained in S_t. For this reason, the vector for exogenous variables for the agent denoted $\mathbf{X}$, is different from $\mathbf{Z}$.

individual choices. This system can be rewritten as follow:

$$\mathbf{v}_t = v(\mathbf{v}_{t+1}, \mathbf{X}_t)$$
$$\mathbf{D}_{t+1} = \Lambda(\mathbf{v}_{t+1}, \mathbf{X}_t)'\mathbf{D}_t$$
$$\mathbf{W}_t = w(\mathbf{v}_{t+1}, \mathbf{X}_t)'\mathbf{D}_t$$

where $\Lambda(\mathbf{v}', \mathbf{X})$ is the transition matrix for the distribution $\mathbf{D}$. Using a linear approximation around the steady state, we deduce

$$\begin{aligned} d\mathbf{v}_t &= v_v d\mathbf{v}_{t+1} + v_x d\mathbf{X}_t \\ d\mathbf{D}_{t+1} &= (\Lambda_v d\mathbf{v}_{t+1} + \Lambda_x d\mathbf{X}_t)'\mathbf{D}_{ss} + \Lambda'_{ss} d\mathbf{D}_t \\ d\mathbf{W}_t &= (w_v d\mathbf{v}_{t+1} + w_x d\mathbf{X}_t)'\mathbf{D}_{ss} + w'_{ss} d\mathbf{D}_t = \underbrace{dw'_t \mathbf{D}_{ss}}_{\text{individual effect}} + \underbrace{w'_{ss} d\mathbf{D}_t}_{\text{distributional effect}} \end{aligned}$$

Knowing $d\mathbf{v}_T = 0$, the terminal condition, and $d\mathbf{D}_0 = 0$ an initial condition, the solution of this system describes the dynamics of individual responses ($d\mathbf{v}$) to a change in an exogenous variable ($d\mathbf{X}$) as well as the changes in the distribution ($d\mathbf{D}$) and thus changes in aggregates ($d\mathbf{W}$). Hence, this system implicitly defines the solution for $\mathcal{A}_t$ and $\mathcal{N}_t$, $\forall t$

$$\begin{pmatrix} \mathcal{A}_t \\ \mathcal{N}_t \end{pmatrix} = h(\mathbf{X}_t)$$

where the differenciability of functions v, Λ and w around ($\mathbf{v}_{ss}$, $\mathbf{X}_{ss}$) ensures that the function h is also differentiable. The solution of the equilibrium dynamics of variable in S_t can also be solved using a linear approximation around the steady state. Therefore, using equation (1), we can deduce

$$\begin{aligned} 0 &= \sum_{s=0}^{\infty} [H_Y]_{t,s} dY_s + \sum_{s=0}^{\infty} [H_Z]_{t,s} dZ_s \quad \text{where} \quad [H_Y]_{t,s} \equiv \frac{\partial H_t}{\partial Y_s} \quad \text{and} \quad [H_Z]_{t,s} \equiv \frac{\partial H_t}{\partial Z_s} \\ \Rightarrow \quad dY &= -H_Y^{-1} H_Z dZ = G dZ \end{aligned}$$

where G is the complete Jacobian of the dynamic system. Let us assume all the exogenous shocks of the model have the following MA(∞) representation: $dZ_t = \sum_{s=0}^{\infty} \mathbf{m}_s^Z \varepsilon_{t-s}^Z$. Then, the outputs of the HA model can be represented by a MA(∞) that involves the model's Jacobians:

$$dY_t = \sum_{s=0}^{\infty} \sum_{\text{shock } z} \left[G^{Y,z}\mathbf{m}^z\right]_s \varepsilon_{t-s}^z \equiv \sum_{s=0}^{\infty} \sum_{\text{shock } z} m_s^{Y,z} \varepsilon_{t-s}^z$$

Replacing ∞ by T "large" and using the Jacobians, one can determine the unique sequence of unanticipated shocks $\{\varepsilon_s\}_{s=0}^T$ allowing the fit a given sequence of $\{dY_s\}_{s=0}^T$.

3.2 Methodology for Ex-Ante Policy Evaluations

Our objective is to evaluate different economic policies that will be implemented after the last sample period. Therefore, we aim to provide ex-ante evaluations of different policies by comparing the implications of each of them to a benchmark scenario. These evaluations must be done before the economist has the observations of the macroeconomic series, i.e. at the moment when the policymaker must make her choice.

In France, when the parliament approves the government's budget, the government commits itself to its expenditures and receipts by presenting the implications of these commitments on the output, inflation and public debt. These "government's forecasts" are based on a mixture of non-structural models, the experience of the forecasters and the knowledge of domain experts. The non-structural models are characterized by a minimal assumption set on the model restrictions and is known for its great performance in forecasting mainly explained by the unrestricted information set that they use. The experience of the forecasters and the knowledge of domain experts are then use to improve the credibility of these forecast, thus based on a very large information set.

Our benchmark scenario will constrain our HANK model to reproduce these "good" government forecasts concerning output, inflation and public debt, conditionally to the paths for government's expenditures and receipts also contained in this project of budgetary law.[8] Therefore, we impose strong restrictions based on theory to offer causal interpretations. The cost of our approach is to describe relationships among a small set of variables, therefore limiting the information set used for forecasting and thus its accuracy relative to larger scale, non-structural models.

Therefore, in a first step (the benchmark scenario), we reveal the time-specific realizations of

[8] There is a large literature on the optimal way to mix non-structural and structural DSGE approaches for forecasting (see e.g. Boivin and Giannoni (2006), Schorfheide et al. (2010), Del Negro and Schorfheide (2013) or Gelfer (2019)). We let future research discuss this point in the context of HANK models.

the structural shocks of our model that make consistent its endogenous variables to government's forecasts. Hence, this time-specific realizations of these shocks can be interpreted as the evolution of the economics conditions necessary to make credible to eyes of the model the government's forecasts.

The limits of this quantitative method based on conditional forecast are first described in Leeper and Zha (2003). "Suppose that the interest rate path is not announced to the public but its implementation requires a sequence of strongly positively correlated unanticipated monetary policy shocks. Over time, the agents in the DSGE model might be able to detect the persistence in the deviation from the systematic part of the monetary policy rule and suspect that the policy rule itself might have changed permanently, which, in turn, creates an incentive to update decision rules." (Del Negro and Schorfheide (2013)).[9] This type of adjustment is not taken into account in our analysis, which means that we assume the changes in the government's policy are "too small" (in the sense of Leeper and Zha (2003)) to trigger a costly learning mechanism leading the agents to believe that the policy regime has shifted.

If we want to evaluate an alternative policy, we then keep the paths of all exogenous variables as given (the time-specific realizations of the structural shocks revealed by the benchmark scenario) and only change one policy tool (e.g. the path of the subsidies to energy expenditures). Thus, the ex-ante evaluations of all alternative policies are done in a specific economic context identical to the one of the benchmark scenario. This allows us to control the environment during the evaluation.

Choice of the shocks. Among the shocks describing the evolution of the economic context, it is necessary to distinguish two groups of shocks.

(i) The shocks that affect the exogenous and observable variables. They are therefore identifiable from the forecasts themselves of these exogenous variables. We use forecasts of energy price (P_{FE}), government expenditures (G), government transfers (T) in order to identify over the sample $t_0 = 4Q2019$ to $t_1 = 4Q2027$ the shocks $\{\varepsilon_s^{P_{FE}}, \varepsilon_s^G, \varepsilon_s^T\}_{s=t_0}^{t_1}$ on exogenous variables $\{P_{FE,s}, G_s, T_s\}_{s=t_0}^{t_1}$

Moreover, we add a supplementary shock that aims at mimicking the dynamics of the subsidies s_h provided by the government to consumers for their energy expenditures over the period 1Q2022 to 4Q2023.

[9] See also Gali (2011) for a critical analysis of conditional forecasts.

For all these exogenous variables, we assume that

$$dZ_t = \rho^Z dZ_{t-1} + \varepsilon_t^Z \quad \text{for } Z = P_{FE}, G, T, s_H$$

(ii) The shocks that affect the unobservable variables, such as preference (β) markup (μ) or lump-sum transfer (t). The shocks $\{\varepsilon_s^\beta, \varepsilon_s^\mu, \varepsilon_s^t\}_{s=t_0}^{t_1}$ on exogenous variables $\{\beta_s, \mu_s, t_s\}_{s=t_0}^{t_1}$, are identified using the model solution

$$d\widetilde{Y}_t = \sum_{s=0}^{\infty} \sum_{\text{shock } z} \left[G^{\widetilde{Y},z} \mathbf{m}^z \right]_s \varepsilon_{t-s}^z \equiv \sum_{s=0}^{\infty} \sum_{\text{shock } z} m_s^{\widetilde{Y},z} \varepsilon_{t-s}^z \tag{2}$$

where $d\widetilde{Y}_t$ contains real GDP, inflation rate and public debt over GDP ratio and $z = P_{FE}, G, T, \beta, \mu, t$. As previously, we assume that

$$dZ_t = \rho^Z dZ_{t-1} + \varepsilon_t^Z \quad \text{for } Z = \beta, \mu, t$$

Therefore the evolution of the economic context $\{\beta, \mu, t, G, T, P_{FE}, s_H\}$ is identified using time series $\{Y, \pi, \frac{b}{Y}, G, T, P_{FE}, s_H\}$ and the model restrictions given by ρ^Z (implying $\mathbf{m}_s^z$) and $G_s^{\widetilde{Y},z}$. The numerical values for the matrices $\mathbf{m}_s^z$ and $G_s^{\widetilde{Y},z}$ are deduced from the calibration.

4 Quantitative Results

4.1 Calibration and Estimation

Income process. In order to model the earning process, we follow Ferriere et al. (2022). Indeed, Guvenen et al. (2017) have shown that labor income dynamics are poorly approximated by a $AR(1)$ process because labor income growth rates are negatively skewed and exhibit excess kurtosis. To account for these features, the productivity e follows a Gaussian Mixture Autoregressive (GMAR) process

$$\log(e_t) = \rho \log(e_{t-1}) + \eta_t \quad \text{where } \eta_t \sim \begin{cases} \mathcal{N}(\mu_1, \sigma_1) & \text{with probability } p \\ \mathcal{N}(\mu_2, \sigma_2) & \text{with probability } 1-p \end{cases} \tag{3}$$

with $\mathbb{E}\eta = p\mu_1 + (1-p)\mu_2 = 0$, so that μ_2 is deduced from μ_1 and p values. Most of the time (p large), the innovation is drawn in the low variance distribution ($\sigma_1 < \sigma_2$) and infrequently ($1-p$ small) in the distribution with a large variance and a negative mean ($\mu_2 \leq 0 \leq \mu_1$). This process generates frequent small and infrequent large negative earnings changes, consistently with the negative skewness and excess kurtosis empirically documented by Guvenen et al. (2017). The method proposed by Farmer and Toda (2017) are used to discretize this process.

Moreover, there exists a high concentration of top labor income (the top 10% earners concentrate a large fraction of labor income). This leads us to follow Hubmer et al. (2020) by assuming that the top earnings follow a Pareto distribution:

$$e_t = \begin{cases} e_t & \text{if } F(e) \leq 0.9 \\ F^{-1}_{\text{Pareto}(\kappa)}\left(\frac{F(e)-0.9}{1-0.9}\right) & \text{if } F(e) > 0.9 \end{cases} \tag{4}$$

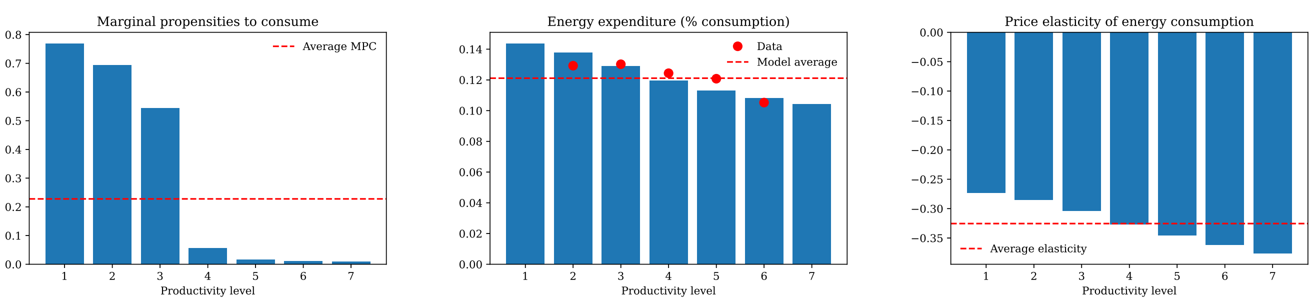
where F is the cdf of e generated by the process described by (3) and $F^{-1}_{\text{Pareto}(\kappa)}$ the inverse cdf for a Pareto distribution with a lower bound $F^{-1}(0.9)$ and a tail coefficient κ. The set of parameters $\{\rho, \sigma_1, \sigma_2, p, \mu_1\}$ is estimated in order to match the variance, the skewness, the kurtosis, and the T10% of the French earnings data (ECHP, see Fonseca et al. (2023)), for a given value of κ. *In this preliminary version, we do not present results with this earning process but results obtained with a basic Markov process calibrated in order to reproduce the size of consumption inequalities.*

Other parameters. The other structural parameters of the model are calibrated to reproduce some stylized facts about the French economy or a set using external information (see Table 2). This calibration results in 19.6% of households being constrained. The Marginal Propensity to Consume (MPC) per level of income are reported in panel (a) of Figure 1. As usual, the agents with low incomes consume a larger fraction of their incomes. Panel (b) of Figure 1 shows that the agents devote a larger share of their expenditures to energy, as in the data. Finally, panel (c) of Figure 1 shows that the agents with low incomes have more difficulty reducing their energy consumption when the price increases. This result comes from the largest share of incompressible consumption in their energy consumption.

As in all dynamic models, the impact of each shock depends on how the agents' except they persist. These persistences (the autocorrelations of the $AR(1)$ processes) are reported in Table 3.

Parameter	Value	Target
Preferences		
Discount factor β	0.9922	Real interest rate $r = 0.5\%$ per quarter
Disutility of labor θ	0.6343	Aggregate labor $L = 1$
Frisch elasticity of labor supply φ	0.5	Auclert el al (2020)
Elasticity of intertemporal substitution σ	1	Log-utility
Incompressible energy consumption $\underline{c}$	0.0370	20% of the households' energy consumption
Wage markup μ_w	1.1	Auclert el al (2020)
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	0.025	Sharing rule: an half of energy to households
Production		
Elasticity of substitution between production inputs σ_f	η_E	Simplifying assumption
Share parameter (energy, labor) α_f	0.075	Sharing rule: an half of energy to firms
Firm markup μ	1.2	Auclert el al (2020)
Aggregate targets		
Share of GDP spent on energy se	3.18%	Share of energy in GDP
Public debt B	4.749	Debt-to-GDP ratio 100% with annual GDP
Public spending G	0.2374	Public spending-to-GDP ratio 20%
Transfers	0.2968	Transfers-to-GDP ratio 25%
VAT rate τ_c	20%	French VAT
Income tax rate τ_l	20%	French employee tax rate
Nominal rigidity		
Price rigidity κ	0.95	Arbitrary lower than Auclert et al (2018)
Wage rigidity κ_w	0.1	Auclert et al (2018)
Monetary policy		
Taylor rule coefficient $\phi_\pi(\mu_{FR} + (1-\mu_{FR})\rho_\pi))$	1.2	With $\phi_\pi = 1.5$ and $\mu_{FR} = 20\%$, the $\rho_\pi = 0.75$
Persistence of monetary policy ρ_r	0.85	Carvalho et al (2021)
Heterogeneity		
Persistence of productivity shocks ρ	0.966	Fonseca et al. (2023) data for France
Volatility of productivity shocks σ	0.5	preliminary values: to match consumption inequalities

Table 2: Calibrated parameters



(a) Marginal Propensity to Consume (b) Energy share in consumption (c) Price elasticity of energy demand

Figure 1: Heterogeneity in household's behaviors (per income level)

The values of these ρ^Z for $Z = \beta, \mu, t, G, T, P_{FE}, s_H$ are estimated by a maximum likelihood method

Shock	Z	**Persistence** ρ^Z
Energy price	p_{FE}	0.8
Government spending	G	0.9
Transfers	T	0.9
Taxes	τ	0.9
Price markup	μ	0.6
Preference	β	0.6

Table 3: Estimated parameters of the $AR(1)$ processes – preliminary values

on the sample 1Q2000 to 4Q2019 using the data set $\{Y, \pi, \frac{b}{Y}, G, T, P_{FE}\}$ and the autocorrelation function of these variables deduced from the model solution (see equation 2). In this preliminary version, these values are set to their approximated mode.

For the energy consumption subsidy, we assume that households expect the government not to remove it all at once, as provided for in the law, but to take a year to remove all these subsidies. Thus, even if we implement in our evaluation what is provided for in the law, i.e. subsidies between 1Q2022 and 4Q2023, households act in the belief that there is a persistence of this subsidy.

4.2 Data for Aggregates

The originality of our work is to propose an ex-ante evaluation of alternative policy scenarios. For doing that we use data that are published by the French government when Prime Minister presents the law on the State's budget. These data contain the government's forecasts for

- $\{G, T, s_H\}$, which are its commitment concerning its policy until 4Q2027.
- $\{P_{FE}\}$, which is a crucial forecast on the exogenous shock that hit France since the end of 2021.
- $\{Y, \pi, \frac{b}{Y}\}$, which summarize its objectives founding its policy.

These data are presented in figures of the Appendix A (raw data). The sample goes from $4Q2019$ to $4Q2027$. In order to estimate the sequences of shocks $\{\varepsilon^\beta, \varepsilon^\mu, \varepsilon^t, \varepsilon^G, \varepsilon^T, \varepsilon^{P_{FE}}, \varepsilon^{s_H}\}_{s=4Q2019}^{4Q2027}$, we use stationarized data reported in the figures of Appendix A.

4.3 Shock Decomposition

In each period, all shocks can materialize. The shock decomposition identifies the most probable surprises to match the seven observed series:

Output (Y), Inflation (π), Debt-to-GDP ratio ($\frac{b}{Y}$)

Government spending (G), Transfers (T), Energy prices (P_{FE}), Subsidies to households (s_H)

For the shock on exogenous variables $\{G, T, P_{FE}, s_H\}$, there is no choice for the identification process and the time series are fully explained by these shocks (see Figure 2).

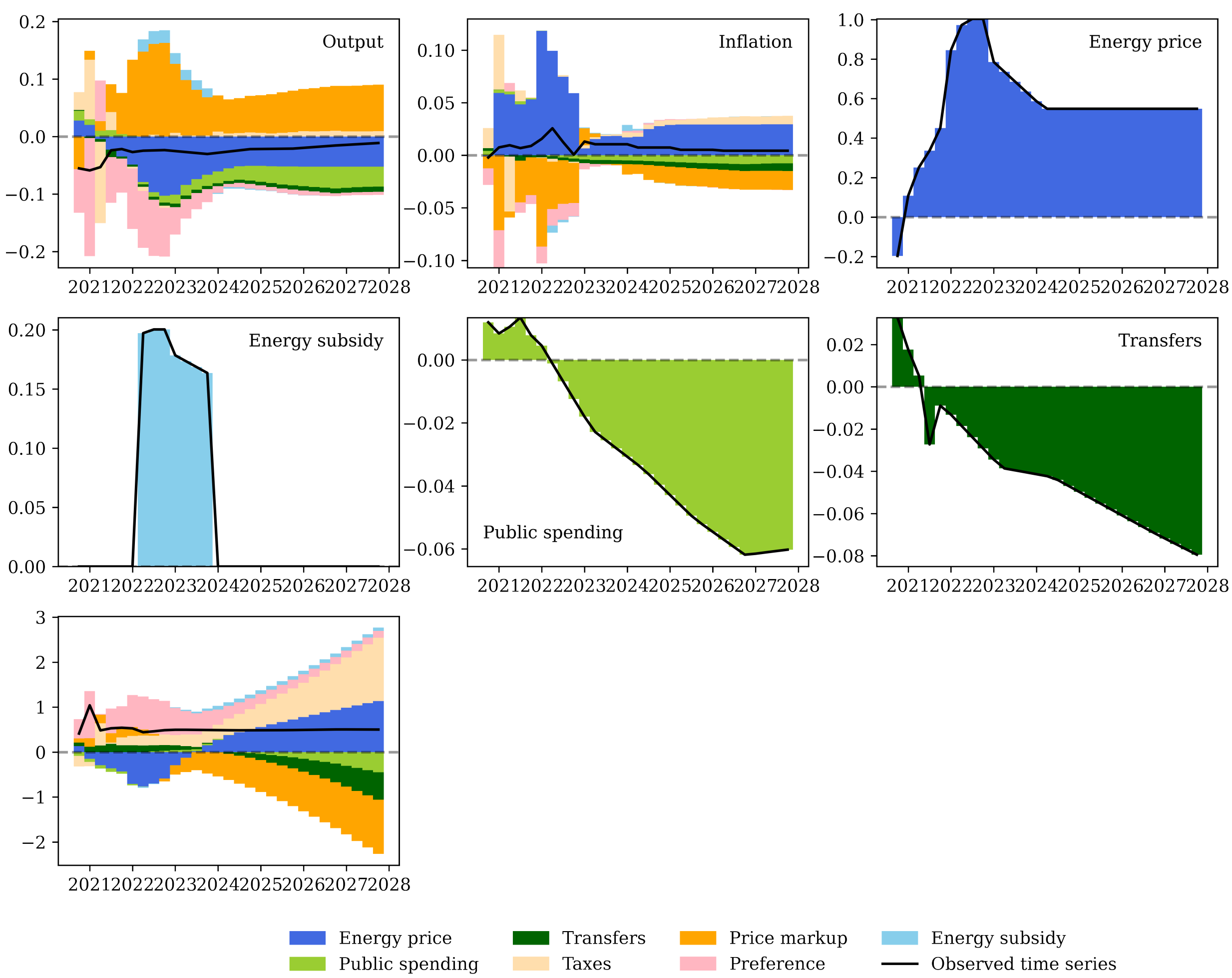


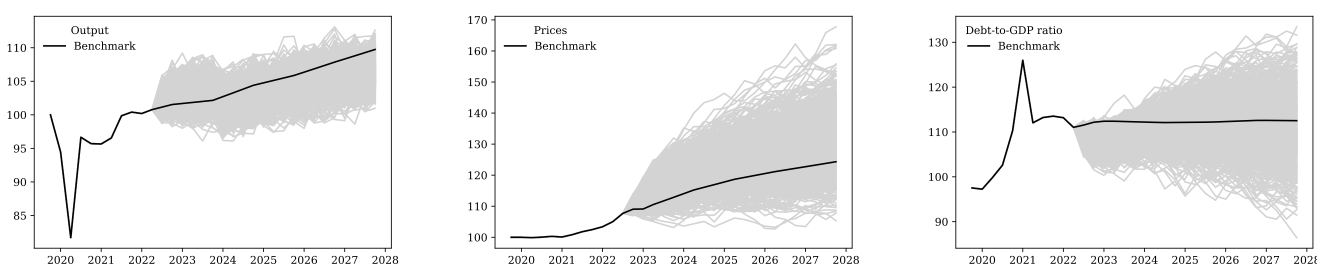
Figure 2: Shock decomposition: focus after 2020 Q4

The shocks on unobservable variables $\{\beta, \mu, t\}$ explain the endogenous variables, Output Y, Inflation π, Debt-to-GDP ratio $\frac{b}{Y}$ (see Figure 2). Lets us notice that the markup shock mixes the firm's markup with technological changes, and thus must be interpreted as a supply shock.

The results show that the oil price shocks explain a large part of the fall in GDP and of the rise in inflation, while the shocks on the firm's profitability combining the adjustments of markups and of technology support growth moderates inflation. Finally, demand shocks (subjective discount rate of households) contribute to slowing growth, but lower prices in 2022 and 2023. The other shocks seem to have a smaller contribution, except for the public expenditure shock after 2024 because the government plans to reduce them sharply after 2024.[10]

4.4 Forecasting

The shocks obtained in the previous decomposition are then used as inputs to the model to construct the economy's response for all macroeconomic variables. Given that all shocks have an innovation normally distributed ($\varepsilon^Z \rightsquigarrow N(0, \sigma_Z^2)$ for $Z = \beta, \mu, t, G, T, P_{FE}$), we use the estimated standard deviation of these shocks over the sample 1Q2022-4Q2027 to compute the confidence intervals of the model's forecasts, under the restriction that the subsidy on energy consumption has no uncertainty. First, it is important to notice that the standard deviation of government and transfer innovations



(a) GDP

(b) Consumer price index

(c) Debt-to-GDP ratio

Figure 3: Uncertainty on Model's Forecasts

(ε^G and ε^T) are very small because the commitment of the French government is close to a trend with respect to these data. Hence, the large surfaces of the confidence bands reported in Figure 3 underline that the innovations of the shocks on $\{\beta, \mu, t, P_{FE}\}$ have a large variance leading to

[10] This shock decomposition is made over a longer sample in Figure 7 of Appendix B.

uncertainty on forecasts. This result suggests that the forecasts reported in the Budget of the French government (*Projet de loi de finances 2023*) are consistent with "large" changes in demand (β), markups (μ), fiscal adjustments (t) and more importantly on energy price (P_{FE}).

4.5 Policy Analysis

4.5.1 On the Effectiveness of the Tariff Shield

	(%)	GDP		Inflation		$\frac{\text{Debt}}{\text{GDP}}$
No tariff shield	2022	1.11	1.0%	7.5	7.2%	110.7%
	2023	0.92		6.4		
Tariff shield 2022 2023	2022	2.85	1.9%	6.4	5.6%	112.5%
	2023	1.00		4.6		
Tariff shield 2022	2022	2.85	1.7%	6.4	5.9%	112.8%
	2023	0.55		5.0		

Table 4: Tariff Shield Impact

With a tariff shield in 2022 and 2023, which represents an annual budgetary cost of 2% of GDP, i.e. 58 billion euros, Table 4 shows that the French government is supporting growth, and smoothing it over the two years, 2022 and 2023.[11] The growth rate for 2022-2023 would have been 1.0% without the tax shield against 1.9% as forecasted by the government. Inflation is contained because the power of the price-wage loop is not engaged: the inflation rate for 2022-2023 would have been 7.2% without the tax shield instead of 5.6%. Indeed, without a tariff shield, the sharp rise in consumer prices causes nominal wages to react strongly, which fuels inflation and increases the cost of labor, which explains why growth is also significantly weaker. If the shield is not renewed in 2023, then there is no longer any smoothing of growth, which then stops abruptly in 2023. Inflation remains contained thanks to the tax shield which operates in the year 2022. This half-measure does not induce budgetary savings because it implies a loss of growth.

Who loses the most with no tariff shield? To have a reference measure for inequalities, we use INSEE data concerning the "Household Budget": individuals located in the Top 10% (T10) of income consume 3 times more than those in the Bottom 10% (B10) income, while they only consume 1.97 times more than those within the middle of the earning distribution. Finally, those

[11] In Appendix C, the complete description of the quarterly path of the aggregates is presented.

in the middle of earning distribution consume 1.52 times more than those in the B10 of income. In the model, the income process involves a distribution given in Table 5.

Model	B1.5	B10	B33	Middle	T33	T10	T1.5
Earnings	0-1.5%	1.5-10%	10-33%	33-66%	66-90%	90-98.5%	98.5-100%

Table 5: Earning inequalities

Without the tariff shield, Figure 4 shows that the consumption of the T10, which was 2.25 higher than that of the B10 in 1Q2022, is 2.48 higher than that of the B10 in 4Q2022, i.e. an increase of 10.2% of this measure of inequality. The energy crisis is therefore increasing consumption inequalities. With the tariff shield, the consumption of the T10 would only be 2.38 higher than that of the B10 in 4Q2022, i.e. a very moderate increase of 6% in this measure of inequality. These figures also show that the amortization of the rise in inequalities occurs above all at the bottom of the distribution (i.e. also for the Middle vs T10).

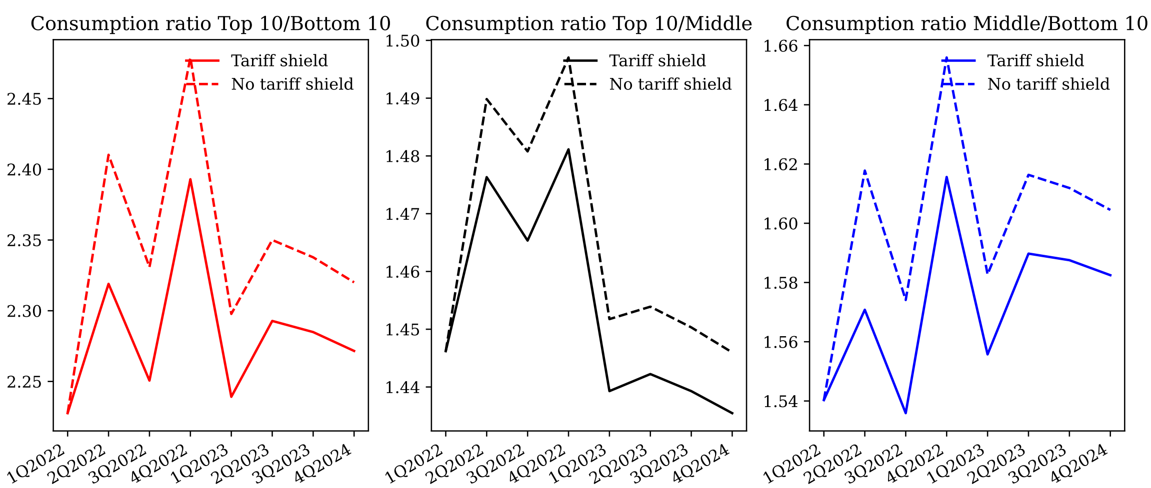


Figure 4: Dynamics of Inequalities with Tariff Shield

4.5.2 Would wage indexation increase the effectiveness of the tariff shield?

The tariff shield makes it possible to attenuate the reduction in purchasing power induced by increases in the price of energy purchased by households but fails to curb those of goods manufactured using also energy. To cope with these declines in purchasing power, a more rapid indexation of wages to consumer prices can be envisaged. To evaluate such a strategy, we then calibrate the nominal wage adjustment cost parameter so that they adjust over the year to variations in inflation.

	(%)	GDP		Inflation		$\frac{\text{Debt}}{\text{GDP}}$
No tariff shield	2022	1.11	1.0%	7.5	7.2%	110.7%
	2023	0.92		6.4		
Tariff shield 2022 2023	2022	2.85	1.9%	6.4	5.6%	112.5%
	2023	1.00		4.6		
Wage indexation	2022	2.22	1.6%	7.5	6.3%	114.1%
	2023	1.03		4.8		

Table 6: Strong Wage Indexation Accompanying Tariff Shield

Table 6 shows that inflation is much stronger when a faster indexation of nominal wages on prices accompanying the tariff shield.[12] This very high inflation, at 7.5% for 2022, favorable to the real hourly wage, sharply reduces employment. As the effect on employment over-compensates that on the real hourly wage, households experience losses in purchasing power. This measure is therefore less effective on growth, which loses 0.61 points over two years compared to the reference scenario with tariff shield over the two years 2022 and 2023. This slowdown in growth reduces the government revenues, which sees its debt ratio on GDP increase by 1.8 points compared to the scenario with tariff shield over the two years 2022 and 2023.

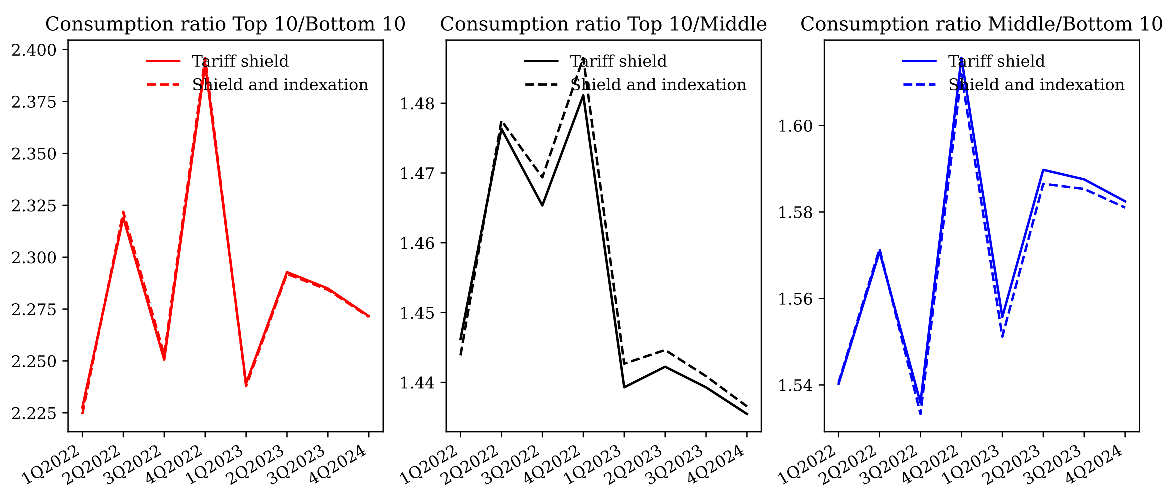


Figure 5: Dynamics of Inequalities When a Strong Wage Indexation Accompanied Tariff Shield

[12]In the Appendix D, the complete description of the quarterly path of the aggregates is presented.

The Figure 5 shows that the redistributive effects of faster wage indexation are very small, leaving inequality at the same level as in the reference scenario.

4.5.3 On the effectiveness of a redistributive demand policy

An alternative policy consists to increase demand by redistributing transfers to households. We, therefore, propose to replace the tariff shield, which can be considered as a "supply" policy because it acts by a price distortion, by a transfer for all households. We assume that all households receive the transfer (demand policy). This transfer represents a higher share of the budget for the most disadvantaged (redistribution). This transfer is targeted to allow households to finance their incompressible energy consumption. We then have to calibrate the part of consumption that the government considers to be incompressible. To do this, it is assumed that the incompressible consumption for all households is evaluated by the government at 20% of the total energy consumption of the average household. The budgetary cost of such a measure is equivalent to 25% of that induced by the tariff shield. This measure is redistributive because the share of incompressible energy consumption in energy consumption for each decile goes from 31% for individuals whose income is in the first decile to 14% for those in the tenth decile.[13]

	(%)	GDP		Inflation		$\frac{\text{Debt}}{\text{GDP}}^*$
No tariff shield	2022	1.11	1.0	7.5	7.2	110.7
	2023	0.92		6.4		
Tariff shield 2022 2023	2022	2.85	1.9	6.4	5.6	112.5
	2023	1.00		4.6		
Subs. to cons.	2022	1.65	1.4	7.8	7.4	119.3
	2023	1.27		6.5		

Table 7: Redistributive Demand Policy

As it is shown in Table 7, this policy is less effective in supporting growth: 1 point of growth is lost over two years.[14] It is also much more inflationary because it activates the price-wage spiral more strongly. Finally, even with a lower fiscal cost, weak growth and higher inflation further increase the ECB rate, increasing the debt burden, explaining the higher growth in the debt-to-GDP ratio than in the case of the tariff shield.

[13]The share of incompressible energy consumption in energy consumption for each decile is 31% for D1, 26% for D2, 24% for D3, 21% for D4, 20% for D5, 19% for D6, 17% for D7, 18% for D8, 16% for D9 and 14% for D10.

[14]In Appendix E, the complete description of the quarterly path of the aggregates is presented.

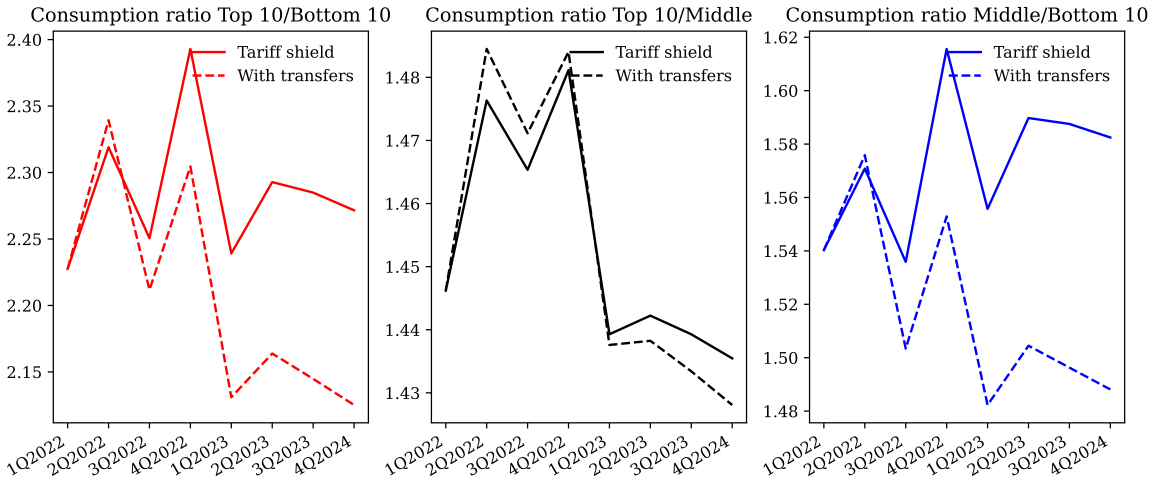


Figure 6: Dynamics of Inequalities: a Redistributive Demand Policy

But this redistributive demand policy leads to a greater reduction in inequalities. With this transfer targeted on the incomprehensible energy consumption, the consumption of the T10 which was 2.25 higher than that of the B10 in 1Q2022 is now only 2.15 higher than that of the B10 in 4Q2023, i.e. a decrease of 4.5% of this measure of inequality. The increase in the consumption ratio of the T10 compared to that of the Middle is identical to that with a tariff shield (benchmark scenario). The ratio of Middle consumption compared to that of B10 drops from 1.60 in 4Q2023 to 1.50, i.e. a 6% drop in this measure of inequality.

5 Conclusion

This article shows that France experienced lower inflation than its European partners notably because it implemented a tariff shield. We show that it is not possible to do better than this strategy without sacrificing growth and further increasing the debt-to-GDP ratio. We estimate the cost of this measure at 58 billion euros in 2022, and 52 billion in 2023, i.e. approximately 2 points of GDP, which will lead to an increase of 2.5 points in the debt-to-GDP ratio in 2027. We show that supporting this policy through wage indexation is not desirable. Finally, the tariff shield is more effective than a redistributive demand policy (direct transfers to households) from a macroeconomic point of view because it provides greater support for employment by containing the cost of labor.

The recent rise in energy prices and its consequences on the purchasing power of households, particularly the poorest, calls into question the acceptability of environmental policies such as the introduction of a carbon tax. Our model can be extended to account for a carbon tax and think of additional policy tools that may help alleviate its negative impacts on the French economy. Such work is done in Langot et al. (2023).

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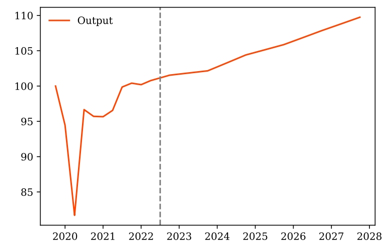
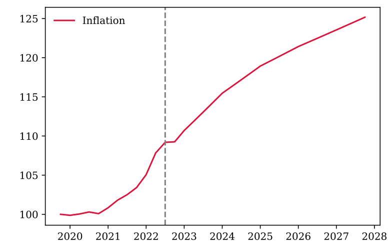
A French Data: 4Q2019 = 100

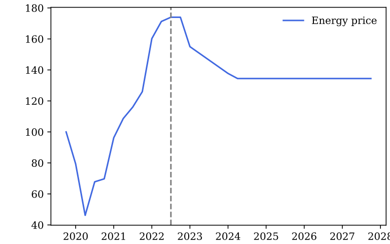
Raw Data: 4Q2019 = 100



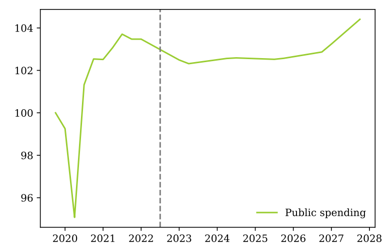
(a) GDP



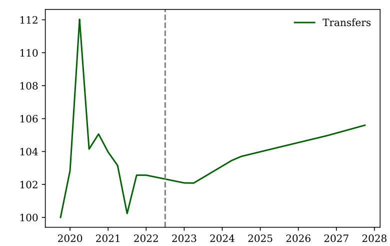
(b) GDP Price Index



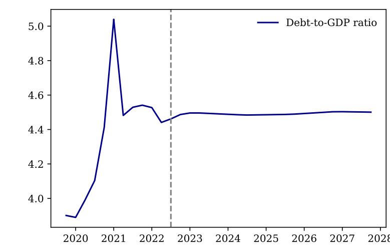
(c) Energy Price Index



(d) Government expenditures

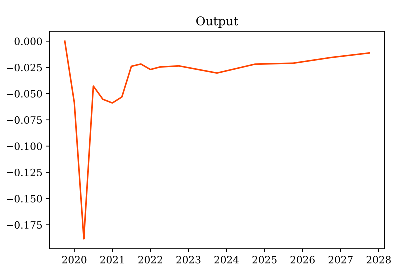


(e) Government transferts

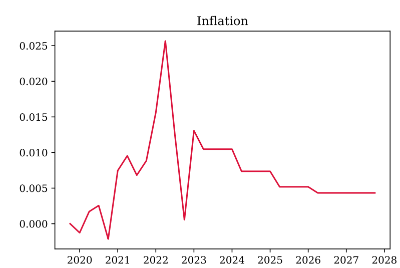


(f) Debt over GDP

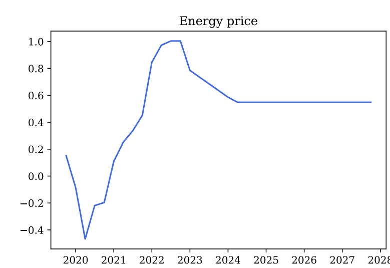
Stationnarized French Data: 2019 Q4 = 100



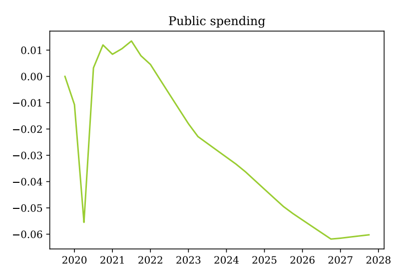
(g) $\frac{GDP_t}{1.0032^t}\frac{1}{100} - 1$



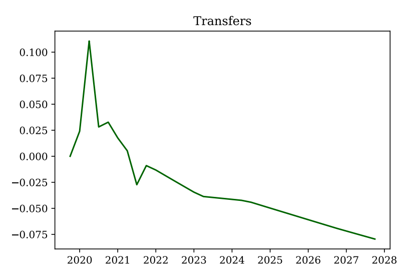
(h) $\frac{P_t - P_{t-1}}{P_{t-1}}$



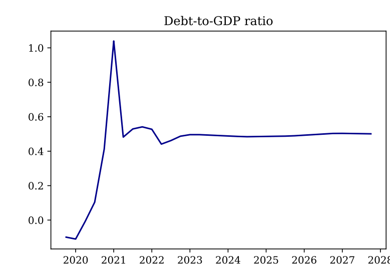
(i) $\frac{\text{Energy Price Index}_t - 86.819}{86.819}$



(j) $\frac{G_t}{1.0033^t}\frac{1}{100} - 1$



(k) $\frac{T_t}{1.0043^t}\frac{1}{100} - 1$



(l) $\frac{B_t}{GDP_t} - 4$

B Shock decomposition

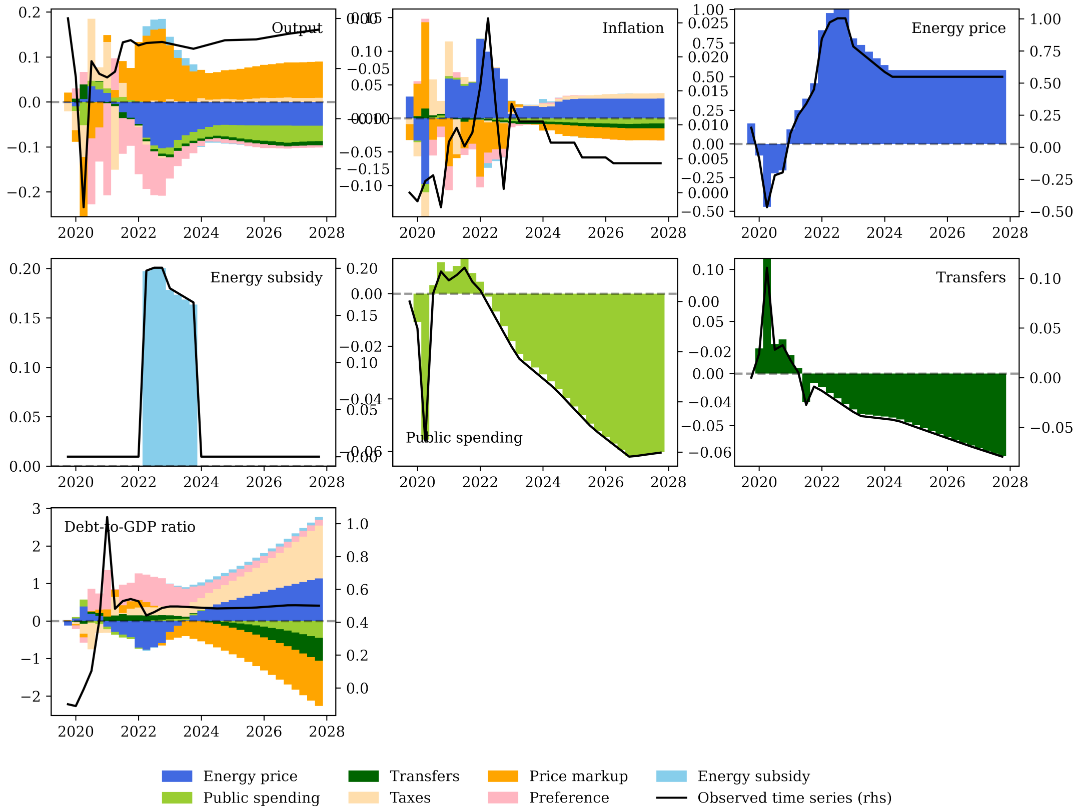
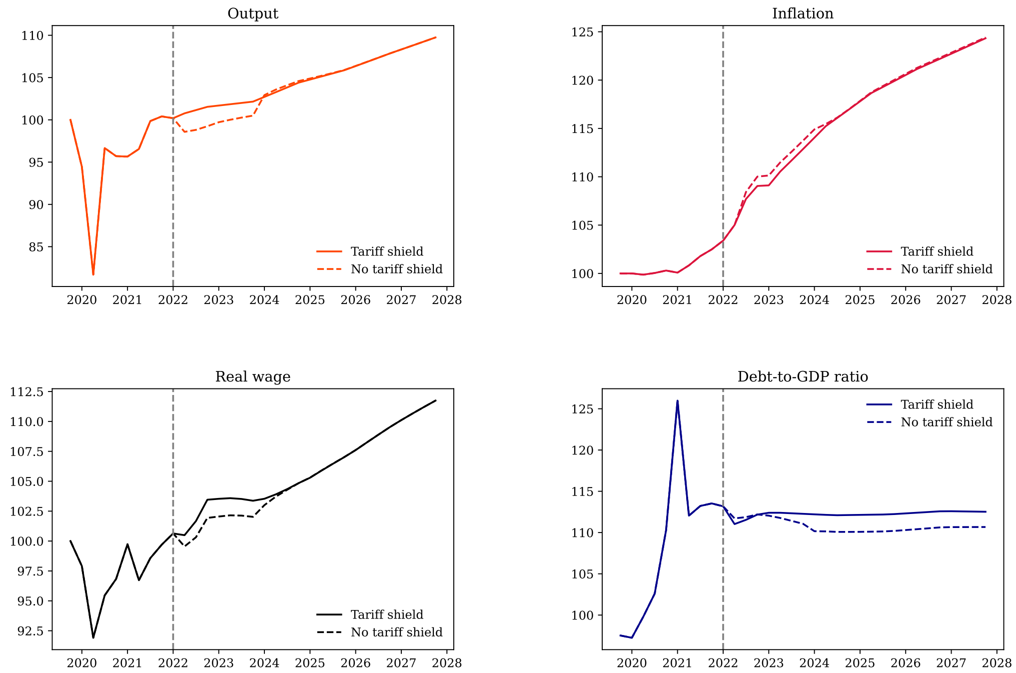
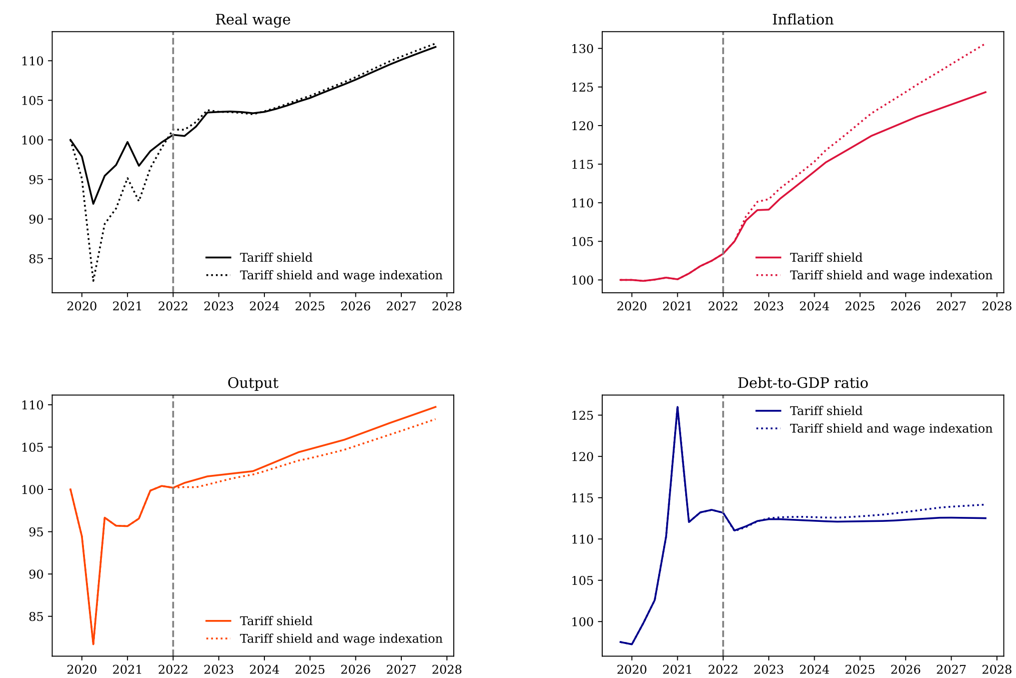


Figure 7: Shock decomposition since 4Q2019

C Tariff shield: Aggregates since 4Q2019



D Re-activating the price-wage spiral: Aggregates since 2019-Q4



E Subsidizing incompressible energy consumption: Aggregates since 4Q2019